



# The 2025 report of the Lancet Countdown on health and climate change

Marina Romanello, Maria Walawender, Shih-Che Hsu, Annalyse Moskeland, Yasna Palmeiro-Silva, Daniel Scamman, James W Smallcombe, Sabah Abdullah, Melanie Ades, Abdullah Al-Maruf, Nadia Ameli, Denitsa Angelova, Sonja Ayeb-Karlsson, Joan Ballester, Xavier Basagaña, Hannah Bechara, Paul J Beggs, Wenjia Cai, Diarmid Campbell-Lendrum, Gina E C Charnley, Orin Courtenay, Troy J Cross, Carole Dalin, Niheer Dasandi, Shouro Dasgupta, Michael Davies, Matthew Eckelman, Chris Freyberg, Paulina Garcia Corral, Olga Gasparyan, Joseph Giguere, Georgiana Gordon-Strachan, Sophie Gumy, Samuel H Gunther, Ian Hamilton, Yun Hang, Risto Hänninen, Stella Hartinger, Kehan He, Julian Heidecke, Jeremy J Hess, Slava Jankin, Ollie Jay, Dafni Kalatzi Pantera, Ilan Kelman, Harry Kennard, Gregor Kiesewetter, Patrick Kinney, Dominic Kniveton, Vally Koubi, Rostislav Kouznetsov, Pete Lampard, Jason K W Lee, Bruno Lemke, Bo Li, Andrew Linke, Yang Liu, Zhao Liu, Rachel Lowe, Siqi Ma, Tafadzwanashe Mabhaudhi, Carla Maia, Anil Markandya, Greta Martin, Jaime Martinez-Urtaza, Mark Maslin, Lucy McAllister, Celia McMichael, Zhifu Mi, James Milner, Kelton Minor, Jan Minx, Nahid Mohajeri, Natalie C Momen, Maziar Moradi-Lakeh, Karyn Morrisey, Simon Munzert, Kris A Murray, Nick Obradovich, Papa Origen, Matthias Otto, Fereidoon Owfi, Olivia L Pearman, Frank Pega, Andrew J Pershing, Ana-Catarina Pinho-Gomes, Jamie Pomattam, Mahnaz Rabbaniha, Tim Repke, Jorge Roa, Elizabeth Robinson, Joacim Rocklöv, David Rojas-Rueda, Jorge Ruiz-Cabrejos, Matilde Rusticucci, Renee N Salas, Adrià San José Plana, Jan C Semenza, Jodi D Sherman, Joy Shumake-Guillemot, Pratik Singh, Henrik Sjödin, Matthew R Smith, Mikhail Sofiev, Cecilia Sorensen, Marco Springmann, Jennifer D Stowell, Meisam Tabatabaei, Federico Tartarini, Jonathon Taylor, Cathryn Tonne, Marina Treskova, Joaquin A Trinanes, Andreas Uppstu, Nicolas Valdes-Ortega, Fabian Wagner, Nick Watts, Hannah Whitcombe, Richard Wood, Pu Yang, Ying Zhang, Shaohui Zhang, Chi Zhang, Shihui Zhang, Qiao Zhu, Peng Gong, Hugh Montgomery, Anthony Costello

## Executive summary

Driven by human-caused greenhouse gas emissions, climate change is increasingly claiming lives and harming people's health worldwide. Mean annual temperatures exceeded 1.5°C above those of pre-industrial times for the first time in 2024. Despite ever more urgent calls to tackle climate change, greenhouse gas emissions rose to record levels that same year. Climate change is increasingly destabilising the planetary systems and environmental conditions on which human life depends.

Authored by 128 multidisciplinary experts worldwide, the 2025 report of the *Lancet* Countdown on health and climate change is the ninth—and most comprehensive—assessment of the links between climate change and health. The data in this report reveal that, as the health risks and impacts of climate change break concerning new records, progress is being reversed across key areas, further threatening health and survival. However, the evidence in this report also exposes important opportunities to accelerate action and prevent the most catastrophic impacts of climate change.

## The growing human costs of delayed climate change actions

The health threats of climate change have reached unprecedented levels. Of the 20 indicators tracking the health risks and impacts of climate change in this report, 12 have set concerning new records in the latest year for which indicator data are available.

On average, 16 (84%) of the 19 life-threatening heatwave days that people were exposed to annually in 2020–24 would not have occurred without climate change. Infants younger than 1 year and adults older than 65 years (the most vulnerable age groups) were exposed to a record-high number of heatwave days in 2024, with infants

younger than 1 year being exposed to 389% more heatwave days each on average, and adults older than 65 years being exposed to 304% more heatwaves days each on average, compared with the average exposure in 1986–2005 (indicator 1.1.1). The higher temperatures and the increasing size of vulnerable populations have led to a 63% increase in heat-related deaths since the 1990s, reaching an estimated 546 000 yearly deaths on average in 2012–21 (indicator 1.1.5). The impacts of heat exposure on an individual's ability to work or exercise outdoors, and on sleep quality have also reached concerning levels, affecting physical and mental health (indicators 1.1.2–1.1.4).

The incidence of extreme precipitation days (which affect health and can trigger flash floods and landslides), increased in 64% of the world's land surface between 1961–90 and 2015–24 (indicator 1.2.3). Meanwhile, a record-breaking 61% of the global land area was affected by extreme drought in 2024, which is 299% above the 1950s average, further threatening food and water security, sanitation, and causing downstream economic losses (indicator 1.2.2). These extremes of heat, precipitation, and droughts can affect crop productivity, disrupt supply chains, hamper the work of agricultural workers, and affect income, further threatening food security. Indeed, the higher number of heatwave days and drought months in 2023 compared with 1981–2010 was associated with 123.7 million more people experiencing moderate or severe food insecurity in 124 countries analysed (indicator 1.4). Additionally, the hotter and drier weather is increasing the risk of wildfires, and 2024 had a record-high 154 000 deaths from wildfire smoke-derived small particulate matter (PM<sub>2.5</sub>) air pollution (indicator 1.2.1).

The changing climatic conditions are also affecting the risk of transmission of deadly infectious diseases. The average climate-defined transmission potential of dengue by *Aedes albopictus* and *Aedes aegypti* increased

Published Online  
October 29, 2025  
[https://doi.org/10.1016/S0140-6736\(25\)01919-1](https://doi.org/10.1016/S0140-6736(25)01919-1)  
**Institute for Global Health, University College London, London, UK** (M Romanello PhD, M Walawender MSPH, Y Palmeiro-Silva PhD, Prof I Kelman PhD, A-C Pinho-Gomes DPhil, H Whitcombe MPH, Prof A Costello MD); **Bartlett School of Environment, Energy & Resources, University College London, London, UK** (S-C Hsu PhD, D Scamman EngD, Prof N Ameli PhD, Prof I Hamilton PhD, P Origen PhD, P Yang PhD); **Department of Geography and Environment, London School of Economics and Political Science, London, UK** (A Moskeland MSc); **Heat and Health Research Centre, University of Sydney, Sydney, NSW, Australia** (J W Smallcombe PhD, T J Cross PhD, Prof O Jay PhD); **Economic Research & Development Impact Department, Asian Development Bank, Manila, Philippines** (S Abdullah PhD); **European Centre for Medium-Range Weather Forecasts, Reading, UK** (M Ades PhD); **Department of Geography and Environmental Studies, University of Rajshahi, Rajshahi, Bangladesh** (Prof A Al-Maruf PhD); **Institute for Ecological Economics,**

University of Vienna, Vienna, Austria (D Angelova PhD); Department of Risk and Disaster Reduction, University College London, London, UK (S Ayele-Karlsson PhD); Barcelona Institute for Global Health, Barcelona, Spain (Prof J Ballester PhD, Prof X Basagaña PhD, J Ruiz-Cabrejos MSc); Data Science Lab, Hertie School, Berlin, Germany (H Bechara PhD, P G Corral MSc, S Munzert PhD); School of Natural Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, NSW, Australia (Prof P J Beggs PhD); Department of Earth System Science, Tsinghua University, Beijing, China (Prof W Cai PhD); Department of Environment, Climate Change and Health, WHO, Geneva, Switzerland (D Campbell-Lendrum PhD, F Pega PhD, N C Momen PhD); Barcelona Supercomputing Center, Barcelona, Spain (G E C Charnley PhD); Zeeman Institute, University of Warwick, Warwick, UK (O Courtenay PhD); School of Life Sciences, University of Warwick, Warwick, UK (O Courtenay); Institute for Sustainable Resources, University College London, London, UK (C Dalin PhD); School of Government, University of Birmingham, Birmingham, UK (N Dasandi PhD, D K Pantera PhD); Euro-Mediterranean Center on Climate Change Foundation, Lecce, Italy (S Dasgupta PhD); Institute for Environmental Design and Engineering (Prof M Davies PhD, N Mohajeri PhD); Department of Civil and Environmental Engineering, Northeastern University, Boston, MA, USA (Prof M Eckelman PhD); Ruby Coast Research Group, Ruby Bay, New Zealand (C Freyberg MSc); Department of Political Science, Florida State University, Tallahassee, FL, USA (O Gasparyan PhD); Climate Central, Princeton, NJ, USA (J Giguere BS, A J Pershing PhD); Tropical Metabolism Research Unit, Caribbean Institute for Health Research, University of the West Indies, Kingston, Jamaica (G Gordon-Strachan PhD); WHO, Geneva, Switzerland

by 48·5% and 11·6%, respectively, from 1951–60 to 2015–24, at least partially contributing to the 7·6 million dengue cases reported globally in early 2024 (indicator 1.3.1). The changing climate pushed the predicted risk of at least one case of locally transmitted case of leishmaniasis up by 29·6% in 2015–24 compared with 1951–60 (indicator 1.3.4); an additional 364 million people were at risk of tick-borne diseases transmitted by *Rhipicephalus sanguineus* and *Hyalomma* spp (including Rocky Mountain spotted fever and Crimean–Congo haemorrhagic fever) in 2015–24 compared with the 1950s (indicator 1.3.5).

The multiple health impacts of climate change are increasingly straining the economy, reducing labour productivity, increasing worker absenteeism, and burdening health systems, which, in turn, affects the socioeconomic conditions that support health and wellbeing. Heat exposure resulted in a record-high 639 billion potential work hours being lost in 2024, 98% above the 1990–99 average. The hours lost in 2024 resulted in potential losses worth US\$1·09 trillion: almost 1% of global domestic product (GDP; indicators 1.1.3 and 4.1.3). Additionally, weather-related extreme events in 2024 caused \$304 billion in global economic losses—a 58·9% increase from the 2010–14 annual average. Growing in both scale and unpredictability, these losses are increasingly straining health systems, which are increasingly incapable of absorbing climate-related damages. Insurance coverage of growing extreme weather event-related losses fell from 67% in 2010–14 to 54% in 2020–24. As a result, losses increasingly fall on public systems and individuals, affecting health and socioeconomic wellbeing, reducing people's capacity to cope and recover from climate change-related impacts, and further exacerbating their vulnerability to climate change (indicator 4.1.1).

Indicators in this report reveal the growing health threats of climate change across every dimension monitored. Yet, when assessed in isolation, these indicators can obscure the compounding and synergistic effects of multiple health impacts occurring simultaneously, which might trigger amplified and cascading harms. These impacts can affect the social, economic, and environmental pillars on which people's health, livelihoods, and survival depend, and further exacerbate the risk of social unrest and conflict.

Delays in unrolling urgently needed adaptation strategies have left people poorly protected in the face of growing hazards, exacerbating the health harms of climate change. Scarce financial support for adaptation remains a key barrier and is still grossly insufficient to cover disclosed financial needs (indicator 4.3.4). A political shift towards reduced foreign aid support from some of the world's wealthiest countries (and those among the most responsible for current climate change) further restricts support for climate change action, leaving all populations increasingly unprotected.

With adaptation measures to date being insufficient to protect people from the current level of heating, accelerated efforts are urgently required to build resilience, minimise impacts, and save lives. However, every unit of greenhouse gases emitted amplifies the risks and exacerbates the economic costs and challenges of adaptation. Simultaneous and effective mitigation is therefore essential to keep adaptation feasible, and to ensure that the world's populations can still be protected from the climatic changes that have now become unavoidable.

### The price of backsliding: putting people in harm's way

Despite decades of scientific warnings, the world is currently heading towards a potentially catastrophic 2·7°C of heating by the end of the century—if not more—and emissions keep rising.

Emissions generated in the production and use of energy increased by 1·6% in 2023, reaching unprecedented levels; global agricultural greenhouse gas emissions reached an all-time high in the latest year of data (2022); and global tree cover loss grew by 24% to over 28 million hectares in 2023, limiting the capacity to reduce atmospheric greenhouse gas concentrations (indicators 3.1.1, 3.3.1, and 3·4).

Paradoxically, as the need for decisive health-protective action grows, some world leaders are disregarding the growing body of scientific evidence on health and climate change, often in favour of short-sighted economic and political interests. The prioritisation of climate change action in political agendas is therefore waning: mentions of health and climate change by governments in their annual UN General Debate statements declined from 62% in 2021 to 30% in 2024 (indicator 5.4.1). This engagement remains mostly driven by countries that are the least responsible for, but most affected by, climate change, whereas engagement is falling in some of the world's greatest greenhouse gas emitters. The new US administration withdrew the country from the 2015 Paris Agreement, and dismantled world-leading research in the field, as well as key health, climate, and environmental agencies. Some countries (eg, Argentina and Hungary) have taken similar obstructive stances, while others have dropped crucial climate commitments. The USA's withdrawal from WHO compounds climate threats, exacerbating health risks globally.

With reduced pressure from powerful political leaders, fossil fuel giants (including Shell, BP, ExxonMobil, and Chevron) have paused, delayed, or retracted their climate commitments, increasingly pushing the world towards a dangerous future. As of March, 2025, the 100 largest oil and gas companies had production strategies that put them on track to exceed their share of production consistent with 1·5°C of heating by 189% in 2040, up from 183% in March, 2024 (indicator 4.2.2). Private banks supported this expansion, as their lending to fossil fuel sector activities surged by 29%, reaching \$611 billion

in 2024, exceeding their green sector lending by 15% (indicator 4.3.3). These fossil fuel investments threaten not only public health but also national economies. The value of coal power sector assets at risk of being stranded in 2030 rose by 44% from 2023 to 2024, reaching \$22.4 billion (indicator 4.2.3). Meanwhile, delayed action and backtracked commitments have further reduced most countries' preparedness for the transition to zero-carbon, health-supporting socioeconomic systems (indicator 4.2.4).

### Missed opportunities paid for in millions of lives

Previous *Lancet* Countdown reports have highlighted the health opportunities of a just and health-centred transition in line with the Paris Agreement. However, these opportunities remain largely untapped, resulting in millions of avoidable deaths yearly.

Increasing access to affordable, off-grid, renewable electricity is essential to tackle the major sources of greenhouse gas emissions and reduce climate risks. With adequate international cooperation, technology transfer, knowledge sharing, and capacity building—alongside regulation to prevent health harms from raw material extraction and waste disposal—renewable energy can also drive development, support the eradication of energy poverty, and reduce environmental health risks. Yet, this potential remains mostly unrealised. Globally, 745 million people still lack access to electricity, around 1 billion people are served by health-care facilities that lack reliable power supplies, and 88% of households in countries with a low Human Development Index (HDI) score still primarily use polluting and unreliable fuels to meet their energy needs (indicator 3.1.2). With structural barriers and global disparities in technology development and access, clean energy access remains deeply unequal: low HDI countries relied on renewables for just 3.5% of energy in 2022, compared with 12% in high HDI countries and 13.3% in very high HDI countries (indicator 3.1.1). Moreover, the air pollution resulting from the household use of dirty fuels and technologies across 65 countries resulted in 2.3 million deaths in 2022 (indicator 3.2.2), including some of the 2.52 million deaths still attributable to ambient air pollution from the burning of fossil fuels globally in 2022 (indicator 3.2.1)—deaths that could largely be avoided by transitioning to clean, renewable energy.

The failure to transition away from fossil fuels has also come at a major financial cost. In response to the fossil fuel price spike that followed Russia's invasion of Ukraine, most countries—still heavily reliant on this source of energy—resorted to subsidies to keep energy affordable and prevent a spike in energy poverty. As a result, 73 (84%) of the 87 countries reviewed (accounting for 93% of global greenhouse gas emissions) provided net explicit fossil fuel subsidies in 2023, allocating a net total of \$956 billion to this purpose—the second-highest value on record, only below the \$1.4 trillion allocated the

year before. Of these countries, 15 (17%) allocated more funds to net fossil fuel subsidies than to national health budgets, reflecting the opportunity cost of fossil fuel dependence (indicator 4.3.2). The fiscal pressures from the local reliance on fossil fuel subsidies can be eliminated by transitioning away from fossil fuels, making funds available to support activities that benefit—rather than harm—human health.

Turning to the food sector, the potential health benefits of more sustainable, climate-friendly diets also remain largely undelivered: mortality related to high-carbon, unhealthy diets increased from 148 per 100 000 people to 150 per 100 000 people between 2021 and 2022, resulting in 11.8 million largely preventable deaths (indicators 3.3.1 and 3.3.2).

These undelivered opportunities highlight the potential of health-centred climate change action in helping tackle some of the major issues facing populations and governments worldwide, from health burdens to fiscal pressures. Countries that commit to prioritising this transition will stand to gain the most from the health and economic benefits and can still lead the way to a prosperous future for present and future generations, both within and beyond their country borders.

### Growing momentum

Amid growing health harms, avoiding the most catastrophic impacts of climate change requires immediate and bold climate change action across every economic sector and social actor. Despite increasingly challenging geopolitical landscapes, some positive signs showcase growing momentum.

The growth of the clean energy sector is underway. The share of electricity generated by modern renewables is growing rapidly, reaching a record-high 12.1% in 2022 (indicator 3.1.1). The shift away from coal, particularly in high and very high HDI countries, resulted in a 5.8% reduction in deaths attributable to ambient PM<sub>2.5</sub> from fossil fuel combustion between 2010 and 2022, avoiding 160 000 deaths annually. Countries leading the clean energy transition have also had substantial economic benefits. In 2023, the clean energy sector accounted for 10% of global GDP growth, with clean energy growth accounting for 6% of GDP growth in the USA, almost 5% of GDP growth in India, and over 30% of GDP growth in the EU. As the UK became the first major economy to halve global emissions from 1990 levels, its green economy grew three times faster than the broader economy. In China, the world's largest single greenhouse gas emitter, renewable energy contributed to a record 10% of its GDP in 2024, and CO<sub>2</sub> emissions fell for the first time while delivering cleaner air and improving health outcomes. Globally, direct and indirect employment in the renewable energy sector increased by 18.3% in 2023, reaching 16.2 million employees globally (indicator 4.2.1), providing healthier and more sustainable job opportunities than the fossil

(S Gurny PhD); Yong Loo Lin School of Medicine, National University of Singapore, Singapore (S H Gunther PhD, Prof J K W Lee PhD); Department of Environmental and Occupational Health Sciences, University of Texas Health Science Center at Houston, Houston, TX, USA (Prof Y Hang PhD); Finnish Meteorological Institute, Helsinki, Finland (R Hänenen DSc, R Kouznetsov PhD, Prof M Sofiev PhD, A Uppstu PhD); School of Public Health and Administration, Universidad Peruana Cayetano Heredia, Lima, Peru (Prof S Hartinger PhD); Institute for Climate and Carbon Neutrality, University of Hong Kong, Hong Kong Special Administrative Region, China (K He PhD); Interdisciplinary Centre for Scientific Computing, Heidelberg University, Heidelberg, Germany (J Heidecke MSc, Prof J Rocklöv PhD); Heidelberg Institute of Global Health, Heidelberg University, Heidelberg, Germany (J Heidecke, M Treskova PhD); Centre for Health and the Global Environment, University of Washington, Seattle, WA, USA (Prof J J Hess MD, M R Smith PhD); Institute for Data and AI, University of Birmingham, Birmingham, UK (Prof S Jankin PhD); Pollution Management Group, Program on Energy, Climate and the Environment, International Institute for Applied Systems Analysis, Laxenburg, Austria (G Kiesewetter PhD, F Wagner PhD, Sha Zhang PhD); Department of Environmental Health, School of Public Health, Boston University, Boston, MA, USA (Prof P Kinney PhD, J D Stowell PhD); School of Global Studies, University of Sussex, Falmer, UK (Prof D Kniveton PhD); Center for Comparative and International Studies, Department of Humanities, Social and Political Science, ETH Zürich, Zürich, Switzerland (Prof V Koubi PhD); Department of Health Sciences, University of York, York, UK (P Lampard PhD); Nelson Marlborough Institute of Technology—Te Pukenga, Nelson, New Zealand



(B Lemke PhD, M Otto MEng); School of Management, Beijing Institute of Technology, Beijing, China (B Li MSc, Prof C Zhang PhD); School of Environment, Society, and Sustainability, University of Utah, Salt Lake City, UT, USA (Prof A Linke PhD); Emory University, Atlanta, GA, USA (Prof Y Liu PhD, Q Zhu PhD); School of Airport Economics, Beijing Institute of Economics and Management, Beijing, China (Z Liu PhD); Catalan Institution for Research and Advanced Studies, Barcelona, Spain (Prof R Lowe PhD); Center for Spatial Information Science and Systems, George Mason University, Fairfax, VA, USA (S Ma PhD); Department of Plant and Soil Sciences, Future Africa, University of Pretoria, Pretoria, South Africa (Prof T Mabhaudhi PhD); Global Health and Tropical Medicine, Instituto de Higiene e Medicina Tropical, Universidade Nova de Lisboa, Lisbon, Portugal (C Maia PhD); BC3 Basque Centre for Climate Change, Santsoena, Spain (Prof A Markandya PhD); Milken Institute School of Public Health, George Washington University, Washington, DC, USA (G Martin PhD); Department of Genetics and Microbiology, School of Biosciences, Universitat Autònoma de Barcelona, Barcelona, Spain (Prof J Martinez-Urtaza PhD); Department of Geography, University College London, London, UK (Prof M Maslin PhD, Prof P Gong PhD); Environmental Studies Program, Denison University, Granville, OH, USA (L McAllister PhD); School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Melbourne, VIC, Australia (Prof C McMichael PhD); The Bartlett School of Sustainable Construction, University College London, London, UK (Prof Z Mi PhD); Department of Public Health, Environments, and Society, London School of Hygiene & Tropical Medicine, London, UK (J Milner PhD); Data Science Institute, Columbia University, New York, NY, USA (K Minor PhD); Mercator Research Institute on Global Commons and Climate Change, Berlin, Germany

fuel sector. Meanwhile, direct fossil fuel employment fell by 0.7%, to 9.06 million jobs (indicator 4.2.1), even as fossil fuel production expanded. Additionally, tree cover loss in Brazil decreased by 15% from 2022 to 2023, and the local loss of primary forest fell by 36%, protecting a region that holds the world's largest carbon sink (indicator 3.4).

Despite waning engagement with climate change and health by some world leaders, the growing engagement of other actors enables important avenues for change. Local governments are emerging as strongholds for change, and a growing number of cities are prioritising the protection of health through climate change action. Of the cities reporting to the CDP (formerly known as the Carbon Disclosure Project) in 2024, which runs the world's biggest system of disclosure of environmental actions, 97% declared having completed, or intending to complete, climate change risk assessments (indicator 2.1.3). Additionally, although mentions of health and climate change within companies' reports to the Global Compact fell in 2024 (indicator 5.5), there are signals of growing private sector support to progress climate change action. Importantly, support for climate change and health finance is growing too, and the launch of the Development Banks' Joint Roadmap for Climate-Health Finance and Action in June, 2024, offers a framework to advance the provision of critically needed finance to advance the protection of health from climate change hazards.

Beyond the support from key organisations, the proactive engagement of individuals with climate change and health, an essential driver of community-led actions, is also growing (indicator 5.2). Individuals and civil society organisations are increasingly improving the protection of the right to health, including by resorting to litigation to advance the protection of the right to health and to a healthy environment, and to keep governments and corporations accountable. In June, 2025, the International Court of Justice's Advisory Opinion on the Obligations of States in respect of Climate Change concluded that states have legal obligations to limit greenhouse gas emissions, that they can incur legal responsibilities, and that they can be required to pay reparations if they fail meet these obligations. This Advisory Opinion now provides a legal springboard for further litigation and the protection of health and survival.

The health sector, a key protector of people's health and survival, is increasingly rising to the challenge. Health-care-related greenhouse gas emissions fell by 12% between 2021 and 2022 (indicator 3.5). As of March, 2025, 112 (58%) of 193 WHO member states had completed a Vulnerability and Adaptation assessment, evaluating health vulnerabilities, adaptive capacity, and adaptation needs, while 116 (60%) member states had completed a Health National Adaptation Plan (indicators 2.1.1 and 2.1.2). The provision of climate change education for health professionals is growing, building capacity for further

progress (indicator 2.2.5). The Global Action Plan on Climate Change and Health, adopted at the 78th World Health Assembly, now opens new opportunities for WHO, countries, and key stakeholders to advance climate change actions that protect and promote health.

### An urgent call to action: all hands on deck

The science is unequivocal. Concrete and meaningful actions are urgently needed to protect the world's populations from the climatic changes that have now become unavoidable, and to prevent an increase of climate change threats that exceeds the possibilities of adaptation.

Preventing climatic changes that exceed the world's capacity to adapt requires high greenhouse gas-emitting countries and corporations to urgently reduce their emissions. However, amid backsliding of commitments from some key decision makers and world leaders, the growing leadership of other actors—local governments, civil society organisations, private sector organisations, local communities, and, importantly, the health sector—offers promise for delivering the urgently needed system-wide transformation that prioritises prosperous economies and improved health. Community-led action, litigation, and civil society organisations are forging new avenues to hold governments and corporations to account in their duty to respond to the evidence and protect people's lives, health, and wellbeing. Crucially, the economic momentum provided by the growth of the clean energy sector can offer new opportunities to tackle greenhouse gas emissions from the energy sector—the biggest single contributor to global greenhouse gas emissions—while providing access to healthier energy and cleaner air.

As the urgency of responding to climate change grows, delivering this health-protecting transformation requires widespread support from all sectors of society. The growth of science-denying populism, misinformation, and disinformation demands concerted efforts by the scientific community, press, world leaders, and social media to break communications silos, and rigorously and effectively build awareness of the scientific evidence on climate change and health. This awareness will be key to inform and enable an evidence-based, health-protecting response.

The evidence in this report reveals priorities and opportunities to deliver these actions and realise transformational public health gains.

With the threats to people's lives and health growing, delivering a health-protective, equitable, and just transition requires all hands on deck. There is no time left for further delay.

### Introduction

The multiple impacts of climate change are converging to create an unprecedented threat to the health and survival of people around the world. In 2024, global annual mean surface temperatures exceeded



### Panel 1: Priorities for the protection of health amid global turmoil

With the threats of climate change growing, successful climate change action requires a coordinated response across all levels of government, society, and the economy. The priorities for action presented in the 2023 *Lancet* Countdown report remain relevant. However, the world has changed since the 2023 report was published. Greenhouse gas emissions reached new record-highs (indicator 3.1.1); mean annual temperature in 2024 surpassed 1.5°C above pre-industrial levels for the first time; the global energy crisis has boosted fossil fuel profits and encouraged further expansion (indicator 4.2.2); climate sceptics now lead multiple countries—including the USA, the world's current largest historical emitter—and many corporations have backtracked on their climate commitments. The risks of climate change to people's health and survival have reached unprecedented levels (section 1).

Against this backdrop, the data in this year's report inform actions and opportunities for different actors to improve health and forge a safer future. To support global health, these actions need to be delivered in ways that are gender-responsive, reduce health inequities, respect and promote the rights and knowledge of Indigenous People, and account for the protection of vulnerable and underserved communities.

#### National governments

Despite a drop in government engagement with health and climate change (indicator 5.4), most country leaders continue to acknowledge the science and urgency of accelerated climate change action. They can promote a safer future by:

- Creating supportive regulations and financial incentives, applied to both the public and private sectors, to enable affordable renewable energy, energy efficiency, and a safe fossil fuel phase-out. This is essential to keep climate risks within levels that countries can still adapt to, and can simultaneously reduce energy poverty and the economic impacts of volatile fossil fuel markets, limit stranded fossil fuel assets, boost economic development, and save millions of lives through cleaner air (indicators 3.1.2, 3.2.1, 3.2.2, 4.2.1, and 4.2.3).
- Monitoring and evaluating the health impacts of climate change and the health benefits of climate change action. This includes establishing national climate change and health observatories that integrate health and meteorological data, and adopting indicators for the Global Goal on Adaptation that enable the assessment of health-related adaptation progress, using them to evaluate and maximise the impact of adaptation interventions (including National Adaptation Plan implementation).
- Assessing and effectively communicating the health and climate benefits of climate change interventions. This involves promoting public understanding and literacy on the connections between health and climate change, thereby increasing support and engagement from individuals, the media, and corporations (indicators 5.1, 5.2, 5.4.1, and 5.5).

- Redirecting net fossil fuel subsidies towards enabling equitable renewable energy access, and towards health promotion and other activities that improve—rather than harm—people's health and wellbeing (indicator 4.3.2). Achieving these improvements requires potential negative impacts on vulnerable groups to be prevented, for example, by utilising the funds redirected away from fossil fuel subsidies for this purpose.
- Supporting low Human Development Index (HDI) countries in the adoption of clean renewable energy and climate change adaptation by bypassing structural barriers, including through knowledge and technology transfer, and financial support, thereby promoting global health and development (indicators 3.1.1, 3.1.2, 3.2.1, and 3.2.2). To tackle energy poverty and prevent the development and lock-in of new, harmful fossil fuel-based energy systems, the rapid scale-up of renewable energy is key.
- Delivering evidence-based Nationally Determined Contributions and long-term low-emission development strategies that match the ambitions laid out in the Paris Agreement, are financially costed, and prioritise interventions with health co-benefits (indicators 3.2, 3.3.2, and 5.4.1).
- Building health resilience by developing and implementing science-based National Adaptation Plans that incorporate health considerations, with well defined and costed interventions that include improvements in people's health and wellbeing as an end goal, including health-tailored early warning and response systems (indicators 2.1.1, 2.1.2, 2.2.1, 2.2.4, 2.3.2, and 4.3.4).
- Including community perspectives in the design of climate and health policies, with particular focus on the most vulnerable communities and Indigenous people (panel 6).
- Protecting multilateralism and international negotiations as key tools to promote global climate and health action (indicator 5.4.1).

#### City governments

Home to 56% of the world population and to the main drivers of greenhouse gas emissions, cities are key in delivering a healthy, equitable transition. Opportunities include:

- Prioritising health in local adaptation interventions, underpinned by evidence-based climate change and health risk assessments and tailored action plans (indicators 2.1.3, 2.3.1, and 2.3.2).
- Expanding urban green and blue space to reduce heat exposure, prevent flooding, and improve mental and physical health (indicators 2.2.2 and 2.2.3).
- Promoting zero-emission public transport and safe active travel through infrastructure and regulation. This would reduce transport-driven emissions, prevent up to 1.45 million deaths from improved air quality, and boost physical activity (indicators 3.1.3 and 3.2.1).

(Continues on next page)

(Prof J Minx PhD, T Repke PhD); **Gastrointestinal and Liver Diseases Research Center, Iran University of Medical Sciences, Tehran, Iran** (Prof M Moradi-Lakeh MD); **JE Cairnes School of Business and Economics, Galway, Ireland** (Prof K Morrissey PhD); **Medical Research Council Unit, The Gambia, London School of Hygiene & Tropical Medicine, Serekunda, The Gambia** (Prof K A Murray PhD); **Laureate Institute for Brain Research, Massachusetts Institute of Technology, Tulsa, OK, USA** (N Obradovich PhD); **Agricultural Research, Education and Extension Organization, Iranian Fisheries Science Research Institute, Tehran, Iran** (F Owfi PhD, M Rabbaniha PhD); **Department of Environmental Studies, University of Colorado at Boulder, Boulder, CO, USA** (O L Pearman PhD); **Global Health and Population, Harvard TH Chan School of Public Health, Boston, MA, USA** (J Ponnammattam MD); **Department of Health Policy, School of Medicine, Stanford University, Stanford, CA, USA** (J Roa MSc); **Graham Research Institute, London School of Economics and Political Science, London, UK** (Prof E Robinson PhD); **Department of Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, CO, USA** (Prof D Rojas-Rueda PhD); **Department of Atmospheric and Ocean Sciences, University of Buenos Aires, Buenos Aires, Argentina** (Prof M Rusticucci PhD); **Harvard Medical School, Harvard University, Boston, MA, USA** (R N Salas MD); **Barcelona Supercomputing Center, Barcelona, Spain** (A S J Plana PhD); **Department of Public Health and Clinical Medicine, Section of Sustainable Health, Umeå University, Umeå, Sweden** (Prof J C Semenza PhD, H Sjödin PhD); **Department of Anesthesiology, Yale School of Medicine, Yale University, New Haven, CT, USA** (J D Sherman MD); **WHO-WMO Joint Climate and Health Office, Geneva, Switzerland** (J Shumake-Guillemot PhD); **Mailman School of Public Health, Columbia University, New York, NY, USA**

(C Sorensen MD); Nuffield Department of Population Health, University of Oxford, Oxford, UK  
(Prof M Springmann PhD); Higher Institution Centre of Excellence, Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, Terengganu, Malaysia  
(Prof M Tabatabaei PhD); Sydney School of Architecture Design and Planning, University of Sydney, Sydney, NSW, Australia  
(F Tartarini PhD); Department of Civil Engineering, Tampere University, Tampere, Finland  
(J Taylor PhD); Department of Electronics and Computer Sciences, Universidade de Santiago de Compostela, Santiago de Compostela, Spain  
(J A Trinanes PhD); Faculty of Medicine, Pontifical Catholic University of Chile, Santiago de Chile, Chile  
(N Valdes-Ortega MSc); Centre for Sustainable Medicine, Yong Loo Lin School of Medicine, University of Singapore, Singapore (Prof N Watts MA); School of Environment, University of Newcastle, Newcastle, NSW, Australia  
(Prof R Wood PhD); Sydney School of Public Health, University of Sydney, Sydney, NSW, Australia (Y Zhang PhD); School of Ecology & Environment, Renmin University of China, Beijing, China (Shi Zhang PhD); Centre for Human Health and Performance, University College London, London, UK (Prof H Montgomery MD)  
Correspondence to: Dr Marina Romanello, Institute for Global Health, University College London, London W1T 4TJ, UK [m.romanello@ucl.ac.uk](mailto:m.romanello@ucl.ac.uk)

(Panel 1 continued from previous page)

- Fostering climate-resilient, sustainable buildings, including through regulation and financial incentives, thereby reducing energy consumption, limiting climate impacts, reducing heat exposure, and limiting reliance on air conditioning (indicators 1.1, 1.2, 2.2.2, 3.1.2, and 3.2.2).
- Reducing inequities and avoiding unintended harms by integrating community perspectives in all climate change actions and supporting community-led initiatives, with particular focus on vulnerable communities and the priorities and knowledge of Indigenous people.
- Developing and implementing evidence-informed adaptation plans, and increasing resilience and capacity to respond to climate hazards (section 1; indicators 2.1.1 and 2.1.2).
- Educating and training the health workforce on preparing for, and responding to, climate change (indicator 2.2.5).
- Reducing their own greenhouse gas emissions footprint by optimising resource use, eliminating unnecessary waste, shifting to renewable energy, and, whenever safe, replacing anaesthetic and inhaler gases with high global warming potential with less damaging alternatives (indicator 3.5).
- Establishing rigorous monitoring and evaluation systems, with science-based indicators and metrics to track climate change impacts, and the effectiveness of adaptation and mitigation interventions (section 1; indicators 2.1.1, 2.1.2, 2.2.1, and 3.5).
- Raising awareness of climate change health risks among patients and the general public, and promoting behaviours that deliver simultaneous benefits to climate change and health, including through green prescribing, and by sharing information on vulnerabilities and protective behaviours available to different patient groups (indicators 3.2.1, 3.2.2, and 3.3.2).

## Individuals and civil society organisations

Individual, community-led, and civil society actions can drive meaningful progress with substantial health benefits (panel 6). Although these actions are often dependent on permissive political landscapes, legal protection, availability of and access to choices, and financial support, some actions they can take include:

- Reducing overconsumption and prioritising the consumption of low-carbon, sustainable products, especially in very high and high HDI countries that contribute the most to consumption-led greenhouse gas emissions and air pollution (indicator 4.2.5).
- In line with nutritional and cultural needs, adopting and promoting low-carbon, healthy diets (indicators 3.3.1 and 3.3.2).
- Choosing zero-emission public transport and active travel over fossil fuel-based options (indicator 3.5).
- Shifting funds away from institutions that invest in fossil fuels (indicator 4.3.3).
- Engaging in community-led action on health and climate change, supporting equitable inclusion of marginalised communities (panel 6).
- Choosing leaders that advocate for accelerated action on health and climate change when local government systems allow (indicator 5.4.1).
- Encouraging and supporting employers in taking science-based and stringent climate change action (indicator 5.5).
- Using litigation as a means to protect their right to health and to a healthy environment, and hold governments and businesses accountable.
- Creating community platforms on climate change and health, including citizen groups, to safely exchange ideas and concerns, build collective resilience and adaptive capacity, and enable engagement with decision makers (panel 6).

## Health systems

Health-care systems are a crucial line of defence against climate hazards (section 2). Yet, the health-care sector contributes substantially to the problem, accounting for 4.2% of global greenhouse gas emissions (indicator 3.5). Health systems can support a safer future by delivering progress in line with the ambitions of the Alliance for Transformative Action on Climate and Health by:

## Private sector organisations

The private sector has direct control over the majority of global greenhouse gas emissions and has substantial influence over governments. They can drive accelerated action by:

- Setting science-based targets to decarbonise their operations and supply chains, eliminating on-site emissions, transitioning to zero-emission energy and transport fleets, increasing energy efficiency, and prioritising suppliers with strong climate change and health commitments.
- Divesting from fossil fuels and the organisations that finance them (indicator 4.3.3).
- Transitioning fossil fuel businesses towards renewable energy, in line with global commitments, and supporting the research and development of climate solutions, especially those with simultaneous health co-benefits (indicators 4.2.2 and 4.2.3).
- Developing collaborations with government and public-private partnerships to enhance the development and transfer of technology, develop innovative financing tools, and advance climate change action.
- Advocating for stronger climate and health governmental policies for a more stable and equitable environment for investments and actions, and promoting climate and health literacy across the workforce, fostering a culture of sustainability and encouraging behaviours that support a zero-carbon, healthier future.
- Adopt standardised systems for monitoring and reporting on greenhouse gas emissions and climate change resilience.

(Continues on next page)

(Panel 1 continued from previous page)

### Funders

Financial support is often essential to make health-promoting climate change action possible. Funder organisations, high-income countries, and those able to provide finance can support a healthy future through the following actions:

- Multilateral banks and climate funds: increasing the disbursement of funding for climate change and health, while ensuring that funding is new and additional, explicitly directed at promoting improved health through climate change and health actions, and in line with the Paris Agreement and the principles laid out in the Development Banks' Joint Roadmap for Climate-Health Finance and Action, and without diverting funds away from other critical climate or health action. When allocating funding for climate change mitigation and adaptation activities, prioritise those that integrate and favour the promotion of health and wellbeing, including by maximising potential health co-benefits (indicator 4.3.4; sections 2 and 3).<sup>32</sup>
- Countries considered developed under the UN Framework Convention on Climate Change: delivering their commitments under the Paris Agreement, increasing bilateral funding, and delivering concrete commitments under the Baku to Belém Roadmap to 1.3T in support of the US\$1.3 trillion funding goal.<sup>33</sup> To support health and equity, this funding for mitigation, adaptation, and addressing loss and damage must be new and additional, prioritise grant-based and concessional finance, and not be substituted with private finance. Additionally, high-income countries can substantially increase financial support for climate change actions by reversing cuts, increasing international aid funding, and by increasing financial support for synergistic climate, health, and development initiatives with mutual co-benefits (indicator 4.3.4).
- Domestic funders: prioritising evidence-informed funding for health-benefiting climate change actions by accounting for the cost of climate change-related health harms and the savings associated with the health co-benefits of climate change actions in their economic appraisals (indicators 4.1.1–4.1.4).
- Private, philanthropic, and individual funders: supporting governmental bodies, civil society organisations, and community initiatives to scale-up health-promoting and inclusive climate change action (panel 6).
- Private sector: making private finance and investments compatible with the Paris Agreement and the protection of health and wellbeing, and diverting funds away from fossil fuels and health-harming activities; supporting the provision of sustainable insurance mechanisms; and investing in advancing health-promoting adaptation and mitigation activities, including by investing in

zero-carbon energy development, nature-based solutions, and climate-resilient infrastructure (indicators 4.2.1–4.2.3, 4.3.1, and 4.3.3).

- Research funders: supporting the generation of evidence needed to inform effective climate change actions for litigation, which can drive reductions in greenhouse gas emissions from the research they fund, and move their investments away from fossil fuels (indicators 5.3.1 and 5.3.2; panel 5).

### Scientists and science communicators

Scientists, researchers, and science communicators play a crucial role in promoting evidence-based actions and information integrity by producing and communicating the evidence that is crucially required to (1) inform the actions needed to protect people's lives and health from climate hazards; and (2) counter the threat of climate misinformation and disinformation, including through:

- Supporting the development of evidence-grounded climate change action plans and policies, by evaluating risks, potential for health co-benefits, and adaptation needs assessments at the local, national, regional, and global levels (indicators 2.1.1–2.1.3).
- Evaluating and communicating the health impact of implemented climate change interventions, helping build the evidence base on efficacy, benefits, and potential unintended harms, and supporting evidence-based course correction and knowledge sharing.
- Engaging constructively with the media to support accurate, evidence-based coverage on the links between health and climate change, helping the public understand the science and actions needed to prevent avoidable death and disease (indicators 5.1 and 5.2).
- Producing evidence suitable to advance litigation cases on climate change and health (panel 5).
- Engaging with national statistical bodies to support data collection and bridge data gaps for a more rigorous evaluation of progress on health and climate change.
- Adopting evidence-based communications frameworks that inspire action and spotlight pathways to a healthy future.

Although extensive, this list of actions is not exhaustive. With the threats of climate change growing, protecting people's health and survival demands simultaneous and unprecedented efforts to advance adaptation and mitigation, and requires an all-hands-on-deck approach. Importantly, navigating this unknown territory will require careful monitoring and evaluation of progress, and evidence-informed course correction to maximise the impact of climate change actions, reduce inequities, and limit unintended harms.



pre-industrial levels by over 1.5°C for the first time on record, and the past 10 years were the hottest ever recorded. Throughout 2024, 152 record-breaking extreme weather events were registered across 61 countries,<sup>1</sup> and life-threatening, extreme heat events are becoming more intense than previously predicted.<sup>2</sup> The economic conditions upon which health depends are being disrupted, with potentially catastrophic impacts.<sup>3,4</sup>

Despite the striking and growing risks that climate change continues to pose to human health, greenhouse gas emissions continue to rise unabated.<sup>5</sup> Since the 29th Conference of the Parties (COP29) in November, 2024, implemented policies and actions put the world on track to a potentially devastating 2.7°C of heating or more by the end of the century.<sup>6</sup>

Against this concerning backdrop, many countries are taking leaps in the wrong direction. In the USA—the world's largest single historical contributor to climate change<sup>7</sup>—the Trump administration dismantled world-leading climate research and key climate and environmental agencies, and pulled the USA out of the Paris Agreement. The associated impact on international diplomacy and climate change mitigation efforts could have irreversible consequences for those in the USA and beyond, as shown by the unprecedented heatwaves, wildfires, and flooding events affecting the USA in recent years.<sup>8–11</sup> Countries such as Argentina and Hungary have taken similar stances. In Canada, Alberta lifted a moratorium on coal exploration,<sup>12</sup> and the EU is pursuing an easing of emissions rules.<sup>13</sup> Meanwhile, major corporations (including fossil fuel giants) have backtracked on their climate commitments, to the detriment of all.<sup>14–17</sup>

Compounding attacks on climate change mitigation, adaptation efforts are also under threat. The USA's withdrawal from WHO resulted in major funding cuts, impairing the ability to safeguard people's health in the face of climate hazards.<sup>8,18</sup> Cuts to the US Agency for International Development, alongside the reversal of aid funding from countries such as the UK, the Netherlands, Belgium, and France, further increase the vulnerability of populations worldwide to soaring climate hazards, putting an equitable transition to a healthy future increasingly out of reach.<sup>8</sup>

Reversing these harmful policies and progressing meaningful climate change action is now crucial to protect people's health and survival. Encouragingly, doing so can simultaneously deliver major and immediate health and economic benefits. Some of these benefits are already occurring. The clean energy sector accounted for 10% of global GDP growth in 2023; including 6% of GDP growth in the USA, almost 5% of GDP growth in India, and over 30% of GDP growth in the EU.<sup>19</sup> The UK became the first major economy to halve its emissions from 1990 levels,<sup>20</sup> and its net-zero greenhouse gas economy grew three times faster than the broader economy, supporting better livelihoods.<sup>21</sup> In

China, clean energy contributed to a record 10% of GDP in 2024, which caused its emissions to fall for the first time.<sup>22,23</sup> Now a world leader in electric mobility, China attained major health and economic benefits from air quality improvements through transport electrification,<sup>24</sup> and prevented 46 000 deaths through the transition to cleaner energy in households between 2018 and 2020.<sup>25</sup> Clean renewable energy—now cheaper than fossil fuels and less vulnerable to geopolitical shocks—can also benefit the approximately 1 billion people still served by health-care facilities without reliable energy,<sup>26</sup> and the 1.18 billion people still living with energy poverty.<sup>27</sup> Since 2017, at least 1000 health-care facilities received solar electrification: progress that needs to be urgently scaled up to enable a sustainable and equitable future.<sup>28</sup>

The Global Action Plan on Climate Change and Health adopted at the 78th World Health Assembly opened new avenues<sup>27</sup> to drive a health-centred, accelerated response to climate change.<sup>29</sup> COP30 offers further opportunities to promote action. Taking stock and responding to countries' updated Nationally Determined Contributions (NDCs), this COP will offer an opportunity to encourage the necessary commitments for a safer future. The final list of indicators to monitor progress against the Global Goal on Adaptation is also expected to be agreed at COP30. This would include specific indicators for improving health resilience and reducing the health impacts of climate change,<sup>30</sup> as well as specific indicators to track adaptation progress in relevant sectors. These indicators will enable further progress in ensuring accountability and meaningful target setting for health protection. The expected Belem Health Action Plan for the Health Sector's Adaptation to Climate Change is also expected to promote more evidence-based and equity-focused action on health system adaptation.<sup>31</sup> Importantly, COP30 will see the conclusion of the Baku to Belém Roadmap to 1.3T, providing an opportunity to close the global climate finance gap.

To inform these urgently needed responses, the 2025 global report of the *Lancet* Countdown on Health and Climate Change presents the most comprehensive picture yet of the health consequences of current progress—or lack thereof—in tackling climate change. The data of this report help inform key priority actions and opportunities for different actors in society to build a safer future (panel 1).

The suite of indicators in this report (panel 2), originally developed in 2016 based on the *Lancet* Commission on Health and Climate Change and an in-depth stakeholder consultation,<sup>34</sup> has been refined to reflect scientific advancements and the changing need for actionable evidence from key stakeholders. These 57 indicators, developed by 128 prominent researchers from diverse disciplines and world regions, represent 9 years of iterative refinement, with most presenting improved models or datasets in this report. New or substantially improved

### Panel 2: The indicators of the 2025 report of the *Lancet* Countdown on health and climate change

#### 1: Health hazards, exposure, and impacts

##### 1.1: Heat and health

- 1.1.1: Exposure of vulnerable populations to heatwaves
- 1.1.2: Heat and physical activity
- 1.3: Change in labour capacity
- 1.1.4: Rising night-time temperatures and sleep loss
- 1.1.5: Heat-related mortality

##### 1.2: Extreme weather-related events and health

- 1.2.1: Wildfires
- 1.2.2: Drought
- 1.2.3: Extreme precipitation
- 1.2.4: Air pollution from sand and dust
- 1.2.5: Extreme weather and sentiment

##### 1.3: Climate suitability for infectious disease transmission

- 1.3.1: Dengue
- 1.3.2: Malaria
- 1.3.3: West Nile virus
- 1.3.4: Leishmaniasis
- 1.3.5: Tick-borne diseases
- 1.3.6: *Vibrio*

##### 1.4: Food security and undernutrition

#### 2: Adaptation, planning, and resilience for health

##### 2.1: Assessment and planning of health adaptation

- 2.1.1: National assessments of climate change impacts, vulnerability, and adaptation for health
- 2.1.2: National Adaptation Plans for health
- 2.1.3: City-level or state-level climate change risk assessments

##### 2.2: Enabling conditions, adaptation delivery, and implementation

- 2.2.1: Climate information for health
- 2.2.2: Benefits and harms of air conditioning
- 2.2.3: Urban green and blue spaces
- 2.2.4: Detection of, preparedness for, and response to health emergencies
- 2.2.5: Climate and health education and training

##### 2.3: Vulnerabilities, health risk, and resilience to climate change

- 2.3.1: Vulnerability to severe mosquito-borne disease
- 2.3.2: Lethality of extreme weather events
- 2.3.3: Rising sea levels, migration, and displacement

#### 3: Mitigation actions and health co-benefits

##### 3.1: Energy use, energy generation, and health

- 3.1.1: Energy systems and health
- 3.1.2: Household energy use
- 3.1.3: Sustainable and healthy road transport

##### 3.2: Air quality and health co-benefits

- 3.2.1: Mortality from ambient air pollution by sector
- 3.2.2: Household air pollution

##### 3.3: Food, agriculture, and health co-benefits

- 3.3.1: Emissions from agricultural production and consumption

- 3.3.2: Diet and health co-benefits

##### 3.4: Tree cover loss

##### 3.5: Health-care sector emissions and harms

#### 4: Economics and finance

##### 4.1: The economic impact of climate change and its mitigation

- 4.1.1: Economic losses due to weather-related extreme events
- 4.1.2: Costs of heat-related mortality
- 4.1.3: Loss of earnings from heat-related labour capacity reduction
- 4.1.4: Costs of the health impacts of air pollution

##### 4.2: The transition to net zero-carbon, health-supporting economies

- 4.2.1: Employment in low-carbon and high-carbon industries
- 4.2.2: Compatibility of fossil fuel company strategies with the Paris Agreement
- 4.2.3: Stranded coal assets from the energy transition
- 4.2.4: Country preparedness for the transition to net zero
- 4.2.5: Production-based and consumption-based attribution of CO<sub>2</sub> and PM<sub>2.5</sub> emissions

##### 4.3: Financial transitions for a healthy future

- 4.3.1: Clean energy investment
- 4.3.2: Net value of fossil fuel subsidies and carbon prices
- 4.3.3: Fossil fuel and green sector bank lending
- 4.3.4: Health adaptation finance flows and disclosed needs

#### 5: Public and political engagement with health and climate change

##### 5.1: Media engagement

##### 5.2: Individual engagement

##### 5.3: Scientific engagement

- 5.3.1: Scientific articles on health and climate change
- 5.3.2: Scientific engagement on the health impacts of climate change

##### 5.4: Political engagement

- 5.4.1: Government engagement
- 5.4.2: Engagement by international organisations

##### 5.5: Corporate sector engagement

indicators have been included to bridge identified gaps, enabling more accurate monitoring of heat-related mortality, tracking the threat of climate-sensitive tick-borne diseases and leishmaniasis, taking stock of the health

impacts of wildfire smoke, capturing the coverage of bodies of water in urban spaces (urban blue spaces), more comprehensively monitoring health adaptation funding for the most vulnerable countries, and assessing proactive

individual engagement on health and climate change. The methodologies, data, caveats, and future improvements of the indicators, alongside further findings, are presented in the appendix—an essential companion to this report.

See Online for appendix

## The new phase of the *Lancet* Countdown on health and climate change

Across its global and regional centres, the *Lancet* Countdown brings together over 300 researchers from over 100 organisations worldwide who produce global and regional indicator reports. In 2024, the *Lancet* Countdown entered a new phase, enabled by the strategic partnership and critical financial support from the Wellcome Trust and an ongoing partnership with WHO. Central to this new phase is strengthening the impact of its work in informing change, undertaking a review of the literature, and running consultations with key stakeholders and decision makers to refine the suite of indicators. This update will help identify priorities for indicator development and refinement, and ensure that it continues to provide data that are urgently needed to inform health-protective climate change action.

Complementing this effort, the *Lancet* Countdown also aims to increase the impact of its work through strengthened policy engagement, dissemination, and capacity building efforts. A new independent board,<sup>35</sup> chaired by the Right Honourable Helen Clark, advises and supervises this work, providing strategic direction, scrutiny, and transparency, while a new scientific advisory group is helping further advance the science and rigour of the collaboration.

Through its new phase, the *Lancet* Countdown continues to operate an open approach to indicator development, now welcoming online proposals for indicators that meet the *Lancet* Countdown criteria to bridge its evidence gaps.<sup>36,37</sup> In support of advancing the science of climate change and health, the *Lancet* Countdown has, wherever possible, made its indicator data available through its data platform, where the data can be explored at higher levels of resolution than allowed for in this report.<sup>38</sup>

At the core of the *Lancet* Countdown's efforts is the strengthening of its regional centres. Centres in Asia (Tsinghua University, Beijing, China), Europe (Heidelberg University, Heidelberg, Germany, and ISGlobal, Barcelona, Spain), Latin America (Universidad Peruana Cayetano Heredia, Lima, Peru), Oceania (Macquarie University, Sydney, NSW, Australia), and Small Island Developing States (University of the West Indies, Kingston, Jamaica) now regularly publish regional assessments of climate change and health, harnessing local knowledge and translating findings to meet the needs of local stakeholders.<sup>39–43</sup> In 2025, the *Lancet* Countdown launched its Africa Regional Centre, headquartered at Pretoria University (Pretoria, South Africa), to advance the local generation of evidence to inform action in one of the world's most vulnerable regions.

The *Lancet* Countdown is further supporting health-centred climate change action through partnerships with

national and international organisations which can make their findings available to inform action at the national and local levels. Additionally, alongside WHO, the *Lancet* Countdown co-leads the Alliance for Transformative Action on Climate and Health (ATACH) Task Team on indicators,<sup>44</sup> supporting members of the task team in the development and adoption of standardised climate change and health indicators for improved accountability and evidence-based action.

Through these efforts, the *Lancet* Countdown will continue to strengthen the evidence base on climate change and health and ensure that decision makers can access the latest science to advance evidence-based, health-protective actions, informing the path towards a healthy future for all.

## Section 1: Health hazards, exposure, and impact

The health impacts of climate change are a function of increasing climate-related hazards, people's exposure to them, and their underlying vulnerabilities. In 2024, the world witnessed heatwaves, wildfires, floods, droughts, and storms of unprecedented scale and intensity.<sup>45</sup> People's lives are directly affected and threatened by the growing disruption of the societal systems that support health. In a series of indicators focusing on heat, other extreme weather-related events, conditions that favour the transmission of infectious diseases, and food insecurity, this section tracks how climate-related hazards and the exposure of vulnerable populations have changed over time.

New indicators measuring climate suitability for the transmission of leishmaniasis and tick-borne diseases further show how climate change is altering the risk of life-threatening infectious diseases. In a major update, a new heat-related mortality indicator uses state-of-the-art epidemiological models to assess risk among populations globally.<sup>46</sup>

### 1.1 Heat and health

Climate change is increasing exposure to health-threatening heat. Older people are especially at risk due to age-related decrements in thermoregulatory capacity.<sup>47</sup> Those with underlying chronic diseases (eg, diabetes, cardiovascular disease, respiratory disease, or kidney disease) are also especially vulnerable.<sup>48</sup> Infants represent a group at high risk due to morphological disadvantages and limited capacity to engage in protective behaviours,<sup>48</sup> while heat exposure during pregnancy increases the risk of adverse birth outcomes.<sup>49</sup>

*Indicator 1.1.1: exposure of vulnerable populations to heatwaves—headline finding: globally, 84% of the heatwave days that people were exposed to on average annually in 2020–24 would have not been expected to occur without climate change; in 2024, people older than 65 years and infants younger than 1 year experienced record-high heatwave exposures—up by 304% and 389%, respectively, from the 1986–2005 baseline*  
This indicator contrasts the number of heatwave days that people were exposed to from 2020 to 2024 with the

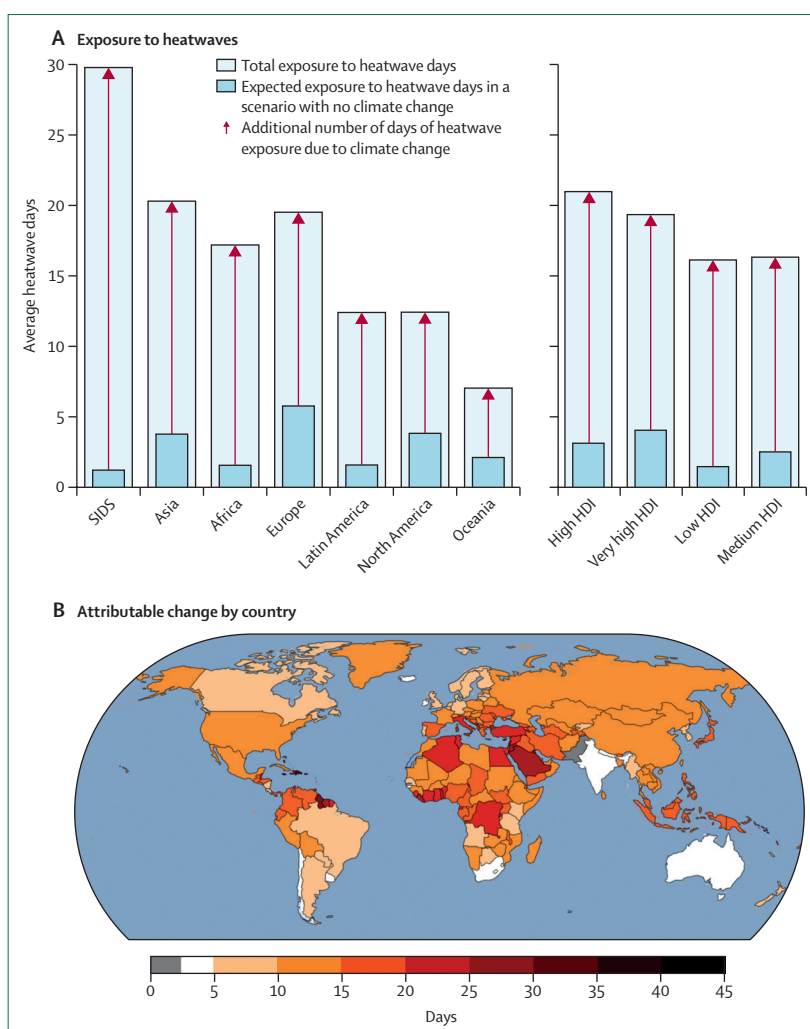
For more on the *Lancet* Countdown's data platform see <https://lancetcountdown.org/explore-our-data>

number of heatwave days that people would have been exposed to in a hypothetical alternative climate scenario with no human-caused global heating (counterfactual scenario). As such, it quantifies the number of extra heatwave days that people were exposed to as a result of climate change. This indicator defines a heatwave as a period of at least 2 consecutive days when the minimum and maximum temperatures were above the 95th percentile in the local climatology (defined on the 1985–2005 baseline).<sup>50</sup> Globally, the average person experienced an average of 19 heatwave days per year. Of these, 84% (16 days) would not have been expected without climate change, resulting in people being exposed to 530% more heatwave days than would have been expected without climate change. On average, 10 or more heatwave days per year that were attributable to climate change occurred over this 5-year period in 175 (79%) of 221 countries globally. More than 30 heatwave days per year that were attributable to climate change occurred in 12% (n=27) of countries. Small Island Developing States, Africa, and Asia had the largest increases in heatwave exposure due to climate change (figure 1).

Of all people exposed, infants younger than 1 year and adults older than 65 years are particularly at risk.<sup>51,52</sup> In 2024, adults older than 65 years (20·8 days per person) and infants younger than 1 year (20·5 days per person) experienced record-high exposure to heatwave days, representing a 304% increase in older adults and a 389% increase in infants compared with the 1986–2005 baseline average. On average, from 2006 to 2024, each adult older than 65 years experienced 10·0 heatwave days per year, and each infant younger than 1 year experienced 8·4 heatwave days per year, of which 5·3 (49%) heatwave days per year in older adults and 4·8 (51%) heatwave days per year in infants were attributable to climate change.

**Indicator 1.1.2: heat and physical activity—headline finding:** in 2024, each person was exposed, on average, to a record-high 1609 hours during which ambient heat posed at least a moderate heat stress risk during light outdoor exercise, 35·8% higher than on average each year in 1990–99. Physical activity is essential for good general health, reducing the risk of chronic disease, cancer, and obesity; contributing to disease management; and improving mental health.<sup>53,54</sup> When replacing fossil fuel-based travel, it reduces greenhouse gas emissions and air pollution.<sup>55</sup> However, heat exposure decreases motivation to engage in outdoor physical activity,<sup>56</sup> and puts those who exercise at risk.<sup>57</sup> This indicator uses temperature, humidity, and solar radiation to estimate the number of hours during which light outdoor physical activity (eg, walking) poses a risk of heat-related illness.<sup>58</sup>

In 2024, each person globally was exposed on average to a record-high 1609 hours of at least moderate heat stress risk during light exercise in outdoor environments—424 hours (35·8%) above the 1990–99 average.



**Figure 1: Average annual heatwave days in 2020–24 by region and HDI level (A) and by country (B)** The lighter grey indicates heatwave days that would have been experienced without human-caused warming, and the darker grey indicates the total exposure to heatwave days. The red arrows indicate the number of heatwave days added due to climate change. SIDS=Small Island Developing States. HDI=Human Development Index.

On average, there were 290 (24·4%) more annual hours of elevated heat stress risk in 2015–24 than in 1990–99.

**Indicator 1.1.3: change in labour capacity—headline finding:** a record-high 640 billion potential work hours were lost in 2024, a 98% increase compared with the 1990–99 annual average. Heat exposure endangers workers' health, particularly those working outdoors or performing strenuous tasks.<sup>59</sup> It also reduces labour productivity and undermines the social determinants of health through impacts on income and livelihoods.<sup>60,61</sup>

This indicator's first part monitors the number of people working outdoors, placing them at a heightened heat-stress risk and attributable burden of disease. Globally, in 2024, an estimated 1·5 billion people—25·3% of the working-age population—worked outdoors, representing a small decrease from 2023 (25·9%). The



proportion of the worker population at risk is highest among males and middle-aged people.

The second part of this indicator combines heat exposure (estimated using wet bulb globe temperature) with typical metabolic rates of worker groups to track potential work hours lost.<sup>59,62</sup> Improvements this year include capturing more island populations and using preferred UN population estimates. This indicator finds that, globally, 640 billion potential work hours were lost due to heat exposure in 2024, exceeding the 1990–99 average by 98·1% and eclipsing the previous high of 2023. Medium HDI countries were most impacted in 2024, losing a total of 316 billion potential work hours, followed by high HDI countries (167 billion potential work hours lost) and low HDI countries (118 billion potential work hours lost). Considering the average potential work hours lost per worker, low and medium HDI countries were most affected, with 250 potential work hours lost in low HDI countries and 358 potential work hours lost in medium HDI countries. These countries collectively bear a growing share of the global potential work hours lost, up from 54·3% in 1990 to 68·0% in 2024. In contrast, high HDI countries lost 120 potential work hours per worker on average, while very high HDI countries were the least affected group, with only 45 potential work hours lost.

Globally, 17·7% of all potential work hours lost affected construction workers, 10·0% affected service workers, 8·8% affected manufacturing workers, and 63·5% affected agricultural workers, with agricultural losses rising to 75·5% in low HDI countries and 66·6% in medium HDI countries.

**Indicator 1.1.4: rising night-time temperatures and sleep loss—headline finding: total sleep time lost due to high night-time temperatures increased by 6% in 2020–24 relative to the 1986–2005 baseline, reaching a record 9% increase in 2024**

Anthropogenic environmental changes have driven night-time temperatures to rise faster than daytime temperatures in many regions,<sup>63–65</sup> intensifying overnight heat stress and challenging nocturnal recovery. Elevated night-time temperatures can disrupt sleep health and are associated with altered sleep timing, quality, and quantity,<sup>66–71</sup> as well as adverse downstream mental and physical health outcomes that are separately sensitive to sleep, including cognitive function and cardiovascular disease.<sup>69,72–76</sup>

Combining global data from European Centre for Medium-Range Weather Forecasts Reanalysis version 5 for night-time minimum temperature data and derived temperature–sleep response functions from a previous multicountry sleep study,<sup>51,71</sup> this indicator estimates that annual sleep loss attributable to suboptimal night-time temperatures rose by an average of 6% in 2020–24 compared with 1986–2005. In 2024, sleep loss increased by 9% from baseline, the largest percentage increase in lost sleep in the past decade. Locations experienced up to

12 hours (698·6 minutes) of extra annual sleep loss per person per year in 2020–24.

**Indicator 1.1.5: heat-related mortality—headline finding: in 2012–21, global heat-related mortality reached an estimated average 546 000 deaths annually, a 63·2% increase compared with the 335 000 annual deaths in 1990–99**

At present, cold temperatures still account for most temperature-related deaths,<sup>77,78</sup> but increases in heat-related mortality are projected to exceed cold-related deaths in most regions if urgent climate adaptation and mitigation actions are not taken.<sup>78–82</sup> This indicator monitors heat-related mortality<sup>83</sup> using a newly developed model framework<sup>46</sup> that builds on a mortality database for 120 countries. It then applies meta-prediction models to consistently estimate the association between temperature and mortality from all causes in all countries globally,<sup>84</sup> and combines them with yearly mortality estimates from the Global Burden of Disease Study, making it the most comprehensive global estimate of heat-related mortality yet.

In 2012–21, heat was associated with 0·96% (95% CI 0·64–1·21) of all deaths occurring globally: up from 0·70% (0·45–0·88) in 1990–99 (37·1% increase). Total average heat-related mortality reached 546 054 deaths per year (362 127–687 553) in 2012–21, compared with 334 672 deaths per year (216 172–423 800) in 1990–99 (63·2% increase). This increase was partially but not wholly driven by increase in population. In 1990–99, heat-related mortality averaged 5·9 deaths per 100 000 people; this increased to 7·2 deaths per 100 000 in 2012–21 (23·3% increase). In 2012–21, heat-related deaths reached 1·73% (0·92–2·38) of all deaths in low HDI countries (66·3% increase from 1990–99), 1·45% (1·04–1·78) of all deaths in medium HDI countries (6·6% increase), 0·60% (0·37–0·82) of all deaths in high HDI countries (87·5% increase), and 0·53% (0·37–0·68) of all deaths in very high HDI countries (82·8% increase; figure 2).

## 1.2 Extreme weather-related events and health

Combined with decades of delays in adaptation, extreme weather events in 2024 caused at least 16 000 deaths, affected at least 166 million people,<sup>85</sup> exacerbated food insecurity,<sup>45</sup> and is estimated to have led to the displacement of over 800 000 people—the highest number of newly displaced people since 2008.<sup>45,86</sup> Detection and attribution studies found that anthropogenic climate change had increased the intensity or probability of occurrence of at least 26 of the most impactful extreme weather events in 2024, jointly accounting for over 3700 deaths.<sup>87</sup> Beyond directly recorded impacts, these events often have pervasive impacts on local communities. While the previous indicators covered heat-related impacts, the following indicators track exposure to, and impacts of, other climate-related extreme weather events.

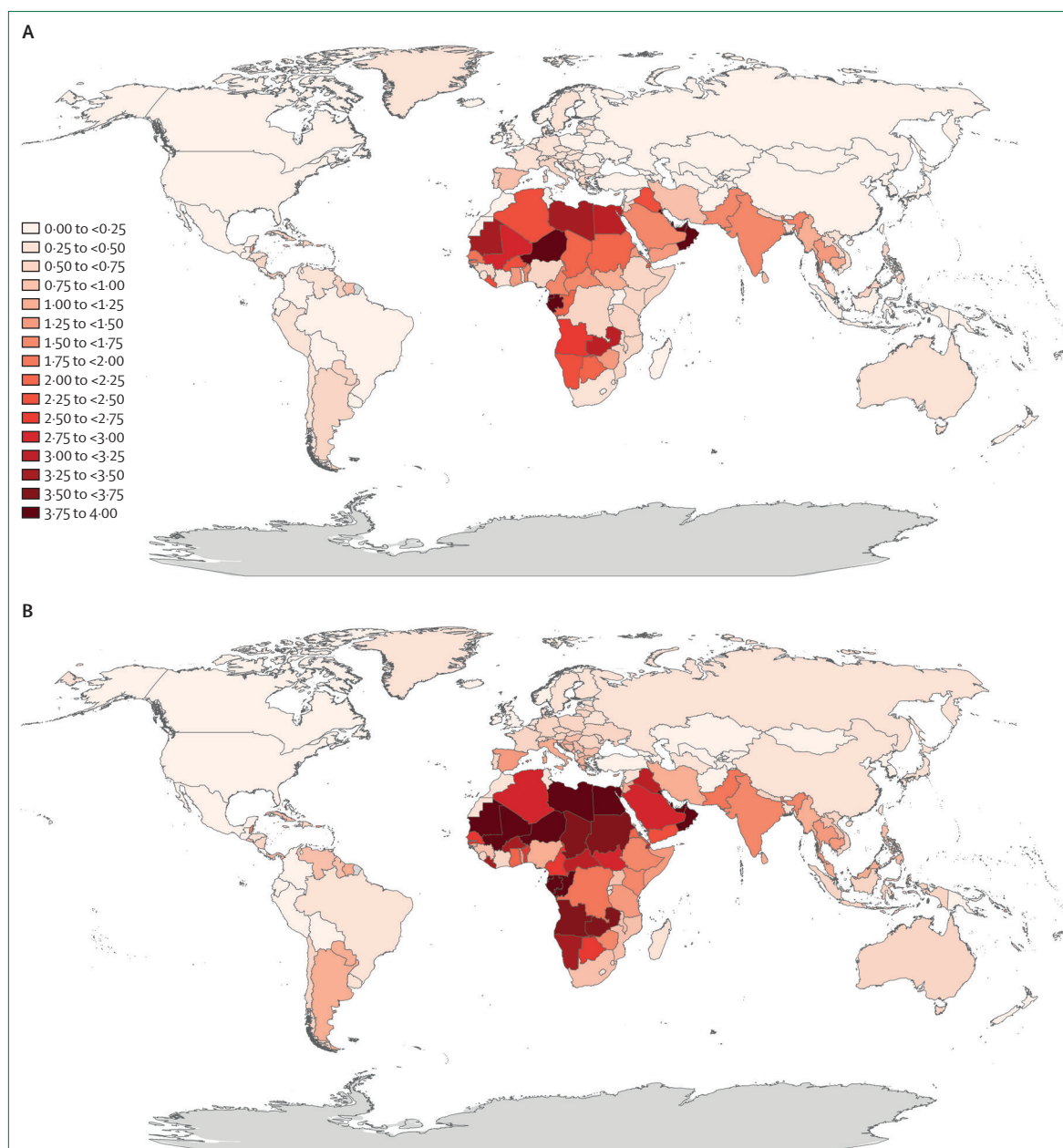


Figure 2: Average percentage of total deaths that were heat-related in 1990–99 (A) and 2012–21 (B)

**Indicator 1.2.1: wildfires—headline finding:** In 2020–24, exposure to days of at least very high wildfire risk increased by 6.6% on average globally, with 6 days per person more than in 2003–12; deaths from wildfire-derived  $PM_{2.5}$  air pollution reached a record-high 154 000 in 2024, up by 36% from the 2003–12 average

With hotter and drier conditions, climate change is increasing the risk of wildfires, which threaten physical and mental health and can damage essential infrastructure, causing cascading health impacts.<sup>88–90</sup> This indicator tracks exposure to days of at least very high meteorological wildfire risk using data from the Copernicus Emergency

Management Service, and also tracks exposure to active wildfires by overlaying population data with wildfire satellite observations. It also estimates wildfire smoke exposure using the System for Integrated Modelling of Atmospheric Composition chemistry transport model and satellite fire detection and—new for this year’s report—associated health impacts based on epidemiological models for  $PM_{2.5}$ -related mortality.<sup>91</sup>

During 2020–24, people were exposed to 103 days of very high or higher wildfire risk on average—6 days more (6.6% increase) than on average during 2003–12. Of the 188 countries for which data are available,

117 (62.2%) had increased exposure to wildfire risk. However, although 133 countries had an increase in human exposure to active wildfires, average exposure decreased from 28 days per person in 2003–12 to 23 days per person in 2020–24—a decrease that could be due to improved wildfire management and prevention, or to the reduction of available fuel for wildfires due to previous wildfires, land-use change, or deforestation. Subnational analysis reveals marked increases in very high and extremely high fire danger days across multiple wildfire-prone regions globally, including California, USA; the Pacific Northwest in the USA and Canada; central Brazil and northern Argentina; northern Algeria and Morocco; and large parts of Mediterranean Europe.

Between 2015 and 2024, people globally experienced an annual average of 10.3 billion person-days (with person-days accounting both for the total number of people exposed and the total number of days they were exposed) during which wildfire-related  $PM_{2.5}$  concentrations exceeded the WHO maximum daily average guideline level of 15  $\mu g/m^3$  (17% higher than in 2003–12). The world saw record-high fire-related  $PM_{2.5}$  exposure in 2024, both in concentration and the number of days.<sup>92</sup>

In 2024, exposure to fire-originated  $PM_{2.5}$  caused a record-high 154 000 deaths (about 2% of all  $PM_{2.5}$ -related deaths), a 36% increase compared with 2003–12. From 2003–12 to 2015–24, the average mortality increased by 9%, with low HDI countries seeing the biggest increase (46%). In 2003–24, 92 countries saw statistically significant ( $p < 0.05$ ) changes in deaths from wildfire-derived  $PM_{2.5}$ , with mortality increasing in 85 (92%) countries.

*Indicator 1.2.2: drought—headline finding: the percentage of the global land area affected by at least 1 month of extreme drought reached a record-breaking 60.7% in 2024, 299% above the 1951–60 average*

Climate change-induced higher temperatures and altered precipitation patterns increase the incidence of droughts, with multidimensional impacts on wellbeing, health, and survival.<sup>93–96</sup> Droughts threaten food productivity and nutritional outcomes, compromise water security and sanitation, and increase the risk of waterborne infectious diseases.<sup>95–97</sup> They also affect air quality by increasing dust exposure and favouring wildfire occurrence (indicators 1.2.1 and 1.2.4), as well as affecting wellbeing and livelihoods by disrupting power generation and compromising river transportation.<sup>98</sup>

This indicator uses the Standardised Precipitation Evapotranspiration Index to track the impact of precipitation and temperature changes on the incidence of extreme drought.<sup>99,100</sup> The percentage of global land area affected by at least 1 month of extreme drought reached a record-breaking 60.7% in 2024, exceeding the 1951–60 average by 299%. 23% of the global land area had over 6 months of extreme drought compared with

1% in baseline years, with the Amazonian region; south, north, and east Africa; and the Horn of Africa in particular being disproportionately affected (figure 3).

*Indicator 1.2.3: extreme precipitation—headline finding: in 2015–24, a record 64% of the global land area had increases in extreme precipitation events from 1961–90; in 2024, the average annual number of extreme precipitation events per 79 km<sup>2</sup> exceeding the 99th percentile reached a record-high of 5* Anthropogenic greenhouse gas emissions have warmed the atmosphere, intensifying the hydrological cycle and increasing the risk of more frequent and intense extreme precipitation events.<sup>64,65,101</sup> These events—and the floods, landslides, and environmental changes they trigger—can directly and indirectly increase the risk of respiratory and cardiovascular diseases, injury or drowning, damage to critical infrastructure, contamination of water supplies, waterborne disease outbreaks, and adverse impacts on mental health and sentiment.<sup>85,102–106</sup>

Compared with the 1961–90 baseline, the land area-weighted average number of annual extreme (>99th percentile) daily precipitation events per 79 km<sup>2</sup> increased by a record 11% in 1995–2024, and rose to a record 5 events in 2024: 1.3 more events than the baseline (35% increase). Concurrently, 64% of the global land area had an increase in extreme precipitation frequency during 2015–24, the highest share observed in the indicator's 30-year record.

*Indicator 1.2.4: air pollution from sand and dust—headline finding: between 2003–12 and 2019–23, the average annual number of days that people were exposed to desert dust levels above WHO guidance levels rose in 38% of countries and declined in 19% of countries*

Sand and dust storms are driven by both climate change and land mismanagement. Hotter, drier conditions;<sup>45</sup> poor land use; and increased burned areas from wildfires intensify erosion. Sand and dust storms substantially raise particulate matter levels and pose numerous health risks, including increased risk for asthma and cardiovascular disease.<sup>107–109</sup> They also spread soil pathogens, causing diseases such as Valley fever and meningitis,<sup>110</sup> and reduce visibility, increasing traffic and aviation accidents.<sup>111,112</sup>

Between 2003–12, and 2019–23, people in middle-to-high latitude (>35°N) countries had higher levels of dust exposure. Days of exposure to desert dust above the WHO daily limit for  $PM_{10}$  (45  $\mu g/m^3$ ) increased in 20 (38%) of 53 countries (90% [18 of 20 countries] of which were high and very high HDI countries), but decreased in six (11%) countries (all of which were high and very high HDI countries). In the lower latitude (<35°N) and southern countries, days of exposure to desert dust above the WHO daily limit for  $PM_{10}$  increased in 38 (23%) of 165 countries (30% [16 of 38 countries] of which were very high and high HDI countries), but decreased in 56 (34%) countries (63% [35 of 56 countries] of which were low and medium HDI countries). People in Africa and

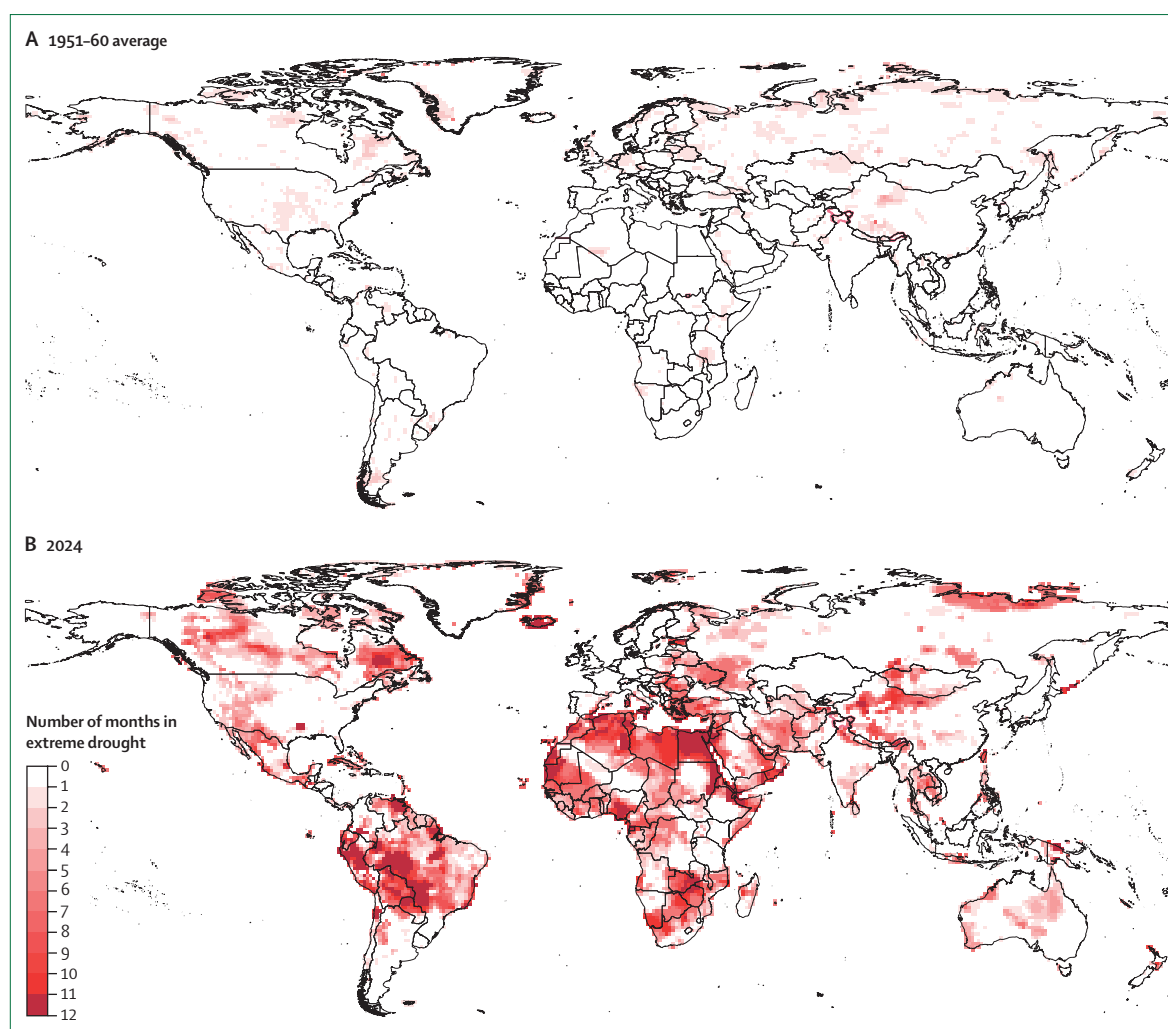


Figure 3: Annual number of months of extreme drought on average in 1951–1960 (A) and 2024 (B)

Asia had the most exposure, with 98–105 days annually in 2019–23.

**Indicator 1.2.5: extreme weather and sentiment—headline finding:** in 2024, extreme heat events cumulatively worsened human sentiment by a record 132% compared with the 2006–22 baseline

A growing body of literature outlines the myriad ways that climate change is challenging mental health globally.<sup>113,114</sup> Among numerous pathways, anthropogenic climate change has increased the frequency, intensity, duration, and extent of heatwaves,<sup>65</sup> which can contribute both directly and indirectly to subclinical psychosocial stress,<sup>102,115–121</sup> and elevate clinical risks of anxiety, depression, mood, and substance use disorders, as well as self-injury and suicide.<sup>73,122–125</sup>

This indicator links a text-based sentiment analysis of over 8 billion geolocated social media posts from X (formerly Twitter) with coincident heatwave exposure via

multivariate fixed-effects models and a multistage cumulative estimation procedure to estimate the impact of extreme heat on the sentiment expressed by X users in their posts. The outcome—ie, the sentiment of lexical expressions on X posts—aims to capture the emotional states of individuals during heatwaves where they reside, compared with typical days at the same place and time of year. Between 2015 and 2024, extreme heat events worsened sentiment by an average of 33% above the 2006–22 baseline effect. In 2024, the annual effect reached 132% (95% CI 102–162) above baseline—the largest annual impact registered thus far.

### 1.3 Climate suitability for infectious disease transmission

Changing environmental conditions are affecting the transmission of vector-borne, waterborne, foodborne, airborne, and soilborne diseases.<sup>126,127</sup> The following indicators track the influence of climate change on the transmission of infectious diseases.



**Indicator 1.3.1: dengue—headline finding:** from 1951–60 to 2015–24, the average climate-defined transmission potential of dengue by *Ae albopictus* and *Ae aegypti* increased by 48·5% and 11·6%, respectively

Increasing human mobility, urbanisation, and increasingly favourable climatic conditions have driven an increased global burden of dengue, which presents a growing public health challenge.<sup>128–130</sup> Approximately 7·6 million cases of dengue were reported to WHO between January, 2024, and April, 2024, a three-fold increase compared with the same period in 2023, resulting in over 16 000 severe cases and more than 3000 fatalities globally.<sup>131</sup> This indicator assesses the transmission dynamics of dengue by tracking its basic reproduction number ( $R_0$ ). It uses a mechanistic framework integrating temperature, rainfall, daylight duration, and human population density data.<sup>132–135</sup> The estimated global average  $R_0$  for *Ae albopictus* and *Ae aegypti* mosquitoes increased 48·5% and 11·6%, respectively, between 1951–60 and 2015–24 (figure 4), reflecting an increased risk of dengue transmission globally. Similar trends were also observed for the transmission suitability of the chikungunya and Zika viruses. Overall,  $R_0$  for chikungunya transmission by *Ae albopictus* increased by 48·5%, and  $R_0$  for Zika transmission by *Ae aegypti* increased by 11·7% globally in 2015–24 compared with the baseline (1951–60).

**Indicator 1.3.2: malaria—headline finding:** although changes in climatically suitable areas for malaria transmission have only marginally increased globally from 1951–60 to 2015–24, there were pronounced increases in highland areas, with a 13·9% increase for *Plasmodium falciparum* and a 13·0% increase for *Plasmodium vivax*

Malaria claims over 500 000 lives annually, with children and pregnant women being disproportionately affected.<sup>136,137</sup> The range and seasonality of malaria transmission are influenced by temperature, rainfall, and humidity, which are affected by climate change. This indicator monitors the length of season with climatically suitable conditions for malaria transmission caused by the two most prevalent malaria parasites (*Plasmodium vivax* and *Plasmodium falciparum*) transmitted by *Anopheles* mosquitoes.

Tropical regions generally show decreases in the length of season that is climatically suitable for malaria transmission, whereas temperate regions show increases in the length of season. From 1951–60 to 2015–24, 43·8% of the land area with *Anopheles* mosquitoes showed an increase, 31·8% of the land area showed a decrease, and 24·4% of the land area remained stable for the length of the transmission season for *P vivax*. For *P falciparum*, the length of the transmission season stayed stable in 28·2% of the land area, whereas 41·7% of the land area had an increase and 30·1% of the land area had a decrease in season length. Over the same period, the global land area suitable for malaria transmission increased by 1·8%

for *P vivax* and by 2·0% for *P falciparum*. In highland regions (>1500 m), areas suitable for *P falciparum* transmission increased by 13·9% and by 13·0% for *P vivax* transmission.

**Indicator 1.3.3: West Nile virus—headline finding:** the temperature suitability for West Nile virus transmission has increased by 0·7% from 1951–60 to 2015–24

West Nile virus is a zoonotic pathogen transmitted by *Culex* mosquitoes, causing potentially fatal neurological disease in humans.<sup>138</sup> The virus is found worldwide and the transmission range is expanding as local temperatures increase.<sup>139</sup> This indicator uses a mechanistic model built on experimental data to track the temperature-dependent relative basic reproduction number of West Nile virus ( $WNV-R_0$ ) of three key *Culex* species.<sup>140</sup> Driven by changes in temperature, the average annual  $WNV-R_0$  was 0·7% higher in 2015–24 versus 1951–60 in the regions where the three *Culex* species are present. During the same period,  $WNV-R_0$  increased in very high (8·0%), high (1·8%), and medium (1·1%) HDI countries. However, low HDI countries had a decrease in  $WNV-R_0$  (–7·4%) as temperatures exceed the optimal range for West Nile virus transmission.

**Indicator 1.3.4: leishmaniasis—headline finding:** Globally, the predicted leishmaniasis risk for 2015–24 increased by 29·6% compared with 1951–60

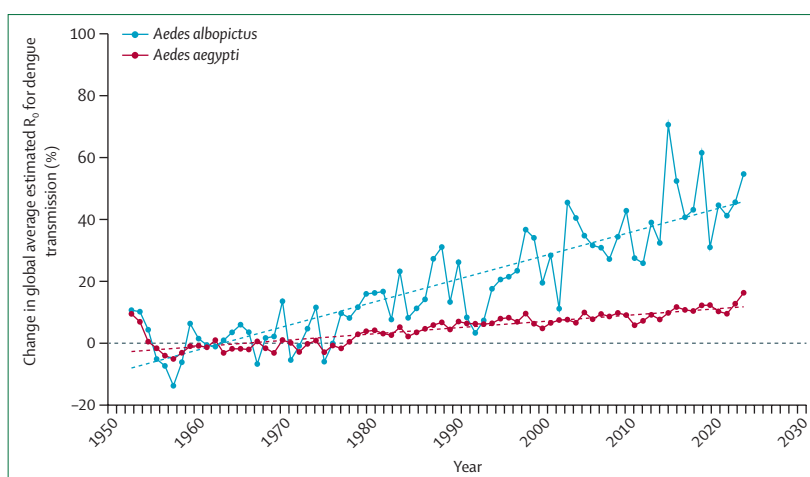
Leishmaniasis are potentially fatal diseases caused by *Leishmania* parasites and transmitted by sand flies.<sup>141</sup> Endemic in 99 countries or territories, they disproportionately affect the most underserved populations, with an estimated 700 000 to 1 million new cases every year, causing 20 000–40 000 deaths.<sup>141</sup> Climate change-driven changes in temperature and humidity affect sand fly activity, metabolism, and development, increasing the length of the vector's infectious period and therefore infection risk.<sup>142,143</sup> This indicator uses a machine-learning model driven by climatic and socioeconomic variables to estimate the probability of least one human leishmaniasis case in a given location (accounting for both cutaneous [the most frequent form] and visceral [the most deadly form] leishmaniasis).<sup>144</sup> The predicted leishmaniasis risk for 2015–24 increased by 29·6% compared with 1951–60. The regions at greatest risk include Africa, Asia, and the Eastern Mediterranean.

**Indicator 1.3.5: tick-borne diseases—headline finding:** compared with 1951–60, the area climatically suitable for *R sanguineus* and *Hyalomma* ticks in 2015–24 had expanded by 6·9% and 3·2%, respectively, putting an additional 364 million people at risk

Ticks are the second most important arthropod vector of infectious disease transmission, after mosquitoes.<sup>145</sup> Their potential to transmit disease—shaped by their feeding behaviour and environmental distribution—can be influenced by climate change.<sup>146</sup> This new indicator tracks

the environmental suitability for tick species that act as the primary vectors for the majority of human cases of tick-borne disease globally (*Ixodes* spp, *Hyalomma* spp, *R. sanguineus*, and *Amblyomma cajennense*).<sup>147–149</sup> It uses a threshold-based model that incorporates temperature, humidity, daylength, and land cover requirements specific to different tick species.

Between 1951–60 and 2015–24, the area with suitable weather conditions for *R. sanguineus* ticks, which are common in tropical, subtropical, and some temperate regions worldwide, increased by 6.9% (an all-time high), while the number of months suitable for disease transmission by these ticks increased by 8.6% for their presence and activity, putting a record-high, approximately 325 million additional people (4.7% increase) at risk of exposure. The suitable area for *Hyalomma* ticks, commonly found in Africa, southern Europe, and Asia, increased by 3.2% from 1951–60 to 2015–24, with a 12.4% increase in suitable months for their presence and activity.



**Figure 4:** Percentage change in the yearly average absolute  $R_0$  for the transmission of dengue by *Aedes albopictus* and *Aedes aegypti* mosquitoes globally in 1950–2024  
 $R_0$ =basic reproduction number.

**Indicator 1.3.6: Vibrio—headline finding: a record-high 91 195 km of coastline waters had environmental conditions suitable for Vibrio transmission in 2024—a 3.2% increase from the previous record in 2023**

Pathogenic *Vibrio* bacteria are transmitted through contact with marine waters or contaminated seafood, potentially causing severe skin, ear, and gastrointestinal infections and life-threatening sepsis.<sup>150</sup> As climate change increases the temperature and in some regions reduces the salinity of coastal waters, the potential for *Vibrio* transmission increases.<sup>151</sup> This indicator uses a mechanistic model incorporating sea surface temperature and salinity to monitor suitable coastal water conditions for *Vibrio* transmission.

In 2024, a record 85 countries showed coastal water conditions suitable for *Vibrio* transmission at any one time, and the coastline length with suitable conditions reached a record-high of 91 195 km—a 3.2% increase from the previous record in 2023 and 36% above the 1990–99 average. The total population living within 100 km of coastal waters with conditions suitable for *Vibrio* transmission reached a record-high of 1.68 billion people in 2024, up by 4.4% from the previous record-high in 2023. Vibriosis cases also hit a record-high in 2024, with an estimated 722 780 cases globally.

#### Indicator 1.4 Food security and undernutrition

**Headline finding: the higher number of heatwave days and drought months in 2023, compared with 1981–2010, was associated with 123.7 million more people experiencing moderate or severe food insecurity**

Between 638 million and 720 million people were undernourished in 2024, and 2.6 billion people (about a third of the world population) were unable to afford a healthy diet in 2022.<sup>152</sup> Numerous factors potentially contribute to this food security crisis, including

increasing temperature and precipitation extremes, which can reduce crop yields and farm worker labour capacity (indicator 1.1.3), jeopardise access to water and sanitation, and disrupt supply chains. Climate change-induced coastal sea surface temperature elevation, reduced oxygenation, ocean acidification, and coral reef bleaching are compromising marine resources.<sup>153–155</sup> Increased food insecurity increases the risk of all forms of malnutrition, which harms both health and economic development.<sup>156</sup>

The first part of this indicator links the increased incidence of drought months (12-month Standardised Precipitation Evapotranspiration Index) and annual heatwave days anomaly (compared with the 95th percentile of the frequency in 1981–2010) during the growing seasons of maize, rice, sorghum, and wheat, using a time-varying panel regression, to the prevalence of moderate or severe food insecurity in 124 countries, as defined by the Food and Agriculture Organization's Food Insecurity Experience Scale.<sup>157,158</sup> Compared with 1981–2010, the anomaly in annual heatwave days was associated with 3.15 percentage points higher moderate or severe food insecurity in 2023, and the greater number of drought months in 2023 was associated with 2.23 percentage points higher food insecurity. The combined effect is equivalent to approximately 123.7 million more people experiencing food insecurity due to the increase in climate change-sensitive extreme weather events.

The second part of this indicator tracks sea surface temperature variations in coastal regions relevant for marine food productivity across 173 countries and territories from 1958 to 2024.<sup>159</sup> Average global coastal sea surface temperatures were 0.62°C higher in 2022–24 than in 1981–2010, with Europe and Asia having the greatest increases. This increase puts marine productivity

at risk, particularly threatening coastal Indigenous and low-income fishing communities.<sup>160,161</sup> The loss of marine productivity can also drive a shift towards farmed fish consumption, which is generally of lower nutritional value than wild-caught fish.

### Conclusion

In 2024, as global temperatures reached record levels, so have most of the health risks of climate change monitored in this section. All-time highs were documented across all heat indicators, with record numbers reported for heatwave exposure per person, hours of unsafe outdoor physical activity, lost labour capacity due to heat stress, and sleep loss from high night-time temperatures (indicators 1.1.1–1.1.4). The new heat-related mortality indicator shows that heat-attributable deaths have risen by more than a third since the 1990s (indicator 1.1.5). The number of deaths from wildfire-derived air pollution and the land area affected by extreme drought reached all-time highs in 2024, while extreme precipitation events and exposure to sand and dust storms continued to grow (indicators 1.2.1–1.2.4).

In 2024, there was a record length of global coastline suitable for *Vibrio* transmission (indicator 1.3.6). Climate-defined suitability for the transmission of potentially fatal dengue, West Nile virus, leishmaniasis, and tick-borne diseases continued to grow, as did the converted land area suitable for malaria (indicators 1.3.1–1.3.4). The increased incidence of heatwaves and droughts also led to a record number of people facing food insecurity (indicator 1.4).

Collectively, this section illustrates the rapidly escalating, life-threatening effects of climate change. However, these indicators in isolation do not capture the potentially synergistic and compounding effects of the multiple health impacts of climate change occurring together, both on individual health as well as health systems and broader determinants of health. Evidence suggests that these multiple impacts are starting to affect the social, political, cultural, and economic conditions on which health depends, simultaneously heightening the risk of social unrest and conflict (panel 3). The scarcity of data disaggregated by age, gender, indigeneity, ethnicity, sexual orientation, disability, socioeconomic status, or underlying health conditions obscures the disproportionate impact on minoritised, marginalised, or vulnerable populations. This lack of disaggregated data makes it difficult to capture the disproportionate impacts of climate change on Indigenous people, such as those living in the circumpolar region, which is heating nearly four times faster than the global average.<sup>166</sup>

Despite these limitations, the year-on-year record-highs across multiple indicators provide evidence that climate change mitigation and adaptation policies to date have been insufficient to protect people's health and survival. Without the urgent and decisive action needed to curb the rising risks, the health impacts, which fall

disproportionately on lower HDI countries, will accelerate.

## Section 2: Adaptation, planning, and resilience for health

Section 1 outlines the growing health risks and impacts that already result from climate change and insufficient adaptation efforts to date. With hazards set to continue growing even under the most ambitious climate change mitigation scenarios, urgent efforts to adapt systems, infrastructure, and communities are urgently needed to protect the health and survival of people today and in the future.

Many of the adaptation actions needed align with low-regret or no-regret public health policies that have historically underpinned public health gains, including strengthening health systems, improving sanitation and hygiene, and advancing disease prevention.<sup>167,168</sup> Accelerating climate change adaptation for health requires efforts to address barriers, especially those that disproportionately affect low-resource settings and further limit the capacity of the most vulnerable communities to adapt.<sup>169,170</sup> These barriers include institutional weaknesses, resource constraints, knowledge gaps, and inadequate financing, many of which were identified in the 2022 Global Stocktake—the world's assessment of progress on climate change actions and reaching the goals of the Paris Agreement.<sup>171</sup> Addressing these barriers is crucial for delivering the necessary move from planning to tangible, widespread implementation of adaptation measures that effectively reach those most in need.

Indicators in this section track the progress and challenges in assessing, planning, and delivering climate change adaptation for health; the conditions that facilitate health adaptation; and the changing vulnerabilities to adverse climate-related health outcomes. Although major data limitations—particularly health impacts with a sufficient level of population, geographical, and temporal resolution—restrict the capacity to develop global indicators to monitor progress on climate change adaptation for health, country-led efforts to report indicators of progress towards WHO's Fourteenth Global Programme of Work, as well as towards the UN Framework Convention on Climate Change's (UNFCCC) Global Goal on Adaptation, could advance the available data to inform an increasingly comprehensive assessment in upcoming years.

### 2.1 Assessment and planning of health adaptation

Comprehensive assessments of climate-related and climate change-related health risks are crucial to inform the planning and implementation of urgent health adaptation interventions. The following indicators build on available global databases from reports of countries and cities to track the progress on health adaptation assessments and planning. The dependence on

### Panel 3: Climate change, health, and conflict

The understanding of the links between climate change and conflict has grown substantially over the past 20 years. This relationship is now widely recognised as a complex, multicausal phenomenon shaped by local social and cultural dynamics, economic fluctuations, and geopolitical forces at both the domestic and international levels.

Structural conditions such as poverty, weak governance, and inequality elevate the risk of conflict.<sup>5</sup> Climate change, alongside delayed and inequitable adaptation measures (section 2), causes system-wide impacts that simultaneously strain each of these drivers, exacerbating the risk of conflict: it undermines development, disrupts livelihoods, harms public health, and damages the economy (section 1; indicator 4.1); and it can strain institutions, drive migration,<sup>6,7</sup> and increase the risk of violence.<sup>8,9</sup> These impacts, although individually might be of limited magnitude, often occur simultaneously, deepening social vulnerabilities,<sup>8,10</sup> compounding each other, and increasing the risk of social tipping points and conflict.<sup>10</sup>

The links between climate change and conflict are most pronounced in rural economies that rely on agriculture and renewable natural resources. Climate stressors such as extreme heat, shifts in rainfall patterns, droughts, and floods reduce crop yields,<sup>11</sup> lower household income,<sup>12</sup> reduce land ownership,<sup>13</sup> and raise food prices. All of these stressors affect the socioeconomic conditions on which health depends, increase the risk of food insecurity and malnutrition, and affect health and wellbeing.<sup>14</sup> As a result, conflict risk then increases as, for example, inequality deepens and related grievances emerge.<sup>8</sup>

Empirical studies across Africa, Asia, and Latin America link droughts, especially during crop growing seasons, to higher risks of riots, communal violence, and insurgency.<sup>15-17</sup> Floods have also been shown to increase public support for violence.<sup>18-20</sup> Historical cases such as the 2007-08 food riots and the Arab Spring illustrate how climate-driven price shocks relate to unrest.<sup>21,22</sup> Newly formed land following floods and extreme rainfall events trigger political instability and conflict where ownership and access to resources become contested.<sup>23-25</sup> Climate change intensifies these tensions as natural resources are further strained, and heatwaves and other climate-related extreme events, food insecurity, and poor health<sup>26</sup> interact to pose complex challenges for governance.<sup>27</sup> Compounding crises also undermine fragile health systems (eg, climate events damage facilities and strain emergency response capacities),<sup>162</sup> while conflict often leads to the targeting of health workers, supply chain disruptions, and reduced care for displaced communities. These overlapping threats are associated with rising levels of psychological distress, burnout, and trauma among frontline workers and affected populations.<sup>163</sup>

Climate change can also influence displacement, straining infrastructure, increasing job competition, and heightening intergroup tensions, especially in ethnically divided or resource-scarce areas.<sup>8</sup> The case in Syria is frequently cited, although contested, as an example of drought-driven migration that might have contributed to unrest.<sup>28,29</sup>

The severe drought recorded between 2006 and 2010 compounded with longstanding grievances, authoritarian governance, and structural inequality to escalate tensions, which prompted large-scale rural displacement. As such, climate change and food price shocks are best understood as aggravating factors, rather than primary causes, of the uprisings across the Arab region.<sup>164,165</sup> Although environmental migrants are often viewed more favourably than economic migrants in high-income countries due to perceived deservingness,<sup>30</sup> studies from sub-Saharan Africa and south Asia show that such distinctions are less pronounced and might result in low-level conflict.<sup>31,32</sup>

Although many studies focus on the links between climate-induced resource scarcity and conflict, climate change and the response to it also increase the risk of conflict linked to resource abundance. In the quest for increasing renewable energy generation, tensions are rising over the ownership and exploitation of land containing essential minerals such as lithium, cobalt, copper, and rare earth elements.<sup>33</sup> The melting of Arctic ice has similarly opened access to oil, gas, and fisheries, intensifying geopolitical competition over these resources.<sup>34</sup>

Preventing climate-related conflict requires a broad commitment to managing the social and economic transformations that accompany climate change. A just transition (ie, one that ensures fairness in how the benefits of climate change action are distributed) can reduce key drivers of instability by protecting livelihoods, addressing inequalities, and fostering inclusive development.<sup>35</sup> Strengthening food systems enhances resilience and reduces the risks of food insecurity and malnutrition, which are linked to social unrest. Likewise, protecting workers from climate-related shocks and disruptions can help prevent economic grievances from escalating into conflict. Although evidence remains limited, health-centred adaptation, such as investing in equitable, climate-resilient health systems, might also contribute to social stability by reducing vulnerability and improving community trust and cohesion. In a time of growing geopolitical volatility, strengthening multilateral cooperation and ensuring that the transition is not only green but also just might be essential to building peace in a climate-affected world.<sup>36</sup>

self-reported status has intrinsic limitations, and highlights the urgency to evaluate the impact of such reported adaptation efforts. It also underscores the

crucial importance of regular and rigorous reporting to global monitoring systems to adequately capture the extent of progress at the national and city levels.



*Indicator 2.1.1: national assessments of climate change impacts, vulnerability, and adaptation for health—headline finding: as of March, 2025, 58% (n=112) of 193 WHO member states reported having ever completed a Vulnerability and Adaptation assessment*

Vulnerability and Adaptation assessments allow for a comprehensive understanding of the potential health risks and impacts associated with climate change. They provide crucial information for decision makers, inform planning and intervention activities, and guide resource allocation.<sup>172</sup>

As of March, 2025, 112 (58%) of 193 WHO member states reported having completed a Vulnerability and Adaptation assessment, while 45 (23%) members had not ever completed an assessment and 36 (19%) member states did not have data available. Of those that have completed a Vulnerability and Adaptation assessment, 19 (17%) are classified as a low HDI country, 17 (15%) are classified as a medium HDI country, 31 (28%) are classified as a high HDI country, and 44 (39%) are classified as a very high HDI country.

ATACH—led by WHO—tracks the implementation of the COP26 Health Programme commitments, including Vulnerability and Adaptation assessments, acts as a community of practice and knowledge sharing, and enables the coordinated advancement of actions on health and climate change.<sup>173</sup> Among the 92 countries that have opted in and made voluntary commitments to make their health systems more resilient and sustainable, 68 (74%) ATACH members had ever completed a Vulnerability and Adaptation assessment, which is a much higher rate than WHO member states that are not part of ATACH (44%; 44 of 101 member states).

*Indicator 2.1.2: National Adaptation Plans for health—headline finding: as of March, 2025, 60% (n=116) of 193 WHO member states reported having ever completed a HNAP*

Health National Adaptation Plans (HNAPs) are crucial for integrating the health risks of climate change into national planning and decision-making processes. They can help to ensure that health is considered and incorporated into climate change adaptation policies, programmes, and interventions.

As of March, 2025, 116 (60%) of 193 WHO member states reported having ever completed a HNAP, while 43 (22%) members had never completed a HNAP and 34 (18%) members did not have data available. Of those with completed HNAPs, 38% (n=44) are classified as very high HDI countries, 29% (n=34) are classified as high HDI countries, 17% (n=20) are classified as medium HDI countries, and 15% (n=17) are classified as low HDI countries.

Of those that voluntarily committed to developing more sustainable and resilient health systems through ATACH, 68 (74%) of 92 members have ever completed a HNAP: a much higher rate than the 101 countries that have not opted into ATACH (n=48; 48%).

*Indicator 2.1.3: city-level or state-level climate change risk assessments—headline finding: in 2024, 834 (97%) of 858 cities reported having completed, being in the process of conducting, or expecting to conduct a city-level climate risk and vulnerability assessment*

With 56% of the world's population currently living in urban areas, and an expected increase to 70% by 2050, cities have a major role to play in protecting health amid growing climate change impacts.<sup>174</sup> Since 2017, this indicator uses data from the CDP (the world's first and largest data collection initiative to report on city-level assessments of climate change risks).<sup>175,176</sup> In 2024, of the 858 cities or states voluntarily responding to the climate risk assessment module, 834 (97%; 1% higher than in 2023) reported they had completed, were in the process of conducting, or were planning to conduct a city-level climate risk and vulnerability assessment within 2 years. Using newly compiled historical data, 1429 (62%) of 2318 cities or states have reported undertaking at least one climate risk and vulnerability assessment since 2015.

Of the 820 (96%) cities responding to the health module (a reporting record), 605 (74%) noted climate change to be impacting either health outcomes, health systems, or other sectors relevant to health. Of these 605 cities, 499 (82%) noted impacts on health outcomes, 219 (36%) noted impacts on health systems, and 77 (13%) noted impacts on other sectors relevant to health. Heat-related illnesses (n=251; 41%), urban flooding (n=170; 28%), disruption to health-related services (n=151; 25%), exacerbation of non-communicable diseases (n=140; 23%), storms (n=127; 21%), heat stress (n=107; 18%), and extreme heat (n=99; 16%), were the leading public health issues identified.

## 2.2 Enabling conditions, adaptation delivery, and implementation

Successful health adaptation requires enabling conditions including good governance, multistakeholder collaboration, stable and long-term financing mechanisms, technology transfer, and capacity building. The following indicators track progress on conditions that are important enablers for health adaptation.

*Indicator 2.2.1: climate information for health—headline finding: in 2024, 161 (83%) of 193 WMO members reported providing climate services for the health sector*

The use of climate data is crucial to effectively anticipate and respond to climate-related health risks and to assist public health planning and decision making.<sup>177</sup> This indicator uses information from the World Meteorological Organization's (WMO) Climate Services Dashboard to track the delivery of climate services to the health sector across WMO member states.<sup>178</sup>

In 2024, 161 (83%) of 193 WMO members reported that their meteorological sector provided climate services for the health sector. The South-West Pacific WMO region

had the most member states providing climate services for health (21 of 22 members; 95%); followed by Africa (47 of 53 members; 89%); Europe (42 of 50 members; 84%); Asia (28 of 34 members; 82%); South America (9 of 12 members; 75%); and North America, Central America, and the Caribbean (14 of 22 members; 64%). Data services were the most commonly provided service (n=149; 77%), followed by climate monitoring (n=120; 62%), climate analysis and diagnostics (n=117; 61%), climate predictions (n=103; 53%), tailored products (n=99; 51%), and climate change projections (n=81; 42%).<sup>178</sup>

**Indicator 2.2.2: benefits and harms of air conditioning—headline finding:** since 2000, the share of households with air conditioning has nearly doubled, reaching 37% in 2023, potentially saving 114 000 lives annually; while 48% of households in high and very high HDI countries had air conditioning, only 2% of households in low HDI countries had air conditioning

As heat-related health risks grow (indicator 1.1), so does the need for cooling to protect vulnerable populations from heat-related morbidity and mortality. Unprecedented heat exposure in 2024 led to a 5% increase in building-related electricity consumption, largely from air conditioning.<sup>179</sup> Although air conditioning is an effective cooling tool, it can exacerbate inequalities in energy consumption, greenhouse gas emissions, air pollution, and environmental degradation.<sup>180</sup> It can also increase outdoor heat exposure through its waste heat.

Data from the International Energy Agency (IEA) show that the proportion of households with air conditioning nearly doubled between 2000 (19%) and 2023 (37%). This increase was primarily driven by an increase in the proportion of households with air conditioning in very high (increasing from 35% to 48%) and high (increasing from 16% to 48%) HDI countries. In China (a high HDI country), the share of households with air conditioning grew from 24% in 2000 to 73% in 2023. In contrast, air conditioning access grew from 1% to only 2% in low HDI countries across the same period (figure 5).

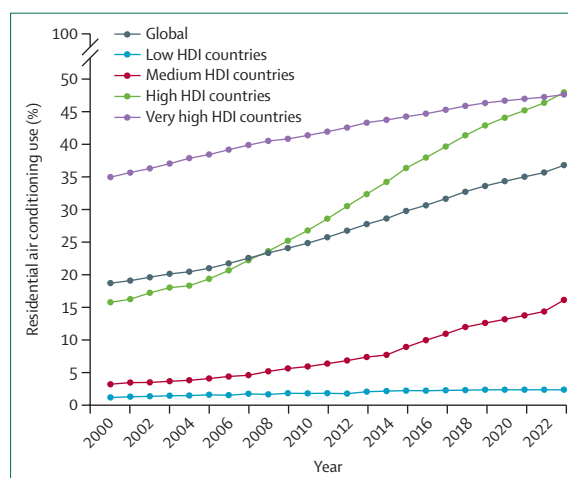
Although the energy efficiency of air conditioning has improved, operating units remain energy intensive and expensive. Since 2000, air conditioning-related greenhouse gas emissions rose by 89%, to 1100 megatonnes of CO<sub>2</sub> emissions in 2023, exceeded by the national emissions of only six countries.<sup>181</sup>

These findings reinforce the need to promote and support behavioural change, implementing supportive policies to increase the uptake of sustainable cooling solutions and reduce reliance on those that are highly energy intensive, wherever safe and suitable to do so. It also underscores the unequal access to air conditioning, and the need to ensure that this technology is available to the most vulnerable populations who need it the most to protect their health and survival.

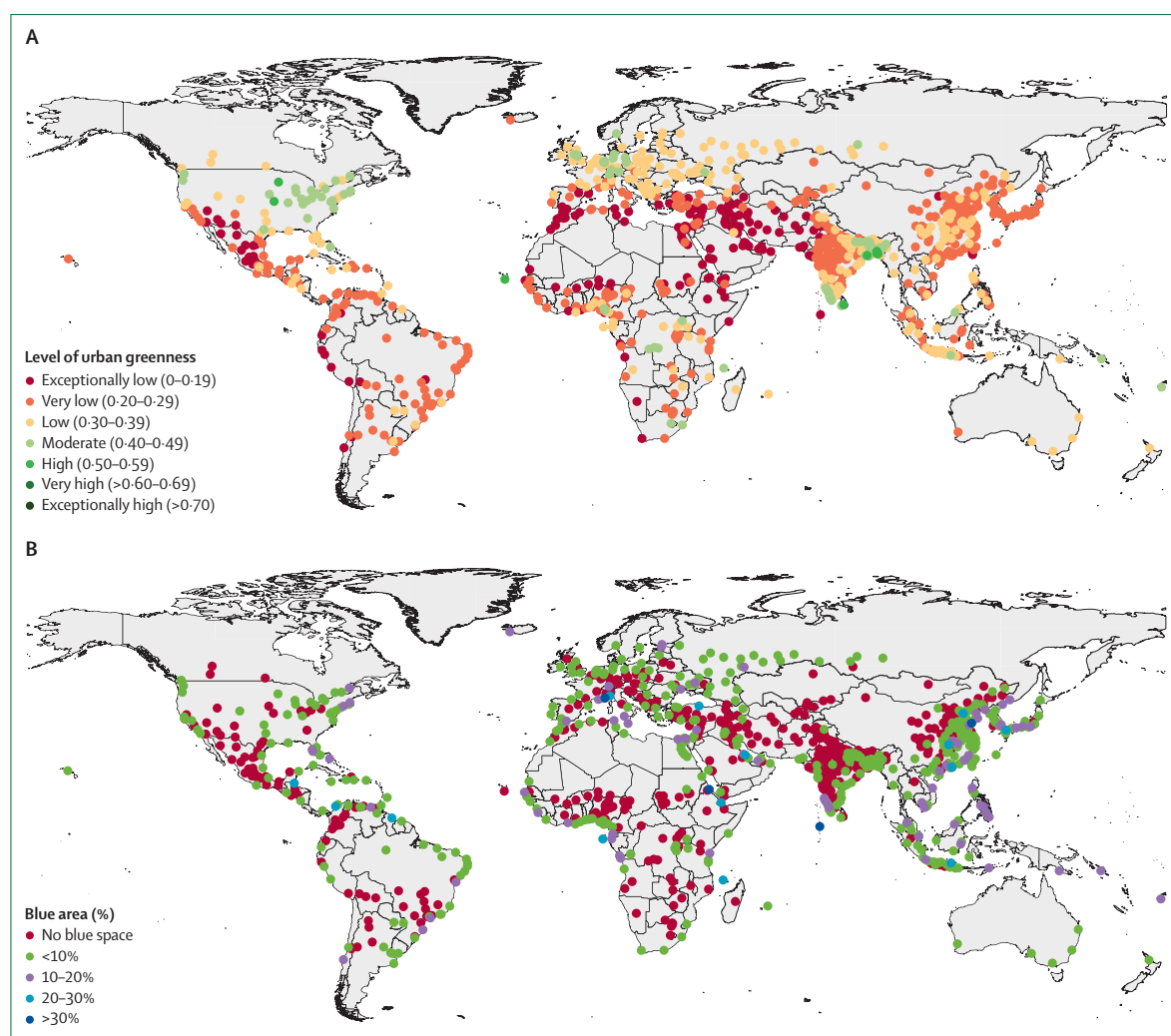
**Indicator 2.2.3: urban green and blue spaces—headline finding:** in 2024, exposure to urban greenspace remained practically unchanged from the 2015–20 average (0.2% increase), with individual city changes ranging from a 34% decrease to a 69% increase

Green spaces can provide local cooling by reducing the intensity of heat islands,<sup>182,183</sup> and they can also reduce flood risk.<sup>184,185</sup> Exposure to urban green spaces can also have substantial positive effects on physical and mental health.<sup>186–189</sup> Similarly, urban blue spaces (eg, rivers, lakes, and coastlines) are also linked to improved mental and physical health.<sup>190</sup> This indicator uses a population-weighted normalised difference vegetation index (NDVI) from Landsat satellite data to estimate greenspace exposure for 1041 urban centres across 173 countries (figure 6A). New to this year's report, this indicator includes a calculation of the percentage of each city that is considered bluespace using satellite-derived landcover data.<sup>191</sup> Although substantial changes were recorded in greenspace exposure in individual cities (from a 69% increase to a 34% decrease), the global and regional population-weighted peak-season NDVI have remained largely unchanged since 2015. On average, cities with a very high and high HDI had slight increases in the NDVI in 2024 (1.6% increase each), whereas those with a medium and low HDI had slight decreases (–2.1% decrease and –1.7% decrease, respectively).

On average across the 1041 cities, blue spaces made up 2.9% of the urban area (figure 6). Blue spaces were more abundant in more developed cities, accounting for 4.2% of the urban area in cities in very high HDI, 3.1% in cities in high HDI, 1.8% in cities in medium HDI, and 1.8% in cities in low HDI countries. Using combined greenspace and bluespace landcover percentages, cities in low HDI countries had a higher proportion of combined greenspace and bluespace (42%) than cities classified as high



**Figure 5: Annual percentage of households with air conditioning from 2000 to 2023, globally and by HDI group**  
HDI=Human Development Index.



**Figure 6: Urban green and blue space coverage**

(A) Urban greenness in urban centres with more than 500 000 inhabitants. Urban greenness is characterised by the population-weighted peak season (greenest) NDVI. (B) Percentage of urban areas with blue spaces (eg, water bodies and permanent wetlands). Each dot represents a city.

HDI (29%) or very high (20%) HDI countries. Given the potential health benefits of urban green spaces, increasing access, while preventing gentrification and managing the risk of infectious disease transmission, could represent a key adaptation tool. Importantly, the deployment of these solutions must ensure equitable access and distribution to ensure their benefits reach vulnerable populations.

*Indicator 2.2.4: detection of, preparedness for, and response to health emergencies—headline finding: in 2024, 135 (69%) of 196 WHO member states reported having high to very high implementation of health emergency management capacity, an increase of four countries with respect to 2023*

Sufficient emergency preparedness and response capacity are key to reducing the impact of health emergencies, including those resulting from extreme

events and disease outbreaks that are increasingly likely due to climate change.<sup>192</sup>

This indicator monitors the level of implementation of the International Health Regulations core capacity on health emergency management (capacity 7) and financing for public health emergency response (capacity 3.2). Self-reported data from the electronic States Parties Self-Assessment Annual Reporting tool are used.<sup>193</sup>

In 2024, 135 (69%) of 196 countries reported a high to very high implementation (score of 61–100) of health emergency management capacities, of which 57 (42%) were very high HDI countries, 38 (28%) were high HDI countries, 26 (19%) were medium HDI countries, and only 11 (8%) were low HDI countries.

The level of implementation of capacity 7 (measuring health emergency management) was positively associated with that of capacity 3.2 (measuring availability of

financing for health emergency response) in 2024, with very high and high HDI countries having the highest levels of implementation for both. This association notes the importance of financial support in enabling health emergency management. Low HDI countries tend to have low to medium levels of implementation for both capacities.

*Indicator 2.2.5: climate and health education and training—headline finding: in 2024, 301 (66%) of 454 public health and 106 (72%) of 147 medical institutions worldwide provided climate and health education, reaching 126 423 (20%) of the 639 409 students enrolled in public health and 62 197 (64%) of the 96 633 students enrolled in medical education*

Health professionals play a pivotal role in addressing climate-related health impacts, and climate education is key to building local capacities for an informed response.

<sup>194–198</sup> This indicator assesses the number of students receiving climate and health education in degree-granting public health and medical institutions, drawing on the world's largest survey in this field, which ran from October, 2024, to February, 2025, covering 454 degree-granting public health institutions across 90 countries and 147 medical institutions across 46 countries.

The offer of climate change and health education by surveyed public health institutions was comparable across all HDI country groups, with highest coverage in very high HDI countries (111 of 152 countries; 73%), 68% (57 of 84 countries) in low HDI countries, 67% (82 of 123 countries) in high HDI countries, and 54% (51 of 95 countries) in medium HDI countries. Most training occurred in master's programmes (229 of 656 institutions; 35%) and was mandatory in only 68 (15%) of 454 institutions. Larger differences were recorded among medical institutions, with 85% (81 of 95 institutions) of those in very high HDI countries providing climate education, compared with 50% (16 of 32 institutions) of those in high HDI countries, 50% (5 of 10 institutions) in medium HDI countries, and 40% (4 of 10 institutions) in low HDI countries. Of the 96 633 medical students surveyed, only 6363 (7%) were from low HDI countries. However, 91 (62%) of 147 institutions made education mandatory.

These findings suggest that climate education remains insufficiently integrated in medical and public health training, leaving many future professionals unprepared to recognise, prevent, and manage climate change-related risks, especially in the most vulnerable countries.<sup>199</sup>

## 2.3 Vulnerabilities, health risk, and resilience to climate change

As climate-related health hazards grow, adaptation measures are needed to reduce vulnerability and minimise associated risks. This group of indicators monitors the change in health vulnerabilities to climate hazards.

*Indicator 2.3.1: vulnerability to severe mosquito-borne disease—headline finding: global vulnerability to severe dengue increased by 32% from 1990–99 to 2015–24, with high HDI countries seeing the largest increase (56·3%)*

Climate change is increasingly favouring the transmission of dengue and other urban mosquito-borne diseases (indicator 1.3.1).<sup>200</sup> Inadequate sanitation and waste management, limited surveillance, inadequate warning and response systems, and limited access to preventive measures and health care can increase the vulnerability to adverse outcomes, exacerbating health risks.<sup>201</sup> This indicator, in an improvement on previous years, captures the relative vulnerability to severe dengue by combining susceptibility from urbanisation and coping capacity from health-care access and quality, measured by dengue mortality.<sup>202</sup>

Global vulnerability to severe dengue increased by 32% from 1990–99 to 2015–24. The highest relative increases were seen in high HDI countries (56·3%) and medium HDI countries (50·6%), followed by low HDI countries (48·1%) and very high HDI countries (10·1%). These increases were mostly driven by urbanisation.

*Indicator 2.3.2: lethality of extreme weather events—headline finding: adjusted for HDI, countries with climate-informed health early warning systems showed a significantly faster decline in the annual mortality rate from floods and storms from 2000 to 2024 than countries without such systems (3·2% vs 1·6% decrease per year;  $p < 0·001$ )*

Extreme weather events are changing in frequency, intensity, and duration,<sup>65</sup> posing direct risks to health and wellbeing.<sup>113</sup> Climate-informed early warning systems for health can help buffer the impact of these events on health outcomes and death.<sup>203</sup>

This indicator combines data from the Centre for Research on the Epidemiology of Disasters' emergency events database, EM-DAT, and data from the 2021 WHO Health and Climate Change Survey.<sup>204</sup> A negative binomial regression model was fitted to evaluate the association between disaster-related mortality (due to floods and storms) and the implementation of health early warning systems for injuries. As HDI level probably has an important role in disaster preparedness and disaster-related health outcomes, the model adjusts for HDI group.

Observed population-weighted mortality rates decreased substantially between 2000–09 and 2015–24. Although countries without a health early warning system showed a notably larger decrease (53%) compared with those with a system (17%); they also had substantially higher mortality rates in the 2000–09 baseline period compared with countries with health early warning systems (0·034 deaths per 100 000 people vs 0·007 deaths per 100 000 people). Consequently, despite achieving a greater percentage reduction, the mortality rate for countries without a health early warning system in 2015–24 (0·016 deaths per 100 000 people) remained



considerably higher than in countries with a system (0·006 deaths per 100 000 people). Overall, countries with health early warning systems showed a significantly higher rate of decline in annual mortality than countries without a system (3·2% vs 1·6% decrease per year;  $p < 0·001$ ).

*Indicator 2.3.3: rising sea levels, migration, and displacement—headline finding: in 2024, 156·7 million people were living less than 1 m above current sea levels; as of December, 2024, 59 national policies identified across 44 countries connected climate change and migration while mentioning health* Between 1993 and 2023, the global average sea level rose by 101·4 mm and is projected to continue rising.<sup>205,206</sup> Sea level rise is already affecting low-lying coastal communities, cities, and islands.<sup>207,208</sup> In 2024, 156·7 million people lived less than 1 m above sea level. Sea level rise impacts include saltwater intrusion, erosion, loss of coastal ecosystems, and flooding, which can negatively affect livelihoods, damage infrastructure, contribute to mental and physical health risks, and lead to direct injury and death.<sup>209,210</sup>

Populations can adapt to sea level rise through engineered coastal defences, ecosystem management, or land reclamation, among others. Human migration and relocation could be a response when in-situ adaptation limits are reached.<sup>211</sup> Some people might be unable or unwilling to move, becoming trapped.<sup>212</sup>

As of December, 2024, 59 national policies identified across 44 countries connected climate change and migration while mentioning health. Three policies, each from a different country, mentioned immobility in the context of climate change. The policies rarely show a strong basis in science by examining links or lack of links among climate change, mobility, and health. Instead, policies focus on the negative impacts of climate change affecting mobility and health, with limited focus on the impacts and responses that might improve health and wellbeing. Some nuances appear, such as by adapting health systems to deal with migration and considering how the health of existing migrants could be affected by climate change.

## Conclusion

The findings from this section reveal some positive steps on adaptation for health, including an increase in city-level risk assessments (indicator 2.1.3), high levels of provision of meteorological services for health (indicator 2.2.1), and evidence suggesting that countries with health early warning systems have reduced mortality from extreme weather events (indicator 2.3.2). However, they also reveal that overall progress has been uneven and insufficient, with high and very high HDI countries making the most progress, whereas low HDI countries are less prepared and supported.

National-level adaptation planning and assessment remains slow, with only a third of countries surveyed by

WHO reporting having completed Vulnerability and Adaptation assessments and HNAPs since 2020 (indicators 2.1.1 and 2.1.2). Key policies on mobility and migration rarely show links among climate change, mobility, and health (indicator 2.3.3). Furthermore, the number of countries reporting high to very high levels of implementation of health emergency management capacity has remained stagnant (indicator 2.2.5), and vulnerability to dengue is increasing globally (indicator 2.3.1).

Although enough evidence and knowledge are available to inform adaptation intervention, the previous two sections show how delays in their delivery have already resulted in avoidable death, disease, and loss of livelihoods. Equitable allocation of sufficient resources is urgently needed to prevent the worst impacts of climate change now and in the future. However, the challenges to adaptation will continue to grow, and the limits to adaptation (eg, financial, technological, and political) loom closer, unless it is accompanied by an urgent decrease in greenhouse gas emissions to keep global temperature rise within the limits of our capacity to adapt.

## Section 3: Mitigation actions and health co-benefits

The gap between current global emissions and the reductions needed to meet the Paris Agreement goals has continued to widen in 2024. With current policies and commitments, the world is heading towards a mean temperature increase of 2·7°C above the pre-industrial average by the end of the century.<sup>213</sup> Without immediate and unprecedented action, the capacity to adapt will be exceeded and climate impacts will continue to grow.<sup>214</sup>

Indicators in this section reflect the multifaceted relationship between mitigation actions and public health outcomes, and monitor progress—or lack thereof—towards limiting climate hazards to health. They track progress on the energy transition that defines both greenhouse gas emissions and health outcomes; the potential health co-benefits from improved air quality resulted from reducing fuel combustion; the health opportunities of transitioning to low-emission food systems and diets; tree cover loss, which is vital due to its impact on carbon sinks, respiratory health, and zoonotic disease risks; and health-care sector emissions; exposing the importance of ensuring that efforts to improve health do not inadvertently generate net harms to health by exacerbating climate change-related risks.

### 3.1 Energy use, energy generation, and health

The energy sector is the largest single contributor to global greenhouse gas emissions, accounting for approximately 68% of total emissions.<sup>215</sup> The transition towards zero emission energy is key for human health and survival: it can not only result in reduced emissions and increased efficiency, but can also improve air quality, equitable and stable access to energy, and ultimately

reduce inequities, improve health, and protect people from the life-threatening risks of climate change.

*Indicator 3.1.1: energy systems and health—headline finding: global energy-related emissions grew by 1·6% during 2023, pushing associated CO<sub>2</sub> emissions to a new all-time high*

The UN Environment Programme's Emissions Gap Report shows that energy-related fossil fuel-derived CO<sub>2</sub>, which accounts for about 68% of global greenhouse gas emissions, was the primary driver of emissions growth in 2023.<sup>215</sup> To prevent the most catastrophic climate change scenarios, global greenhouse gas emissions must rapidly drop, especially in the energy sector. This indicator tracks energy sector mitigation based on data from the IEA. The energy sector had a 1·6% increase in emissions in 2023, and this increase translated to a 2% rise in global greenhouse gas emissions (above the 0·3% increase in 2022). The share of fossil fuels (including coal, oil, and natural gas) in the global total energy supply has decreased minimally: from 82% in 2016 (when the Paris Agreement entered into force) to 81% in 2022 (equivalent to 1993 levels).<sup>216</sup> In line with this drop, the carbon intensity of the energy sector reached a new record-low of 54·8 tonnes of CO<sub>2</sub> per terajoule in 2022, falling by 3·7% from 2016 to 2022.<sup>216</sup>

Among fossil fuels, coal emits the most carbon per unit of energy and causes the highest levels of toxic air pollution, including PM, SO<sub>2</sub>, NO<sub>x</sub>, and other contaminants. Coal phase-out is therefore crucial to protect people's health from immediate harms, as well as for those posed by climate change. However, the share of coal used for electricity supply has increased to record levels in low HDI countries since 2016, reaching 9·9%. Although medium, high, and very high HDI countries reduced these shares, coal still supplied 55·5% of electricity in medium HDI countries, 49·6% of electricity in high HDI countries, and 18·6% of electricity in very high HDI countries in 2022. These trends highlight the persistent global inequalities in access to clean energy. As countries work to meet the growing demand for electricity, keeping health and equity at the heart of that transition is important to avoid exacerbating disparities.

Modern renewable energy enhances energy efficiency, reduces pollution, and benefits public health. It can also be delivered in remote locations, helping reduce energy poverty and driving progress towards net-zero emissions and sustainable development.<sup>217</sup> The share in the use of modern renewable energy for electricity generation has continued to grow, from 5·5% in 2016 to a record-high 12·1% in 2022. All HDI groups show an increase in the share of clean renewables: 2·2% in low HDI countries, 4·4% in medium HDI countries, 7·6% in high HDI countries, and 6·6% in very high HDI countries. However, disparities persist in access to clean renewable energy. Although 13·3% of energy in very high HDI countries and 12% of energy in high HDI countries

comes from renewables, this share is only 8·6% of energy in medium HDI countries and just 3·5% of energy in low HDI countries in 2022.

The unequal transition to clean energy and the continued growth in energy-sector emissions show that a structural transformation in this sector is urgently needed to avoid the most dangerous climate change scenarios.

*Indicator 3.1.2: household energy use—headline finding: the proportion of household energy coming from harmful solid biomass dropped from 28% in 2016 to 26% in 2022; however, 88% of energy in low HDI countries and 64% of energy in medium HDI countries still came from solid biomass in 2022*

Energy access is essential to good health, enabling healthy indoor temperatures, the refrigeration of food and medicines, providing access to information and education, and supporting everyday activities and employment.<sup>218</sup> Energy-poor households often rely on highly polluting biomass to meet their energy needs. This reliance widens intra-household inequities, as women and children are often in charge of sourcing this fuel, which exposes them to risks of violence and injury, and hinders their capacity to undertake employment and education.<sup>219</sup> Globally, although 15 million people gained electricity access between 2022 and 2023, 745 million people still do not have access to this essential resource.<sup>220</sup>

Using IEA data, this indicator monitors the main fuel types used in the residential sector. Globally, per-capita household energy consumption rose by 2% between 2016 and 2022. Although the share of household electricity use grew from 26% in 2016 to 28% in 2022, the use of heavily polluting solid biomass in the household sector decreased from 28% in 2016 to 26% in 2022, and coal use decreased by 1·5%, driven by progress in medium and high HDI countries. The use of natural gas—which is less polluting than solid fuels but still contributes to household air pollution and, importantly, to climate change—increased by 0·8% between 2016 and 2022. There was very little change in solid biomass and electricity use in both low and very high HDI countries. In 2022, solid biomass remained the dominant source of household energy in low HDI countries, accounting for 88% of household energy, while electricity made up just 6% of household energy.

Despite some improvement since 2010, there were still 675 million people without access to electricity and 2·3 billion people relying on polluting fuels and outdated technologies for cooking globally in 2022, hindering sustainability and public health.<sup>221,222</sup> Dirty fuel combustion for cooking creates severe indoor air pollution, disproportionately harming women and children in low and medium HDI countries.<sup>223</sup> According to WHO data tracking progress towards Sustainable Development Goal (SDG) 7, 77% of the urban population had access to fuels that are cleaner than solid fuels (including electricity, liquefied petroleum gas, natural gas, biogas, solar energy,

and alcohol) in 2023, compared with only 60% of the global rural population, with the largest number deficits in access in sub-Saharan Africa.<sup>224</sup> Major inequities persist between countries, with just 13% of the population in low HDI countries having access to these resources versus 98% in very high HDI countries.

Notably, although SDG 7 classifies natural gas and liquefied petroleum gas as clean fuels, their combustion still releases toxic nitrogen dioxide, and its burning contributes to climate change, threatening people's health and survival. Liquefied petroleum gas and natural gas are often considered transition fuels, as they are typically less polluting than coal. However, between 2016 and 2022, the use of liquid fossil fuels and natural gas in households remained steady at around 35%. Usage rates varied substantially during this period, averaging 47·3% in very high HDI countries, 33·9% in high HDI countries, 16·7% in medium HDI countries, and only 6·5% in low HDI countries. These figures highlight the importance of addressing energy poverty by expanding access to reliable, healthy, and renewable energy sources, especially in the world's most underserved regions.

*Indicator 3.1.3: sustainable and healthy road transport—headline finding: despite rapid uptake of electric vehicles, less than 0·38% of global road transport energy was supplied by electricity in 2022, up from 0·28% in 2021*

The shift away from combustion engine vehicles is essential to climate change mitigation. If done right, this transition can help avoid nearly 1·5 million deaths caused by transport-derived air pollution (indicator 3.2.1), encourage more equitable access to public transport, help reduce traffic in urban centres, and improve population health if safe active travel options are implemented. The global road transport system is in the early stages of a major technological shift away from fossil fuels towards the use of electric vehicles. China is leading this shift, where 49% of new car sales in 2024 were for electric vehicles.<sup>225</sup> In contrast, the growth in electric vehicles has slowed in the USA and Europe.<sup>226</sup> This indicator tracks the share of overall road transport energy by fuel type using data from the IEA. Although the use of electricity for road travel increased by 36% from 2021 to 2022, it remained at only 0·38% of global road energy. In China, electricity still accounted for only 2% of all road travel energy in 2022; whereas fossil fuels accounted for the remaining 98%, exceeding the proportion in most European countries. The use of electricity increased to 5·2% in Norway and 1·6% in Sweden, where fossil fuel use fell to 83·7% in Norway and 71% in Sweden of road transport in 2022.

Phasing out fossil fuel vehicles is necessary for limiting climate change and has the substantial benefit of reducing harmful air pollution. However, the greatest health gains are available through shifting to active travel and zero emissions public transport.<sup>227</sup> Ensuring this shift occurs and promotes equity and health requires investments in improving access to public transport, and

developing safe infrastructures for active travel that prevent an unintentional increase in road accidents.

### 3.2 Air quality and health co-benefits

Many sources of greenhouse gas emissions also contribute to air pollution, exposure to which increases the risk of respiratory and cardiovascular disease, certain cancers, diabetes, neurological issues, and complications during pregnancy.<sup>228</sup> This section examines how mitigation measures might offer health co-benefits by reducing air pollution.

*Indicator 3.2.1: mortality from ambient air pollution by sector—headline finding: deaths attributable to ambient PM<sub>2.5</sub> from fossil fuel combustion decreased by 5·8%, from 2·68 million deaths in 2010 to 2·52 million deaths in 2022*

Understanding the source of emissions of greenhouse gases and air pollution is key to devising effective climate change mitigation measures with health co-benefits. This indicator combines atmospheric modelling with emitting sectors' activities information to estimate mortality associated with anthropogenic ambient PM<sub>2.5</sub>.

This indicator uses estimates of sectoral source contributions to annual mean exposure to ambient PM<sub>2.5</sub> calculated with the greenhouse gas–air pollution interactions and synergies (or GAINS) model and calculates their health impact using a Fusion risk model.<sup>91</sup> The model now accounts for emissions from vehicles that do not comply with emissions standards, leading to higher figures than in previous reports. Since 2010, global average exposure to total anthropogenic PM<sub>2.5</sub> decreased by 9·0%, from 23·1 µg/m<sup>3</sup> to 21·0 µg/m<sup>3</sup>, while exposure to PM<sub>2.5</sub> from fossil fuels decreased by 18·7%, from 10·1 µg/m<sup>3</sup> to 8·2 µg/m<sup>3</sup>. A large part of this reduction, however, was caused by the introduction of more stringent air pollution control technologies that did not reduce CO<sub>2</sub> emissions.<sup>43</sup>

Deaths attributable to total ambient PM<sub>2.5</sub> air pollution increased from 7·5 million deaths in 2010 to 8·5 million deaths in 2022 (7·6% increase); while deaths attributable to ambient PM<sub>2.5</sub> air pollution from human activities grew from 5·9 million deaths in 2010 to 6·5 million deaths in 2022 (11·3% increase). From those deaths, the number of deaths attributable to PM<sub>2.5</sub> ambient air pollution derived from fossil fuels decreased from 2·68 million to 2·52 million (5·8% decrease) from 2010 to 2022, avoiding 160 000 deaths annually, which was mostly driven by reduced coal use in very high and high HDI countries (figure 7). Despite the reduction, 1·00 million annual deaths were still attributable to coal combustion globally in 2022. In the same year, the use of fossil fuels in road travel resulted in 1·20 million deaths globally, while fossil fuels in the power sector accounted for 0·74 million deaths, and the use of polluting fuels (including biomass) in the household sector contributed to 1·18 million deaths—in addition to the many more deaths resulting from indoor air pollution.

The agricultural sector contributed to 19% of all anthropogenic PM<sub>2.5</sub>-related deaths in 2022, stemming from the emissions of ammonia (NH<sub>3</sub>) and other pollutants (eg, SO<sub>2</sub> and NO<sub>x</sub>) that contribute to the formation of PM<sub>2.5</sub> concentrations in the atmosphere from the use of fossil fuels in the agricultural sector and from waste and land burning.

Lockdowns during the COVID-19 pandemic only caused a small decrease in PM<sub>2.5</sub> in 2020 and 2021, mostly due to reduced traffic, and did not have a lasting effect on longer-term trends. Low HDI countries, with comparably younger populations and lower ambient air pollution, had the lowest ambient anthropogenic PM<sub>2.5</sub>-related mortality in 2022 (33 deaths per 100 000 people); however, mortality from fossil fuel-derived PM<sub>2.5</sub> in this group increased by 13% between 2010 and 2022, from 8.0 per 100 000 people to 9.1 per 100 000 people. Meanwhile, mortality from fossil fuel-derived PM<sub>2.5</sub> decreased by 40% in very high HDI countries. Medium HDI countries, which are still heavily dependent on fossil fuels but have not yet adopted efficient air pollution emission controls, have the highest mortality from fossil fuel-derived PM<sub>2.5</sub> (43 deaths per 100 000 people).

**Indicator 3.2.2: household air pollution—headline finding:** in 2022, household use of dirty fuels and inefficient technologies for cooking and heating resulted in 2.3 million deaths and accounted for 7% of global CO<sub>2</sub> emissions

The persistent use of dirty fuels and inefficient technologies in the household sector leads to high levels of exposure to indoor PM<sub>2.5</sub> air pollution (including highly toxic black carbon; indicator 3.1.2).<sup>229</sup> This indicator uses a Bayesian hierarchical model to estimate exposure to household air pollution by source of emission in 65 countries that are most dependent on dirty fuels and inefficient technologies for cooking and heating.<sup>230</sup> The use of polluting fuels for cooking and heating across these countries led to national-level average household indoor PM<sub>2.5</sub> concentrations of 410 µg/m<sup>3</sup> (95% CI 351–469) in 2022, vastly exceeding the WHO's annual air quality guideline level of 5 µg/m<sup>3</sup>. This was a very small decrease (0.5%) from 2020. Rural households are most affected, with an average of 511 µg/m<sup>3</sup> (443–579) compared with 149 µg/m<sup>3</sup> (125–173) in urban households in 2022.<sup>121,230</sup> Using previous estimates that people in these countries spend about 60% of their time indoors,<sup>230,231,232</sup> exposure to this air pollution would result, on average, in 78 (72–84) deaths per 100 000 people, with a rural average of 84 (78–90) deaths and an urban average of 60 (54–66) deaths per 100 000 people. For the 65 countries studied, this would have resulted in 2.3 million deaths in 2022, a slight decrease (0.03%) from 2020.<sup>121</sup>

The use of biomass, charcoal, and coal for cooking and heating across the 65 countries emitted about 2.69 gigatonnes (Gt) of CO<sub>2</sub>: 2.21 Gt of CO<sub>2</sub> from rural areas and 0.48 Gt of CO<sub>2</sub> from urban areas. This accounts for approximately 7% of global CO<sub>2</sub> emissions.<sup>233</sup> The

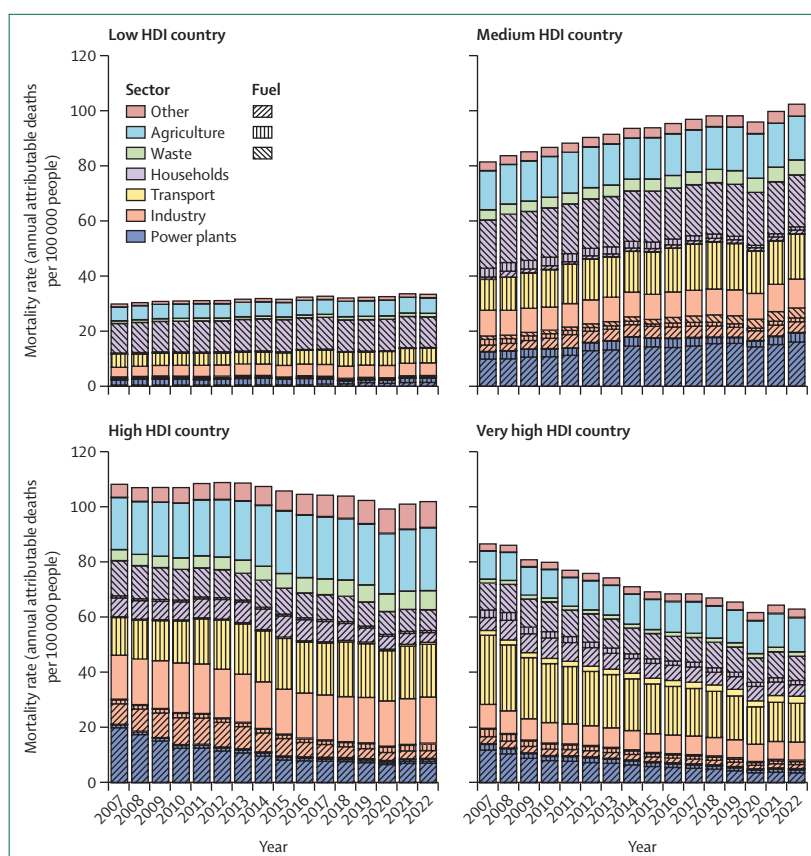
burning of charcoal, coal, and unsustainably harvested biomass in households resulted in 0.94 Gt of CO<sub>2</sub>: 0.72 Gt of CO<sub>2</sub> emitted in rural areas and 0.22 Gt of CO<sub>2</sub> in urban areas. This accounts for approximately 2.3% of global energy-related CO<sub>2</sub> emissions,<sup>233</sup> which remains a substantial contribution.

### 3.3 Food, agriculture, and health co-benefits

Food systems account for up to a third of global greenhouse gas emissions, with the agricultural sector being a major contributor. Many of these emissions are related to unhealthy diets, leading to high levels of morbidity and mortality. This group of indicators monitors greenhouse gas emissions from the agricultural sector, and the potential health gains from a transition to low-emission diets.

**Indicator 3.3.1: emissions from agricultural production and consumption—headline finding:** global agricultural greenhouse gas emissions increased by 36% from 2000 to 2022, with red meat and dairy responsible for 55% of agricultural emissions in 2022

Agricultural emission sources include fertilisers, manure, rice paddies, enteric fermentation in ruminants, and



**Figure 7: Annual mortality rates attributable to anthropogenic PM<sub>2.5</sub> exposure from 2007 to 2022 by fuel, sector, and HDI level**

PM<sub>2.5</sub>=fine particulate matter. HDI=Human Development Index



peatland drainage. Using observed data and statistical models, this indicator shows that, although the global average agricultural emissions per person remained stable at approximately 0.9 tonnes CO<sub>2</sub> equivalent (tCO<sub>2</sub>e) from 2000 to 2022, total emissions reached an all-time high in 2022, up by 36% from 2000 and 2% from 2021, with red meat and dairy responsible for 55% of these emissions. Improvements in agricultural efficiency were undermined by faster increases in red meat consumption.

Agricultural emissions per person in very high HDI countries increased by 8% between 2000 and 2022, reaching 1.2 tCO<sub>2</sub>e per person, which is 74% higher than in low HDI countries. Of these, 55% comes from red meat and dairy consumption. High HDI countries follow next, with 1.0 tCO<sub>2</sub>e emissions per person and 40% coming from red meat. Emissions per person are similar in low (0.8 tCO<sub>2</sub>e per person; 68% associated with red meat consumption) and medium (0.7 tCO<sub>2</sub>e per person; 52% associated with red meat consumption) HDI countries. In low HDI countries (notably sub-Saharan Africa), red meat-related emissions are mainly driven by inefficient agricultural practices and natural constraints that lead to low productivity and high emission intensity of animal rearing, rather than high consumption.

As food systems become increasingly strained by environmental changes (indicator 1.4), dietary shifts

towards less polluting, more resource-efficient foods and food production systems will be needed.<sup>234</sup>

**Indicator 3.3.2: diet and health co-benefits—headline finding:** between 2021 and 2022, deaths related to unhealthy diets increased from 148 deaths per 100 000 people to 150 deaths per 100 000 people, reaching 11.8 million deaths, including 1.9 million deaths from excessive red meat and dairy intake. Diets that are high in animal-source foods are not only a major driver of greenhouse gas emissions (indicator 3.3.1), but they also impact health.<sup>235,236</sup> Red and processed meats are risk factors for non-communicable diseases, and excessive intake of animal-source foods also contributes to weight-related morbidity and mortality.<sup>237,238</sup>

This indicator is based on a comparative risk assessment of diet and weight-related diseases using risk–disease relationships from meta-analyses of epidemiological cohort studies, updated data on food intake, bodyweight, and population numbers, and projections of cause-specific mortality.<sup>239,240</sup>

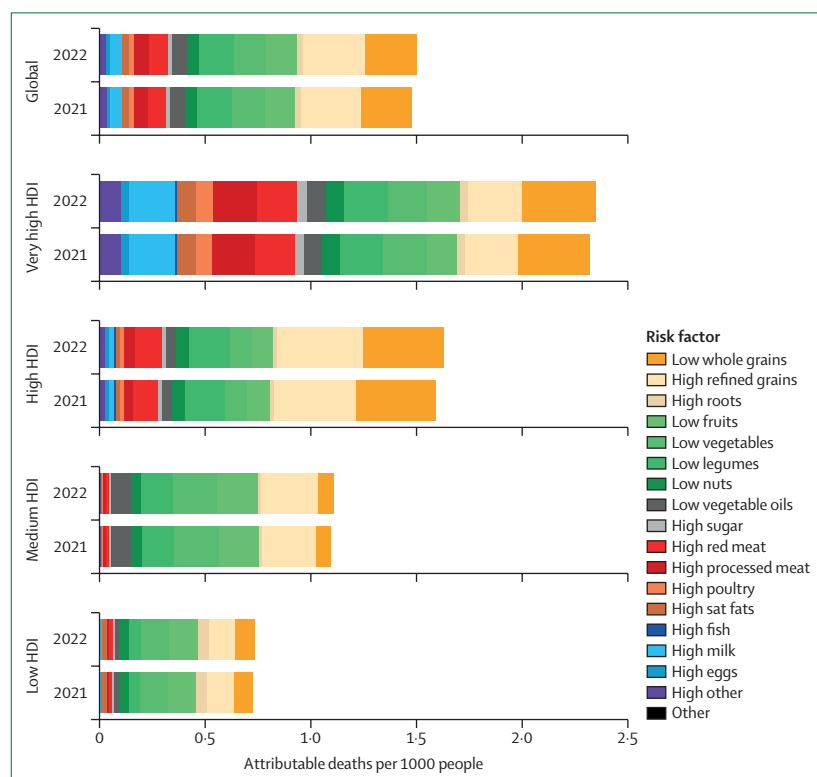
Between 2021 and 2022, diet-related deaths increased from 148 deaths per 100 000 people to 150 deaths per 100 000 people (an increase of 265 000 deaths), leading to 11.8 million attributable deaths. This change included an increase from 23 deaths per 100 000 people to 25 deaths per 100 000 people that were attributable to red meat and dairy intake (8.7% increase), reaching 1.9 million deaths.

The largest proportional increases in total attributable deaths came from high meat intake (an increase of 85 000 deaths per 100 000 people; 6%), followed by excessive intake of refined grains (increase of 115 000 deaths per 100 000 people; 5%). The relative increases in diet-related disease burden were greatest in high HDI countries (increase of 4 deaths per 100 000 people; 2.5%), followed by low HDI countries (increase of 1 death per 100 000 people; 1.5%), very high HDI countries (increase of 3 deaths per 100 000 people; 1%), and medium HDI countries (increase of 1 death per 100 000 people; 1%; figure 8).

The health impacts of imbalanced diets have increased further between 2021 and 2022, with particularly large increases from excessive intake of meat and refined grains. Greater efforts, including dedicated food policies, will be needed to help citizens adopt diets that are healthier and more climate friendly.<sup>236,241,242</sup>

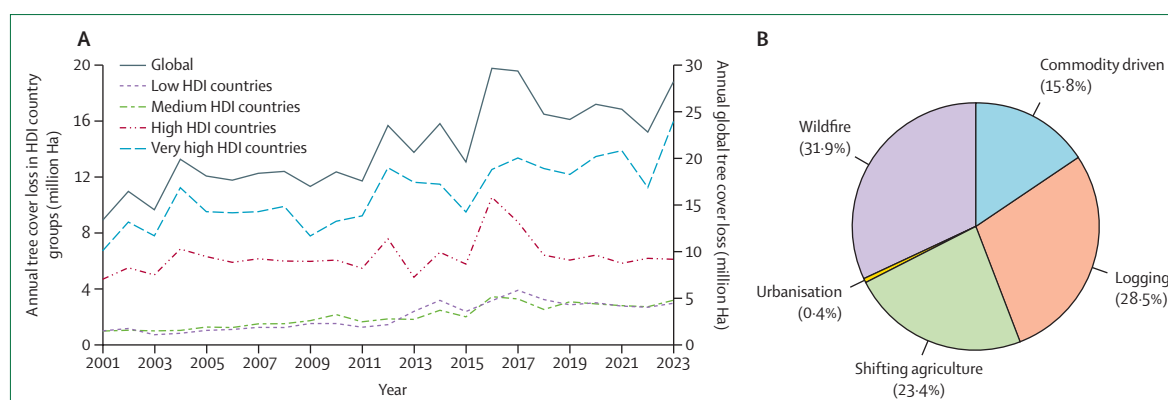
### 3.4 Tree cover loss

**Headline finding:** in 2023, global tree cover loss increased to over 28 million hectares (increase of 24%, from 23 million in 2022), with unprecedented wildfire-driven losses in Canada. Trees and forests are carbon sinks and biodiversity reservoirs, providing essential ecosystem services that protect public health.<sup>243</sup> Tree cover loss, particularly in urban areas, increases heat exposure and reduces air quality, while deforestation can increase the risk of zoonotic infections.<sup>244,245</sup>



**Figure 8: Deaths attributable to imbalanced diets by HDI group, year, and risk factor**

Risk factors include direct risks from imbalanced dietary composition, as well as indirect factors from imbalanced energy intake of food groups. HDI=Human Development Index. High sat fat=high saturated fat.



**Figure 9: Global tree cover loss globally and by HDI group from 2001 to 2023 (A) and by global drivers in 2023 (B)**  
(A) Annual loss of tree cover in different HDI groups (left axis; linear graph) and globally (right axis; area graph). (B) Global drivers of tree cover loss in 2023. HDI=Human Development Index.

Between 2001 and 2023, the cumulative annual tree cover lost reached 487 million hectares, of which 28 million were lost in 2023 alone—the third highest level recorded since 2001. Of the losses in 2023, 31.9% were due to wildfires, 28.5% to logging, and 23.4% to shifting agriculture. Very high HDI countries had the highest-recorded level of tree cover loss in 2023, reaching approximately 16 million hectares—an increase from 11 million in 2022. Annual tree cover loss remained relatively unchanged between 2022 and 2023 in medium and low HDI countries (around 3 million hectares in each group), as well as in high HDI countries (around 6 million hectares; figure 9).

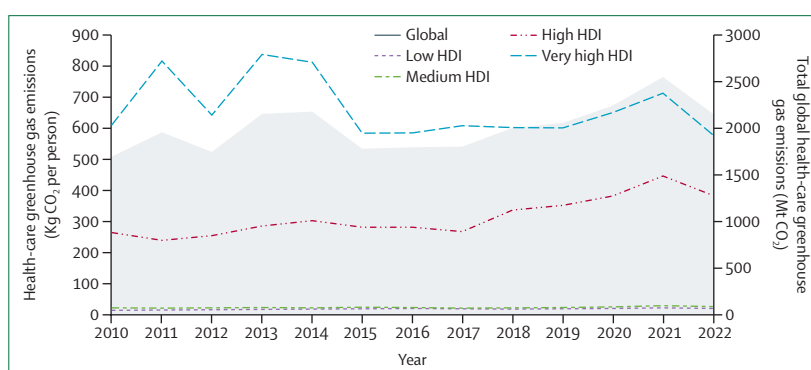
Many countries had substantial increases in tree cover loss between 2022 and 2023 following years of relatively stable levels, including Nicaragua (140.0% increase), Australia (60.3% increase), Indonesia (57.6% increase), and Laos (38.5% increase). Canada had the biggest absolute increase, losing 8.57 million hectares (an increase of 272%, representing 30.3% of global losses), mostly due to wildfires (accounting for 76.4% of its tree cover loss in 2022). The health implications of these losses are profound, particularly for Indigenous communities whose lands contain 36% of intact global forests.<sup>246</sup>

Encouragingly, following an increase of tree cover loss of 10.6% between 2021 and 2022 in Brazil, this trend has now been reversed by the new Government, in a move towards the protection of the world's largest carbon sink. Tree cover loss in Brazil fell by 15% between 2022 and 2023, and other reports suggest that the loss of primary forest fell by 36% in the same period.<sup>247,248</sup>

### 3.5 Health-care sector emissions and harms

**Headline finding:** following spikes in emissions related to the COVID-19 pandemic, health care-associated greenhouse gas emissions fell by 16% between 2021 and 2022, to 4.2% of global emissions

The health-care sector, which accounts for approximately a tenth of global GDP,<sup>249</sup> contributes to polluting



**Figure 10: Annual greenhouse gas emissions from the health-care sector from 2010 to 2022, globally and by HDI group**  
Left axis indicates greenhouse gas emissions per person by HDI group (lines). Right axis indicates global greenhouse gas emissions (grey area). HDI=Human Development Index. Mt=megatonne.

emissions through its activities. This indicator quantifies health-care sector emissions of greenhouse gases, ozone, and PM<sub>2.5</sub> using a top-down, spend-based method using the environmentally extended multiregion input-output model, EXIOBASE, and health expenditure data, alongside epidemiological models of air pollution-related health damages. For the first time, this indicator also estimates emissions using the scopes of the Greenhouse Gas Protocol: scope 1 (direct on-site emissions), scope 2 (purchased energy), and scope 3 (value chain).<sup>250</sup>

Health care contributed 4.2% (2.15 Gt CO<sub>2</sub>e) of global greenhouse gas emissions in 2022, falling for the first time since 2016 (16% reduction from 2021), although remaining 20% higher than in 2016 (figure 10). Associated PM<sub>2.5</sub> and ozone pollution also fell back to 2020 levels, accounting for approximately 4 million disability-adjusted life-years lost. Of all health-care greenhouse gas emissions, scope 1 and scope 2 contributed to 8.5% of emissions each, with scope 3 making up the remaining 83% of emissions. The reduction in emissions in 2022 was led by post-COVID decreases in health expenditure and by falling carbon intensities of electricity, especially in China

and the USA, which together contributed 63% of global health-care emissions and 30% of the decrease. Low and medium HDI countries, where expansion of health services is a priority, contributed just 4% of total health-care emissions. To achieve decarbonisation and health-care quality goals, health systems must tackle their emissions while improving health-care access and quality. By prioritising improvements in energy efficiency, reducing inappropriate care, and selecting goods with fewer emissions, immediate benefits to care quality with fewer emissions can be realised.

### Conclusion

This section highlights both the persistent challenges and emerging opportunities at the intersection of climate change mitigation and public health. The continued growth in global energy-related emissions driven by fossil fuel use, the increase in coal use for electricity in many countries, the widespread reliance on highly polluting fuels for household energy (particularly in low HDI countries), and the slow progress in decarbonising road transport increasingly threaten people's health. Similarly, the burden of diet-related diseases linked to high meat and refined grain intake is rising, as is global tree cover loss, with detrimental implications for biodiversity and human health.

Yet, the opportunities for protecting health and addressing climate change are evident in the continuous decrease in the share and carbon intensity of fossil fuels in the total energy supply, and the increasing global uptake of modern renewable energy. Progress in reducing the use of harmful solid biomass in households and the global decrease in deaths attributable to fossil fuel PM<sub>2.5</sub> are encouraging. The potential for progressing mitigation while also improving health outcomes through cleaner cooking solutions, shifts towards healthier diets, and increasing health-care appropriateness highlight the crucial need for accelerated and equitable transitions across all sectors to safeguard public health while achieving climate goals.

### Section 4: Economics and finance

Climate change continues to pose profound risks to the global economy, with escalating impacts on health, wellbeing, and social stability. Physical damages and sectoral disruptions, particularly in agriculture and tourism, are driving direct economic losses, while health-related impacts reduce labour productivity and increase health-care costs.<sup>251,252</sup> Extreme weather is rendering more assets uninsurable (panel 4), and as climate volatility intensifies, financial institutions and governments face the mounting costs of inaction, often without adequate policy frameworks or investment strategies for long-term resilience.<sup>255,256</sup> Without accelerated mitigation and adaptation action, climate change could erode 19% of the global income by 2050, with a likely range of 11% to 29%, depending on the

severity of physical impacts and economic vulnerabilities.<sup>3</sup> Left unaddressed, these pressures risk deepening poverty and inequality, especially in countries facing structural vulnerabilities.

COP29 provided an opportunity to advance international climate finance. Although some procedural progress was made on the New Collective Quantified Goal, the agreed \$300 billion annually fell far short of the demands of countries classified as developing under the UNFCCC.<sup>257</sup> A loose commitment to mobilise \$1·3 trillion annually lacks guarantees for concessional or grant-based funding, while accountability mechanisms remain undefined. Similarly, although the Loss and Damage Fund launched at COP28 attracted new pledges at COP29, disbursement mechanisms and donor commitments remain opaque.<sup>258,259</sup> Little progress has been made in delivering the \$1 billion pledged at COP28 for climate and health.<sup>260</sup> The situation has worsened through 2025, with the global climate finance landscape showing signs of fragmentation and retreat, as international commitments weaken in the face of rising anti-climate populism and nationalism.<sup>261,262</sup>

This section tracks indicators across three areas that are crucial to the economic transition towards a healthier, low-carbon future: the economic costs of climate-related health impacts; progress in restructuring economies for health and sustainability; and the alignment—or misalignment—of financial systems with these objectives. A new indicator on adaptation finance also monitors the growing shortfalls in funding.

#### 4.1 The economic impact of climate change and its mitigation

As climate change-related health impacts grow, so do the associated economic losses. The following indicators monitor the economic losses associated with delayed climate change action, which further undermine the socioeconomic conditions foundational to good health.

*Indicator 4.1.1: economic losses due to weather-related extreme events—headline finding: in 2024, weather-related extreme events caused \$304 billion in global economic losses, a 58·9% increase from the 2010–14 annual average*

As extreme weather events become more frequent and intense in the changing climate, their health and economic impacts are also increasing. In 2024, the USA alone had 27 separate extreme weather events that each caused over \$1 billion in damages.<sup>263</sup> This indicator monitors economic losses from extreme weather events using data from Swiss Re.<sup>264</sup>

In 2024, weather-related extreme events caused \$304 billion in global economic losses, representing 0·27% of global GDP, and of which 55·7% were uninsured. Losses in 2024 were 58·9% higher than the 2010–14 annual average. From 2010–14 to 2020–24, average annual economic losses from extreme weather increased by 38% in real terms, to \$264 billion, and the

#### Panel 4: Uninsurable futures? Climate change, health risks, and failing safety nets

The financial mechanisms underpinning disaster recovery—principally insurance—are facing escalating pressure as climate change intensifies the frequency and severity of extreme weather events.

The growing scale and unpredictability of extreme weather have driven record-breaking insured losses. In 2023, global insured losses from natural catastrophes totalled US\$108 billion, marking the fourth consecutive year surpassing the \$100 billion threshold.<sup>253</sup> Total economic losses reached \$280 billion, indicating that approximately 60% of global exposures were uninsured—costs that must be absorbed by individuals, businesses, and governments. The protection gap is even wider in low and medium Human Development Index countries: in Africa, for example, only about 7% of disaster losses are insured, compared with over 57% in North America.<sup>253</sup>

This gap extends beyond property loss. Public health systems are increasingly absorbing the costs of uninsured climate damages. From heat waves and floods to disease outbreaks, health-care infrastructure faces mounting pressure, yet insurance coverage remains minimal. Although data are limited, disasters such as Hurricane Maria in Puerto Rico and Cyclone Idai in Mozambique show how uninsured health-care costs (including emergency care, hospital damage, and mental health services) are often absorbed by strained public systems, or go unaddressed altogether. This strain further undermines health-care capacity, compromising health and leaving systems even more vulnerable to future climate impacts. The resulting self-reinforcing feedback loop ultimately risks generating irreparable damage to health-care systems.

Although increasing insurance coverage is crucial to enable systems to recover from climate shocks, the growing impacts of climate change further erode the insurance model, which depends on accurate risk estimates. In the USA, the uncertainty and stress on insurance is already manifesting in substantial

premium increases, with average rates rising by 33% between 2020 and 2023, and even more in areas at high risk: flood insurance premiums have increased by some 500% in high-risk coastal regions, while premiums more than doubled in wildfire-exposed zones in California over the past decade.<sup>254</sup> These increases reflect an industry-wide shift towards the recalibration of risk models—moving from historical loss patterns to forward-looking climate projections—prompting insurance withdrawal from increasingly risky markets. As these dynamics unfold, growing shares of uninsurable assets (eg, properties in floodplains, wildfire zones, and coastal areas) pose systemic risks to the broader economy. When insurers deem these areas too risky, households, municipalities, and entire sectors are left dangerously exposed. The resulting economic repercussions compound social inequities and exacerbate health vulnerabilities. These shifts raise a critical question: can insurance remain a reliable safety net, or is it approaching a threshold of widespread uninsurability?

Urgent, integrated strategies are essential to preserve insurance as a pillar of climate resilience. Integrating insurance with social protection, early warning systems, resilient health infrastructure, and anticipatory financing can close crucial gaps. Public-private partnerships, regional risk pools, and index-based health insurance offer promising yet underused solutions. Not-for-profit and government-run insurance schemes that prioritise coverage over profit, particularly in high-risk and underserved regions, also represent important alternatives. Transparent data on insured and uninsured losses can pinpoint where gaps are widest and policy action is most urgent. Although increasingly constrained, the insurance industry remains vital to climate resilience, but it must be complemented by systemic reforms and innovative solutions to remain viable in a rapidly warming world.

percentage of global losses that were uninsured fell from 67·0% to 54·2%. Although 52·1% of losses in very high HDI countries were insured in 2024, only 2·9% of losses in low HDI countries, 0·9% of losses in medium HDI countries, and 7·2% of losses in high HDI countries were insured. Hence, much work is still needed to close the insurance protection gap, and to prevent the inequitable distribution of the economic burden of climate change onto lower HDI countries.

*Indicator 4.1.2: costs of heat-related mortality—headline finding: the average annual monetised costs of global heat-related mortality for those older than 65 years for 2020–24 were \$261 billion, an increase of 208% from 2000–04*

In 2024, record-breaking high temperatures resulted in record-breaking heat-related mortality and associated economic losses globally. This indicator calculates the monetised value of age-structured heat-related deaths by

combining years of life lost with the value of a statistical life-year. The global economic value of heat-related deaths of people older than 65 years rose to \$344 billion in 2024—the highest level since 2000, and 306% higher than the 2000–04 annual average. Average annual costs during 2020–24 were \$261 billion, 208% higher than in 2000–04. Low HDI countries saw greater growth from 2000–04 to 2020–24 than the global average at 235%, with growth of 224% in medium HDI countries, 270% in high HDI countries, and 160% in very high HDI countries.

*Indicator 4.1.3: loss of earnings from heat-related labour capacity reduction—headline finding: labour capacity reduction due to heat exposure led to \$1·09 trillion in global potential income losses in 2024, 39% of which occurred in the agricultural sector*

Heat exposure can make work less productive or more dangerous (indicator 1.1.3). Associated reductions in



labour capacity result in income losses. In turn, loss of livelihoods can undermine the socioeconomic determinants of physical and mental health. This indicator uses the International Labour Organization's wage data to quantify the potential loss of earnings resulting from potential heat-related labour capacity loss estimates from indicator 1.1.3.<sup>265</sup>

In 2024, heat exposure resulted in a record-high global potential loss of income worth \$1.09 trillion, equivalent to 0.97% of global GDP—breaching \$1 trillion for the first time following a 17% growth from 2023. These losses were unequally distributed, reaching an average equivalent of 5.3% (up from 4.8% in 2023) of GDP in low HDI countries and 4.3% (up from 3.9% in 2023) of GDP in medium HDI countries, compared with 1.3% of GDP in high HDI countries and 0.7% of GDP in very high HDI countries. The agricultural sector was most affected, with 39% of all global losses, and an average of 74% of potential losses in low HDI countries and 64% of potential losses in medium HDI countries. The global construction sector saw 28% of all losses.

**Indicator 4.1.4: costs of the health impacts of air pollution—headline finding: in 2022, the monetised value of air pollution-related mortality was \$4.84 trillion, equivalent to 4.7% of global GDP**

This indicator estimates the monetised value of the years of lost life from exposure to anthropogenic PM<sub>2.5</sub> (as per indicator 3.2.1).

The value of these losses was \$4.84 trillion in 2022, equivalent to 4.7% of global GDP—down by 4.7% since 2021. Although absolute losses were highest in very high HDI countries (\$2.31 trillion), these fell by 33% since 2007, in line with more stringent air quality control. However, absolute losses rose by 72% in low HDI countries, 121% in medium HDI countries, and 154% in high HDI countries since 2007. Relative to GDP, average losses in 2022 were highest in medium HDI countries (8.3% of GDP) and high HDI countries (7.3% of GDP), compared with 3.3% of GDP in very high HDI countries. Losses were

only 3.2% of GDP in low HDI countries in 2022, reflecting a lower level of industrialisation rather than a transition to clean technology, and that these estimates do not account for household air pollution-related deaths.

#### 4.2 The transition to net zero-carbon, health-supporting economies

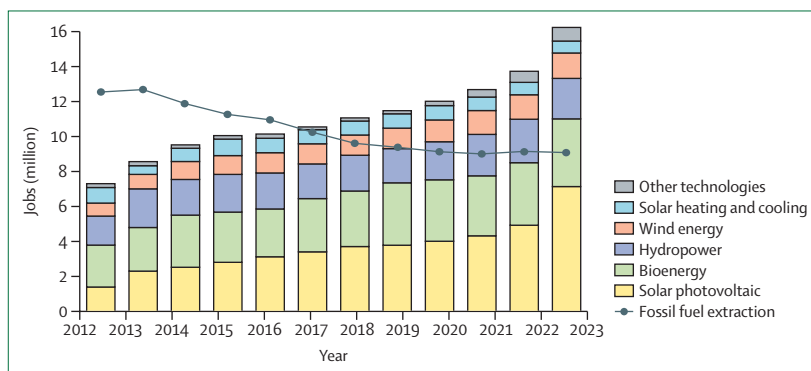
A rapid and safe transition away from a fossil fuel-dependent global economy is key to a healthy future. This transition can bring major health benefits. To do so, it must avoid unintended and unequitable consequences. This section monitors progress in enacting this economic transformation in employment, company strategies, stranding risks, exposure, resilience, and transboundary emissions, highlighting current inequities in the transition.

**Indicator 4.2.1: employment in low-carbon and high-carbon industries—headline finding: direct and indirect employment in renewable energy grew by 18.3% in 2023 to**

**16.2 million employees, while direct employment in fossil fuel extraction decreased by 0.7%, to 9.06 million employees**  
Employees in the fossil fuel sector often face greater health risks than in the renewable sector,<sup>266,267</sup> and the renewable energy sector can provide more local job opportunities per unit of investment.<sup>268</sup> This indicator uses data from the International Renewable Energy Agency and IBISWorld to compare direct and indirect employment in renewable energy with direct employment in fossil fuel extraction.

In 2023, 16.2 million people were directly or indirectly employed in the renewable energy industry: an unprecedented annual 18.3% rise since 2022 and a 60.4% increase since 2016, reaching 6.1 million jobs. Of the employees in 2023, 65% were in Asia (46% in China). The solar photovoltaic sector had the biggest increase in employment (45%) in 2023, reaching 7.1 million jobs. Direct employment in fossil fuel extraction decreased by 0.7%, to 9.06 million jobs, between 2022 and 2023: a drop of 17.1% (1.87 million jobs) since 2016 (figure 11).

**Indicator 4.2.2: compatibility of fossil fuel company strategies with the Paris Agreement—headline finding: as of March, 2025, the strategies of the 100 largest oil and gas companies put them on track to exceed their share of production consistent with 1.5°C of heating by 189% in 2040, up from 183% in March, 2024**  
The world is probably experiencing the early years of a decade with average temperatures exceeding pre-industrial levels by 1.5°C—the limit that countries committed to pursuing in the Paris Agreement. Fossil fuel burning has been the biggest driver of global temperature increase to date.<sup>215</sup> This indicator uses data from Rystad Energy to assess the extent to which the world's largest 100 oil and gas companies (responsible for 78% of projected production in 2040) are contributing to breaching this threshold.<sup>269</sup> Projections are based on current announced commercial activities and strategies, regardless of commitments and pledges.



**Figure 11: Annual direct and indirect employment in the renewable energy sector and direct employment in fossil fuel extraction from 2012 to 2023**

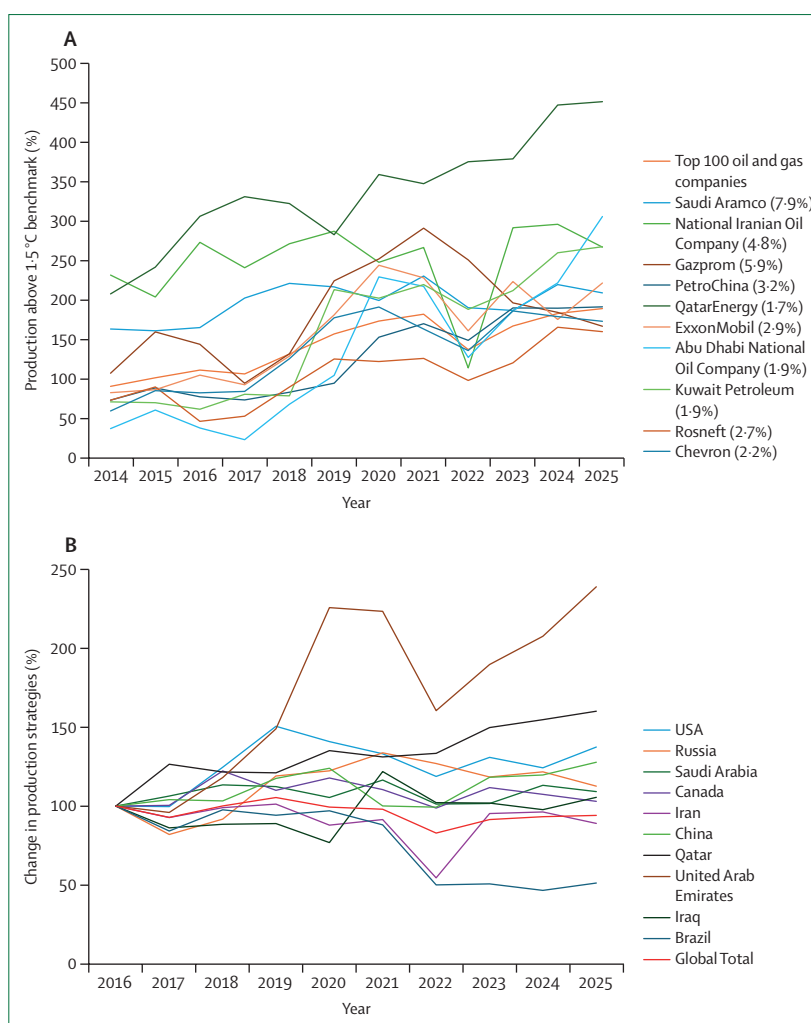
Direct employment are jobs within the specified industry (eg, building wind farms), whereas indirect employment are jobs in supporting industries (eg, equipment manufacturing).

Since the Paris Agreement came into force in November, 2016, the total production projected by 2040 from the top 100 oil and gas companies increased by 41·4%, with 85% of these companies increasing their planned production. As of March, 2025, these 100 companies were on track to exceed their share of production compatible with 1·5°C of heating by an average of 189% in 2040 (up from 183% in 2024; figure 12). Of these 100 companies, 81 are projected to more than double their share of 1·5°C-compatible production levels by 2040, and 27 will more than quadruple their share. Of the ten largest projected producers, eight are state-owned national oil and gas companies, which are together projected to account for 34·0% of global oil and gas production in 2040 (Saudi Aramco, National Iranian Oil Company, Gazprom, PetroChina, QatarEnergy, Abu Dhabi National Oil Company, Kuwait Petroleum, and Rosneft). The USA alone is projected to produce 22·7% of the world's total oil and gas by 2040, twice as much as any other country, and 10·6% more than was projected based on 2024 strategies—a reflection of its shift to policies that threaten the health and survival of people in the USA and worldwide.

**Indicator 4.2.3: stranded coal assets from the energy transition—headline finding: in line with persistent coal investments, the value of global coal-fired power sector assets that are projected to become stranded in 2030 grew from \$16 billion in 2023 to \$22·4 billion in 2024**

Continued investment in fossil fuels is incompatible with commitments set under the Paris Agreement,<sup>270,271</sup> hampering greenhouse gas mitigation, causing air pollution-related deaths, and worsening economic losses.<sup>272,273</sup> It also leads to economic losses, as fossil fuel units must cease operating before their economic lifespan ends to stay on track with Paris Agreement commitments and becoming what is known as stranded assets. Using Global Energy Monitor data, this indicator tracks the extent to which investments are changing the value of coal-fired power assets at risk of stranding, calculating the value of assets that are expected to be stranded in the year 2030 as a benchmark.

From 2023 to 2024, the persistent investment in coal assets that are incompatible with a safer future pushed the value of current coal-fired power assets that will be stranded in 2030 on a path to the 1·5°C goal to grow from \$16 billion to \$22·4 billion.<sup>274</sup> From 2023 to 2024, the share of stranded assets expected in 2030 declined by 3·4 percentage points in very high HDI countries, 9·6 percentage points in high HDI countries, and 0·2 percentage points in low HDI countries, while the share in medium HDI countries nearly doubled, rising from 14·4% to 27·7%. According to 2024 projections for assets at risk of stranding in 2030, 48·7% are in high HDI countries (largely in China), with 23·5% in very high HDI countries, 27·7% in medium HDI countries, and 0·1% in low HDI countries. The cumulative economic loss in the upcoming 10 years (2026–35) is expected to be \$222·4 billion, up from \$168·7 billion



**Figure 12: Compatibility of projected production of oil and gas by 2040 with the Paris Agreement's 1·5°C target per organisation and country**

(A) Projected global oil and gas production levels expressed as percentage of excess of levels compatible with the Paris Agreement's 1·5°C climate target in 2040 for the 100 largest oil and gas companies (red line), projected based on production strategies declared yearly from 2014 to 2025. The excess production of the ten largest oil and gas companies (by 2040 projected production) is also shown. Percentages in brackets in the legend represent average 2018–24 global market share. Higher values represent larger production. (B) Changes in projected production of oil and gas according to organisation's declared strategies, presented by country for the ten largest producing countries (as projected in 2025) and global total (red line). Note: some countries have more than one oil and gas company.

for 2025–34. These results underline the importance of refraining from opening further coal-fired power plants to protect the economy from growing stranded losses.

**Indicator 4.2.4: country preparedness for the transition to net zero—headline finding: from 2023 to 2024, the global average preparedness for the low-carbon transition decreased by 3·43%**

Transitioning towards a net-zero greenhouse gas economy is essential for safeguarding public health and ensuring long-term societal wellbeing. To prepare, countries need to reduce their over-reliance on fossil fuels, strengthen their institutions, build local capacities,

and establish governance structures that enable a just and equitable shift. This indicator assesses countries' transition preparedness through a composite indicator that incorporates 25 institutional, economic, societal, and technological factors, weighted to derive a final preparedness score ranging from 0 to 1.

Contrary to the urgent need to improve preparedness, the global average preparedness score fell from 0.520 in 2023 to 0.502 in 2024 (3.43% decrease). Although countries with higher HDI scores generally also had higher absolute preparedness scores, there were decreases in preparedness across all HDI groups. Countries with a high or very high HDI had the greatest decreases in preparedness scores: from 0.476 in 2023 to 0.447 in 2024 (6.17% decrease) for high HDI countries, and from 0.740 in 2023 to 0.718 in 2024 (2.98% decrease) for very high HDI countries. Medium HDI countries had a decrease in preparedness score from 0.322 in 2023 to 0.318 in 2024 (1.41% decrease), while low HDI countries had a decrease in score from 0.201 in 2023 to 0.198 in 2024 (1.89% decrease). These findings outline an alarming trend in global preparedness for the low-carbon transition and show the inequalities in preparedness among countries at different stages of development.

*Indicator 4.2.5: production-based and consumption-based attribution of CO<sub>2</sub> and PM<sub>2.5</sub> emissions—headline finding: from 2019 to 2023, very high HDI countries remained net importers of goods and services whose production caused net CO<sub>2</sub> and PM<sub>2.5</sub> emissions in lower HDI countries, accounting for 4.0% of CO<sub>2</sub> and 5.4% of PM<sub>2.5</sub> global emissions in 2023*

Countries can induce harmful emissions of greenhouse gases and air pollutants beyond their borders through their consumption of imported goods and services. To capture these transboundary environmental impacts, this indicator uses an environmentally extended, multiregional input-output model<sup>275,276</sup> to quantify countries' contribution to CO<sub>2</sub> and PM<sub>2.5</sub> emissions, examining production-based accounting (which attributes emissions to the country where they physically occur) and consumption-based accounting (which assigns emissions to the country where the final consumption of goods and services takes place).

Between 2019 and 2023, the overall differences between consumption-based and production-based emissions for CO<sub>2</sub> and PM<sub>2.5</sub> among different HDI country groups remained mostly unchanged. Very high HDI countries were the only group with more consumption-based than production-based emissions for both CO<sub>2</sub> and PM<sub>2.5</sub> (in 2023, consumption-based emissions: 46.9% for CO<sub>2</sub> and 25.2% for PM<sub>2.5</sub>; production-based emissions: 42.8% for CO<sub>2</sub> and 19.8% for PM<sub>2.5</sub>). This indicates that a substantial share of emissions originated from the consumption of goods and services in very high HDI countries—many of which were produced abroad, particularly in lower HDI countries. As a result, very high HDI countries generated a net balance of emissions

outsourced through international trade amounting to 4.0% of global CO<sub>2</sub> and 5.4% of global PM<sub>2.5</sub> emissions in 2023. Low HDI countries displayed a different pattern. Although they had slightly higher consumption-based than production-based CO<sub>2</sub> emissions (rising from 0.3% of global emissions in 2019 to 0.5% of global emissions in 2023), they exhibited lower consumption-based than production-based PM<sub>2.5</sub> emissions (increasing by more than double: from 0.9% of global emissions in 2019 to 2.0% of global emissions in 2023), potentially reflecting limited capacity to regulate air pollution in domestic production processes. These findings highlight the responsibility of those in very high HDI countries to address unsustainable consumption patterns, which often generate harm in those living in lower HDI countries, and the imperative for equitable and just decarbonisation of global supply chains.

#### 4.3 Financial transitions for a healthy future

The transition to a clean and healthy future demands a fundamental redirection of established financial flows. This section monitors progress in reallocating global finance to support sustainable economies through investments, subsidies, and bank lending, and introduces a new indicator to track how well health-related adaptation funding aligns with identified needs.

*Indicator 4.3.1: clean energy investment—headline finding: global clean energy investment grew by 8.7% in 2024 to \$2.03 trillion, exceeding fossil fuel investment by 69%*

Investing in clean energy is essential for mitigating climate change, and can also stimulate economic growth.<sup>277</sup> Using data from the IEA, this indicator tracks global investment in energy supply, energy efficiency, and electricity grids.<sup>278</sup>

Global clean energy investment reached \$2.03 trillion in 2024: an increase of 8.7% from 2023 and 69% higher than fossil fuel investment of \$1.20 trillion. Spending on the clean energy supply including renewables grew by 6.1% to \$858 billion, with solar the largest component at \$455 billion. Investment in electricity grids and storage grew by 12.5% to \$445 billion in 2024, while spending on energy efficiency and electrification increased by 9.5% to \$729 billion. However, global investment in renewables still needs to double and spending on efficiency and electrification to nearly triple to achieve the Renewables and Energy Efficiency 2030 Pledge agreed at COP28.<sup>279</sup>

Clean energy investment in Emerging Market and Developing Economies (EMDE) outside China accounted for only 17.5% of the global total, with investment in these countries becoming more difficult due to currency depreciation and higher interest rates. Africa received just 2% of global clean energy investment in 2024, despite having 20% of the world's population, and Africa's debt servicing costs are expected to reach over 85% of total energy investment in 2025. International public finance can fill this gap, but averaged only around

7% of EMDE's clean energy investment in 2022–24. The Baku to Belém Roadmap, agreed at COP29, aims to activate \$1.3 trillion per year for low emissions projects in developing economies by 2035,<sup>280</sup> and reducing the cost of capital must be a key part of this.

**Indicator 4.3.2: net value of fossil fuel subsidies and carbon prices—headline finding:** 83% of the 87 countries reviewed had a net-negative carbon price in 2023, generating a net fossil fuel subsidy of \$956 billion; of these, 15 countries allocated more funds to net fossil fuel subsidies than to health

Carbon prices promote the transition to cleaner and healthier fuels, while fossil fuel subsidies hinder this transition.<sup>281,282</sup> This indicator compares carbon price revenues and fossil fuel subsidies, and calculates net carbon prices and revenues across the 87 countries responsible for 93% of global CO<sub>2</sub> emissions.

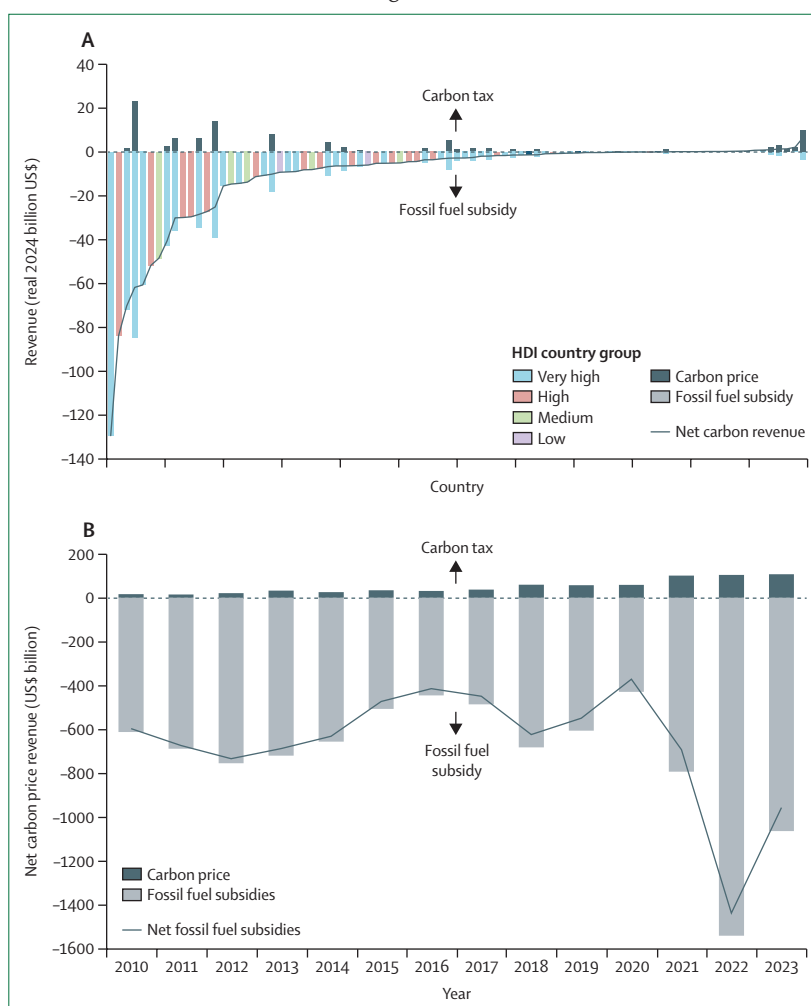
In 2023, countries issued \$1063 billion in fossil fuel subsidies, nearly ten times the \$107 billion raised from carbon price revenues, and generating a net fossil fuel subsidy of \$956 billion (figure 13). This is the second-highest annual net subsidy recorded, after only 2022, when the energy price spike that followed the invasion of Ukraine pushed fossil fuel-reliant countries to allocate \$1436 billion in net subsidies, and it still exceeds more than three times the \$300 billion committed in support of the most vulnerable countries within the New Collective Quantified Goal on Climate Finance.<sup>280</sup> In 2023, only 15 countries produced a net-positive carbon price (ie, net carbon tax): all but one of these countries were very high HDI countries (figure 13), while 72 (83%) of the 87 countries reviewed had a net-negative carbon price (ie, net fossil fuel subsidy). Six countries exceeded \$50 billion of net subsidies each (Russia, Iran, Japan, Germany, Saudi Arabia, and China). In 42 (48%) of 87 countries, the equivalent of over 10% of their health budgets was allocated to net fossil fuel subsidies, while 15 (17%) countries allocated more to net fossil fuel subsidies than to health. Five countries (Iran, Libya, Algeria, Venezuela, and Uzbekistan) spent more than double their health budgets on net fossil fuel subsidies.

Growing global geopolitical and economic instability threatens to drive further spikes in fossil fuel prices. Urgently decreasing reliance on fossil fuels is key to prevent these shocks from affecting countries' energy security, or forcing increased national spend on fossil fuel subsidies. Doing so would simultaneously free up resources in support of the clean energy transition, and for activities that reduce inequities and improve health and wellbeing.<sup>270,283</sup>

**Indicator 4.3.3: fossil fuel and green sector bank lending—headline finding:** private bank lending to the green sector increased by 13% from 2023 to 2024, reaching \$532 billion; meanwhile, fossil fuel lending surged by 29% to \$611 billion Redirecting finance from fossil fuels to green sectors is essential to realising climate and health goals. To achieve

the net-zero transition, estimates suggest that 70% of green energy investment would need to come from private sources, with debt-based instruments playing a growing role.<sup>284</sup> Using Bloomberg data, this indicator tracks private bank lending towards fossil fuels (including for exploration, production, operation, and marketing activities in oil and gas) and green investments (including for renewable energy, energy efficiency, green buildings and infrastructure, agriculture, and forestry, clean water, and waste management).

Green lending increased by 13% between 2023 and 2024, reaching a record-high \$532 billion. Several European banks (including Nordea, UBS, Deutsche Bank, BNP Paribas, and Barclays) have reduced fossil fuel lending since the Paris Agreement entered into force in 2016, some by over 50%, which in part reflects stronger regulatory pressure.<sup>285–287</sup> However, half of the top 40 fossil fuel lenders have increased lending since the Paris



**Figure 13: Fossil fuel subsidies, carbon prices, and net revenue**

(A) Revenue from fossil fuel subsidies and carbon prices, and net total revenue by country and HDI group in 2023. Each bar represents a different country, ordered from lowest to highest net carbon revenue. (B) Global total carbon price and fossil fuel subsidy revenue (bar chart) and net total revenue (line graph) from 2010 to 2023. HDI=Human Development Index.



Agreement entered into force. Fossil fuel lending reached a 5-year high of \$611 billion in 2024, up by 29% from 2023, and exceeding green lending by 15%. Between 2022 and 2024, banks lent \$1.6 trillion to fossil fuel activities—\$117 billion more than for green investments. The Net Zero Banking Alliance lost 22% of its asset coverage between December, 2024, and January, 2025, after several US banks exited over regulatory and fiduciary concerns.<sup>288</sup> Accelerating the transition to a healthier future will require policies steering lending away from fossil fuels and towards green investments.

*Indicator 4.3.4: health adaptation finance flows and disclosed needs—headline finding: between 2020 and 2022, the Green Climate Fund provided \$166 million for health adaptation, while the World Bank's financing for climate change and health adaptation reached \$1.12 billion in 2024, 221% more than in 2023*

Climate change funding for health is essential to support effective adaptation actions. However, the quantification of climate finance remains challenging. Although multilateral development banks and public development banks agreed on a Joint Roadmap for Climate-Health Finance and Action in 2024,<sup>32</sup> it will take some time until robust and coherent reporting for climate health adaptation finance is achieved.

Considering these limitations, this indicator tracks financial support for health adaptation in the world's most vulnerable countries, as provided by the Green Climate Fund<sup>289</sup> and the World Bank. This is complemented by tracking sovereign bilateral, private, and philanthropic bilateral flows of climate-related development funding reported to the Organization for Economic Cooperation and Development (OECD; covering adaptation projects that primarily pursue a climate health adaptation objective).<sup>290</sup> It also monitors the demand for climate and health adaptation finance by capturing the finance needs stated in countries' National Adaptation Plans (NAPs) and NDCs.<sup>290–292</sup>

Of the 64 UNFCCC-designated developing countries that submitted costed NAPs and NDCs as of March 21, 2025, only 28 (44%) included quantified estimates for health adaptation needs. Collectively, these countries reported health adaptation needs exceeding \$7 billion per year for the 2025–30 period. These figures reflect only the subset of measures for which cost estimates were explicitly provided, and probably underestimate the broader scope of health-related adaptation needs—especially given that many developing countries, including many Small Island Developing States, have yet to submit costed estimates.

Adaptation finance for health in UNFCCC-designated developing countries remains scarce, even if considering these under-reported financial needs: between 2021 and 2022, the Green Climate Fund provided \$166 million for health-focused adaptation (\$341 million including cross-cutting projects in which health was not the

primary objective). The World Bank has substantially scaled up its climate and health adaptation financing in 2024, reaching \$1.12 billion,<sup>293</sup> a 221% increase from \$348 million the year before.<sup>294</sup>

From 2020 to 2022, bilateral development commitments for principal climate health adaptation projects reported to the OECD totalled just \$84 million.

Limited disclosure of quantified health needs partially reflects persistent data and capacity gaps that impede effective adaptation planning. The Baku to Belém Roadmap for \$1.3 trillion offers an opportunity to close these gaps—both in measurement and in scaling finance under the New Collective Quantified Goal. Strengthening data systems and systematically integrating health into adaptation planning will be essential to protecting lives and building resilience in a warming world.<sup>295–297</sup>

## Conclusion

The escalating economic costs of climate change are becoming ever more visible, with profound implications for human health and societal stability. In 2024, weather-related extreme events caused over \$304 billion in losses, while declines in labour productivity drove losses exceeding \$1 trillion (indicators 4.1.1–4.1.3). The monetised cost of air pollution mortality reached \$4.85 trillion in 2023 (indicator 4.1.4), which is equivalent to more than the entire GDP of Germany (the world's third largest economy)<sup>298</sup> the same year, underscoring how environmental degradation translates directly into economic harm. These impacts fall disproportionately on low-income and middle-income countries, deepening existing global inequities.

Although clean energy investment surpassed fossil fuel spending by 69% in 2024 (indicator 4.3.1) and renewable energy employment exceeded employment in fossil fuel extraction by 79% in 2023 (indicator 4.2.1), structural financial barriers persist. In 2023, the wealthiest countries continued to outsource 4.0% of global CO<sub>2</sub> emissions to less wealthy nations through embodied emissions (indicator 4.2.5). Net fossil fuel subsidies remained close to \$1 trillion, and bank lending to fossil fuel projects rose sharply by nearly 30% in 2024 (indicators 4.3.2 and 4.3.3). This sustained financial support is enabling the expansionary strategies of fossil fuel companies, whose projected production is set to exceed 1.5°C-compatible levels by 189% by 2040 (indicator 4.2.2). Such financing undermines climate goals, perpetuates fossil fuel dependence, and increases the risk of stranded assets, already valued at \$22.4 billion in the coal sector alone for 2030 (indicator 4.2.3). Meanwhile, country-level preparedness for the low-carbon transition is deteriorating (indicator 4.2.4), compounding systemic vulnerabilities. Crucial financial mechanisms remain insufficient: health-related adaptation finance remained far below disclosed needs (indicator 4.3.4).

To reverse this trajectory, a decisive and coordinated realignment of financial flows is essential. Delivering on

emerging international commitments, such as the New Collective Quantified Goal on climate finance, and operationalising the Loss and Damage Fund with clear mechanisms for equitable disbursement, will be critical to bridging the growing gap between escalating climate impacts and financial support. A decisive redirection of capital towards health-promoting, climate-resilient investments, grounded in the principle of equity, is essential to safeguard global health and foster economic resilience and social stability.

## Section 5: Public and political engagement with health and climate change

The previous sections show that the threat climate change poses to people's health is reaching unprecedented levels, and these impacts are set to continue worsening given delays in meaningful action. They also highlight that the adaptation and mitigation policies needed to address climate change could simultaneously deliver major benefits for people's health.<sup>299</sup> This requires key societal actors at all levels of governance—including governments, corporations, civil society, and the wider public—to engage with health and climate change and put health at the forefront of climate change actions.<sup>121,300,301</sup>

This section tracks engagement with health and climate change by actors in the public and political domain on whom the transition to a net zero and healthy future depends. It tracks engagement by the media, scientists, the public, governments, international organisations, and corporations. It also sheds light on the growing role of climate change litigation in driving action on health and climate change (panel 5).

### 5.1 Media engagement

*Headline finding: in 2024, 24.8% of climate change articles mentioned health, up from 23.5% in 2023; however, average coverage of health and climate change across sources fell by 15%, from 204 articles per news source to 173 articles per news source*

The news media is a crucial source of information about climate change, shaping public engagement and the political agenda.<sup>315,316</sup> This indicator tracks coverage of health and climate change in articles published in 59 newspapers from 35 countries, using keyword searches of newspaper databases, covering five languages and all WHO regions.

Average newspaper coverage of health and climate fell by 15% between 2023 and 2024, from 204 articles per news source to 173 articles per news source. This is connected to a trend of decreasing media engagement with climate change since the peak in 2021, with the average number of articles per news source falling from 1068 articles in 2021 to 699 articles in 2024 (35%). However, the proportion of climate change articles that reference health increased slightly between 2023 and 2024, from 23% (204 of 869 articles per news source) in 2023 to 25% (173 of 699 articles per

news source) in 2024. This is still below the peak of 26% (180 of 695 articles per news source) in 2020. Additionally, more articles explicitly referenced fossil fuels between 2023 and 2024 (from an average of 63 articles per news source to 112 articles per news source), suggesting that newspapers are increasingly connecting the health impacts of climate change to the burning of fossil fuels.

### 5.2 Individual engagement

*Headline finding: individuals' proactive engagement with health and climate change is increasing, with the average global Google search index increasing from 49.4 in 2023 to 59.9 in 2024, with the world's most affected countries dominating the trend*

There is growing evidence that health framings of climate change can increase people's support for climate policies and pro-environmental behaviour.<sup>317–319</sup> This can be a crucial driver for individual-led and community-led action, especially amid waning engagement from political leaders (panel 6). Hence, greater public engagement with health and climate change has the potential to strengthen climate change action.<sup>334,335</sup>

The first part of this indicator tracks people's interest in climate change and health by tracking visits to climate change and health articles on English-language Wikipedia, which receives around 50% of global Wikipedia visits.<sup>336</sup> Visits to dedicated content on the effects of climate change on health on English-language Wikipedia declined in 2024, although there was no change in wider engagement with climate change content. Interest in the links between health and climate change, measured by clicks from a health article to a climate change one, also fell in 2024 by 20%.

The second part of this indicator (new to this year's report) tracks online proactive individual engagement with health and climate change by analysing health and climate change searches on Google, the most visited website in the world.<sup>337</sup> Google searches tend to reflect broader but less in-depth engagement with health and climate change than Wikipedia visits.<sup>338</sup> This indicator performs health and climate change keyword searches in Google Trends data to track the monthly normalised Google search rate of "climate change health" globally between January, 2014, and December, 2024, in English, Spanish, and French.<sup>339</sup> Data are presented as a search index, where 100 represents the maximum number of searches for the given term in the time series.

There has been growing engagement with climate change and health using the Google search engine since 2020, with the average global search index increasing from 49.4 in 2023 to 59.9 in 2024 (figure 14). The lowest rates of engagement occur in very high HDI countries (average search rate of 2.2) compared with high HDI countries (search rate of 7.8), medium HDI countries (search rate of 13.6), and low HDI countries (search rate of 6.0). Engagement in high HDI countries is led by several Small Island Developing States

### Panel 5: Litigation as an emerging tool to advance action for a healthy future

Climate change is threatening the human right to a clean, healthy, and sustainable environment, adopted by the UN General Assembly in 2022.<sup>302</sup> It is also threatening the human right to health; children's rights to life, survival, and development, and their right to health and health services.<sup>303,304</sup> With mitigation and adaptation measures failing to adequately respond to this threat, people and organisations increasingly turn to the courts to push for greater climate change action.<sup>305</sup> As the UN Environment Programme states, "litigation is central to efforts to compel governments and corporate actors to undertake more ambitious mitigation and adaptation goals".<sup>306</sup> In recent years, climate litigation has been brought to national, regional, and international courts and tribunals by different groups, including citizens, civil society organisations, and even governments of countries most impacted by climate change.

The health impacts of climate change are increasingly becoming the focus of climate litigation, particularly litigation that challenges governments for failing to address climate risks.<sup>305</sup> This can be seen in the landmark case brought against Switzerland by a group of older Swiss women, known as the *KlimaSeniorinnen Schweiz*, for failing to meet greenhouse gas emissions reduction targets.<sup>307</sup> In April, 2024, the European Court of Human Rights ruled that Switzerland had violated the human rights of these women by failing to adequately address climate change. Evidence on the health impacts of climate change—including evidence provided by the *Lancet Countdown*—was crucial to this outcome, as the court's decision was based on the specific heat-related harms to older women.<sup>308</sup>

The health impacts of climate change have featured in other high-profile cases. In the case brought against the Dutch Government by the Urgenda Foundation in 2015, the Dutch Supreme Court upheld the Government's duty to reduce greenhouse gas emissions, citing the risks that climate change poses to public health.<sup>309</sup> Similarly, the successful legal challenge launched by a group of young people against the German Government due to the country's insufficient targets for reducing greenhouse gas emissions focused on evidence regarding the different health impacts of climate change, which

they argued violated their right to life and physical integrity as set out in the German constitution.<sup>310</sup> Public health evidence is also part of ongoing international tribunals, such as the request for advisory opinion submitted to the International Court of Justice on defining state obligations and the repercussions of climate-related harm, which includes written contributions from WHO.<sup>305,308</sup>

Recent climate litigation has focused on a wide range of health impacts of climate change, such as heat stress, respiratory ailments, the spread of infectious disease, extreme weather events, and food and water security, among others.<sup>311,312</sup> Climate litigation has also begun to consider the mental health impacts of climate change.<sup>305</sup> This can be seen in the recent South African *Cancel Coal* case in which a youth-led group challenged the South African Government's plans to add more coal-fired power stations to the national grid.<sup>313</sup> The claimants used evidence about the impacts of climate change on both their mental and physical health, with the High Court ruling in their favour at the end of 2024.<sup>305</sup>

The growing focus on health outcomes in climate litigation has been used, in particular, to make the case that governments' failure to address climate change is a violation of people's human rights, with evidence on health impacts helping to show the effects of climate change on specific human rights, such as the right to life, to private and family life, to health, and to culture.<sup>308,311</sup> This has highlighted the need to better understand how public health evidence can be used to establish the links between climate change and specific human rights; in which legal settings such evidence can be used; and the types of evidence required to make legal claims, particularly with the challenge of attribution.<sup>311,312,314</sup> The rise of climate sceptical political parties in many high-emitting countries means that the courts will undoubtedly be a crucial arena for individuals and independent organisations to hold governments and corporations accountable and advance health-protecting climate change action. The scientific community has a key role to play in ensuring the generation of evidence tailored to support these critical efforts.

(eg, Marshall Islands with a search rate of 50, Fiji with a search rate of 39, and Tonga with a search rate of 37) that see disproportionate impacts of climate change on local health outcomes.

### 5.3 Scientific engagement

Peer-reviewed articles published in academic journals are the main source of scientific evidence for governments, international organisations, the media, civil society, and the public, playing a crucial role in driving climate change action.<sup>340,341</sup> The following indicators monitor engagement with health and climate change in the scientific literature.

*Indicator 5.3.1: scientific articles on health and climate change—headline finding: the number of scientific articles on health and climate change published in 2024 declined by 2.2% compared with 2023, but remained higher than for every other year*

This indicator uses a machine-learning approach to monitor peer-reviewed journal articles on health and climate change.<sup>342</sup> It classifies articles according to their coverage of health impacts, adaptation actions, and mitigation actions, identifying all topics covered (ie, the same article can be classified as covering impacts, adaptation, and mitigation), as well as identifying the main topic the article covers. Between 1990 and 2024, there was a rapid expansion in the scientific literature on

### Panel 6: Leading the transformation from the bottom up: community-led action for a healthier future

Delivering the necessary progress to promote health and survival in the face of climate change requires meaningful action from the system level to the individual level. When national government engagement wanes (indicator 5.4.1), action by subnational governments, corporations, civil society organisations, communities, and individuals can contribute to keeping the planet within inhabitable limits. Community-led actions are those spearheaded by self-organised individuals within a community, working together for a common goal.<sup>320</sup> Rooted in local societal, cultural, and economic contexts, they can promote equity, empower local actors, and strengthen climate resilience.<sup>296,297,321–323</sup> Tailored to local needs, community-led actions are more likely than top-down interventions to maximise health benefits, bypass the limitations of implementing top-down solutions,<sup>297,320</sup> and can help avoid unintended harms such as gentrification or increased inequalities.<sup>297</sup> Community-led actions can also foster agency, increase attachment to the local environment, and promote social interactions, all of which help reduce the mental health impacts of climate change and increase awareness.<sup>324,325</sup> These grassroots activities can grow into formal organisations with national or international influence.

Many laudable examples exist. In Poland, a small group concerned about air quality grew into a nationwide movement (Polish Smog Alert), contributing to saving some 10 000 lives annually through improved air quality. Through bans on coal burning, this simultaneously translated to reduced greenhouse gas emissions.<sup>326</sup> In Nepal, community forests user groups have grown into a state-sponsored and legally mandated initiative, under which local communities, including Indigenous Peoples, manage 37.7% of national forests—augmenting carbon sinks, enhancing food access, and improving livelihoods.<sup>327</sup> Across the Sahel, farmers have implemented Farmer Managed Natural Regeneration, a technique pioneered in the 1980s and now supported by multiple non-governmental organisations. These farmer-led interventions resulted in increased tree coverage, crop yields, drought resistance, and access to traditional medicines, contributing to improved health outcome and poverty reduction. In Niger alone, it resulted in 500 000 additional tonnes of cereal produced annually,

improving food security for 2.5 million people, and generating \$17–21 million in income in the Maradi region.<sup>328</sup>

Children and young people stand to lose the most from climate change. However, they can be effective actors for change, supporting a future that meets their needs and preferences, and ensuring lasting change. UNICEF has committed to supporting youth engagement in climate change action, while the UNESCO Youth Climate Action Network, launched at COP25, brings together over 105 500 young people from 184 countries, including 38 youth networks advancing climate change action.<sup>329</sup>

Despite their capacity to enact change, community-led initiatives depend on the willingness and possibilities of local actors.<sup>330</sup> Without adequate resources, they can be short-lived and of limited impact, or inadvertently exacerbate inequities if underserved community members are less able and not supported to engage.<sup>324,325,327</sup>

To ensure their equitable, lasting, and scalable impact, community-led projects need sustainable funding and logistical support. Partnerships with governments can help, but they can sometimes compromise independence.<sup>331</sup> Independent funders and non-governmental organisations can be key to ensuring the longevity, independence, and impact of community-led efforts.

Concerningly, grassroots movements can be targets for threats, persecution, or attacks in breach of the Aarhus Convention, particularly when engaging in protests or civil disobedience. In 2024, the UN Special Rapporteur on Environmental Defenders under the Aarhus Convention reported a concerning increase in the “repression and criminalization of environmental defenders engaged in peaceful protest and civil disobedience”.<sup>332</sup> Beyond deterring communities from engagement in environmental activism, these attacks pose a grave danger to those who do.<sup>332</sup> A Global Witness report found that 196 activists were killed in 2023 (57% in Latin America),<sup>333</sup> with minoritised and Indigenous groups disproportionately affected.

Protecting environmental defenders in line with international conventions is critical to enabling community-led interventions, and providing a fertile ground for grassroots initiatives to deliver life-saving progress on health and climate change.

health and climate change, with 56 996 articles published (figure 15). In 2024, 5789 articles on health and climate change were published, a 2.2% decrease from 2023 (5914 articles). Of the articles published across 1990–2024, 45 839 (80.4%) articles covered the health impacts of climate change, with adaptation (n=9304; 16.3%) and mitigation (n=3293; 5.8%) receiving less attention. However, articles covering adaptation increased to 1184 (20.5%) of all 5789 health and climate change publications in 2024.

Of the 56 996 articles published between 1990 and 2024, 36 538 (64.1%) reference at least one geographical

location in their title or abstract, and 21 337 (37.4%) mention more than one location. Of the articles with location attribution, most cover very high HDI countries (n=20 455; 56.0%) or high HDI countries (n=11 508; 31.5%), with only 6478 (17.7%) covering medium HDI countries and 3463 (9.5%) covering low HDI countries. This global inequality in scientific knowledge production is further reflected in the institutional affiliations of the authors. Of the 286 161 authorships, 216 050 (75.5%) were matched to a specific country. Of all 56 996 articles, 30 096 (52.8%) had at least one author based in a very high HDI



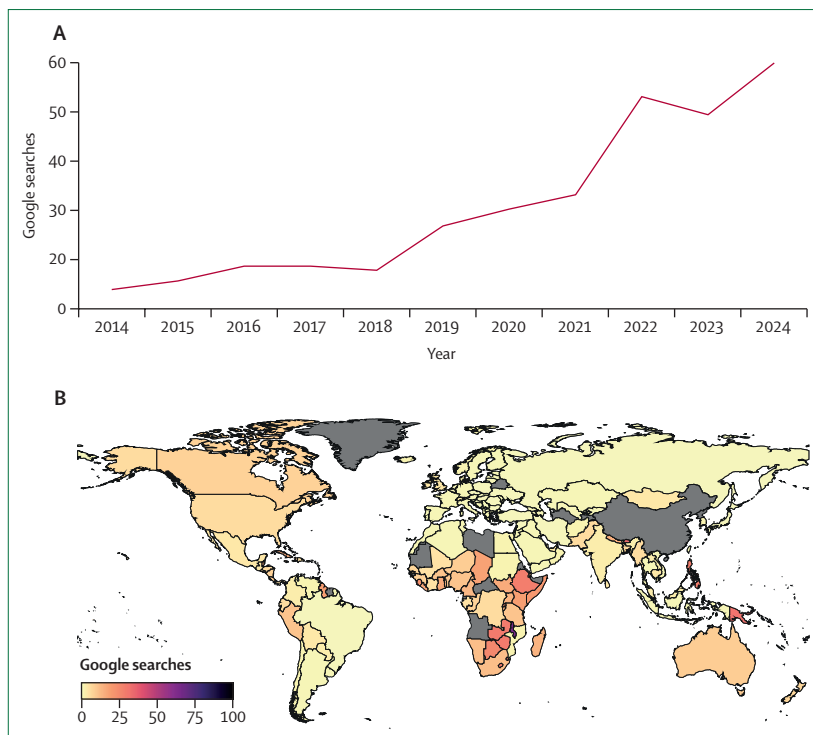


Figure 14: Normalised number of annual search rates of health and climate change from Google Trends in English, French, and Spanish

(A) Globally by year between 2014 and 2024. (B) By country in 2024.

country and 11 576 (20·3%) in a high HDI country, compared with 4667 (8·2%) in a medium HDI country and 2443 (4·3%) in a low HDI country.

**Indicator 5.3.2: scientific engagement on the health impacts of climate change—headline finding:** 62% (n=29 150) of the 46 803 scientific publications covering the health impacts of climate change since 1990 focus on events in which changes in climate variables can be attributed to human influence; however, the number of such studies fell by 12·7% between 2023 and 2024

This indicator tracks scientific publications on health impacts resulting from changes in precipitation or temperature in cases in which those changes in the studied location can be attributed to human influence on the climate using global climate models (ie, attributable studies).<sup>343</sup>

Of the 46 803 articles concerning the impacts of climatic changes on health published between 1990 and 2024, 29 150 (62·3%) mention at least one location with attributable trends, of which 26 158 (89·7%) specifically focus on climate drivers. However, the number of attributable studies published in 2024 (n=2482) declined by 12·7% from 2023 (n=2842). The proportion of attributable studies and the distribution of examined climate drivers have remained relatively constant over time, with changes in temperature (n=23 012), precipitation (n=11 915), and humidity (n=11 339) being

the most examined variables. Most evidence on health outcomes focuses on mortality and morbidity (n=18 990), infectious diseases (n=13 630), and cardiovascular diseases (n=11 475).

#### 5.4 Political engagement

Active engagement of governments and political leaders with the health dimensions of climate change is essential to tackle climate change and enable a healthy future.<sup>344,345</sup> The following indicators track political engagement of national leaders and key international organisations with health and climate change.

**Indicator 5.4.1: government engagement—headline finding:** government engagement with health and climate change continued to decrease in 2024, with only 30% of countries mentioning health and climate change in their UN General Debate statement, down from 62% in 2021

The General Debate of the UN General Assembly is a major global forum each year where national governments deliver an address highlighting the issues they consider most important for the international community.<sup>346,347</sup> This indicator monitors engagement of national governments with health and climate change by tracking references to health and climate change in their annual UN General Debate statements.

Following the 2021 peak, when a record 120 (62%) of 194 countries discussed health and climate change in their UN General Debate statements, engagement declined for 3 consecutive years. In 2024, only 57 (30%) of 192 countries referenced the health–climate change relationship. The drop in engagement occurred across all regions, although engagement remains highest among the countries least responsible but most affected by climate change—particularly African nations and Small Island Development States, which represented 18 (32%) of the 57 governments discussing health and 17 (30%) of the governments discussing climate change. Their statements included calls for more financial support for adaptation measures in the most vulnerable countries.

The second part of this indicator tracks engagement with health in the NDCs: instruments under the Paris Agreement in which countries are mandated to document increasingly ambitious contributions towards international climate commitments every 5 years. Countries are due to update their NDCs in 2025.<sup>348–350</sup> As of Sept 30, 2025, 68 parties had submitted preliminary or updated NDCs throughout 2024 and 2025, of which 21 (31%) were very high HDI, 19 (28%) were high HDI, 18 (26%) were medium HDI, and only 7 (10%) were low HDI countries (three countries have no HDI classification). Of all the submitted NDCs, 57 (84%) referenced health. Very high HDI countries were the least likely to reference health, with only 67% (14 of 21) of their NDCs doing so. In contrast, 100% (19 of 19) of NDCs from high HDI countries, 89% (16 of 18) of NDCs from medium HDI countries, and 86% (6 of 7) of NDCs

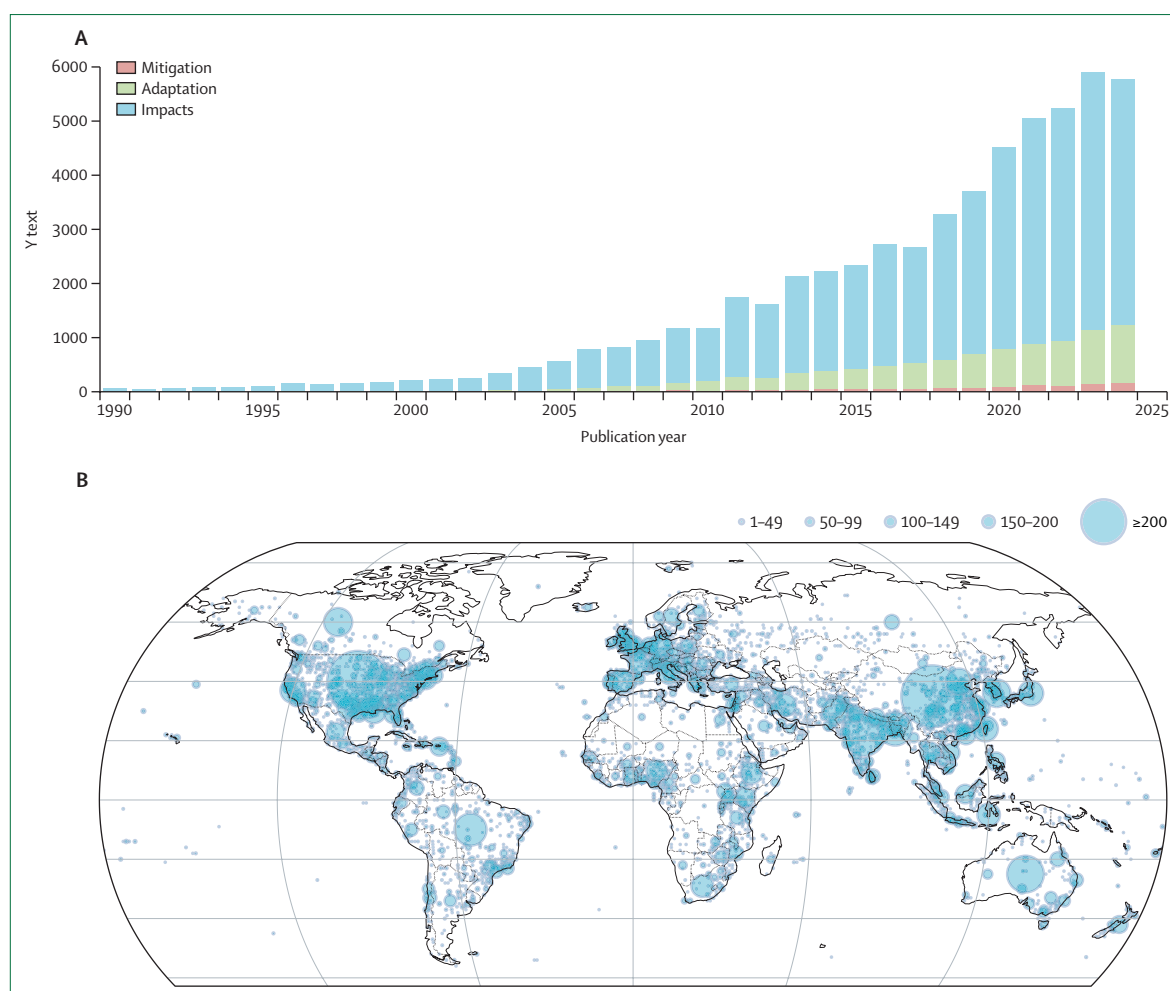


Figure 15: Number of scientific articles on health and climate change by year and topic between 1990 and 2024 (A), and by location in 2024 (B)

from low HDI countries referenced health. Additional NDCs are anticipated in the lead-up to COP30.

Although crucial to climate change action, many recently elected heads of state have cast doubt over the scientific consensus on the anthropogenic influence of climate change, and the existential dangers climate change represents—most notably in the USA, but also in countries such as Argentina and Hungary. Climate-sceptic political parties are also gaining force in Italy, France, Germany, and Brazil, among others. Protecting climate change action from populist responses will be critical to ensure progress towards a liveable future.

**Indicator 5.4.2: engagement by international organisations—headline finding: the proportion of X posts by international organisations referencing health co-benefits of climate mitigation continued to increase in 2024, reaching a record-high of 25% of X posts in November, 2024**

International organisations, including UN agencies, international financial institutions, and supranational bodies, play an increasingly important role in driving

climate change action and engagement with health and climate change.<sup>351–353</sup> This indicator monitors engagement with health co-benefits of climate mitigation from international organisation accounts on X (formerly Twitter), which remains a key platform for these organisations' public communication.<sup>354,355</sup>

This indicator tracks engagement with health co-benefits of mitigation using a dataset of English-language X posts made between 2010 and 2024 from 39 international organisations that have an operational focus on climate mitigation or adaptation across different sectors (eg, security, development, and humanitarian, trade, and finance). There was a slight increase in engagement with the health co-benefits of climate mitigation between 2023 and 2024 from 19.7% (10 069 of 51 113 posts) to 20.2% (8293 of 41 048 posts), with a record-high in engagement occurring in November, 2024, with 24.6% (911 of 3705) of posts referencing health co-benefits of mitigation. Engagement by international organisations has increased across the 15-year period.

### 5.5 Corporate sector engagement

*Headline finding: in 2024, only 51% of companies referred to the health dimensions of climate change in their UN Global Compact reports, down from 63% in 2023*

As major contributors to greenhouse gas emissions, corporations play a crucial role in the transition to a net-zero, healthy future.<sup>356</sup> The UN Global Compact encourages businesses to adopt environmentally and socially responsible policies, the implementation of which they report in annual Communication of Progress reports. Over 25 000 companies from 167 countries have signed up to the UN Global Compact, making it the largest global corporate sustainability initiative.<sup>357</sup> Despite criticism for enabling greenwashing, evidence suggests that companies' involvement in the UN Global Compact is associated with improved sustainability performance.<sup>358–360</sup> This indicator tracks corporate sector engagement with health and climate change through references to health and climate change in companies' Communication of Progress reports.

Although 2833 (63·1%) of 4487 companies referenced the health-climate change relationship in their 2023 Communication of Progress reports (the highest level of engagement since the UN Global Compact was established), this proportion dropped to 3984 (51·1%) of 7793 companies in 2024. This fall followed over a decade of increasing corporate sector engagement with health and climate change (between 2014 and 2024) and occurred in all regions and across all sectors.

With less pressure from key political figures, some of the world's biggest organisations have relaxed their climate commitments. Notwithstanding these findings, surveys suggest that most business executives still strongly endorse a rapid shift to renewable energy, and in Europe, most companies support science-aligned climate policies from countries.<sup>361,362</sup> This suggests that some companies might be responding to political narratives in their official reporting, while support for climate change action is strong.

### Conclusion

This section tracks engagement by key societal actors that are crucial for driving climate change action that protects people's health. As we noted in the 2024 *Lancet* Countdown report, engagement with health and climate change across these different actors has generally increased since 2016 when the Paris Agreement came into effect.<sup>121</sup> However, despite the rapidly escalating climate risks, there are concerning signs that engagement might have peaked across several indicators and is now declining. This can be seen with the media, governments, and the corporate sector, which all showed signs of backsliding in 2024. These trends provide growing evidence of a backlash to climate change action around the world, which can be seen with the election of populist far-right governments in several high greenhouse gas-emitting countries that propagate

climate scepticism and fuel opposition to mitigation policies.<sup>363–366</sup>

In addition to backsliding across these societal domains, the public and political indicators continue to point to substantial global inequities. Scientific evidence generation is still concentrated in higher HDI countries rather than those most exposed to the health impacts of climate change. Although engagement with health and climate change is led by those countries that are most at risk of the impacts of climate change, rather than those countries that are most responsible for greenhouse gas emissions. This dangerous combination of backsliding and inequality in public and political engagement with health and climate change risks further delaying the climate change action needed to protect the most vulnerable around the world from the increasingly evident health impacts of the climate crisis.

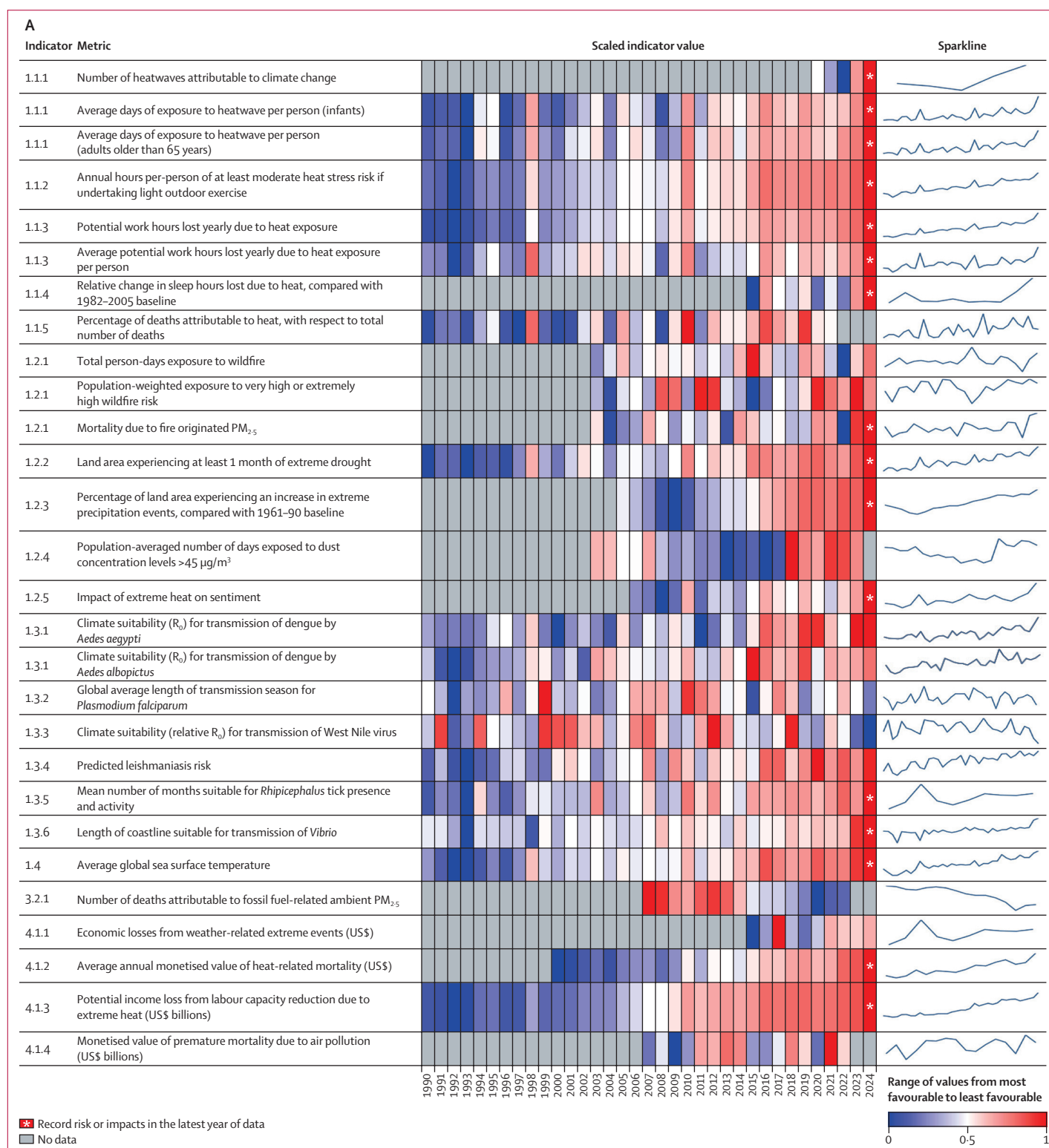
### Conclusion: the 2025 report of the *Lancet* Countdown

The 2025 report of the *Lancet* Countdown exposes a world in turmoil. Climate change threatens to human health and survival continue breaking concerning records, while delayed—and oftentimes reversed—actions exacerbate the threats on health and survival.

People worldwide are facing unprecedented climate change health risks. Of the 20 indicators monitoring climate change-related health risks, 12 (60%) reached unprecedented levels in the latest year of data (figure 16A).<sup>121</sup>

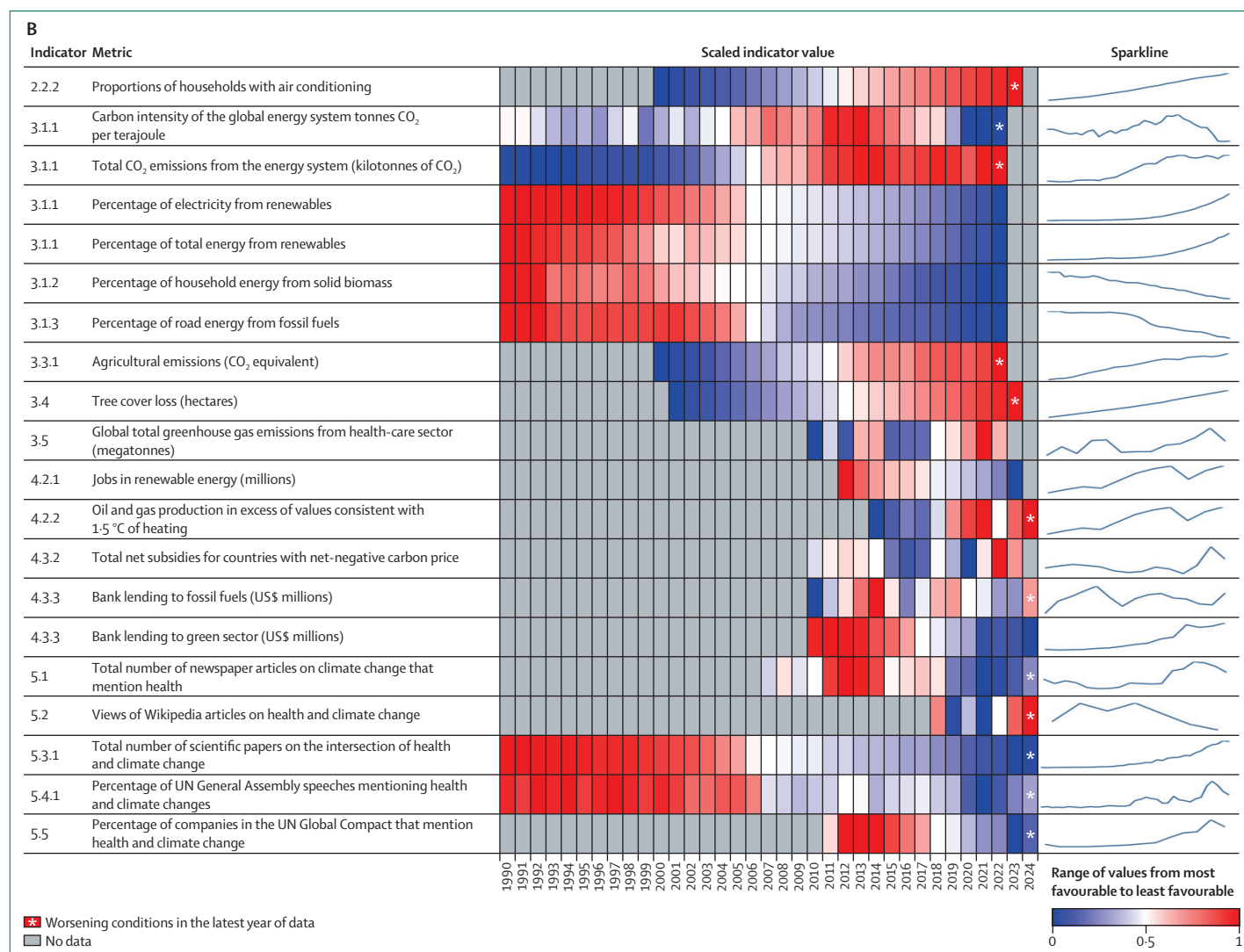
Heatwave exposure reached record-high levels in 2024, and high temperatures are increasingly affecting good health (indicators 1.1.1, 1.1.2, and 1.1.4). With increasing temperatures, heat-related deaths reached an estimated average 546 000 deaths annually in 2012–21, up by 63·2% from 1990–99 (indicator 1.1.5). In 2024, a record-breaking 60·7% of the global land area had extreme drought, and a record 64% had increases in extreme precipitation events between 1961–90 and 2015–24, putting water security, food security, and sanitation at risk (indicators 1.2.2, 1.2.3, and 1.4). Exposure to dangerous levels of airborne sand and dust PM<sub>2.5</sub> is growing, and wildfire-derived PM<sub>2.5</sub> caused a record-high 154 000 deaths in 2024 (indicators 1.2.1 and 1.2.4). Weather conditions are also increasingly suitable for the spread of deadly infectious diseases, and have driven record-high risks for vibriosis and tick-borne diseases (indicators 1.3.4 and 1.3.5).

The direct health impacts of climate change are compounded by socioeconomic impacts. Heat exposure alone caused a record-high \$1·09 trillion in potential income losses in 2024, while weather-related extreme events caused over \$304 billion in global losses. Insurance systems are increasingly strained, leaving more people unprotected from growing hazards (indicators 4.1.1 and 4.1.3; panel 4). These multiple health impacts often compound each other, strain health systems, and exacerbate the drivers of social instability and conflict (panel 3).



(Figure 16 continues on next page)





**Figure 16: Summary of the evolving links between health and climate change since 1990**

Summary of values of the indicators in the 2025 report of the *Lancet* Countdown for which quantitative data per year are available, presented as from 1990. The heatmaps present the time series for each indicator, with values linearly scaled into the range 0–1, such that 0 and 1 represent the minimum or maximum values in the time series shown, and 0.5 represents the median. The sparklines present a line graph with the indicator value in the y-axis. The scaling and colouring are principally for visualisation, meaning that changes can be overemphasised even if they are not statistically significant. Values do not reflect whether the level of progress made is adequate nor offer a comparison between the magnitude of different risks faced. For accurate interpretation, please refer to the data presented in the indicator text and the *Lancet* Countdown's data visualisation platform. (A) Indicators of health hazards, exposures, and impacts (section 1 and section 4.1); higher values (red tones) denote higher levels of health hazards, exposures, or impacts within the time series; lower values (blue tones) denote lower levels of health hazards, exposures, or impacts within the time series. Asterisks denote that the indicator reached a record-high health risk or impact in the most recent year of data. (B) Indicators reflecting responses to climate change (sections 2–5); indicator time series were scaled from 0 to 1, and, if necessary, inverted such that higher values in the heatmap (red tones) denote conditions within the time series that are less favourable towards efforts for tackling climate change and its health risks, and lower values (blue tones) denote conditions within the time series that are more favourable towards efforts for tackling climate change and its health risks. The asterisk sign indicates that actions have worsened, or resulting health risks have increased in the most recent year of data compared with the previous year. PM<sub>2.5</sub>=small particulate matter. R<sub>0</sub>=basic reproduction number.

Despite these growing threats, climate change action not only remains inadequate, but also, in many cases, progress is reversing: of the 20 indicators and subindicators for which time-series data on climate change and health actions are available, 12 moved in the wrong direction in the latest year of data, and six show reversal of previous progress (figure 16B).

Rather than falling, global energy-related emissions reached an all-time high in 2023, fuelling climate hazards

(indicator 3.1.1). Oil and gas companies keep expanding their production plans, and as of March, 2025, were on track to exceeding their 1.5°C-compatible production share by 189% by 2040—up from 183% 1 year before (indicator 4.2.2). Private banks are financing this expansion: their fossil fuel lending grew 29% between 2023 and 2024 (indicator 4.3.3). The persistent expansion of fossil fuels is not only increasing life-threatening climate risks, but also claimed 2.52 deaths

from fossil fuel-derived outdoor air pollution, and 2·3 million deaths from dirty fuel-derived household air pollution in 2022 alone (indicator 3.2).

Unhealthy food systems are also contributing to the growing harms. Agricultural emissions grew by 36% from 2000 to 2022, with 55% coming from red meat and dairy production, the overconsumption of which caused 1·9 million avoidable deaths in 2022 alone (indicators 3.3.1 and 3.3.2). Largely driven by agricultural expansion, forestry, and wildfires, tree cover loss increased by 24% from 2022 to 2023, limiting the world's capacity to mitigate climate change (indicator 3.4).

In the face of growing emissions and climate threats, adaptation finance is critically limited (indicator 4.3.4), and scarce capacity for climate change adaptation planning constrains the possibilities of effective health-protective interventions. As a result, people are increasingly at risk from climate hazards, and often resort to maladaptive solutions that further harm the environmental conditions on which health depends (indicators 2.2.2–2.2.4).

Growing greenhouse gas emissions are exacerbating the risks, deepening the adaptation gap, and amplifying the challenges and costs of adaptation—exposing how mitigation is an essential prerequisite for adaptation to be possible.

Robust and meaningful climate change and health policies were never so urgently needed. Yet, governmental prioritisation of health and climate change could be falling, with only 30% of governments referring to health and climate change in their 2024 UN General Debate statements, and media and private sector engagement with health and climate change dropping in 2024 (indicators 5.1, 5.4.1, and 5.5).

Urgent efforts are needed from the private sector, local authorities, civil society, and, importantly, individuals and communities to both deliver and demand accelerated action. These efforts can yield immediate health benefits from cleaner air, better diets, healthier cities, and improved socioeconomic conditions.

Some indicators show that this progress is possible. Although insufficient to displace fossil fuels, renewables, which are now cheaper and less vulnerable to geopolitical instability, reached 12·1% of all global electricity generation in 2022 (indicator 3.1.1), employing 18·3% more people in 2023 than the year before (indicator 4.2.1). Private bank lending to the green sector increased by 13% from 2023 to 2024, and clean energy investment grew by 8·7% (indicators 4.3.1 and 4.3.3). The health-care sector is also championing climate change action. Health-care greenhouse gas emissions fell by 16% in 2022 (indicator 3.5), and 64% of medical students globally received climate and health education in 2024 (indicator 2.2.5). Importantly, individuals' interest in health and climate change, which is essential for individual and community-led action, is growing (indicator 5.2; panel 6).

As a growing number of world leaders threaten to reverse the little progress to date, these incipient positive actions need to be reinforced and expanded for the world to continue to sustain healthy human lives. Panel 1 provides an overview of key priorities for different actors to drive the way to a healthier future. With climate change impacts growing, the health and lives of the world's 8 billion people are now at stake.

#### Contributors

Five working groups were responsible for the design, drafting, and review of their individual indicators and sections. All authors contributed to the overall paper structure and concepts and provided input and expertise to the relevant sections. The conceptualisation, coordination, strategic direction, and editorial support for the *Lancet Countdown 2025* were provided by AC, HM, PG, MRo, and MW. MA, JB, XB, GECC, OC, TJC, SD, CF, JG, SG, SHG, YH, RH, JH, OJ, RK, JKWL, BLe, YL, RL, SMa, CMa, JM-U, KMi, NCM, MM-L, AMo, KAM, NO, MO, FO, FP, AJP, MRa, ER, JRoc, MRo, JR-C, MRu, ASJP, JCS, PS, HS, JWS, MSO, MTa, FT, MTr, JAT, AU, MW, and QZ contributed to section 1. SA-K, DC-L, SD, JJH, IK, PK, DK, GM, CMc, KMo, YP-S, JCS, JS-G, MRS, CS, JDSt, and YZ contributed to section 2. CD, MD, ME, IH, S-CH, HK, GK, JMil, NM, DR-R, JDSh, MSp, JT, NV-O, and ShaZ contributed to section 3. SA, NA, DA, WC, KH, GK, BLi, ZL, AMa, ZM, PO, A-CP-G, DS, FW, RW, PY, CZ, and ShiZ contributed to section 4. HB, WC, ND, PGC, OG, SJ, DKP, PL, LM, JMin, SMu, OLP, TR, JRoa, and CT contributed to section 5. AA-M, PJB, GG-S, SH, VK, AL, TM, MM, JP, RNS, NW, and HW contributed to panels and provided overall feedback and editorial support.

#### Declaration of interests

PJB, AC, IH, JJH, S-CH, IK, KAM, YP-S, MRo, MW, and HW were compensated for their time while drafting and developing the *Lancet Countdown's* report via the *Lancet Countdown: tracking progress on health and climate change* Wellcome Trust grant (grant number 304972/Z/23/Z). MSO, RH, and RK acknowledge the funding of Research Council of Finland VFSP-WASE (grant number 359421), together with the EU Horizon projects FirEURisk (grant number 101003890) and ClimAir (grant 101156799). CD was supported by the European Commission via European Research Council (FLORA, grant number 101039402); and acknowledges funding by the National Research Institute for Agriculture, Food, and Environment in France via project PREF-Alim. JG and AJP were supported by the Bezos Earth Fund and the Schmidt Family Foundation via grant funding for attribution science. YH, YL, and QZ were supported by the National Aeronautics and Space Administration. KMi was compensated for his time by Columbia University, USA. DKP, MRo, and MSp were supported by the Horizon Europe CATALYSE project (CATALYSE grant number 101057131; HORIZON-HLTH-2021-ENVHLTH-02, with UK Research and Innovation reference number 10041512). MRo and JCS were supported by the Horizon Europe programme through the IDAlert project (101057554) and the UK Research and Innovation project (reference number 10056533). AU was supported by the Finnish Foreign Ministry via the IBA-ILMA project (grant number VN/13798/2023). GG-S acknowledges funding from the National Institute of Health and Care Research UK for the Global Health Research Group on Diet and Activity (NIHR133205 with sub-award contract number G109900-SJ1/171 with University of Cambridge). JJH acknowledges a grant from the Wellcome Trust, the National Institutes of Health via the Research and Engagement on Adaptation for Climate and Health project, the National Institute of Standards and Technologies, and the New Frontiers in Research Fund via the Urgently Accelerating Climate Mental Health Research & Equity through Global Networks project; and acknowledges honoraria from Columbia University, Harvard University, and Arizona State University. OJ acknowledges grants from the National Health and Medical Research Council (Heat and Health: building resilience to extreme heat in a warming world, GNT1147789) and the Wellcome Trust (Heat stress in ready-made garment factories in Bangladesh and the Heat inform pregnant study); has received support from the Global Heat and Health information Network to attend a management committee

meeting in Washington, DC, USA (February, 2023), from the Minderoo Foundation to attend a meeting in Boston, MA, USA (June, 2024), and from the SE Asia Global Heat and Health Information Network Hub to attend a meeting in Singapore (January, 2025); and holds a patent for the Environmental Measurement Unit. RNS acknowledges a contract with Massachusetts General Hospital and Mass General Brigham; acknowledges honoraria for presentations and work with the Mayo Clinic, Academy of Behavioral Medicine Research, University of Oregon, Cambridge College, Cleveland Clinic Foundation, University of North Carolina, Agency for Healthcare Research and Quality, Bezos Earth Fund, Association of American Medical Colleges, *New England Journal of Medicine*, and American College of Emergency Physicians; has received support for travel from the National Academy of Science, Engineering, and Medicine, the International Society of Behavioral Medicine, the University of Oregon, the Health Evolution, Fortune Brainstorm Health, the American Philosophical Society, the Bill and Melinda Gates Foundation, and Clinton Global Initiative; acknowledges participation and involvement in The National Academies Climate Crossroads Advisory Committee, The National Academy of Medicine Grand Challenge Steering Committee, and the Agency for Healthcare Research and Quality Study Section. NO acknowledges an in-kind contract with OpenAI via their researcher access programme. MSP acknowledges funding from the Wellcome Trust (Career Development Award number 225318/Z/22/Z), the European Commission's Horizon Europe Programme via the BrightSpace project (grant number 101060075) and the ACT4CAP project (grant number 101134874). JDS acknowledges funding from the Canadian Institutes for Health Research, the Commonwealth Fund, the European Commission against Racism and Intolerance, the Institute for Healthcare Improvement, and the Yale University Planetary Solutions Initiative; has received royalties from UpToDate; has received honoraria for lectures from the University of British Columbia Department of Surgery, the George Washington University Winston Health Policy Fellowship, the Columbia University Life Cycle Assessment Bootcamp, the Weil Cornell Department of Anesthesiology, the Healthcare Information and Management Systems Society, Project Echo, and the University of Southern California Department of Anesthesiology and Department of Population Health; has received honoraria from the Johns Hopkins School of Medicine and CASCADES; has received support for travel from WHO (Alliance for Transformative Action on Climate and Health), the American Hospital Pharmacists Association, the Galien Forum, the National Academy of Medicine, the European Society of Anaesthesiology and Intensive Care, the *British Journal of Anaesthesiology*, the World Federation of Societies of Anaesthesiologists, the American Society of Anaesthesiologists, the Johns Hopkins School of Nursing, the Society for Paediatric Anaesthesiology in New Zealand and Australia/Australian and New Zealand Association of Paediatric Surgeons, the Centre for Sustainable Health and Care, University of Toronto, the Endocrine Society, the American Thoracic Society, and the International Forum on Perioperative Safety and Quality; and is the chair of the committee on environmental health for the American Society of Anesthesiologists, and the chair of the sustainability committee for the World Federation of Societies of Anaesthesiologists. JDSt acknowledges a grant from the Health Effects Institute (no funds were used in connection with the writing of the report). CT received funding from the European Commission's Horizon Europe Programme (CATALYSE and EXPANSE projects) and from the Health Effects Institute; and has received payment for a lecture as part of the G7 satellite event related to climate change and health: Turning Goals into Actions: Research and Innovation for climate change mitigation; organised by the Municipality of Taranto. JT has received honoraria from the University of Oulu, Finland; and has received funding from the Research Council of Finland (T-Winning Spaces 2035 project), the UK Medical Research Council (PICNIC project), the Finnish Ministry of the Environment (SEASON project), and Business Finland (GIANT project). ME acknowledges fees received from AstraZeneca, Asc Academics, and the UK National Health Service for personal consulting; and has received support for travel from the US National Academy of Medicine. PJB, KAM, and RNS received support for travel from the Wellcome Trust via the *Lancet Countdown*: tracking progress on health and climate change grant (grant number 304972/Z/23/Z). AC received support from the Wellcome Trust

via 'The *Lancet Countdown*: Tracking Progress on Health and Climate Change' Wellcome Trust grant (grant number 304972/Z/23/Z) to attend the 2025 World Health Assembly; and has involvement as chair of the data safety monitoring board for the TARA trial in Delhi, India (ended in 2023). HM acknowledges his role as unpaid Charity Trustee and co-lead for sustainability of the UK Intensive Care Society. KAM acknowledges his role as board member of the Soulsby Foundation and his role as scientific committee member of the Regenerative Society Foundation. All other authors declare no competing interests.

#### Acknowledgments

We thank the Wellcome Trust for financial and strategic support, without which this research collaboration would not be possible. The *Lancet Countdown*'s work was supported by an unrestricted grant from the Wellcome Trust (grant number 304972/Z/23/Z). We also thank the following individuals for their invaluable technical advice and input: Jessica Beagley, Santiago Begueria, Lucia Bevere, Max Callahan, Laura Clarke, Tara Daniel, Elise Digga, Robert Dubrow, Marcellin Guilbert, Jerome Jean Haegeli, Muhammad Hasan, Jennifer Israelsson, Samuel Julier, Mingyu Li, Vesna Milanovic, Mahnoor Saeed, Clare Scully, Daniel Tong, Sergio Vicente, Camille Voirin, and Peng Xian.

Editorial note: The Lancet Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

#### References

- World Meteorological Organization. 2024 extreme events dashboard. <https://experience.arcgis.com/experience/5cb119c71c6c4f8a89b837bf5cf353b8> (accessed April 22, 2025).
- Kornhuber K, Bartusek S, Seager R, et al. Global emergence of regional heatwave hotspots outpaces climate model simulations. *Proc Natl Acad Sci USA* 2024; 121: e2411258121.
- Kotz M, Levermann A, Wenz L. The economic commitment of climate change. *Nature* 2024; 628: 551–57.
- Trust S, Saye L, Bettis O, et al. Planetary solvency—finding our balance with nature. Global risk management for human prosperity. January, 2025. <https://global-tipping-points.org/wp-content/uploads/2025/01/planetary-solvency-finding-our-balance-with-nature.pdf> (accessed March 3, 2025).
- World Meteorological Organization. Record carbon emissions highlight urgency of Global Greenhouse Gas Watch. Nov 19, 2024. <https://wmo.int/media/news/record-carbon-emissions-highlight-urgency-of-global-greenhouse-gas-watch> (accessed April 22, 2025).
- Elis J, Geiges A, Gonzales-Zuñiga S, et al. Climate action tracker: 2024 warming projection update. Nov 14, 2024. <https://climateanalytics.org/publications/cat-global-update-as-the-climate-crisis-worsens-the-warming-outlook-stagnates> (accessed April 22, 2025).
- Friedlingstein P, O'Sullivan M, Jones MW, et al. Global carbon budget 2024. *Earth Syst Sci Data* 2025; 17: 965–1039.
- Romanello M, Beggs PJ, Cai W, et al. From crisis to opportunity: a united response to Trump's attacks on climate action. *Lancet* 2025; 405: 1647–50.
- Zachariah M, Philip S, Pinto I, et al. Extreme heat in North America, Europe and China in July 2023 made much more likely by climate change. July 25, 2023 <https://spiral.imperial.ac.uk/handle/10044/1/105549> (accessed April 22, 2025).
- Clarke B, Barnes C, Sparks N, et al. Climate change key driver of catastrophic impacts of Hurricane Helene that devastated both coastal and inland communities. Oct 9, 2024. <https://www.worldweatherattribution.org/climate-change-key-driver-of-catastrophic-impacts-of-hurricane-helene-that-devastated-both-coastal-and-inland-communities/> (accessed April 22, 2025).
- Barnes C, Keeping T, Madakumbura G, et al. Climate change increased the likelihood of wildfire disaster in highly exposed Los Angeles area. Jan 28, 2025. <https://www.worldweatherattribution.org/climate-change-increased-the-likelihood-of-wildfire-disaster-in-highly-exposed-los-angeles-area/> (accessed April 22, 2025).
- Alberta Energy Regulator. Bulletin 2025-03. Jan 20, 2025. <https://www.aer.ca/about-aer/media-centre/bulletins/bulletin-2025-03> (accessed May 19, 2025).
- Abnett K. EU countries want red tape cut in energy laws, draft shows. Reuters, May 8, 2025. <https://www.reuters.com/sustainability/climate-energy/eu-countries-want-red-tape-cut-energy-laws-draft-shows-2025-05-08/> (accessed May 19, 2025).

- 14 Noor D. US energy industry's climate retreat is putting profits over people, advocates say. *The Guardian*, March 12, 2025. <https://www.theguardian.com/us-news/2025/mar/12/fossil-fuels-oil-gas-conference-ceraweeek> (accessed April 25, 2025).
- 15 Igin M. These companies are backtracking on climate in bow to conservatives. *Earth.org*, March 18, 2025. <https://earth.org/these-companies-are-backtracking-on-climate-in-bow-to-conservatives/> (accessed April 25, 2025).
- 16 Di Sario F. Orbán's think tank is on a mission to break Europe's climate 'consensus'. *Politico*, May 28, 2024. <https://www.politico.eu/article/brussels-hungary-think-tank-viktor-orban-breaking-europe-climate-consensus/> (accessed April 25, 2025).
- 17 Taylor M, Gayle D. Cop 29: Argentina's negotiators ordered to withdraw from climate summit; French minister cancels trip—as it happened. *The Guardian*, Nov 13, 2024. <https://www.theguardian.com/environment/live/2024/nov/13/cop-29-leaders-speak-after-report-finds-climate-pledges-not-kept-live-updates> (accessed April 25, 2025).
- 18 The White House. Withdrawing the United States from the World Health Organization. Jan 20, 2025. <https://www.whitehouse.gov/presidential-actions/2025/01/withdrawing-the-united-states-from-the-worldhealth-organization/> (accessed May 19, 2025).
- 19 Cozzi L, Gül T, Spencer T, Levi P. Clean energy is boosting economic growth. *International Energy Agency*. April 18, 2024. <https://www.iea.org/commentaries/clean-energy-is-boosting-economic-growth> (accessed May 16, 2025).
- 20 Department for Energy Security and Net Zero. UK first major economy to halve emissions. *Gov.uk*. Feb 6, 2024. <https://www.gov.uk/government/news/uk-first-major-economy-to-halve-emissions> (accessed May 19, 2025).
- 21 Gravener I. Growth and innovation in the UK's net zero economy. *Confederation of British Industry*. Feb 24, 2025. <https://www.cbi.org.uk/articles/growth-and-innovation-in-the-uk-s-net-zero-economy/> (accessed May 16, 2025).
- 22 Myllyvirta L, Qin Q, Qiu C. Analysis: clean energy contributed a record 10% of China's GDP in 2024. *Centre for Research on Energy and Clean Air*. Feb 19, 2025. <https://energyandcleanair.org/analysis-clean-energy-contributed-a-record-10-of-chinas-gdp-in-2024/> (accessed May 29, 2025).
- 23 Myllyvirta L. Analysis: clean energy just put China's CO<sub>2</sub> emissions into reverse for first time. May 15, 2025. <https://www.carbonbrief.org/analysis-clean-energy-just-put-chinas-co2-emissions-into-reverse-for-first-time/> (accessed May 29, 2025).
- 24 Zhang S, Jiang Y, Zhang S, Choma EF. Health benefits of vehicle electrification through air pollution in Shanghai, China. *Sci Total Environ* 2024; **914**: 169859.
- 25 Geng G, Liu Y, Liu Y, et al. Efficacy of China's clean air actions to tackle PM<sub>2.5</sub> pollution between 2013 and 2020. *Nat Geosci* 2024; **17**: 987–94.
- 26 WHO. Energizing health: accelerating electricity access in health-care facilities. *World Health Organization*, 2023.
- 27 Min B, O'Keeffe ZP, Abidoye B, et al. Lost in the dark: a survey of energy poverty from space. *Joule* 2024; **8**: 1982–98.
- 28 UN Development Programme. Solar for all. <https://www.undp.org/energy/solar-health> (accessed April 22, 2025).
- 29 WHO. Climate change and health: draft Global Action Plan on climate change and health. *World Health Organization*, 2025.
- 30 UN Framework Convention on Climate Change. Outcome of the first global stocktake. Dec 13, 2023. [https://unfccc.int/sites/default/files/resource/cma2023\\_L17\\_adv.pdf](https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf) (accessed April 21, 2025).
- 31 30th Conference of Parties. Belém Health Action Plan proposes climate response with a focus on justice and equity. July 31, 2025. <https://cop30.br/en/news-about-cop30/belem-health-action-plan-proposes-climate-response-with-a-focus-on-justice-and-equity> (accessed Aug 17, 2025).
- 32 Development Bank Working Group for Climate-Health Finance. Development Banks' joint roadmap for climate-health finance and action. 2024 <https://www.who.int/publications/i/item/9789240036727> (accessed Aug 13, 2025).
- 33 UN Framework Convention on Climate Change. Baku to Belém Roadmap to 1.3T. <https://unfccc.int/topics/climate-finance/workstreams/baku-to-belem-roadmap-to-1.3t> (accessed Aug 13, 2025).
- 34 Watts N, Adger WN, Agnolucci P, et al. Health and climate change: policy responses to protect public health. *Lancet* 2017; **386**: 1861–1914.
- 35 *Lancet Countdown*. *Lancet Countdown welcomes new independent board*. May 13, 2025. <https://lancetcountdown.org/news/lancet-countdown-welcomes-new-independent-board/> (accessed May 19, 2025).
- 36 *Lancet Countdown*. Our indicators. <https://lancetcountdown.org/our-indicators/> (accessed April 22, 2025).
- 37 *Lancet Countdown*. Contribute to our science. <https://lancetcountdown.org/contribute-our-science/> (accessed April 22, 2025).
- 38 *Lancet Countdown*. Explore our data. <https://lancetcountdown.org/explore-our-data/> (accessed April 22, 2025).
- 39 Zhang S, Bai Y, Zhao Q, et al. The 2024 China report of the *Lancet Countdown* on health and climate change: launching a new low-carbon, healthy journey. *Lancet Public Health* 2024; **9**: e1070–88.
- 40 Hartinger SM, Palmeiro-Silva YK, Llerena-Cayo C, et al. The 2023 Latin America report of the *Lancet Countdown* on health and climate change: the imperative for health-centred climate-resilient development. *Lancet Reg Health Am* 2024; **33**: 100746.
- 41 Gordon-Strachan GM, Parker SY, Harewood HC, et al. The 2024 Small Island Developing States report of the *Lancet Countdown* on health and climate change. *Lancet Glob Health* 2025; **13**: e146–66.
- 42 Beggs PJ, Woodward AJ, Trueck S, et al. The 2024 report of the *MJA–Lancet Countdown* on health and climate change: Australia emerging as a hotspot for litigation. *Med J Aust* 2025; **222**: 272–96.
- 43 van Daalen KR, Tonne C, Semenza JC, et al. The 2024 Europe report of the *Lancet Countdown* on health and climate change: unprecedented warming demands unprecedented action. *Lancet Public Health* 2024; **9**: e495–522.
- 44 Alliance for Transformative Action on Climate and Health. ATACH task teams. <https://www.atachcommunity.com/about-atach/atach-strategy/atach-task-teams/> (accessed April 22, 2025).
- 45 World Meteorological Organization. State of the global climate 2024. <https://library.wmo.int/records/item/69455-state-of-the-global-climate-2024> (accessed Jan 15, 2025).
- 46 Basagaña X, Ballester J. Unbiased temperature-related mortality estimates using weekly and monthly health data: a new method for environmental epidemiology and climate impact studies. *Lancet Planet Health* 2024; **8**: e766–77.
- 47 Kenney WL, Munce TA. Invited review: aging and human temperature regulation. *J Appl Physiol* 2003; **95**: 2598–603.
- 48 Ebi KL, Capon A, Berry P, et al. Hot weather and heat extremes: health risks. *Lancet* 2021; **398**: 698–708.
- 49 Chersich MF, Pham MD, Areal A, et al. Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis. *BMJ* 2020; **371**: M3811.
- 50 de Perez EC, van Aalst M, Bischiniotis K, et al. Global predictability of temperature extremes. *Environ Res Lett* 2018; **13**: 054017.
- 51 Hersbach H, Bell B, Berrisford P, et al. The ERA5 global reanalysis. *Q J R Meteorol Soc* 2020; **146**: 1999–2049.
- 52 WorldPop. Global high resolution population denominators project. *WorldPop*, 2018.
- 53 Klarenberg H, van der Velde JH, Peeters CF, et al. Leisure time physical activity is associated with improved diastolic heart function and is partly mediated by unsupervised quantified metabolic health. *BMJ Open Sport Exerc Med* 2024; **10**: e001778.
- 54 Skurvydas A, Istomina N, Dadelienė R, et al. Mood profile in men and women of all ages is improved by leisure-time physical activity rather than work-related physical activity. *BMC Public Health* 2024; **24**: 546.
- 55 Li Y, Tian C. Does active transport create a win-win situation for environmental and human health: the moderating effect of leisure and tourism activity. *Environ Sci Pollut Res Int* 2023; **31**: 4563–81.
- 56 Wagner AL, Keusch F, Yan T, Clarke PJ. The impact of weather on summer and winter exercise behaviors. *J Sport Health Sci* 2019; **8**: 39–45.
- 57 Vanos J, Guzman-Echavarria G, Baldwin JW, Bongers C, Ebi KL, Jay O. A physiological approach for assessing human survivability and liveability to heat in a changing climate. *Nat Comm* 2023; **14**: 1–14.
- 58 Tartarini F, Smallcombe JW, Lynch GP, Cross TJ, Broderick C, Jay O. A modified Sports Medicine Australia extreme heat policy and web tool. *J Sci Med Sport* 2025; **28**: 690–99.



- 59 Kjellstrom T, Freyberg C, Lemke B, Otto M, Briggs D. Estimating population heat exposure and impacts on working people in conjunction with climate change. *Int J Biometeorol* 2018; **62**: 291–306.
- 60 International Labour Organization. Working on a warmer planet: the impact of heat stress on labour productivity and decent work. International Labour Organization, 2019.
- 61 Flouris AD, Dinas PC, Ioannou LG, et al. Workers' health and productivity under occupational heat strain: a systematic review and meta-analysis. *Lancet Planet Health* 2018; **2**: e521–31.
- 62 Liljegren JC, Carhart RA, Lawday P, Tschopp S, Sharp R. Modeling the wet bulb globe temperature using standard meteorological measurements. *J Occup Environ Hyg* 2008; **5**: 645–55.
- 63 Cox DTC, Maclean IMD, Gardner AS, Gaston KJ. Global variation in diurnal asymmetry in temperature, cloud cover, specific humidity and precipitation and its association with leaf area index. *Glob Change Biol* 2020; **26**: 7099–111.
- 64 Donat MG, Alexander LV, Yang H, et al. Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: the HadEX2 dataset. *J Geophys Res D Atmospheres* 2013; **118**: 2098–118.
- 65 Intergovernmental Panel on Climate Change. Climate change 2021: the physical science basis. Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2021.
- 66 Wang C, Liu K, Wang H. The effects of temperature on sleep experience: evidence from China. *Appl Econ* 2023; **55**: 4678–94.
- 67 Ferguson T, Curtis R, Frayse F, et al. Weather associations with physical activity, sedentary behaviour and sleep patterns of Australian adults: a longitudinal study with implications for climate change. *Int J Behav Nutr Phys Act* 2023; **20**: 1–11.
- 68 Rifkin DI, Long MW, Perry MJ. Climate change and sleep: a systematic review of the literature and conceptual framework. *Sleep Med Rev* 2018; **42**: 3–9.
- 69 Chevanec G, Minor K, Vielma C, et al. A systematic review of ambient heat and sleep in a warming climate. *Sleep Med Rev* 2024; **75**: 101915.
- 70 Obradovich N, Migliorini R, Mednick SC, Fowler JH. Nighttime temperature and human sleep loss in a changing climate. *Sci Adv* 2017; **3**: e1601555.
- 71 Minor K, Bjerre-Nielsen A, Jonasdottir SS, Lehmann S, Obradovich N. Rising temperatures erode human sleep globally. *One Earth* 2022; **5**: 534–49.
- 72 Carias ME, Johnston DW, Knott R, Sweeney R. Temperature's toll on decision-making. *Econ J* 2024; **134**: 2746–71.
- 73 Mullins JT, White C. Temperature and mental health: evidence from the spectrum of mental health outcomes. *J Health Econ* 2019; **68**: 102240.
- 74 Obradovich N, Migliorini R. Sleep and the human impacts of climate change. *Sleep Med Rev* 2018; **42**: 1–2.
- 75 Goldstein AN, Walker MP. The role of sleep in emotional brain function. *Annu Rev Clin Psychol* 2014; **10**: 679–708.
- 76 Cappuccio FP, Cooper D, Delia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. *Eur Heart J* 2011; **32**: 1484–92.
- 77 Gasparrini A, Guo Y, Hashizume M, et al. Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *Lancet* 2015; **386**: 369–75.
- 78 Martínez-Solanas E, Quijal-Zamorano M, Achebak H, et al. Projections of temperature-attributable mortality in Europe: a time series analysis of 147 contiguous regions in 16 countries. *Lancet Planet Health* 2021; **5**: e446–54.
- 79 Ballester J, Robine JM, Herrmann FR, Rodó X. Long-term projections and acclimatization scenarios of temperature-related mortality in Europe. *Nat Commun* 2011; **2**: 1–8.
- 80 Gasparrini A, Guo Y, Sera F, et al. Projections of temperature-related excess mortality under climate change scenarios. *Lancet Planet Health* 2017; **1**: e360–67.
- 81 Quijal-Zamorano M, Martínez-Solanas E, Achebak H, et al. Seasonality reversal of temperature attributable mortality projections due to previously unobserved extreme heat in Europe. *Lancet Planet Health* 2021; **5**: e573–75.
- 82 Masselot P, Mistry MN, Rao S, et al. Estimating future heat-related and cold-related mortality under climate change, demographic and adaptation scenarios in 854 European cities. *Nat Med* 2025; **31**: 1294–302.
- 83 Gallo E, Quijal-Zamorano M, Méndez Turrubiates RF, et al. Heat-related mortality in Europe during 2023 and the role of adaptation in protecting health. *Nat Med* 2024; **30**: 3101–05.
- 84 Zhao Q, Guo Y, Ye T, et al. Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: a three-stage modelling study. *Lancet Planet Health* 2021; **5**: e415–25.
- 85 Tonnelier M, Delforge D, Below R, et al. What makes an epidemic a disaster: the future of epidemics within the EM-DAT International Disaster Database. *BMC Public Health* 2025; **25**: 3495.
- 86 World Meteorological Organization. 2024 extreme events dashboard. 2025. <https://experience.arcgis.com/experience/5cb119c71c6c4f8a89b837bf5cf353b8> (accessed Aug 8, 2025).
- 87 Otto F, Giguere J, Clarke B, et al. When risks become reality: extreme weather in 2024. Dec 27, 2024. <https://spiral.imperial.ac.uk/server/api/core/bitstreams/627ce5e5-26c4-4474-89f1-d3c0b6a472c9/content> (accessed March 20, 2025).
- 88 Heft-Neal S, Gould CF, Childs ML, et al. Emergency department visits respond nonlinearly to wildfire smoke. *Proc Natl Acad Sci USA* 2023; **120**: e2302409120.
- 89 Modaresi Rad A, Abatzoglou JT, Kreidler J, et al. Human and infrastructure exposure to large wildfires in the United States. *Nat Sustain* 2023; **6**: 1343–51.
- 90 To P, Eboime E, Agyapong VIO. The impact of wildfires on mental health: a scoping review. *Behav Sci* 2021; **11**: 126.
- 91 Burnett RT, Spadaro JV, Garcia GR, Pope CA. Designing health impact functions to assess marginal changes in outdoor fine particulate matter. *Environ Res* 2022; **204**: 112245.
- 92 WHO. WHO global air quality guidelines: particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization, 2021.
- 93 Zachariah M, Fioravanti G, Acosta Navarro JC, et al. Climate change key driver of extreme drought in water scarce Sicily and Sardinia. Sept 4, 2024. <https://spiral.imperial.ac.uk/server/api/core/bitstreams/0835e122-a174-4e8e-a918-b40045982079/content> (accessed April 22, 2025).
- 94 Otto F, Clarke B, Rahimi M, et al. Human-induced climate change compounded by socio-economic water stressors increased severity of drought in Syria, Iraq and Iran. Nov 7, 2023. <https://spiral.imperial.ac.uk/server/api/core/bitstreams/f7ef145a-3867-45a2-b756-307cbbfad70b/content> (accessed April 22, 2025).
- 95 Stanke C, Kerac M, Prudhomme C, Medlock J, Murray V. Health effects of drought: a systematic review of the evidence. *PLoS Curr* 2013; **5**: ecurrents.dis.7a2cee9e980f91ad7697b570bcc4b004.
- 96 Vins H, Bell J, Saha S, Hess JJ. The Mental health outcomes of drought: a systematic review and causal process diagram. *Int J Environ Res Public Health* 2015; **12**: 13251.
- 97 Salvador C, Nieto R, Vicente-Serrano SM, García-Herrera R, Gimeno L, Vicedo-Cabrera AM. Public health implications of drought in a climate change context: a critical review. *Annu Rev Public Health* 2023; **44**: 213–32.
- 98 National Integrated Drought Information System. Drought, navigation, & transport impacts. 2025. <https://www.drought.gov/sectors/navigation-and-transportation> (accessed April 27, 2025).
- 99 Beguería S, Vicente-Serrano SM, Reig F, Latorre B. Standardized precipitation evapotranspiration index (SPEI) revisited: parameter fitting, evapotranspiration models, tools, datasets and drought monitoring. *Int J Climatol* 2014; **34**: 3001–23.
- 100 Standardised Precipitation-Evapotranspiration Index. Global SPEI database. 2025. <https://spei.csic.es/database.html> (accessed March 27, 2025).
- 101 Knutson TR, Zeng F. Model assessment of observed precipitation trends over land regions: Detectable human influences and possible low bias in model trends. *J Clim* 2018; **31**: 4617–37.
- 102 Romanello M, Di Napoli C, Drummond P, et al. The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. *Lancet* 2022; **400**: 1619–54.
- 103 Zhao B, Zhang L, Gu X, Luo W, Yu Z, Yuan L. How is the occurrence of rainfall-triggered landslides related to extreme rainfall? *Geomorphology* 2025; **475**: 109666.
- 104 Lynch VD, Sullivan JA, Flores AB, et al. Large floods drive changes in cause-specific mortality in the United States. *Nat Med* 2025; **31**: 663–71.
- 105 He C, Zhu Y, Zhou L, et al. Flood exposure and pregnancy loss in 33 developing countries. *Nature Commun* 2024; **15**: 1–10.

- 106 Ebi KL, Vanos J, Baldwin JW, et al. Extreme weather and climate change: population health and health system implications. *Annu Rev Public Health* 2020; **42**: 293–315.
- 107 Zhang X, Zhao L, Tong DQ, Wu G, Dan M, Teng B. A systematic review of global desert dust and associated human health effects. *Atmosphere* 2016; **7**: 158.
- 108 Tobias A, Karanasiou A, Amato F, Roqué M, Querol X. Health effects of desert dust and sand storms: a systematic review and meta-analysis protocol. *BMJ Open* 2019; **9**: e029876.
- 109 Lewin KS, Tobias A, Chua PL, et al. Effects of desert dust and sandstorms on human health: a scoping review. *Geohealth* 2023; **7**: e2021RG000728.
- 110 Tong DQ, Gill TE, Sprigg WA, et al. Health and safety effects of airborne soil dust in the Americas and beyond. *Rev Geophys* 2023; **61**: e2021RG000763.
- 111 Nickovic S, Cvetkovic B, Petkovic S, et al. Cloud icing by mineral dust and impacts to aviation safety. *Sci Rep* 2021; **11**: 6411.
- 112 Tong D, Feng I, Gill TE, Schepanski K, Wang J. How many people were killed by windblown dust events in the United States? *Bull Am Meteorol Soc* 2023; **104**: e1067–84.
- 113 Intergovernmental Panel on Climate Change. Climate change 2022: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2022.
- 114 Connecting Climate Minds. The Global Research and Action Agenda for Climate Change and Mental Health. <https://hub.connectingclimateminds.org/research-and-action/global-agenda> (accessed May 6, 2025).
- 115 Baylis P, Obradovich N, Kryvasheyeu Y, et al. Weather impacts expressed sentiment. *PLoS One* 2018; **13**: e0195750.
- 116 Baylis P. Temperature and temperament: evidence from Twitter. *J Public Econ* 2020; **184**: 104161.
- 117 Obradovich N, Minor K. Identifying and preparing for the mental health burden of climate change. *JAMA Psychiatry* 2022; **79**: 285–86.
- 118 Obradovich N, Migliorini R, Paulus MP, Rahwan I. Empirical evidence of mental health risks posed by climate change. *Proc Natl Acad Sci USA* 2018; **115**: 10953–58.
- 119 Romanello M, McGushin A, Di Napoli C, et al. The 2021 report of the *Lancet* Countdown on health and climate change: code red for a healthy future. *Lancet* 2021; **398**: 1619–62.
- 120 Romanello M, di Napoli C, Green C, et al. The 2023 report of the *Lancet* Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *Lancet* 2023; **402**: 2346–94.
- 121 Romanello M, Walawender M, Hsu S-C, et al. The 2024 report of the *Lancet* Countdown on health and climate change: facing record-breaking threats from delayed action. *Lancet* 2024; **404**: 1847–96.
- 122 Nori-Sarma A, Sun S, Sun Y, et al. Association between ambient heat and risk of emergency department visits for mental health among US adults, 2010 to 2019. *JAMA Psychiatry* 2022; **79**: 341–49.
- 123 Zhou Y, Gao Y, Yin P, et al. Assessing the burden of suicide death associated with nonoptimum temperature in a changing climate. *JAMA Psychiatry* 2023; **80**: 488–97.
- 124 Burke M, González F, Baylis P, et al. Higher temperatures increase suicide rates in the United States and Mexico. *Nat Clim Chang* 2018; **8**: 723–29.
- 125 Vergunst F, Berry HL, Minor K, Chadi N. Climate change and substance-use behaviors: a risk-pathways framework. *Perspect Psychol Sci* 2023; **18**: 936–54.
- 126 Mora C, McKenzie T, Gaw IM, et al. Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Clim Chang* 2022; **12**: 869–75.
- 127 Hess J, Lowe R, Al Maslamani M, et al. Climate change and communicable diseases. *British Medical Journal*. Nov 15–20, 2020. <https://www.bmj.com/communicable-diseases> (accessed April 10, 2025).
- 128 Stanaway JD, Shepard DS, Undurraga EA, et al. The global burden of dengue: an analysis from the Global Burden of Disease Study 2013. *Lancet Infect Dis* 2016; **16**: 712–23.
- 129 Bhatt S, Gething PW, Brady OJ, et al. The global distribution and burden of dengue. *Nature* 2013; **496**: 504–07.
- 130 Clarke J, Lim A, Gupte P, Pigott DM, van Panhuis WG, Brady OJ. A global dataset of publicly available dengue case count data. *Sci Data* 2024; **11**: 296.
- 131 WHO. Dengue—global situation. May 30, 2024. <https://www.who.int/emergencies/disease-outbreak-news/item/2024-DON518> (accessed March 13, 2025).
- 132 Barman S, Semenza JC, Singh P, Sjödin H, Rocklöv J, Wallin J. A climate and population dependent diffusion model forecasts the spread of *Aedes Albopictus* mosquitoes in Europe. *Commun Earth Environ* 2024; **6**: 276.
- 133 Colón-González FJ, Sewe MO, Tompkins AM, et al. Projecting the risk of mosquito-borne diseases in a warmer and more populated world: a multi-model, multi-scenario intercomparison modelling study. *Lancet Planet Health* 2021; **5**: e404–14.
- 134 DiSera L, Sjödin H, Rocklöv J, et al. The mosquito, the virus, the climate: an unforeseen Réunion in 2018. *Geohealth* 2020; **4**: e2020GH000253.
- 135 Metelmann S, Caminade C, Jones AE, Medlock JM, Baylis M, Morse AP. The UK's suitability for *Aedes albopictus* in current and future climates. *J R Soc Interface* 2019; **16**: 20180761.
- 136 WHO. Malaria. Dec 11, 2024. <https://www.who.int/news-room/fact-sheets/detail/malaria> (accessed April 10, 2025).
- 137 Naghavi M, Liane Ong K, Aali A, et al. Global burden of 288 causes of death and life expectancy decomposition in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet* 2024; **403**: 2100–32.
- 138 Heidecke J, Lavarello Schettini A, Rocklöv J. West Nile virus eco-epidemiology and climate change. *PLOS Clim* 2023; **2**: e0000129.
- 139 Erazo D, Grant L, Ghisbain G, et al. Contribution of climate change to the spatial expansion of West Nile virus in Europe. *Nat Commun* 2024; **15**: 1196.
- 140 Heidecke J, Wallin J, Fransson P, et al. Uncovering temperature sensitivity of West Nile virus transmission: novel computational approaches to mosquito-pathogen trait responses. *PLOS Comput Biol* 2025; **21**: e1012866.
- 141 WHO. The Global Health Observatory: leishmaniasis. <https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/leishmaniasis> (accessed March 4, 2025).
- 142 Alten B, Maia C, Afonso MO, et al. Seasonal dynamics of phlebotomine sand fly species proven vectors of Mediterranean leishmaniasis caused by *Leishmania infantum*. *PLoS Negl Trop Dis* 2016; **10**: e0004458.
- 143 Fischer D, Moeller P, Thomas SM, Naucke TJ, Beierkuhnlein C. Combining climatic projections and dispersal ability: a method for estimating the responses of sandfly vector species to climate change. *PLoS Negl Trop Dis* 2011; **5**: e1407.
- 144 Carvalho BM, Rangel EF, Ready PD, Vale MM. Ecological niche modelling predicts southward expansion of *Lutzomyia (Nyssomyia) flaviscutellata* (Diptera: Psychodidae: Phlebotominae), vector of *Leishmania (Leishmania) amazonensis* in South America, under climate change. *PLoS One* 2015; **10**: e0143282.
- 145 WHO. Vector-borne diseases. Sept 26, 2024. <https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases> (accessed April 10, 2025).
- 146 Rochlin I, Toledo A. Emerging tick-borne pathogens of public health importance: a mini-review. *J Med Microbiol* 2020; **69**: 781–91.
- 147 Dong Y, Zhou G, Cao W, et al. Global seroprevalence and sociodemographic characteristics of *Borrelia burgdorferi sensu lato* in human populations: a systematic review and meta-analysis. *BMJ Glob Health* 2022; **7**: 7744.
- 148 Gong L, Diao L, Lv T, et al. A comprehensive review of tick-borne disease epidemiology, clinical manifestations, pathogenesis, and prevention. *Animals Zoonoses* 2025; published online May 21. <https://doi.org/10.1016/J.AZN.2025.05.004>.
- 149 Lippi CA, Ryan SJ, White AL, Gaff HD, Carlson CJ. Trends and opportunities in tick-borne disease geography. *J Med Entomol* 2021; **58**: 2021–29.
- 150 Baker-Austin C, Lake I, Archer E, Hartnell R, Trinanes J, Martinez-Urtaza J. Stemming the rising tide of *Vibrio* disease. *Lancet Planet Health* 2024; **8**: e515–20.
- 151 Dupke S, Buchholz U, Fastner J, et al. Impact of climate change on waterborne infections and intoxications. *J Health Monit* 2023; **1**: 62–77.

- 50



- 197 Sullivan JK, Basu G, Patel L, Teherani A, Sorensen C. Editorial: climate and health education: defining the needs of society in a changing climate. *Front Public Health* 2023; 11: 1307614.
- 198 Sorensen C, Magalhães D, Hamacher N, et al. Climate and health education in public health schools worldwide during 2023–24: a survey. *Lancet Planet Health* 2024; 8: e1010–19.
- 199 Canadian Federation of Medical Students Health, Environment Adaptive Response Task Force. Canadian Federation of Medical Students Health and Environment Adaptive Response Task Force (CFMS HEART) planetary health educational competencies. 2021. <https://www.cfms.org/files/HEART/CFMS-HEART-Planetary-Health-Competencies-Update---122021.pdf> (accessed March 29, 2025).
- 200 Farooq Z, Segelmark L, Rocklöv J, et al. Impact of climate and *Aedes albopictus* establishment on dengue and chikungunya outbreaks in Europe: a time-to-event analysis. *Lancet Planet Health* 2025; 9: e378–83.
- 201 Semenza JC, Paz S. Climate change and infectious disease in Europe: Impact, projection and adaptation. *Lancet Reg Health Eur* 2021; 9: 100230.
- 202 Global Burden of Disease Collaborative Network. GBD results. 2021. <https://vizhub.healthdata.org/gbd-results/> (accessed March 30, 2025).
- 203 Ebi KL, Schmier JK. A stitch in time: improving public health early warning systems for extreme weather events. *Epidemiol Rev* 2005; 27: 115–21.
- 204 WHO. 2021 WHO health and climate change survey report. World Health Organization, 2021.
- 205 Intergovernmental Panel on Climate Change. Climate Change 2023: synthesis report. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, 2023.
- 206 World Meteorological Organization. State of the global climate 2023. WMO-No 1347. Geneva, 2024. <https://wmo.int/publication-series/state-of-global-climate-2023> (accessed April 25, 2025).
- 207 Oppenheimer M, Glavovic B, Hinkel J, et al. Chapter 4: sea level rise and implications for low-lying islands, coasts and communities. Intergovernmental Panel on Climate Change. 2019. <https://www.ipcc.ch/srocc/chapter/chapter-4-sea-level-rise-and-implications-for-low-lying-islands-coasts-and-communities/> (accessed April 25, 2025).
- 208 Martyr-Koller R, Thomas A, Schleussner CF, Nauels A, Lissner T. Loss and damage implications of sea-level rise on Small Island Developing States. *Curr Opin Environ Sustain* 2021; 50: 245–59.
- 209 Kabir S, Newnham EA, Dewan A, Islam MM, Hamamura T. Sea-level rise and mental health among coastal communities: a quantitative survey and conditional process analysis. *SSM Popul Health* 2024; 25: 101640.
- 210 Hauer ME, Fussell E, Mueller V, et al. Sea-level rise and human migration. *Nat Rev Earth Environ* 2019; 1: 28–39.
- 211 Magnan AK, Oppenheimer M, Garschagen M, et al. Sea level rise risks and societal adaptation benefits in low-lying coastal areas. *Sci Rep* 2022; 12: 10677.
- 212 Kelman I, Ayeb-Karlsson S. Toward an evidence-based action agenda on the climate-(im)mobility (un)nexus(es). In: Bayes A, Bishawjit M, eds. Handbook on Climate Mobility. Edward Elgar Publishing, 2025.
- 213 Climate Action Tracker. CAT Thermometer. November, 2024. <https://climateactiontracker.org/global/cat-thermometer/> (accessed April 25, 2025).
- 214 Keramidas K, Fosse F, Aycart Lazo Fj, et al. Global energy and climate outlook 2024. Jan 29, 2025. <https://publications.jrc.ec.europa.eu/repository/handle/JRC139986> (accessed Feb 19, 2025).
- 215 UN Environment Programme. Emissions Gap Report 2024: no more hot air...please! With a massive gap between rhetoric and reality, countries draft new climate commitments. UN Environment Programme, 2024.
- 216 International Energy Agency. Energy statistics data browser. Dec 21, 2023. <https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource> (accessed April 18, 2025).
- 217 International Renewable Energy Agency. Tracking energy transition progress. <https://www.irena.org/Energy-Transition/Outlook/Tracking-progress> (accessed April 18, 2025).
- 218 Jessel S, Sawyer S, Hernández D. Energy, poverty, and health in climate change: a comprehensive review of an emerging literature. *Front Public Health* 2019; 7: 470168.
- 219 Pradhan Shrestha R, Mainali B, Mokhtara C, Lohani SP. Bearing the burden: understanding the multifaceted impact of energy poverty on women. *Sustainability* 2025; 17: 2143.
- 220 Cozzi L, Wetzel D, Tonolo G, Diarra N, Roge A. Access to electricity improves slightly in 2023, but still far from the pace needed to meet SDG7—analysis. International Energy Agency. Sept 15, 2023. <https://www.iea.org/commentaries/access-to-electricity-improves-slightly-in-2023-but-still-far-from-the-pace-needed-to-meet-sdg7> (accessed April 18, 2025).
- 221 International Energy Agency. World energy outlook 2024. 2024. <https://www.iea.org/data-and-statistics/data-product/world-energy-outlook-2024-free-dataset> (accessed April 2, 2025).
- 222 International Energy Agency. A vision for clean cooking access for all. 2023. <https://www.iea.org/reports/a-vision-for-clean-cooking-access-for-all> (accessed April 18, 2025).
- 223 WHO. Burning opportunity: clean household energy for health, sustainable development, and wellbeing of women and children. March 31, 2016. <https://www.who.int/publications/i/item/9789241565233> (accessed April 25, 2025).
- 224 International Energy Agency, International Renewable Energy Agency, UN Statistics Division, World Bank, WHO. Tracking SDG7: the energy progress report 2023. 2023. <https://www.irena.org/Publications/2023/Jun/Tracking-SDG7-2023> (accessed April 18, 2025).
- 225 Moritsugu K, Soo Z. China's electric car sales grew in 2024. AP News, Jan 13, 2025. <https://apnews.com/article/china-autos-evs-exports-3f5860634a1d46446dd0dd9e78c2abb> (accessed April 18, 2025).
- 226 McHugh D, St JOHN A, Moritsugu K. Electric car sales are slowing in the US and Europe. AP News, Nov 27, 2024. <https://apnews.com/article/ev-emissions-china-eu-trump-electric-b6a432557ac314d02654008bfbba09fb> (accessed April 18, 2025).
- 227 Dilian O, Beckers C, Witlox F, Davidovitch N, Martens K. Examining the health effects of public transport use on older adults: a systematic review. *J Transp Health* 2024; 39: 101931.
- 228 Murray C, Abbafati C, Abbas KM, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020; 396: 1223–49.
- 229 Bennitt FB, Wozniak S, Causey K, et al. Global, regional, and national burden of household air pollution, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet* 2025; 405: 1167–81.
- 230 Mohajeri N, Hsu S-C, Milner J, et al. Urban–rural disparity in global estimation of PM<sub>2.5</sub> household air pollution and its attributable health burden. *Lancet Planet Health* 2023; 7: e660–72.
- 231 Klepeis NE, Nelson WC, Ott WR, et al. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *J Expos Sci Environ Epidemiol* 2001; 11: 231–52.
- 232 Liu Y, Ma H, Zhang N, Li Q. A systematic literature review on indoor PM<sub>2.5</sub> concentrations and personal exposure in urban residential buildings. *Heliyon* 2022; 8: e10174.
- 233 Friedlingstein P, O'Sullivan M, Jones MW, et al. Global carbon budget 2022. *Earth Syst Sci Data* 2022; 14: 4811–900.
- 234 van Hoeven WS, Simons M, Czymoniewicz-Klippel MT, Veling H. Creating a healthy and sustainable food environment to promote plant-based food consumption: clear barriers and a gradual transition. *BMC Public Health* 2024; 24: 1–16.
- 235 Willett W, Rockström J, Loken B, et al. Food in the anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet* 2019; 393: 447–92.
- 236 Springmann M, Wiebe K, Mason-D'Croz D, Sulser TB, Rayner M, Scarborough P. Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. *Lancet Planet Health* 2018; 2: e451.
- 237 Bechthold A, Boeing H, Schwedhelm C, et al. Food groups and risk of coronary heart disease, stroke and heart failure: a systematic review and dose-response meta-analysis of prospective studies. *Crit Rev Food Sci Nutr* 2019; 59: 1071–90.
- 238 Di Angelantonio E, Bhupathiraju SN, Wormser D, et al. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *Lancet* 2016; 388: 776–86.



- 239 Springmann M, Spajic L, Clark MA, et al. The healthiness and sustainability of international and global food based dietary guidelines: modelling study. *BMJ* 2020; **370**: 2322.
- 240 WHO Regional Office for Europe. The diet impact assessment model: a tool for analyzing the health, environmental and affordability implications of dietary change. Nov 6, 2023. <https://www.who.int/europe/publications/i/item/WHO-EURO-2023-8349-48121-71370> (accessed April 18, 2025).
- 241 Springmann M, Freund F. Options for reforming agricultural subsidies from health, climate, and economic perspectives. *Nature Commun* 2022; **13**: 1–7.
- 242 Springmann M, Dinivitzer E, Freund F, Jensen JD, Bouyssou CG. A reform of value-added taxes on foods can have health, environmental and economic benefits in Europe. *Nat Food* 2025; **6**: 161–69.
- 243 Daba MH, Dejene S workeneh. The role of biodiversity and ecosystem services in carbon sequestration and its implication for climate change mitigation. *Int J Environ Sci Nat Resour* 2018; **11**: 55810.
- 244 Tazerji SS, Nardini R, Safdar M, Shehata AA, Duarte PM. An overview of anthropogenic actions as drivers for emerging and re-emerging zoonotic diseases. *Pathogens* 2022; **11**: 1376.
- 245 Walsh JF, Molyneux DH, Birley MH. Deforestation: effects on vector-borne disease. *Parasitology* 1993; **106**: S55–75.
- 246 Estrada A, Garber PA, Gouveia S, et al. Global importance of Indigenous peoples, their lands, and knowledge systems for saving the world's primates from extinction. *Sci Adv* 2022; **8**: 29.
- 247 Global Forest Watch. Brazil deforestation rates & statistics. 2025. <https://www.globalforestwatch.org/dashboards/country/BRA/?category=forest-change&location=WYJb3VudHJ5liwiQlJlB10%3D> (accessed Aug 13, 2025).
- 248 Goldman L, Carter S. Global Forest Watch's 2023 tree cover loss data explained. Global Forest Watch. April 4, 2024. <https://www.globalforestwatch.org/blog/data-and-tools/2023-tree-cover-loss-data-explained/> (accessed Aug 13, 2025).
- 249 WHO. Global spending on health: weathering the storm. Dec 10, 2020 <https://www.who.int/publications/i/item/9789240017788> (accessed April 25, 2025).
- 250 World Business Council for Sustainable Development, World Resources Institute. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. World Business Council for Sustainable Development, 2015.
- 251 Sun Y, Zhu S, Wang D, et al. Global supply chains amplify economic costs of future extreme heat risk. *Nature* 2024; **627**: 797–804.
- 252 Botzen W, Deschenes O, Sanders M. The economic impacts of natural disasters: a review of models and empirical studies. *Rev Environ Econ Policy* 2019; **13**: 167–88.
- 253 Swiss Re Institute. Natural catastrophes in 2023: gearing up for today's and tomorrow's weather risks. Mar 26, 2024. <https://www.swissre.com/dam/jcr:c9385357-6b86-486a-9ad8-78679037c10e/2024-03-signal-natural-catastrophes.pdf> (accessed April 25, 2025).
- 254 US Government Accountability Office. Flood insurance: FEMA's new rate-setting methodology improves actuarial soundness but highlights need for broader program reform. July 31, 2023 <https://www.gao.gov/products/gao-23-105977> (accessed April 18, 2025).
- 255 World Economic Forum. The cost of inaction: a CEO guide to navigating climate risk. December, 2024. [https://reports.weforum.org/docs/WEF\\_The\\_Cost\\_of\\_Inaction\\_2024.pdf](https://reports.weforum.org/docs/WEF_The_Cost_of_Inaction_2024.pdf) (accessed April 25, 2025).
- 256 Financial Stability Board. The implications of climate change for financial stability. 2020 <https://www.fsb.org/uploads/P231120.pdf> (accessed April 25, 2025).
- 257 UN Trade & Development. Countries agree \$300 billion by 2035 for new climate finance goal—what next? Dec 10, 2024. <https://unctad.org/news/countries-agree-300-billion-2035-new-climate-finance-goal-what-next> (accessed April 25, 2025).
- 258 UN Trade & Development. Key takeaways from COP29 and the road ahead for developing countries. Dec 19, 2024 <https://unctad.org/news/key-takeaways-cop29-and-road-ahead-developing-countries> (accessed April 25, 2025).
- 259 Waskow D, Larsen G, Robinson M, et al. Key outcomes from COP29: unpacking the new global climate finance goal and beyond. World Resources Institute. Nov 27, 2024, <https://www.wri.org/insights/cop29-outcomes-next-steps> (accessed April 25, 2025).
- 260 Wyna A. 5 breakthroughs on climate and health at COP28—and what comes next. Jan 15, 2024. <https://climahealth.info/5-breakthroughs-on-climate-and-health-at-cop28-and-what-comes-next/> (accessed April 25, 2025).
- 261 World Economic Forum. Navigating global financial system fragmentation. Jan 23, 2025. [https://reports.weforum.org/docs/WEF\\_Navigating\\_Global\\_Financial\\_System\\_Fragmentation\\_2025.pdf](https://reports.weforum.org/docs/WEF_Navigating_Global_Financial_System_Fragmentation_2025.pdf) (accessed April 25, 2025).
- 262 Organisation for Economic Co-operation and Development. Global outlook on financing for sustainable development 2025. Feb 7, 2025 [https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/02/global-outlook-on-financing-for-sustainable-development-2025\\_6748f647/753d5368-en.pdf](https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/02/global-outlook-on-financing-for-sustainable-development-2025_6748f647/753d5368-en.pdf) (accessed April 25, 2025).
- 263 Smith AB. 2024: an active year of US billion-dollar weather and climate disasters. National Oceanic and Atmospheric Administration Climate.gov. Jan 10, 2025. <https://www.climate.gov/news-features/blogs/beyond-data/2024-active-year-us-billion-dollar-weather-and-climate-disasters> (accessed May 16, 2025).
- 264 Swiss Re Institute. Sigma 1/2025: natural catastrophes: insured losses on trend to USD 145 billion in 2025. Swiss Re Institute. April 29, 2025. <https://www.swissre.com/institute/research/sigma-research/sigma-2025-01-natural-catastrophes-trend.html> (accessed May 16, 2025).
- 265 International Labour Organization. ILOSTAT: statistics on wages. 2025. <https://ilostat.ilo.org/topics/wages/> (accessed March 5, 2025).
- 266 Johnston JE, Lim E, Roh H. Impact of upstream oil extraction and environmental public health: a review of the evidence. *Sci Total Environ* 2019; **657**: 187–99.
- 267 Finkelman RB, Wolfe A, Hendryx MS. The future environmental and health impacts of coal. *Energy Geosci* 2021; **2**: 99–112.
- 268 Hanna R, Heptonstall P, Gross R. Green job creation, quality, and skills: a review of the evidence on low carbon energy. April, 2022 <https://ukerc.ac.uk/publications/green-jobs/> (accessed April 25, 2025).
- 269 Ryastad Energy. UCube database. 2024. <https://www.rystadenergy.com/energy-themes/oil-gas/upstream/u-cube/> (accessed March 7, 2025).
- 270 Rogelj J, Den Elzen M, Höhne N, et al. Paris Agreement climate proposals need a boost to keep warming well below 2°C. *Nature* 2016; **534**: 631–39.
- 271 Tanaka K, O'Neill BC. The Paris Agreement zero-emissions goal is not always consistent with the 1.5°C and 2°C temperature targets. *Nat Clim Chang* 2018; **8**: 319–24.
- 272 Oh TH. Carbon capture and storage potential in coal-fired plant in Malaysia—a review. *Renew Sustain Energy Rev* 2010; **14**: 2697–709.
- 273 Jakob M, Steckel JC, Jotzo F, et al. The future of coal in a carbon-constrained climate. *Nat Clim Chang* 2020; **10**: 704–07.
- 274 International Monetary Fund. World Economic Outlook database. October, 2024. <https://www.imf.org/en/Publications/WEO/weo-database/2024/October> (accessed April 23, 2024).
- 275 Stadler K, Wood R, Bulavskaya T, et al. EXIOBASE 3: developing a time series of detailed environmentally extended multi-regional input-output tables. *J Ind Ecol* 2018; **22**: 502–15.
- 276 He K, Mi Z, Zhang J, Li J, Coffman D. The polarizing trend of regional CO<sub>2</sub> emissions in China and its implications. *Environ Sci Technol* 2023; **57**: 4406–14.
- 277 Ekins P, Drummond P, Scamman D, Paroussos L, Keppo I. The 1.5°C climate and energy scenarios: impacts on economic growth. *Oxford Open Energy* 2022; **1**: oiad005–oiad005.
- 278 International Energy Agency. World Energy Investment 2025. June, 2025. <https://www.iea.org/reports/world-energy-investment-2025> (accessed June 18, 2025).
- 279 28th Conference of Parties. Global renewables and energy efficiency pledge. Feb 2, 2023. <https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge> (accessed June 18, 2025).
- 280 UN Framework Convention on Climate Change. New collective quantified goal on climate finance. <https://unfccc.int/NCQG> (accessed April 27, 2025).
- 281 Stiglitz JE. Addressing climate change through price and non-price interventions. *Eur Econ Rev* 2019; **119**: 594–612.
- 282 Zapf M, Pengg H, Weindl C. How to comply with the Paris Agreement temperature goal: global carbon pricing according to carbon budgets. *Energies* 2019; **12**: 2983.

- 283 Inter-agency Task Force on Financing for Development. Financing for Sustainable Development report 2024. UN Trade & Development, 2024.
- 284 International Energy Agency. World Energy Outlook 2019. November, 2019 <https://www.iea.org/reports/world-energy-outlook-2019> (accessed April 18, 2025).
- 285 European Banking Authority. EBA publishes its report on management and supervision of ESG risks for credit institutions and investment firms. June 23, 2021. <https://www.eba.europa.eu/publications-and-media/press-releases/eba-publishes-its-report-management-and-supervision-esg-risks> (accessed June 2, 2025).
- 286 European Commission. Communication on the European Green Deal. Dec 11, 2019. [https://commission.europa.eu/publications/communication-european-green-deal\\_en](https://commission.europa.eu/publications/communication-european-green-deal_en) (accessed June 2, 2025).
- 287 European Central Bank. 2022 Climate Risk Stress Test. European Central Bank, 2022.
- 288 de Barros Fritz L. What does the NZBA exodus tell us about banks' climate ambitions? ABN Amro. Feb 5, 2025. <https://www.abnamro.com/research/en/our-research/esg-strategist-what-does-the-nzba-exodus-tell-us-about-banks-climate> (accessed April 25, 2025).
- 289 Green Climate Fund. Approved projects. <https://www.greenclimate.fund/projects> (accessed May 16, 2025).
- 290 Organization for Economic Cooperation and Development. OECD creditor reporting system. <https://webfs.oecd.org/climate/RecipientPerspective/> (accessed May 16, 2025).
- 291 UN Framework Convention on Climate Change. Nationally Determined Contributions registry. <https://unfccc.int/NDCREG> (accessed May 16, 2025).
- 292 UN Framework Convention on Climate Change. Adaptation Communications registry. <https://unfccc.int/ACR> (accessed May 16, 2025).
- 293 World Bank. World Bank climate finance 2024. 2025. <https://thedocs.worldbank.org/en/doc/737327d214f08db1ac7a1d655a343029-0020012024/original/World-Bank-Climate-Finance-FY24.pdf> (accessed Aug 17, 2025).
- 294 World Bank. World Bank climate finance 2023. 2024. <https://thedocs.worldbank.org/en/doc/d4a3fae669d0274d249ef9331dffe73b-0020012024/original/FY23-Project-level-CCB-data.pdf> (accessed Aug 17, 2025).
- 295 Organization for Economic Cooperation and Development. Scaling up adaptation finance in developing countries: challenges and opportunities for international providers. Nov 16, 2023. [https://www.oecd.org/en/publications/scaling-up-adaptation-finance-in-developing-countries\\_b0878862-en.html](https://www.oecd.org/en/publications/scaling-up-adaptation-finance-in-developing-countries_b0878862-en.html) (accessed Jan 10, 2025).
- 296 Strange KF, Satorras M, March H. Intersectional climate action: the role of community-based organisations in urban climate justice. *Local Environ* 2024; **29**: 865–85.
- 297 Breton-Carbonneau AC, Anguelovski I, O'Brien K, et al. Exploring ownership of change and health equity implications in neighborhood change processes: a community-led approach to enhancing just climate resilience in Everett, MA. *Health Place* 2024; **89**: 103294.
- 298 World Bank Group. GDP (Current US\$). 2025. <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD> (accessed March 28, 2025).
- 299 Moutet L, Bernard P, Green R, et al. The public health co-benefits of strategies consistent with net-zero emissions: a systematic review. *Lancet Planet Health* 2025; **9**: e145–56.
- 300 Rauner S, Bauer N, Dirmaichner A, Dingenen R Van, Mutel C, Luderer G. Coal-exit health and environmental damage reductions outweigh economic impacts. *Nat Clim Chang* 2020; **10**: 308–12.
- 301 Jackson RB, Friedlingstein P, Andrew RM, Canadell JG, Le Quéré C, Peters GP. Persistent fossil fuel growth threatens the Paris Agreement and planetary health. *Environ Res Lett* 2019; **14**: 121001.
- 302 UN. Resolution 76/300: the human right to a clean, healthy and sustainable environment. Aug 1, 2022. <https://docs.un.org/en/A/RES/76/300> (accessed April 23, 2025).
- 303 UN. Universal Declaration of Human Rights. UN. <https://www.un.org/en/about-us/universal-declaration-of-human-rights> (accessed April 23, 2025).
- 304 UN. Convention on the Rights of the Child. Nov 20, 1989. <https://www.ohchr.org/sites/default/files/crc.pdf> (accessed April 23, 2025).
- 305 Setzer J, Higham C. Global trends in climate change litigation: 2024 snapshot. London School of Economics. June 27, 2024. <https://www.lse.ac.uk/granthaminstitute/publication/global-trends-in-climate-change-litigation-2024-snapshot/> (accessed April 23, 2025).
- 306 UN Environment Programme. Global Climate Litigation report 2023 status review. UN Environment Programme, 2023.
- 307 Sabin Center for Climate Change Law. KlimaSeniorinnen v Switzerland (ECtHR). 2020. <https://climatecasechart.com/non-us-case/union-of-swiss-senior-women-for-climate-protection-v-swiss-federal-council-and-others/> (accessed April 23, 2025).
- 308 Phelan AL, Patterson D, Tahzib F, et al. Collective action and legal mobilisation for the right to health in the climate crisis. *Lancet* 2024; **403**: 2272–74.
- 309 Cox R. A Climate Change litigation precedent: Urgenda Foundation v the State of the Netherlands. Nov 4, 2015. <https://www.cigionline.org/publications/climate-change-litigation-precedent-urgenda-foundation-v-state-netherlands/> (accessed April 23, 2025).
- 310 Kotzé LJ. Neubauer et al. versus Germany: planetary climate litigation for the anthropocene? *German Law J* 2021; **22**: 1423–44.
- 311 Nordlander L. The road (not) taken: implications of health-focused arguments for rights-based climate change litigation in Europe. *Int J Hum Rights* 2025; **29**: 495–516.
- 312 Toolan N, Marcus H, Hanna EG, Wannous C. Legal implications of the climate-health crisis: a case study analysis of the role of public health in climate litigation. *PLoS One* 2022; **17**: e0268633.
- 313 Loser N. Litigation against coal-fired power in South Africa: lessons from and for global climate litigation to reduce greenhouse gas emissions. In: Bouwer K, Etemire U, Field T-L, Jegede AO, eds. Climate litigation and justice in Africa. Bristol University Press, 2024: 68–101.
- 314 McCormick SP, Simmens SJ, Glicksman R, Paddock LR, Kim D, Whited B. The role of health in climate litigation. *Am J Public Health* 2018; **108**: S104–08.
- 315 Langer AI, Gruber JB. Political agenda setting in the hybrid media system: why legacy media still matter a great deal. *Int J Press/Polit* 2021; **26**: 313–40.
- 316 Schmidt A, Ivanova A, Schäfer MS. Media attention for climate change around the world: a comparative analysis of newspaper coverage in 27 countries. *Glob Environ Change* 2013; **23**: 1233–48.
- 317 Campbell E, Uppalapati SS, Kotcher J, Maibach E. Communication research to improve engagement with climate change and human health: a review. *Front Public Health* 2023; **10**: 1086858.
- 318 Dasandi N, Graham H, Hudson D, Jankin S, van Heerde-Hudson J, Watts N. Positive, global, and health or environment framing bolsters public support for climate policies. *Commun Earth Environ* 2022; **3**: 1–9.
- 319 Kotcher J, Feldman L, Luong KT, Wyatt J, Maibach E. Advocacy messages about climate and health are more effective when they include information about risks, solutions, and a normative appeal: evidence from a conjoint experiment. *J Clim Change Health* 2021; **3**: 100030.
- 320 Henfrey T, Feola G, Penha-Lopes G, Sekulova F, Esteves AM. Rethinking the sustainable development goals: Learning with and from community-led initiatives. *Sustain Dev* 2023; **31**: 211–22.
- 321 Ebi KL, Semenza JC. Community-based adaptation to the health impacts of climate change. *Am J Prev Med* 2008; **35**: 501–07.
- 322 Simon K, Diprose G, Thomas AC. Community-led initiatives for climate adaptation and mitigation. *Kotuitui* 2020; **15**: 93–105.
- 323 Kipp A, Cunsolo A, Gillis D, Sawatzky A, Harper SL. The need for community-led, integrated and innovative monitoring programmes when responding to the health impacts of climate change. *Int J Circumpolar Health* 2019; **78**: 1517581.
- 324 Rong T, Risteovski E, Carroll M. Exploring community engagement in place-based approaches in areas of poor health and disadvantage: a scoping review. *Health Place* 2023; **81**: 103026.
- 325 Alexiou K, Zamenopoulos T, Alevizou G. Valuing Community-led design. [https://valuing-community-led-design.weebly.com/uploads/1/2/8/5/12856329/vclld\\_summary\\_report.pdf](https://valuing-community-led-design.weebly.com/uploads/1/2/8/5/12856329/vclld_summary_report.pdf) (accessed May 22, 2025).
- 326 Polish Smog Alert. Our successes. <https://www.polishsmogalert.org/polish-smog-alert/our-our-successes/> (accessed April 25, 2025).
- 327 World Bank Group. Supporting the Indigenous peoples and local communities in Nepal's forest sector. World Bank. Aug 8, 2024. <https://www.worldbank.org/en/news/feature/2024/08/08/supporting-the-indigenous-peoples-and-local-communities-in-nepal-s-forest-sector> (accessed April 25, 2025).

- 328 UN Department of Economic and Social Affairs. Farmer Managed Natural Regeneration (FMNR): a technique to effectively combat poverty and hunger through land and vegetation restoration. [https://sdgs.un.org/partnerships/farmer-managed-natural-regeneration-fmnr-technique-effectively-combat-poverty-and?utm\\_source=chatgpt.com](https://sdgs.un.org/partnerships/farmer-managed-natural-regeneration-fmnr-technique-effectively-combat-poverty-and?utm_source=chatgpt.com) (accessed April 25, 2025).
- 329 Youth Climate Action Network. UNESCO. <https://www.unesco.org/en/youth/climate-action-network?hub=390> (accessed April 25, 2025).
- 330 Butel J, Braun KL. The role of collective efficacy in reducing health disparities: a systematic review. *Fam Community Health* 2019; **42**: 8–19.
- 331 Reeves A, Lemon M, Cook D. Jump-starting transition? Catalysing grassroots action on climate change. *Energy Effic* 2014; **7**: 115–32.
- 332 Forst M. State repression of environmental protest and civil disobedience: a major threat to human rights and democracy. UN, 2024.
- 333 Global Witness. More than 2100 defenders killed between 2012 and 2023. Sept 10, 2024. <https://globalwitness.org/en/press-releases/more-than-2100-land-and-environmental-defenders-killed-globally-between-2012-and-2023/> (accessed April 25, 2025).
- 334 Choi-Schagrin W. Effort to reframe climate change as a health crisis gains steam. The New York Times, Nov 4, 2021. <https://www.nytimes.com/2021/11/04/climate/public-health-climate-change.html> (accessed April 18, 2025).
- 335 Rossa-Roccor V, Giang A, Kershaw P. Framing climate change as a human health issue: enough to tip the scale in climate policy? *Lancet Planet Health* 2021; **5**: e553–59.
- 336 Wikimedia Commons. Wikipedia page views by language over time. Wikimedia Commons. Feb 7, 2024. <https://commons.wikimedia.org/w/index.php?curid=99654507> (accessed April 27, 2025).
- 337 Similarweb. Google.com traffic analytics, ranking & audience. February, 2025. <https://www.similarweb.com/website/google.com/#overview> (accessed April 18, 2025).
- 338 Gianfredi V, Nucci D, Nardi M, Santangelo OE, Provenzano S. Using Google Trends and Wikipedia to investigate the global public's interest in the pancreatic cancer diagnosis of a celebrity. *Int J Environ Res Public Health* 2023; **20**: 2106.
- 339 Dasandi N, Jankin S, Pantera DK, Romanello M. Public engagement with health and climate change around the world: a Google Trends analysis. *Lancet Planet Health* 2025; **9**: e236–44.
- 340 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. *Lancet* 2018; **391**: 581–630.
- 341 Bornmann L. Scientific peer review. *Annu Rev Inform Sci Tech* 2011; **45**: 197–245.
- 342 Berrang-Ford L, Sietsma AJ, Callaghan M, et al. Systematic mapping of global research on climate and health: a machine learning review. *Lancet Planet Health* 2021; **5**: e514–25.
- 343 Callaghan M, Schleussner CF, Nath S, et al. Machine-learning-based evidence and attribution mapping of 100,000 climate impact studies. *Nat Clim Chang* 2021; **11**: 966–72.
- 344 Abbas A, Ekowati D, Suhariadi F, Fenitra RM. Health implications, leaders societies, and climate change: a global review. In: Chatterjee U, Akanwa AO, Kumar S, Singh SK, Dutta Roy A, eds. Ecological footprints of climate change. Springer 2022: 653–75.
- 345 Dasandi N, Graham H, Lampard P, Mikhaylov SJ. Intergovernmental engagement on health impacts of climate change. *Bull World Health Organ* 2021; **99**: 102–111B.
- 346 Chelotti N, Dasandi N, Jankin Mikhaylov S. Do intergovernmental organizations have a socialization effect on member state preferences? Evidence from the UN General Debate. *Int Stud Q* 2022; **66**: sqab069.
- 347 Jankin S, Batur A, Dasandi N. Words to unite nations: the complete United Nations General Debate Corpus, 1946–present. *J Peace Res* 2024; **62**: 1339–51.
- 348 Vogt-Schilb A, Hallegatte S. Climate policies and nationally determined contributions: reconciling the needed ambition with the political economy. *Wiley Interdiscip Rev Energy Environ* 2017; **6**: e256.
- 349 Dasandi N, Graham H, Lampard P, Jankin Mikhaylov S. Engagement with health in national climate change commitments under the Paris Agreement: a global mixed-methods analysis of the nationally determined contributions. *Lancet Planet Health* 2021; **5**: e93–101.
- 350 UN Framework Convention for Climate Change. Adoption of the Paris Agreement. Dec 12, 2015. <https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf> (accessed Feb 3, 2025).
- 351 Maria DL, Maria-Therese G, Ece K. Global adaptation governance: explaining the governance responses of international organizations to new issue linkages. *Environ Sci Policy* 2020; **114**: 204–15.
- 352 Dörfler T, Heinzel M. Greening global governance: INGO secretariats and environmental mainstreaming of IOs, 1950 to 2017. *Rev Int Organ* 2023; **18**: 117–43.
- 353 Kural E, Dellmuth LM, Gustafsson MT. International organizations and climate change adaptation: a new dataset for the social scientific study of adaptation, 1990–2017. *PLoS One* 2021; **16**: e0257101.
- 354 Ecker-Ehrhardt M. IO public communication going digital? Understanding social media adoption and use in times of politicization. In: Bjola C, Zaiotti R, eds. Digital Diplomacy and International Organisations: Autonomy. Routledge, 2020: 21–51.
- 355 Goritz A, Schuster J, Jörgens H, Kolleck N. International public administrations on Twitter: a comparison of digital authority in global climate policy. *J Comp Policy Anal* 2022; **24**: 271–95.
- 356 Carbon Majors. The Carbon Majors database: launch report. April, 2024. <https://influencemap.org/briefing/The-Carbon-Majors-Database-26913> (accessed May 14, 2025).
- 357 UN Global Compact. Why report? <https://unglobalcompact.org/participation/report> (accessed March 31, 2025).
- 358 Voegtlin C, Pless NM. Global governance: CSR and the role of the UN Global Compact. *J Bus Ethics* 2014; **122**: 179–91.
- 359 Nicolò G, Zampone G, De Iorio S, Sannino G. Does SDG disclosure reflect corporate underlying sustainability performance? Evidence from UN Global Compact participants. *J Int Financ Manag Account* 2024; **35**: 214–60.
- 360 Msiska M, Ng A, Kimmel RK. Doing well by doing good with the performance of United Nations Global Compact Climate Change Champions. *Humanit Soc Sci Commun* 2021; **8**: 1–11.
- 361 InfluenceMap. European industry and the EU's climate policy 2024–29. May, 2025. <https://influencemap.org/briefing/European-Industry-and-the-European-Union-s-Climate-Policy-in-2024-29-32272> (accessed May 30, 2025).
- 362 E3G. Powering up: business perspectives on shifting to renewable electricity. April, 2025. [https://www.e3g.org/wp-content/uploads/Powering-up\\_Business-perspectives-on-shifting-to-renewable-electricity\\_.pdf](https://www.e3g.org/wp-content/uploads/Powering-up_Business-perspectives-on-shifting-to-renewable-electricity_.pdf) (accessed May 27, 2025).
- 363 Patterson JJ. Backlash to climate policy. *Glob Environ Polit* 2023; **23**: 68–90.
- 364 Lockwood M. Right-wing populism and the climate change agenda: exploring the linkages. *Env Polit* 2018; **27**: 712–32.
- 365 Schwörer J, Fernández-García B. Climate sceptics or climate nationalists? Understanding and explaining populist radical right parties' positions towards climate change (1990–2022). *Polit Stud* 2024; **72**: 1178–202.
- 366 van Daalen KR, Kriit HK, Chen-Xu J, et al. Europe's climate leadership in an 'America first' era. *Lancet Reg Health Eur* 2025; **51**: 101257.

Copyright © 2025 Elsevier Ltd. All rights reserved, including those for text and data mining, AI training, and similar technologies.