The 2025 China report of the *Lancet* Countdown on health and climate change: empowering cities for synergistic action

Wenjia Cai*, Chi Zhang*, Shihui Zhang*, Yuqi Bai, Bin Chen, Jifei Chen, Liangliang Cheng, Weicheng Fan, Lianfang Feng, Dabo Guan, Congkai Hong, Yixin Hu, Junyi Hua, Cunrui Huang, Hong Huang, Jianbin Huang, Xiaomeng Huang, John S Ji, Qiaolei Jiang, Xiaopeng Jiang, Haidong Kan, Jun Kang, Gregor Kiesewetter, Bo Li, Guoao Li, Tiantian Li, Weiyi Liao, Borong Lin, Hualiang Lin, Huan Liu, Qiyong Liu, Xinghan Liu, Yanxiang Liu, Zehua Liu, Zhao Liu, Zhu Liu, Shuhan Lou, Bo Lu, Chenxi Lu, Wei Ma, Zhifu Mi, Yanqing Miao, Guangju Mo, Tim Repke, Chao Ren, Marina Romanello, Jianxiang Shen, Jing Su, Rui Su, Yuze Sun, Xu Tang, Maria Walawender, Can Wang, Hui Wang, Qing Wang, Qiong Wang, Yongyue Wang, Wangyu Wei, Sanmei Wen, Hui Xiong, Bing Xu, Xiu Yang, Yuren Yang, Fanghong Yao, Mingjun Yin, Le Yu, Zhaowu Yu, Jing Zhang, Rui Zhang, Shangchen Zhang, Shaohui Zhang, Zhenyu Zhang, Mengzhen Zhao, Qiang Zhao, Dashan Zheng, Hao Zhou, Jingbo Zhou, Yuye Zhou, Yong Luo†, Peng Gong†

Executive summary

According to the World Meteorological Organization (WMO), 2024 was the hottest year on record. China had unprecedented heat and heavy precipitation, with a national average temperature of 10·9°C, 1·01°C higher than the historical average (1991–2020), and annual precipitation of 697·7 mm, which is 9·0% higher than the average. As 2025 marks the 10th anniversary of the Paris Agreement and a key juncture for submitting new contributions, accelerating global climate action is imperative, especially in cities, which account for 58% of the world's population and 70% of total carbon emissions.

The sixth annual *Lancet* Countdown China report on health and climate change, led by the Lancet Countdown Asia Centre at Tsinghua University and coauthored by 80 experts from 27 institutions, tracks 33 indicators across five domains. This year's report features several key updates. Methodologically, the Countdown used the China Meteorological Administration's Chinese global land-surface reanalysis product (CRA40) reanalysis dataset to replace European reanalysis product (ERA5, the fifth generation European Centre for Medium-Range Weather Forecasts reanalysis dataset) data for improved accuracy. The report expanded 17 indicators from the provincial to city level to support targeted local policy making. Furthermore, the report introduced three new indicators—sleep loss (indicator 1.1.4), compound heatwaves (indicator 1.1.5), and the Greenspace Exposure Inequality Index (indicator 2.2.3), along with two new panels on city-level research. As with previous years, where possible, all indicators have been updated with the latest data and methodological refinements.

Eight of 13 indicators hit record highs, signalling red alerts for climate-related health risks

In 2024, climate-related health risks in China intensified, with eight of the 13 tracked risks (some indicators track more than one kind of risk, such as indicator 1.2.2, drought and extreme rainfall) reaching record highs. Further notable changes included potential labour capacity loss (indicator 1.1.2), reduced physical activity (indicator 1.1.3), sleep disruption (indicator 1.1.4), and rising health threats linked to drought, extreme rainfall (indicator 1.2.2), and climate-sensitive diseases (indicator 1.3).

Heatwave-related mortality reached 20100 deaths—1·7 times greater than the historical 1986–2005 average—although this was a decrease from 2023, possibly due to shifting high-temperature zones towards less populated western and northern regions (indicator 1.1.1). Proven to be more life-threatening than daytime-only or nighttime-only heatwaves, the exposure of day–night compound heatwaves reached 6·35 events per city, marking a 197·9% increase from historical levels and nearly doubling from 2023 (indicator 1.1.5). The effects of extreme heat extended beyond mortality associated with older people. Extreme heat exposure exceeded outdoor activity safety thresholds for an average of 2·52 hours per day across China, which is an 85% increase from historical levels between 1986 and 2005 (indicator 1.1.3). Warmer nighttime temperatures caused considerable sleep disruption, with a total loss of 1383 min per person, which is an increase of 14·9% from the 1986–2005 baseline average (indicator 1.1.4).

Additionally, while wildfire exposure in 2024 declined compared with 2023, it was still 61·8% higher than the 2001–05 baseline, with 26 provinces showing an increasing trend (indicator 1.2.1). Extreme rainfall and drought also contributed to rising health risks, with excess infectious diarrhoea risk increasing by 3·0% in the past decade, particularly in northern and western China, while drought-related risks increased by 1·9%, most notably in the west (indicator 1.2.2).

The economic toll of climate change on health in China has been substantial. In 2024, heatwave-related mortality among working-age individuals resulted in economic losses of US$42·7 million (indicator 4.1.1). Heat-induced labour productivity caused losses of $282·6 billion, or 1·77% of China's gross domestic product (GDP) loss—an increase of 23% from 2023 (indicator 4.1.2). Additionally, extreme weather events caused sharp rises in economic damages, further straining the national economy (indicator 4.1.4).

While China is a leader in renewable energy, more is needed against escalating climate-health risks

Despite the urgent need for mitigation, China's total carbon dioxide emissions increased by 0·5% in 2024,

Lancet Public Health 2025; 10: e1066–85

Published Online October 30, 2025 https://doi.org/10.1016/S2468-2667(25)00230-0

*Contributed equally

†Co-chairs

Department of Earth System Science (Prof W Cai PhD, Prof Y Bai PhD, Prof D Guan PhD, C Hong BS, Prof X Huang PhD, W Liao BSc, Prof Z Liu PhD, S Lou BSc, J Shen BSc, Y Sun Beng, Prof B Xu PhD, L Yu PhD, S Zhang BS, Q Zhao MS, Prof Y Luo PhD), **Ministry of Education Key Laboratory for Earth System Modeling, Institute for Global Change Studies** (Prof Y Bai, Q Zhao), **Vanke School of Public Health** (L Cheng PhD, Prof C Huang PhD, J S Ji ScD, Z Liu MSc), **School of Safety Science** (Prof W Fan PhD, Prof H Huang PhD, M Yin BS), **School of Journalism and Communication** (Prof Q Jiang PhD, W Wei BA, S Wen PhD), **School of Architecture** (Prof B Lin PhD, Y Yang MSc), **School of Environment** (Prof H Liu PhD, Y Wang MS), **School of Humanities** (J Su PhD), **State Key Joint Laboratory of Environment Simulation and Pollution Control (SKLESPC), School of Environment** (Prof C Wang PhD), **Institute of Climate Change and Sustainable Development** (X Yang PhD), **Division of Sports Science and Physical Education** (F Yao PhD), **Institute for Urban Governance and Sustainable Development, Think Tank Center** (H Zhou PhD), **Tsinghua University, Beijing, China; School of Journalism and Communication, Xinjiang University of Finance and Economics, Urumqi, China** (J Zhang MS); **School of Management and Economics**

(Prof C Zhang PhD), School of Management (B Li MS, H Wang MS, M Zhao PhD), Beijing Institute of Technology, Beijing, China; School of Ecology and Environment, Renmin University of China, Beijing, China (S Zhang PhD); School of Environment, Beijing Normal University, Beijing, China (B Chen PhD, R Su MA); The Thrust of Artificial Intelligence, The Hong Kong University of Science and Technology, Guangzhou, China (Prof H Xiong PhD); Department of Computer Science and Engineering, The Hong Kong University of Science and Technology, Hong Kong Special Administrative Region, China (Prof H Xiong); National Key Laboratory of Intelligent Tracking and Forecasting for Infectious Diseases, National Institute for Communicable Disease Control and Prevention (L Feng MS, G Mo MSc), China CDC Key Laboratory of Environment and Population Health, National Institute of Environmental Health (Prof T Li PhD, Prof Q Wang PhD), State Key Laboratory of Infectious Disease Prevention and Control, National Institute for Communicable Disease Control and Prevention (Prof Q Liu PhD), Chinese Center for Disease Control and Prevention, Beijing, China; Department of Global, Environmental, and Occupational Health, School of Public Health, University of Maryland, College Park, MD, USA (J Chen MPhil); School of Economics and Management, Southeast University, Nanjing, China (Y Hu PhD); School of International Affairs and Public Administration, Ocean University of China, Qingdao, China (J Hua PhD); College of Resources and Environment, University of Chinese Academy of Sciences, Beijing, China (J Huang PhD); Office of the WHO Representative, World Health Organization, Beijing, China (X Jiang MPh); School of Public Health, Key Lab of Public Health Safety of the Ministry of Education and NHC Key Lab of Health Technology Assessment (Prof H Kan PhD), FDU IRDR ICoE (Prof X Tang PhD), Department of Environmental Science and Engineering (Prof Z Yu), Department of Atmospheric and Oceanic Sciences and

highlighting the crucial challenge of reversing this trend for China to meet its dual carbon goals and support the global 1·5°C target (indicator 3.1). Avoiding a high-carbon lock-in from continued coal expansion requires a decisive shift in investment and urgent structural reforms. The energy transition shows both progress and contradictions. The share of coal in the energy mix declined to 64·9% (indicator 3.2), and renewable generation grew strongly, with solar and wind increasing by 28·7% and 5·5%, respectively (indicator 4.2.1). However, the energy sector's susceptibility to climate change was underscored as severe droughts reduced hydropower generation (indicator 4.1.4). Investment reflects this complexity: while renewable energy investment grew by 11% to $117·3 billion, investment in coal-fired power also surged by 52·4% (indicator 4.2.1). This transition is reshaping the labour market, with employment in the renewable sector rising 34% to 7·39 million workers, while fossil fuel-related employment slightly declined to 3·135 million (indicator 4.2.2). Positive economic incentives are strengthening, as fossil fuel subsidies dropped by 40% in 2023 and the national carbon price increased by 43·4% (indicator 4.2.3). These efforts yield considerable health benefits by reducing premature mortality from lower $PM_{2.5}$ concentrations (indicator 3.3), yet they also entail economic risks, with stranded coal assets projected to reach $8·57 billion by 2030 (indicator 4.2.5).

China's climate adaptation capacity improved in the past year, with regional disparities beginning to narrow. The national health emergency response score increased to 78·81 in 2023 (indicator 2.2.1), and cross-sector collaboration between meteorological and health agencies expanded to enhance early warning systems (indicator 2.4). Following the release of the first national Health National Adaptation Plan (HNAP) in September, 2024, the number of provinces with local health adaptation plans increased from five to 19 (indicator 2.1). Concrete adaptation measures are yielding results: air conditioning use prevented an estimated 51000 heat-related deaths (indicator 2.2.2), while urban greening efforts prevented around 76000 deaths (indicator 2.2.3). Despite this progress, inequalities in greenspace access and overall adaptation capacity remain a key challenge, especially in less developed areas.

Cities: both a challenge and a solution

Cities, as both amplifiers of climate risks and hubs for climate action, require targeted urban strategies to address health susceptibilities. This year's Countdown explores this nexus with 17 city-level indicators, providing granular insights into urban climate-health challenges and responses.

City-level analysis reveals crucial risk hotspots often obscured by provincial data. Among 375 cities, 107 showed higher increases in wildfire exposure compared with their provincial averages (indicator 1.2.1), emphasising the need for city-specific adaptation planning.

Many climate-related health risks are highly concentrated at the city level, raising concerns about inequality. Heatwave-related mortalities are localised, with the top five cities accounting for 14·7% of all deaths (indicator 1.1.1). Similarly, for wildfire exposure, the top 20% of cities contain 60% of the total exposed population (indicator 1.2.1). The economic costs are also concentrated, with 39 cities—mostly in the middle-lower Yangtze River Plain—having a more than a 100% increase in direct costs from heatwave mortality (indicator 4.1.1), with Changsha, Wuhan, and Yichang recording the highest burdens. Meanwhile, lower-income southern cities, such as Qinzhou, Beihai, and Zhanjiang, had the highest relative costs, exceeding 4·9% of their local GDP (indicator 4.1.1).

Coastal cities are another major hotspot. Risks from heatwave mortality (indicator 1.1.1), lost outdoor activity hours (indicator 1.1.3), sleep loss from nighttime heat (indicator 1.1.4), and compound heatwaves (indicator 1.1.5) are often concentrated in coastal cities within coastal provinces. From 2004 to 2023, dengue transmission suitability increased across 204 cities, with the highest potential in southern coastal cities, such as Yulin and Sanya (indicator 1.3). Projections for Taizhou—the city with the highest anticipated relative sea level rise—indicate that 62–77% of its population could be affected by 2100 (indicator 1.4).

In response, China's cities are advancing localised mitigation and adaptation efforts. In 2024, cities, including Chongqing, Tianjin, and Shanghai, led in expanding renewable energy capacity (indicator 4.2.1) and saw substantial growth in carbon pricing (indicator 4.2.3). However, challenges persist. Cities, such as Ordos, Bijie, and Xuchang, face high risks of stranded coal assets with the 1·5°C pathway (indicator 4.2.5). Furthermore, emission patterns differ, with service-driven cities, such as Beijing, contributing more via consumption-based emissions, while industrial hubs, such as Tangshan, are dominant sources of production-based emissions (indicator 4.2.4). On the adaptation front, urban greenspaces are becoming more accessible, with 68% of cities improving greenness, which has narrowed intra-city equity gaps, reflected by the national Greenspace Exposure Inequality Index declining from 0·635 in 2021, to 0·608 in 2024 (indicator 2.2.3).

Advancing city-level climate and health action is both urgently needed and economically justified. While analyses show that many urban climate measures can generate substantial health co-benefits, there is a persistent mismatch between research hotspots and actual on-the-ground risk hotspots. This misalignment limits the effectiveness and equity of current responses. To ensure that climate actions are targeted and impactful, it is essential to strengthen city-level evidence, align research with local susceptibilities, and empower cities with tailored and evidence-based strategies to accelerate a fair climate transition.

Making comprehensive progress and leveraging the power of cities

Strengthening urban climate resilience will be essential to protect public health and sustain growth. The following recommendations highlight key priorities for accelerating mitigation and adaptation at the city level:

1. Prioritise city-specific evidence-based action

Cities vary greatly in terms of climate-health risks, governance, and economic capacity. Provincial averages obscure crucial local differences. Mandating city-level climate-health risk profiles, supported by an urban typology that classifies cities by risk patterns and capacities, would provide a scientific foundation for tailored, equitable interventions.

2. Expand research and standardise cost–benefit analysis

All major urban climate initiatives should be required to apply a standardised cost–benefit analysis (CBA) framework that incorporates China-specific valuation methods, quantifies health co-benefits, and addresses equity. Priority research should develop CBA+ models capable of assessing trade-offs under deep uncertainty, and pilot them in cities representing distinct climate-health profiles. A national city clustering template—grouping municipalities by hazard exposure, economic structure, and energy mix—would enable efficient peer learning, streamline policy transfer, and ensure inclusion of smaller, underserved cities.

3. Avoid fossil fuel lock-in and transition risks

China should introduce a moratorium on new coal plants to avoid stranded assets worth potentially hundreds of billions. China should phase out fossil fuel subsidies and redirect funds to support just transition for coal-dependent regions. China should establish retirement schedules for inefficient plants and strengthen the carbon market to hasten market-driven closures while supporting worker retraining and economic diversification.

4. Implement integrated, people-centred early warning systems

Nationwide adoption of the UN's Early Warnings for All framework could deliver a nine-fold return on investment. These systems should integrate meteorological and public health data, with clear last mile communication protocols for susceptible populations. Research should focus on understanding the socio-behavioural drivers of responses to warnings to enable more effective risk communication and life-saving action.

5. Foster inter-city cooperation and regional coordination

China should create regional platforms to share resources, develop joint infrastructure, and exchange expertise. Energy-intensive cities can partner with renewable-rich areas, while climate-susceptible regions can learn from adaptation leaders. China should establish climate action alliances in key economic zones, supported by co-investment funds, to overcome local protectionism and enable coordinated decarbonisation. Knowledge-sharing networks modelled on the C40 or the EU Cities Mission can speed up the transfer of technologies and policy innovations nationwide.

Introduction

The year 2024 was confirmed as the hottest on record by the World Meteorological Organization. China saw exceptional warming, with the national average temperature reaching 10·9, 1·01°C higher than the 1991–2020 average, alongside frequent regional droughts and prolonged dry spells, despite a modest overall increase (9%) in annual precipitation.

As 2025 marks the 10th anniversary of the Paris Agreement, countries have an opportunity to align mitigation pathways and submit more ambitious Nationally Determined Contributions. The World Meteorological Day 2025 theme of Closing the Early Warning Gap Together underscores the dual urgency of enhancing resilience, especially in cities, where susceptibilities and emissions are concentrated.

In 2024, China made continued progress in both mitigation and adaptation. Non-fossil energy consumption increased to 18·9%, supported by new measures on carbon control, energy conservation, and an expanded national carbon market (eg, Working Group 3 of the Intergovernmental Panel on Climate Change). Adaptation planning also advanced, with 29 provinces releasing climate adaptation plans with growing attention given to climate-related health risks under China's first Health National Adaptation Plan (HNAP). Actions included heatwave early warnings and pilot climate-health literacy programmes in urban communities.

The 2024 China report of the *Lancet* Countdown on health and climate change continues to monitor the evolving links between climate risks and health outcomes. Coordinated by the Lancet Countdown Asia Centre at Tsinghua University with contributions from over 80 experts from 26 institutions, the report tracks 33 indicators across five thematic domains. This year, 17 indicators have been expanded to the city level, reflecting the need for more localised and actionable assessments (panel 1). Three new indicators—sleep loss from higher nighttime temperatures (indicator 1.1.4), compound heatwave-related mortality (indicator 1.1.5), and a sub-indicator on greenspace inequality (indicator 2.2.3)—were added, alongside the use of CRA40 reanalysis data to improve spatial accuracy in climate-health tracking. Two dedicated panels in this year's Countdown further enhance city-level insights. Together, the indicators and panels provide a multidimensional map of risks, gaps, and opportunities, to help cities move from awareness to evidence-based action.

Institute of Atmospheric Sciences (X Liu BS), **Fudan University, Shanghai, China; Zhongshan School of Medicine** (J Kang MD), **School of Public Health** (H Lin PhD, Q Wang PhD, D Zheng MS), **Sun Yat-sen University, Guangzhou, China; Pollution Management Research Group, Energy, Climate, and Environment Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria** (G Kiesewetter PhD, S Zhang PhD); **Department of Epidemiology, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China** (G Li MS, Prof W Ma PhD); **CMA Public Meteorological Service Centre** (Prof Y Liu PhD), **National Climate Center** (B Lu PhD), **China Meteorological Administration, Beijing, China; School of Airport Economics and Management, Beijing Institute of Economics and Management, Beijing, China** (Z Liu PhD); **Sustainability Economics of Human Settlements, Technical University Berlin, Berlin, Germany** (C Lu PhD); **The Bartlett School of Sustainable Construction** (Prof Z Mi PhD), **Institute for Global Health** (M Romanello PhD, M Walawender MPh), **University College London, London, UK; Department of Health Development Strategy and Health Care System Research, China National Health Development Research Centre, Beijing, China** (Prof Y Miao PhD); **Potsdam Institute for Climate Impact Research, Potsdam, Germany** (T Repke PhD); **Faculty of Architecture** (C Ren PhD), **Institute for Climate and Carbon Neutrality** (Prof P Gong PhD), **Department of Earth Sciences and Department of Geography** (Prof P Gong), **The University of Hong Kong, Hong Kong Special Administrative Region, China; Department of Physical Education** (Prof R Zhang MS), **Department of Public Health** (Prof Z Zhang PhD), **Peking University, Beijing, China; Business Intelligence Lab, Baidu Research, Beijing, China** (J Zhou PhD); **Department of Landscape Architecture and Environmental Planning, University of California, Berkeley, CA, USA** (Y Zhou MSc)

Correspondence to:
Prof Peng Gong, Department of Earth Sciences and Department of Geography, The University of Hong Kong, Hong Kong Special Administrative Region 999077, China
penggong@hku.hk

***Panel 1:* The 2025 China *Lancet* Countdown report indicators**

Climate change impacts, exposures, and vulnerability
- 1.1: health and heat
  - 1.1.1: heatwave-related mortality*
  - 1.1.2: change in labour capacity*
  - 1.1.3: heat and physical activity*
  - 1.1.4: sleep loss from higher nighttime temperatures*†
  - 1.1.5: compound heatwave exposure*†
- 1.2: health and extreme weather events
  - 1.2.1: wildfires*
  - 1.2.2: extreme rainfall and drought*
- 1.3: climate-sensitive infectious diseases*
- 1.4: population exposure to regional sea level rise*

Adaptation, planning, and resilience for health
- 2.1: adaptation planning and assessment
- 2.2: adaptation delivery and implementation
  - 2.2.1: detection, preparedness, and response to health emergencies
  - 2.2.2: air conditioning—benefits and harms
  - 2.2.3: urban greenspace*
- 2.3: climate information services for health
- 2.4: health risk early warning service

Mitigation actions and health co-benefits
- 3.1: energy system and health
- 3.2: clean household energy
- 3.3: air pollution, transport, and energy*
- 3.4: carbon emissions from health care

Economics and finance
- 4.1: health and economic costs of climate change and its mitigation
  - 4.1.1: economic costs of heatwave-related mortality*
  - 4.1.2: economic costs of heat-related labour productivity loss*
  - 4.1.3: economic costs of air pollution-related premature deaths*
  - 4.1.4: economic costs due to climate-related extreme events*
- 4.2: the economics of the transition to zero-carbon economies
  - 4.2.1: investment in new coal and low-carbon energy and energy efficiency
  - 4.2.2: employment in low-carbon and high-carbon industries
  - 4.2.3: net value of fossil fuel subsidies and carbon prices
  - 4.2.4: production-based and consumption-based attribution of carbon dioxide and $PM_{2·5}$ emissions
  - 4.2.5: stranded coal assets from the low-carbon transition*

Public and political engagement
- 5.1: media coverage of health and climate change
  - 5.1.1: coverage of health and climate change on social media
  - 5.1.2: newspaper coverage of health and climate change
- 5.2: individual engagement in health and climate change*
- 5.3: coverage of health and climate change in scientific journals
- 5.4: government engagement in health and climate change response

*Indicators with city-level results. †Newly added indicators.

Section 1: climate change impacts, exposures, and vulnerability

In response to the need for more localised and actionable assessments, this section tracks climate health risks with major methodological updates: spatial resolution that has been refined from 31 provinces to 375 cities, and CRA40 reanalysis data (produced by China Meteorological Administration and better aligned with observational data) that has been adopted for several applicable indicators (indicators 1.1.1, 1.1.4, 1.1.5, 1.2.2, and 1.3). To expand the understanding on heat-related health risks, two new indicators have been introduced: sleep loss from elevated nighttime temperatures (indicator 1.1.4) and compound heatwave exposure (indicator 1.1.5).

Indicator 1.1: health and heat

Indicator 1.1.1: heatwave-related mortality

As the climate changes, heatwaves are becoming increasingly frequent and intense, increasing death tolls worldwide.[1,2] In 2024, more than 20 100 premature deaths in China were related to heatwave exposure, 1·7 times more than the annual mean in the baseline period, 1986–2005. Of all heatwave-related mortality, 52·9% and 25·1% occurred in cities located in eastern and central China, respectively. At the city level, the highest attributable deaths occurred in Suzhou (5·1%), followed by Shanghai (3·4%), Wuxi (2·4%), Nanjing (2·0%), and Hangzhou (1·8%) for the total attributable deaths in 2024. Together, these five cities contributed to 14·7% of the total attributable deaths across all 375 cities, and the proportion of total population in these five cities is 4·8%. These data underscore the urgency of city-level actions to protect at-risk populations.

Indicator 1.1.2: change in labour capacity

Using finer-resolution climate data for 2025, this indicator reveals potential heat-related labour capacity loss at the city level for the first time in China. In 2024, potential work hours lost due to heat stress reached 40·1 billion hours (equivalent to 13·7 million full-time jobs), 49·1% higher than in 1986–2005 and 20·8% than in 2023. While most losses were in the agricultural sector, due to rapid urbanisation and increased industrialisation, the potential work hours lost in construction, manufacturing, and services continued to increase, which accounts for a combined total of 38·9% of the country's total losses.[3] The worst losses were mainly in cities in southern, southwestern, and central China. It is noteworthy that the fourth and fifth cities in China's gross domestic product (GDP) rankings, namely Guangzhou (1·0 billion hours lost) and Chongqing (0·9 billion hours lost), have the highest heat-related potential work hours lost, primarily attributable to their dense labour forces and heightened summer heat exposure.

Indicator 1.1.3: heat and physical activity

Climate change is increasing the frequency of hot and humid conditions, under which the health risks of outdoor exercise can surpass its benefits.[4–6] In 2024, extreme heat led to an average of 2·52 hours per day exceeding the caution threshold for outdoor activity across China, which is an 85·0% increase compared with the 1986–2005 baseline. The highest potential activity hours lost values were recorded in cities in Hainan, a province highly dependent on tourism and seeking to develop its health and wellness industry, with Wenchang (7·7 h), Danzhou (7·5 h), and Haikou (7·4 h) with the greatest losses. Every analysed city had an increase in potential activity hours lost due to extreme heat compared with the historical average. Notably, more than half of the 50 most affected cities were concentrated in Hainan, Guangdong, and Guangxi—all in the southeastern region of China—which underscores the need for more heat-resilient urban design to support safe physical activity in these regions.

Indicator 1.1.4: sleep loss from higher nighttime temperatures

Growing evidence shows that hot nights and the consequent reduced sleep duration pose a serious threat to health.[7,8] This new indicator estimates sleep loss from warmer nights using more than 11 million sleep records from 268 Chinese cities, combined with temperature data via a fixed-effects panel model (figure 1; appendix pp 9–12).

The average total sleep duration of the participants was 426 min per night including 110 min of deep sleep and 316 min of light sleep (appendix pp 11–12). When comparing 2015–24 with 1986–2005, higher nighttime temperatures were associated with an average estimated 9·2% more total sleep loss: 13·1% in deep sleep loss and 7·1% in light sleep loss. Notably, 2024 was a record high, with total sleep loss increasing by 14·9%, deep sleep loss increasing by 20·4%, and light sleep loss increasing by 12·1% (appendix pp 11–12). Most of the sleep loss occurred in summer. Cities with high sleep loss are mainly located in southern and southwestern China.

Indicator 1.1.5: compound heatwave exposure

Climate change is causing shifts in the timing and nature of heatwaves.[9] Based on our estimations,

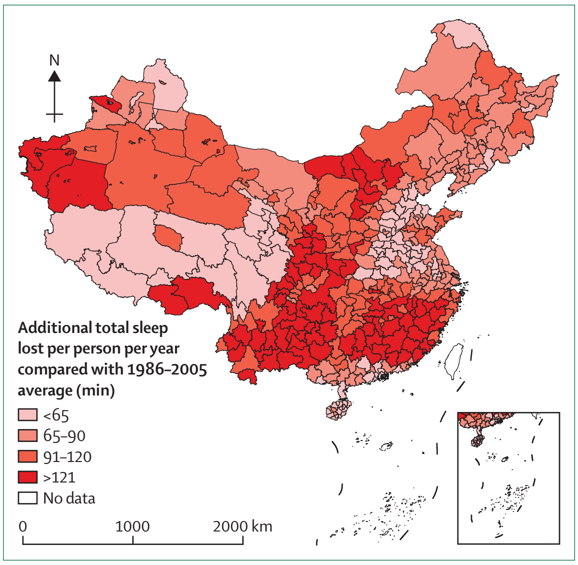

Figure 1: **The average net change in annual temperature-attributed total sleep loss in 2015–24, compared with 1986–2005**

day–night compound heatwaves pose substantially greater all-cause mortality risks and burdens than the combined effects of daytime-only and nighttime-only heatwaves (appendix pp 14–15), particularly in regions with wide summer temperature variation.[10] In 2024, people living in cities were exposed to 6·35 days of compound heatwaves, marking an increase of approximately 197·9% compared with the baseline period (1986–2015; 6·35 *vs* 2·13 days) and about 1·56 times more than observed in 2023 (6·35 *vs* 4·07 days). There were high numbers of compound heatwave areas in southeastern coastal regions, and in northwestern and southwestern China (appendix pp 14–15).

Indicator 1.2: health and extreme weather events

Indicator 1.2.1: wildfires

Although wildfire exposure in 2024 was lower than in 2023, the annual average wildfire exposure in person-days still increased by 61·8% in 2020–24 compared with the baseline period (2001–05). A total of 26 provinces showed an upward trend, with 18 (69·2%) seeing increases exceeding 100%. Among 375 cities, wildfire exposure increased in 270 (72·0%). For provinces with large land areas, the added value of city-level analysis is more apparent. For example, in Hunan Province, wildfire exposure increased in northern cities, even as the overall provincial trend was decreasing. Even when all cities within a province face increasing risks, growth rates can differ drastically; in Inner Mongolia, for instance, wildfire exposure in Wuhai increased by 120 times, compared with 53·0% in Hulunbuir, a disparity of more than 200 times. Policy makers should prioritise actions in high-risk regions accordingly.

See Online for appendix

Indicator 1.2.2: extreme rainfall and drought

Driven by climate change, extreme rainfall and drought events have become more frequent in China, posing growing health risks.[11,12] From 2015 to 2024, population exposure to extreme rainfall increased most in eastern China (appendix p 21), while drought exposure was more widely spread (appendix p 21). In 2024, population exposure to drought and extreme rainfall reached 14 686·8 million person-months and 5979·0 million person-events, respectively, 111·4% and 33·5% increases compared with 2023 (appendix pp 22–23).

Infectious diarrhoea poses a large disease burden in China,[13] with extreme hydrometeorological conditions as key risk factors.[14,15] Compared with 1986–2005, the annual average excess risk of infectious diarrhoea associated with extreme rainfall increased by 3·0% during 2015–24, especially in north and western China, while the risk related to drought increased by 1·9%, with the greatest increases in western China (appendix pp 22–23). There is substantial heterogeneity among cities within some provinces. For example, drought-related diarrhoea risk in Yunnan Province increased in the north but fell in the south, highlighting the need for localised health policies.

Indicator 1.3: climate-sensitive infectious diseases

Climate-sensitive infectious diseases refer to communicable diseases with epidemiological characteristics (eg, onset, development, and prevalence patterns) that are directly or indirectly influenced by meteorological and climate-related factors. Dengue fever is one of the most important climate-sensitive infectious diseases that is driven by urbanisation, globalisation, and climate change, and poses growing health and economic burdens.[16,17] The geographical spread of dengue fever cases in China has noticeably expanded since 2013.[18] This indicator assesses the impact of climate change on dengue transmission at the city level using two sub-indicators: vectorial capacity of *Aedes aegypti* and *Aedes albopictus* mosquitoes for dengue fever transmission, and China's dengue disease burden.

From 2004 to 2023, dengue vector transmission capacity increased across 204 (54·4%) of 375 cities, with the greatest increases in Southern China, particularly in Yulin, Laibin, Zhongshan, and Sanya (appendix p 27). Dengue caused 730 person-years of disability-adjusted life-years, rising to 874 in 2024, which is a sharp increase from just 21 in 2022.

Indicator 1.4: population exposure to sea level rise

Coastal areas are densely populated, economically active, and highly susceptible to storm surges and coastal flooding.[15,19] This indicator projects population exposure to future sea level rise in coastal cities, integrating regional sea level projections, extreme sea levels, population growth, hydrological connectivity, and coastal protection standards. The indicator estimates the share of a city's population exposed under different greenhouse gas emission scenarios. Under the low-emission shared socioeconomic pathways (SSPs) scenario (SSP1–2·6), the most exposed cities in 2100 include Taizhou (Jiangsu, 62%), Taizhou (Zhejiang, 49%), and Huzhou (47%). Under SSP5–8·5, exposure rises further, with Taizhou (Jiangsu, 77%), Nantong (70%), and Wuxi (61%) most affected. By 2100, total projected exposure along China's mainland coast is 41·1 million people for SSP1–2·6, 49·1 million for SSP2–4·5, and 66·4 million for SSP5–8·5. Reducing greenhouse gas emissions is crucial for minimising the long-term coastal risk.

Conclusion

In 2024, eight (61·5%) of the 13 tracked climate-related health risks reached record-high levels, including change in labour capacity, heat and physical activity restrictions, sleep loss from higher nighttime temperatures, excess risk of infectious diarrhoea attributed to drought and extreme rainfall, population exposure to drought and extreme rainfall, and climate-sensitive infectious diseases (last updated in 2023, with the historical high occurring in that year). Heat-related risks increased sharply compared with the historical baseline (1986–2005), with heatwave-related mortality (170%), labour productivity loss (42·2%), reduced outdoor physical activity hours (85·0%), and sleep loss rising (14·9%), along with a 20·4% increase in deep sleep loss.

City-level risk increases were striking in 2024. In most cities, the fastest-increasing climate-related health risk increased by more than 150% compared with the historical baseline (figure 2A), and nearly half faced multiple risks exceeding this threshold. The most common fastest-increasing risks were per person drought exposure (221 cities), compound heatwave exposure (65), and per person wildfire exposure (56). City-level analysis in 2025 has enabled more granular identification of risks often masked at the provincial level. For example, in Yunnan Province, drought-related infectious diarrhoea risk decreased in the south but increased in northern cities, while wildfire exposure increased in the north and declined in the south in Hunan Province. A city was defined as an outlier if its 5-year average increase was at least twice the provincial average, or if its trend increased while the provincial trend declined. Outliers were widespread: 47 cities for heat-related mortality, 20 for labour productivity loss, 45 for reduced physical activity, 107 for wildfire exposure, and 19 for climate-sensitive diseases. These findings underscore the importance of city-level assessments to inform targeted adaptation strategies.

Section 2: adaptation, planning, and resilience for health

With health risks rising under all climate scenarios, robust adaptation is essential. Meanwhile, accelerating

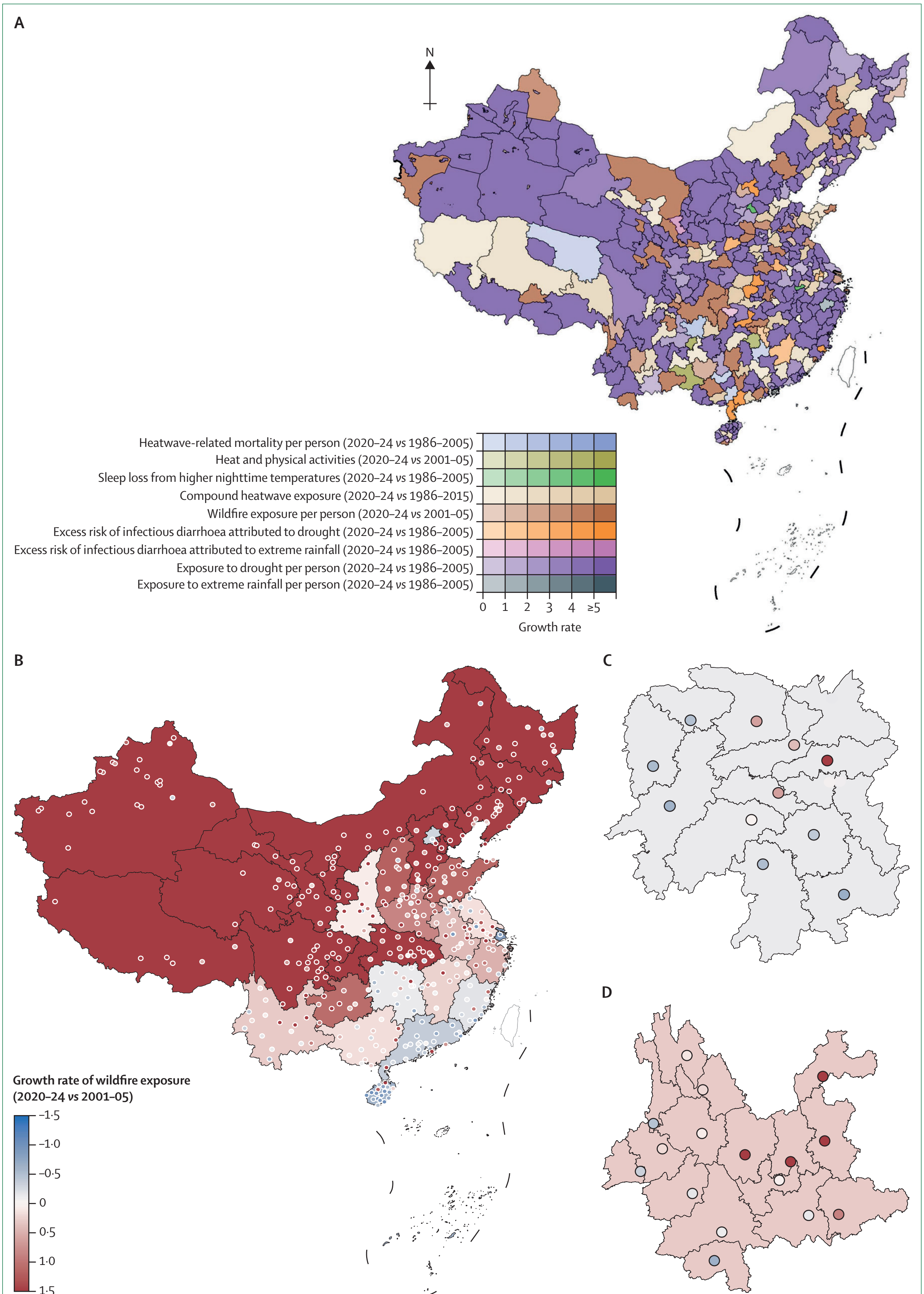

***Figure 2:* City-level climate-related health risks growth in China (2024)**
Fastest-increasing climate-related health risk per person in each city (A), city-level versus provincial-level increases: the case of wildfire exposure (B), detail of city-level wildfire exposure in Hunan Province (C; a zoom-in of panel B), and detail of city-level wildfire exposure in Yunnan Province (D; a zoom-in of panel B). The increase in risk is calculated as the average value within the past 5 years relative to the historical baseline. To ensure comparability across cities, all indicators are presented as per person values to remove the influence of population change, which could otherwise affect total exposure or impact trends. Only the single fastest-increasing risk is shown for each city in panel A; however, many cities face multiple climate-related health risks with increases exceeding 150%. In this Countdown, all such risks have been identified for each city (appendix pp 30–42). To highlight city-level patterns that might be masked by provincial averages, panel B compares the increase in a selected risk (wildfire) at the city versus provincial level. The colour of each province represents the provincial growth rate; each point represents a city, with the colour of each point indicating the city's growth rate. Similar comparisons for other indicators are also provided in the appendix (pp 42–44).

warming underscores the urgent need for ambitious mitigation to limit future harms and ensure that adaptation remains feasible. This section tracks China's heath adaptation measures with the following indicators: adaptation planning and assessment (indicator 2.1), adaptation delivery and implementation (indicators 2.2.1–2.2.3), climate information services for health (indicator 2.3), and health risk early warning services (indicator 2.4). With indicator 2.2.3, a new city-level Greenspace Exposure Inequity Index is introduced, with other sub-indicators also enhanced at the city level.

Indicator 2.1: adaptation planning and assessment

This indicator tracks national and provincial progress in health adaptation in China. As of April, 2025, 7 months after the release of China's first HNAP, a survey conducted by China's Center for Disease Control and Prevention (CDC) showed that 19 (63·3%) of 30 responding provinces implemented health adaptation measures in 2024, up from just five (16·1%) in 2023. Additionally, 22 (73·3%) provinces conducted health impact assessments, 12 (40·0%) conducted vulnerability assessments, and eight (26·7%) conducted adaptation assessments, marking slight improvements. Zunyi became the first city to announce a health adaptation plan. Key challenges remain: 77% of provinces reported a lack of multisectoral coordination, 67% cited insufficient funding, and 53% faced gaps in surveillance systems and risk assessment technologies.

Indicator 2.2: adaptation delivery and implementation

Indicator 2.2.1: detection, preparedness, and response to health emergencies

This indicator uses a multilevel index to measure provinces' capacities to respond to public health emergencies and combines 23 indicators, including risk exposure and preparedness, health emergency detection and early warnings, and medical resources. From 2022 to 2023, the national average score for public health emergency response capabilities increased from 75·55 to 78·81, reflecting a 4·4% improvement, which could have been driven by the increased health resources and improved primary health-care access. While inter-provincial disparities narrowed, eastern provinces still outperformed western ones, scoring 64% higher on average (68·2 east *vs* 41·5 west). Coastal regions, such as Guangdong face greater epidemic challenges, with infectious disease mortality rates surpassing those in the Yangtze River Delta for 2 years.

Indicator 2.2.2: air conditioning—benefits and costs

In 2023, air conditioner ownership among Chinese households increased, with approximately 76% of households owning at least a unit. Around 51 000 people avoided heat-related deaths due to air conditioning, roughly 2·2 times the number in 2021. However, the energy consumption of air conditioning systems typically accounts for about 50% of the building's (or non-residential building's) energy consumption.[20] While the urban heat island effect reduces heating demand in cold regions,[21] it also exacerbates heatwaves,[22] particularly in southeastern China where average temperatures are generally higher than 28°C in summer.[23] Addressing the effects of air conditioning on urban heat and energy consumption and expanding other cooling techniques are crucial for mitigating heatwaves and reducing carbon emissions.[24]

Indicator 2.2.3: urban greenspace

Living in green environments is linked to better mental health and lower mortality.[25,26] Greenspaces also help mitigate urban heat. This indicator uses a population-weighted Normalised Difference Vegetation Index (NDVI) to assess urban greenness and its impact on mortality. Notably, the year 2025 introduces a new evaluation of greenspace accessibility and inequity,[27,28] with spatial resolution refined from provincial to city level.

In 2024, the median NDVI was 0·381 (up 6·36% from 2023) with 68% of cities, especially in the north and west, seeing greenness growth. About 46% of cities had moderate or higher NDVI (≥0·4), with 27 more cities reaching high or very high levels. In 2024, the increase in greenspaces (compared with the reference period in 2013–23) is estimated to have been associated with 75 967 averted deaths in China (95% CI 56 320–116 637).

The new Greenspace Exposure Inequality Index, based on the Gini coefficient, showed modest improvement nationally (from 0·635 in 2021 to 0·608 in 2024) with the largest gains in south China. Shenzhen had the lowest inequality (0·195), while Ngari (0·879) and Guoluo (0·865) had the highest. City-level results highlight persistent disparities, especially in lower-income areas, emphasising the need for equitable greenspace policies.

Indicator 2.3: climate information services for health

In 2024, the health-meteorological survey expanded to 32 provincial meteorological bureaus and six national-level research institutions, covering ten areas including services, monitoring, early warning, risk assessment, research, and policy recommendations. Compared with 2023, 15 provinces and institutions newly launched health-meteorological services, with notable increases in the Public Meteorological Service Center of the China Meteorological Administration, Guizhou, Jiangxi, Shandong, and Chongqing. 18 provinces conducted health-meteorological risk assessments, and three provinces or municipalities issued joint health-meteorological warnings with local health departments. Examples include Tianjin issuing stroke risk warnings, Beijing conducting pollen monitoring with hospitals, and Zhejiang organising health-themed volunteer activities. These developments indicate growing momentum in integrating meteorological insights into public health responses.

Indicator 2.4: health risk early warning service

Early warning systems for health risks serve as crucial adaptation tools, delivering timely and accurate information to both decision makers and the public. This indicator monitors the advancement of early warning systems for health risks implemented by provincial and municipality-level CDCs, as assessed with a nationwide survey conducted by the China CDC in April, 2025. The early warnings for health risks related to climate change primarily include high temperatures (heatwaves) and low temperatures (cold waves). By 2024, the coverage of health risk early warnings for heatwaves had extended to two provinces and 25 municipalities, and to 17 provinces and 125 municipalities for warnings for low temperatures. In comparison to 2023, the number of people covered by health risk early warning systems increased by 203·2% in 2024, reaching 587·97 million. These warnings are predominantly distributed via the official websites, mobile applications, and WeChat accounts of local CDCs.

Conclusion

2024 witnessed noteworthy developments in China's climate-health adaptation. Driven by improved primary health-care access, the national health emergency response score increased by 4·4% to reach 78·81. The launch of the first HNAP has spurred localised action, leading to 23·5% of provinces developing local plans that prioritise evidence-based actions and health risk early warning systems. Provinces, such as Shandong, Yunnan, and Guizhou, are notable for having comprehensive policies at both provincial and city levels. In parallel, rising air conditioner ownership and improved vegetation cover (ie, NDVI), particularly in northern and western regions, have been crucial in mitigating climate-related health risks. Despite these advancements, sustained financial support remains essential to ensure the continued implementation of these crucial adaptation strategies.

Section 3: mitigation actions and health co-benefits

As the world largest carbon dioxide emitter, China's efforts to reverse emission growth and accelerate decarbonisation are crucial to both domestic and global public health. In 2024, the Chinese Government released a series of new mitigation policies, including the Work Plan to Accelerate the Establishment of a Dual-Control System for Carbon Emissions,[25] the 2024–2025 Energy Conservation and CO_2 Reduction Plan,[26] and the industrial expansion of the national carbon market. Compared with previous plans, these initiatives provide more detailed and sector-specific strategies, outlining key actions for various industries and incorporating carbon emission targets into national planning and the evaluation system for local officials. To track policy implementation, this section tracks China's progress on transitioning to a low-carbon energy system (indicator 3.1), clean household energy (indicator 3.2), air quality improvement and the associated health effects (indicator 3.3), and carbon emissions from the health-care industry (indicator 3.4).

Indicator 3.1: energy system and health

This indicator tracks changes in the carbon intensity of the Chinese energy system, coal phase-down, and renewable electricity development. In 2024, China's carbon intensity continued its downward trend, decreasing by approximately 5·3% from 2023. Meanwhile, carbon emissions increased by 0·5%, in line with a substantial GDP growth of 5·1%.

As the current system does not yet support the reporting of energy system progress in 375 Chinese cities, the status in all four provincial-level cities (ie, Beijing, Tianjin, Shanghai, and Chongqing) are reported here. These four municipalities accounted for 11% of China's GDP and 6% of its population in 2023. The shares of coal used in total energy consumption are 1·0% in Beijing, 31·7% in Tianjin, 30·3% in Shanghai, and 50·7% in Chongqing in 2022. Beijing and Tianjin both saw a rapid decline in coal consumption and its share of total energy consumption in recent decades. In contrast, Chongqing showed stable coal consumption while share in total energy consumption has been consistently declining, aligning with the national trend. Shanghai showed a modest increase in both coal consumption and its share of total energy consumption.

In 2024, power generation continued to grow, reaching 3702 terawatt hours for low carbon (16·6% increase *vs* 2023) and 3257 terawatt hours for renewable power generation (18·8% increase *vs* 2023) and accounting for 36·7% (low carbon) and 32·3% (renewable) of national power generation. Coal consumption also continued to rise, although at a slower rate, with an increase of 1·7% compared with 2023. Solar power generation saw the fastest growth, increasing by approximately 40% compared with 2023, followed by wind power at 14·7%. Meanwhile, the share of thermal power in total electricity generation decreased to 65·2% from 68·3% in 2023, primarily due to its slow growth rate of approximately 1·8%, which was substantially lower than the expansion rate of renewable energy capacity. Regionally, renewable electricity in the north increased by 20·5%, and by 19·4% in the northeast, 23·2% in the east, 22·7% in south central, 13·8% in the southwest, and 18·7% in the northwest region compared with 2023.

Indicator 3.2: clean household energy

Household energy use contributed 71% of indoor $PM_{2·5}$ concentrations,[27] primarily due to the incomplete combustion of solid fuels and kerosene used in cooking, which was associated with a mortality rate of 50·7 deaths per 100 000 people in China in 2019, making the

For the **Greenhouse gas and Air pollution Interactions and Synergies model** see https://iiasa.ac.at/models-tools-data/gains

promotion of cleaner household energy alternatives key to maintaining good health.[28]

From 2010 to 2022, China's per person residential energy consumption increased by 83·2%. The proportion of coal use decreased by 68·7%, with an absolute reduction of 42·6%, yet it still accounted for 7·8% of total household energy consumption in 2022. Meanwhile, the proportion of electricity use increased by 40·7%, with an absolute increase of 157·7%, reaching 24·3% of the total energy consumption in 2022. Compared with 2021, the per person energy consumption of urban residents increased by 2·4%, while that of rural residents increased by 7·9% in 2022. Growth in rural energy use has outpaced that of urban areas since 2010: the annual per person residential energy consumption of urban residents increased by 44·1% from 2010 to 2022, while consumption of rural residents grew by 151·5%, nearly four times higher than the increase in urban residents' energy consumption.[29] Analysis based on the China Family Panel Studies data[30] also shows that the overall inequality in energy consumption levels between urban and rural households in China is gradually decreasing, as energy transition policies are implemented and the process of urban–rural integration accelerates.[31] Historically, rural households relied on polluting solid fuels, leading to both energy and health disparities. The widespread promotion of clean energy substitution and rural electrification has considerably reduced these gaps, aligning urban and rural energy structures and improving household energy equity. According to the target set in the National Population Development Plan (2016–30) issued by the State Council, China aims for 70% urbanisation by 2030,[32] making electricity-related emissions the largest source of carbon emissions from urban households.[32] Prioritising low-carbon household electricity transformation can sharply reduce urban emissions without compromising development or public welfare.

Indicator 3.3: air pollution, transport, and energy

In 2024, $PM_{2·5}$ pollution in China reversed the increasing trend observed in 2023, declining from 31 μg per m³ in 2023 to 30 μg per m³. Similarly, the number of cities with $PM_{2·5}$ levels lower the WHO's Interim Target 1 (35 μg per m³) increased from 219 in 2015 to 233 in 2024,[33] highlighting that more urban areas are now meeting air quality targets. In the so-called 2+26 Cities—ie, Beijing, Tianjin, and 26 other prefectures of Hebei, Shandong, and Shanxi provinces in northern China with the highest pollution—the median $PM_{2·5}$ concentration dropped from 45 μg per m³ in 2023 to 41 μg per m³ in 2024, representing a 9% reduction. Compared with 2023, the annual daily maximum 8-hour average ozone concentration remains at 144 μg per m³, 6·7% higher than 2015. The number of cities meeting WHO's Interim Target 1 for ozone concentrations (160 μg per m³) decreased from 277 in 2015 to 256 in 2024,[33] This reduction was mainly attributed to pre-2017 nitrogen oxide reductions (ie, weakening the titration effect),[34] $PM_{2·5}$ declines that enhanced ozone formation,[35] and increased heatwaves resulting in emissions of anthropogenic volatile organic compounds.[36]

The Greenhouse gas and Air pollution Interactions and Synergies model is used to estimate premature deaths related to ambient $PM_{2·5}$ from different sectors and fuel types, at regional and country levels, and the megacities of Beijing, Chongqing, Shanghai, and Tianjin. 182 000 premature deaths per year were avoided between 2015 and 2022. The industry and household sectors were dominant contributors to premature deaths in 2022, accounting for 21% and 11%, respectively, which is 3% and 7% lower than in 2015. Northeast China had the largest number of avoidable premature deaths (55% of total), followed by eastern China (17%), and southwestern China (13%). For the megacities of Beijing, Chongqing, and Tianjin, 12 000 premature deaths have been avoided during the same period. The avoided premature deaths in these three megacities have occurred in the power, industry, and household sectors, due to the clean air policies in the regions.[37] Due to clean air policy (eg, fuel substitution), Beijing has the largest improvement in public health, followed by Chongqing, and Tianjin of the megacities.

In the road transport sector, pollutant emissions from each sector were estimated by combining vehicle types, fuel types, emission standards, travel distance, and emission factors. Since 2011, substantial progress has been achieved in reducing the emission intensity of nitrogen oxides, $PM_{2·5}$, and carbon monoxide from road vehicles in China. By 2024, the emissions of nitrogen oxides decreased to 3·90 million tons (56% reduction), $PM_{2·5}$ to 0·04 million tons (91% reduction), and carbon monoxide to 4·61 million tons (74% reduction) compared with 2023 levels. Vehicle electrification played a crucial role in reducing pollutant emissions, contributing to reductions of 8·5% for nitrogen oxides, 13·7% for $PM_{2·5}$, and 10·9% for carbon monoxide.

Indicator 3.4: carbon emissions from health care

This indicator adopted an environmentally extended input–output model to assess the carbon emissions of health-care sectors at provincial levels in China. In 2023, the sector's emissions reached 307·07 million tons, marking a 28% increase from 2020 levels (239·65 million tons), mirroring a 25·49% rise in China's total health expenditure[38] within the same period. Of the 31 studied provinces, the highest levels of emissions in their health-care sector were in Shandong at 44·87 million tons, in Hebei at 27·36 million tons, and in Guangdong at 20·72 million tons, possibly due to their high economic scale, population density, and concentration of medical resources. Chemical products including pharmaceuticals and medical consumables are the largest contributors, accounting for 50·9% of total emissions, reflecting the energy-intensive nature of chemical production and the widespread use of disposable medical supplies. Commercial and other services also contribute to 26·0% of emissions, mainly from hospital operations and logistics. The newly released HNAP emphasised emissions monitoring and the promotion of low-carbon health-care infrastructure.

Conclusion

In 2024, China's carbon emission intensity continued to decline, and green and low-carbon initiatives brought considerable health benefits by reducing air pollution. However, as many countries' commitment to climate goals fades, posing a challenge to achieving the 1·5°C temperature control target,[39–41] China, as a rising leader and the biggest single emitter in this field, has the potential to change trajectories. It is imperative to adopt more proactive emission reduction measures to reduce the health impacts of future climate change.

Section 4: economics and finance

Economic losses from climate change affect people's livelihoods and the economy, deteriorating the determinants of health. Energy transition is essential for good health, and so are the associated investments in a healthy present and future. This section assesses the economic and financial implications of climate change (indicators 4.1.1–4.1.4) and climate action (indicators 4.2.1–4.2.5) in China, with a new focus on city-level impacts this year. In panel 2 we discuss the importance of cost–benefit analysis of city-level climate action, highlighting the economic rationale for local responses. These insights provide essential evidence to support climate policies and economic decision making. Data in this section are presented in 2020 US$.

Indicator 4.1: health and economic costs of climate change and its mitigation

Indicator 4.1.1: economic costs of heatwave-related mortality

This year's methodology has been improved to estimate the total economic costs of heatwave-related mortality among working-age individuals at the city level from 2017 to 2024, using the 2017 Chinese city-level multi-regional input–output table (appendix pp 106–07).[61] The costs comprise both direct production losses from labour shortages and indirect costs from ripple effects propagating through supply chains. Due to the new climate data source used in section 1, historical results about economic loss of working-age mortality were re-estimated accordingly. In 2024, the national economic costs of heatwave-related mortality among working-age individuals reached US$42·7 million, representing a 1·27-times increase from 2023.

A paradoxical trend emerged: despite a 13·5% decrease in working-age mortality in 2024 relative to the 2017–21 baseline, total economic costs increased by 16·9%, which is attributed to a geographical redistribution of mortality towards economically crucial regions. This shift is evident as 39 cities had a more than 100% increase in direct economic costs, with 34 (87·2%) cities located in the middle-lower Yangtze River Plain. These cities serve as key industrial manufacturing hubs, highlighting their increasing vulnerability to climate-related challenges.

The economic impact was further amplified via supply chains, with indirect costs calculated to be 1·52 times greater than direct costs. These higher indirect costs underscore how extensive inter-sectoral and inter-regional disruptions magnify the overall economic consequences of heatwave mortality. Consequently, although a few cities gained economic benefits with multiregional trade, 84·3% of cities still incurred net economic losses. The concentration of these costs was stark, with 13 (86·7%) of the top 15 cities with the highest total economic costs located in Hunan, Hubei, and Jiangxi provinces. The three most affected cities in 2024 were Changsha ($3·53 million), Wuhan ($2·14 million), and Yichang ($1·66 million).

Indicator 4.1.2: economic costs of heat-related labour productivity loss

This indicator introduces a city-level assessment of the economic costs associated with heat-related labour productivity loss from 2020 to 2024. Estimates for years preceding 2024 have been recalibrated based on updated city-level data (appendix pp 108–09). In 2024, the national economic costs of heat-related labour productivity loss amounted to $282·6 billion, equivalent to 1·77% of China's GDP, marking a 23% increase from 2023 (ie, $229·8 billion, 1·45% of GDP). This sharp rise underscores the intensifying economic pressures imposed by climate change. These costs, comprising direct costs from immediate productivity reductions (65%) and indirect costs propagating via supply chain disruptions (35%), showed substantial spatial disparities. High-income cities, such as Shanghai, Guangzhou, and Shenzhen incurred the highest absolute costs ($8·9–$11·5 billion) but maintained lower relative costs (1·83–2·54% of local GDP, appendix p 113), which indicates that their larger economic bases and resource availability provide these cities greater resilience and adaptive capacity to climate impacts. In contrast, lower-income cities in southern provinces—particularly Qinzhou and Beihai (Guangxi) and Zhanjiang (Guangdong)—showed disproportionate susceptibility, with relative costs exceeding 4·9% of local GDP, despite lower absolute costs ($1·0–2·6 billion). Notably, Foshan in Guangdong emerged as an important target for intervention, registering both high absolute and relative costs ($5·8 billion, 3·43% of GDP), indicative of systemic climate risk exposure. In 2020–24, 49 (15·7%) of 312 cities had a more than 100% increase in economic costs, predominantly located in Shandong (13 cities), Hebei (9), and Liaoning (8) provinces. Despite starting from a low baseline ($0·01 billion), Tibet recorded the steepest growth trajectory with a 263% increase, highlighting

Panel 2: The importance of cost–benefit analysis of city-level climate actions in China

As cities constitute the fundamental units of climate action, city-scale cost–benefit analyses of climate actions provide a compelling scientific basis for promoting climate initiatives. In response to this need, this panel reviews existing research and summarises the costs and benefits of climate change actions at city level in China.

Mitigation actions generate health co-benefits via multiple pathways, including less air pollutant emissions, lower temperature rise, and alterations in precipitation patterns and extreme events distribution.[42,43] Most existing studies are conducted at national or provincial levels and have identified considerable health co-benefits. With specific conditions, these co-benefits can offset or even substantially exceed the costs of mitigation measures.[44–48] Only a few studies have analysed the benefits of mitigation actions for specific cities, most of which focus on the transportation sector in megacities. Beijing's transportation mitigation policies, including electric vehicle promotion and quota restrictions, are projected to prevent economic losses of up to US$2·26 billion.[49] Similarly, Suzhou's transition to electric transportation under the net-zero pathway could deliver carbon reduction and health benefits valued at $2·01 billion by 2050.[50]

Research that has compared benefits and costs is even fewer. One study examined transportation decarbonisation measures in Xiamen, finding that health benefits equalled or exceeded mitigation costs in some scenarios.[51] Another study discovered that the health benefits of replacing conventional vehicles with new energy vehicles in Chongqing exceeded government subsidies.[52] While existing city level studies support national and provincial findings that mitigation actions are cost-effective when health benefits are included, further localised research is needed to substantiate the cost-effectiveness in other cities.

Research on the cost–benefit assessment of climate change health adaptation measures at city-level in China also remains limited, with most empirical studies focusing on high-income cities in eastern China, such as Shanghai, Beijing, Shenzhen, and Qingdao. This focus on high-income cities is largely because they often serve as pilot sites for adaptation measures in China, benefiting from more comprehensive monitoring data and well-established impact evaluation frameworks. Consistent with findings from global and national studies, research conducted at city level in China has also shown that the benefits of implementing adaptation measures can outweigh the costs. Previous studies have reported a wide range of estimated cost–benefit ratios for adaptation measures implemented at city level, varying from approximately three to 20.[53–55]

Among these adaptation measures, heatwave early warning systems show the highest benefit–cost ratio,[55] largely due to their extensive coverage and large health benefits. A study conducted between October, 2021 and September, 2022 evaluated the effectiveness of the chronic obstructive pulmonary disease (COPD) early warning system in Shanghai, involving 2589 participants. The findings revealed that the incidence of acute attacks for COPD decreased by approximately 16·08% after the implementation of the early warning intervention, and the medical expenditure dropped by about 56·1%, from $466·1 to $204·6.[56] Another study showed that if 247 cities in China had implemented a heatwave early warning system in 2023, the estimated health benefits could have reached $20·25 billion, averaging approximately $82 million per city.[57] The benefit-to-cost ratio (BCR) of the heatwave early warning systems could reach 9–10.[54] However, it is important to note that the BCR of such interventions can vary considerably across cities. Wang and colleagues[16] highlighted that the effectiveness of the heatwave early warning system in Shenzhen was lower compared with Jinan and Qingdao.[57]

Green infrastructure measures—eg, greenspaces, green roofs, and cool walls—tend to have lower BCRs due to their lower coverage and higher installation cost. However, the long-term benefits of these measures could still exceed their costs. Compared with economic loss from heat-related labour productivity loss in the 2010s, cool walls in 231 cities could generate annual benefits of $260 million between 2050 and 2060 by reducing heat-related labour productivity losses, averaging $1·125 million per city. Similarly, green roofs could generate $210 million ($0·9 million per city), while cool ground surfaces could provide $190 million ($0·8 million per city).[58] Studies conducted in Beijing and Hong Kong have further shown that green roofs can achieve a lifecycle BCR ranging from 1·6 to 3·8,[53,58] highlighting their potential long-term economic viability despite higher upfront costs.

Many adaptation measures have not yet been systematically evaluated at the city level due to the limited research, despite documented effectiveness at national or provincial levels. These measures include cooling technologies, such as air conditioning[59] and strategic interventions, such as shifting work hours.[60] However, the increased use of air conditioning raises concerns regarding higher energy consumption and the resulting carbon emissions, which could lead to considerable external costs.[60] In contrast, strategic adaptation measures often do not need any explicit financial costs and still yield substantial health benefits.

Despite existing research indicating substantial health co-benefits from city-scale climate actions, there is an urgent need for more localised cost–benefit assessment studies. Current studies have primarily focused on economically developed cities, failing to adequately reflect the specific circumstances of cities at different developmental stages, scales, and geographical–climatic characteristics. Furthermore, the cost–benefit analysis of many mitigation and adaptation measures is insufficient. More comprehensive cost–benefit analyses at local levels are needed across sectors. Such localised analyses are essential to inform evidence-based, context-specific decision making, and can accelerate city-level climate actions.

distinct susceptibility pathways within China's economic geography.

Indicator 4.1.3: economic costs of air pollution-related premature deaths

This indicator updates the economic costs of $PM_{2·5}$-related premature deaths to year 2022 with data on $PM_{2·5}$ pollution from indicator 3.3. Using similar methods as indicators 4.1.1 and 4.1.2, both direct costs and indirect costs were evaluated. The national economic costs of $PM_{2·5}$-related premature deaths reached $7·3 billion in 2022 (0·046% of GDP), representing a decrease of 8·08% compared with 2015. Progress towards air pollution control seen since 2015 continued during 2022.[62] Among all provinces, Hebei (0·095% of GDP), Xinjiang (0·089%), and Henan (0·087%) were the top three provinces suffering the greatest economic costs relative to their GDPs. Four municipality-level cities—Beijing, Chongqing, Shanghai, and Tianjin—were further analysed. Between 2015 and 2022, these four cities showed a decline in economic costs relative to their local GDPs, aligning with the national trend—from 0·137% to 0·085% in Chongqing, 0·078% to 0·064% in Tianjin, 0·043% to 0·031% in Beijing, and 0·026% to 0·019% in Shanghai. Chongqing and Tianjin incurred higher economic costs in both absolute and relative terms compared with Beijing and Shanghai, indicating greater challenges in air pollution control. More specifically, Chongqing and Tianjin recorded the highest economic costs in the secondary industry (51–55% in Chongqing and 52–53% in Tianjin), whereas Beijing and Shanghai exhibited the highest economic costs in the tertiary industry (72–74% in Beijing and 55–59% in Shanghai). This divergence could be attributed to differences in economic structure, as Chongqing and Tianjin serve as major industrial hubs, while Beijing and Shanghai are more business-oriented and commerce-oriented.

Indicator 4.1.4: economic losses due to climate-related extreme events

This indicator tracks changes in economic losses due to climate-related extreme events, including droughts, floods, hailstorms, thunderstorms, cyclones, blizzards, and extreme low temperatures, using updated provincial-level data from 2012 to 2023. National economic losses due to climate-related extreme events peaked in 2021 at $215·2 billion (1·26% of GDP), sharply declining to $64·4 billion (0·40% of GDP) in 2022, before rising to $80·0 billion (0·51% of GDP) in 2023. The peak observed in 2021 was primarily driven by unprecedented rainfalls and floods in Henan, a key economic hub in central China, which accounted for 41% of direct damage and 90% of indirect losses nationwide that year. At the city level, between 2012 and 2023, Chongqing had the highest economic losses from climate-related extreme events among the four municipality-level cities, with losses ranging from $0·5 billion (0·13% of its GDP) in 2019 to $6·2 billion (1·74% of its GDP) in 2020. Both Beijing and Tianjin had similar loss patterns, possibly because of their geographical proximity. In 2023, the total economic losses in Beijing and Tianjin surged considerably, reaching $10·7 billion (1·91% of Beijing's GDP) and $0·86 billion (0·38% of Tianjin's GDP), mainly due to a record-breaking rainfall and flooding caused by Typhoon Doksuri (appendix pp 123–25).

Indicator 4.2: the economics of the transition to zero-carbon economies

Indicator 4.2.1: investment in new coal and low-carbon energy and energy efficiency

This indicator monitors changes in China's investments in new coal power generation and low-carbon energy. Despite a 52·4% increase in investment in new thermal power generation (from $14·2 billion in 2023 to $21·6 billion in 2024), there was a 12·1% decline in new thermal power generation capacity (from 65·7 gigawatts [GW] in 2023 to 57·7 GW in 2024).[63] This growth in investment was primarily driven by a 73·4% increase in unit installation costs from 2023, stemming from rising raw material prices and higher environmental protection costs.[64,65] The new capacity of renewable energy expanded by 23% compared with 2023, reaching 371·6 GW in 2024, with corresponding investment rising by 11%, from $105·9 billion in 2023 to $117·3 billion in 2024. The new capacity of low-carbon energy (including hydrological, wind, solar, and nuclear power) continued to grow steadily, reaching 375·5 GW in 2024. However, due to the rising unit costs of new thermal power capacity, the investment ratio between low-carbon energy and thermal power declined from 8·4:1 in 2023 to 6·4:1 in 2024.

At the provincial level, Xinjiang ($9·2 billion), Inner Mongolia ($7·3 billion), and Jiangsu ($4·6 billion) were the top three provinces for renewable energy investment in 2024. For the four municipality-level cities, notable discrepancies exist between investment and capacity expansion in renewable energy. In 2024, Chongqing's new renewable energy capacity (2·48 GW) was 13·8 times greater than Beijing's (0·18 GW), while new renewable energy capacity in Tianjin reached 2·29 GW and in Shanghai reached 1·09 GW. Challenges, such as overcapacity in upstream manufacturing and global policy uncertainty, highlight the need for China's renewable energy investments not only in expanding renewable energy installation capacity, but also in optimising system efficiency.

Indicator 4.2.2: employment in low-carbon and high-carbon industries

This indicator tracks both direct and indirect employment in renewable energy sectors and direct employment in fossil fuel extraction industries using data from the International Renewable Energy Agency[66] and the China Premium Database (CEIC).[67] In 2023, employment in the renewable energy sector in China had its fastest growth in nearly a decade, rising from 5·53 million employees in 2022 to 7·39 million in 2023, an increase of 34%. This growth was primarily driven by a 54% surge in solar sector employment. Conversely, severe droughts caused by extreme heat in 2023 led to substantial reduced hydropower generation, and a 10% decline in hydropower employment. Also, employment in the fossil fuel sector saw a slight decline, decreasing from 3·138 million in 2022 to 3·135 million in 2023.

Indicator 4.2.3: net value of fossil fuel subsidies and carbon prices

This indicator uses the same methodology as the previous report.[68] Contrary to the rapid growth trend observed from 2020 to 2022, fossil fuel subsidies in China declined 40% from 2022, but still amounted to $75 billion in 2023. This decline is attributable to reduced subsidies for electricity and natural gas. Notably, China has maintained a downward trend in its contribution to total fossil fuel subsidies worldwide since 2016, which decreased from 7·5% in 2022 to 6·8% in 2023. Amid a global decline in carbon prices,[69] the carbon price in China's national carbon emissions trading market increased by 41·9% from $9·1 in 2023 to $12·9 in 2024, driven by expectations of tighter quotas and stricter penalties for violations,[70] boosting demand for quota purchases.[71] Meanwhile, the average carbon price across China's eight pilot carbon emissions trading markets decreased by 6·6% from $8·1 in 2023 to $7·6 in 2024.[63] Originally established as provincial and municipal carbon trading systems, these pilot markets now primarily cover industries not yet included in the national carbon emissions trading system. This decrease was primarily due to a 32·8% drop in Guangdong's carbon price from 2023 to 2024, caused by the postponed compliance deadline, which has reduced short-term quota demand.[71] However, carbon prices in the pilot markets increased by 24·0% in Chongqing, 1·5% in Tianjin, and 16·3% in Shanghai. Although the carbon price in Beijing's pilot market fell by 5·0% year-on-year (from $16·1 in 2023 to $15·3 in 2024), it remained among the highest in China. Policy advanced considerably as the national carbon market expanded to include approximately 60% of total emissions by adding the steel, cement, and electrolytic aluminium sectors in 2024. Furthermore, China enacted its first climate-specific law, the Interim Regulation on Carbon Emission Trading, marking substantial progress.

Indicator 4.2.4: production-based and consumption-based attribution of carbon dioxide and $PM_{2·5}$ emissions

This indicator investigates carbon dioxide and $PM_{2·5}$ emissions generated by the production of goods and services traded among Chinese cities.[72,73] In 2019, net inter-city trade accounted for 57·1% of China's carbon dioxide emissions, while in 2020, it contributed to 50·4% of $PM_{2·5}$ emissions. Economic hub cities, primarily driven by the service sector, had larger consumption-based emissions than production-based emissions. In Beijing, consumption-based carbon dioxide and $PM_{2·5}$ emissions were 2·72 and 4·21 times higher than their respective production-based emissions, while in Shenzhen, these ratios reached 4·10 and 3·74. In contrast, cities with heavy industries or energy industries had larger production-based emissions than consumption-based emissions. In Tangshan, where iron and steel production are the main industries, production-based carbon dioxide and $PM_{2·5}$ emissions were 6·55 and 5·25 times higher than their consumption-based emissions. Similarly, in Yulin and Erdos, where energy production is one of the most important industries, production-based carbon dioxide emissions were 5·90 and 4·08 times higher than their consumption-based emissions.

Indicator 4.2.5: stranded coal assets from the low-carbon transition

Stranded assets refer to the lost financial value of coal-fired units retired early due to carbon emission restrictions. This indicator estimates the value of stranded coal assets from the low-carbon transition in line with achieving the 1·5°C climate target. New to 2025, planned coal-fired units are excluded from the coal power plant database and the stranded assets estimates are re-calculated and presented at the city level. Based on the current state of coal power plants until the end of 2023, the stranded coal assets in 2030 would be $7·08 billion. However, as new coal-fired units joined forces in 2024, more coal assets would need to be stranded to keep the 1·5°C target viable and estimated to be $8·57 billion, 21% larger than the previous-year estimate. The three cities with the highest stranded asset values in 2030 are Ordos (Inner Mongolia, $498 million), Bijie (Guizhou, $273 million), and Xuchang (Henan, $266 million). Currently, China is retrofitting coal-fired power plants to allow for less utilisation hours, which implies that stranded coal assets would be lower than the current estimates.[74–76] However, the stranded asset values would still reach $6·6 billion in 2030 under a 20% reduction in utilisation hours scenario, or $5·2 billion under a 30% reduction scenario. This large number implies that every dollar of new investment into coal is adding to the future bill of transition risks. Avoiding such investments requires clear coordination between central and local governments, given their differing roles and incentives.

Conclusion

Despite continued progress in air pollution control, the economic burden from heatwave-induced mortality and labour productivity losses has surged. This trend exacerbates occupational health risks, particularly in industrial cities across middle and southern China, highlighting their growing susceptibility. Meanwhile, economic losses from climate extremes, such as severe floods and typhoons, are shifting northward to cities in Hebei and Beijing. While renewable energy investment is rising, notable regional disparities challenge an equitable low-carbon transition and hinder clean air initiatives. Additionally, financial risks from stranded coal assets have intensified, with cities, including Ordos, Bijie, and Xuchang, facing high potential losses and residents facing prolonged exposure to coal-derived $PM_{2\cdot5}$ pollution.

As cities are central to addressing these diverse climate risks,[77] they should prioritise tailored, integrated adaptation and mitigation strategies, reinforced by inter-city cooperation. Expanding the carbon market will further strengthen incentives for decarbonisation. This strategic transition can transform urban climate risk hotspots into hubs of sustainable growth,[78] enhancing economic resilience, fostering long-term productivity, and creating substantial green investment opportunities.

Section 5: public and political engagement

This section examines engagement with climate change and health across different societal sectors, including media (indicator 5.1), individuals (indicator 5.2), academia (indicator 5.3), and government (indicator 5.4). By highlighting the essential role of public and political engagement in driving climate action, this indicator offers a comprehensive overview of the ongoing discourse.

Indicator 5.1: media coverage of health and climate change

Indicator 5.1.1: coverage of health and climate change on social media

This indicator analyses Weibo content from five media accounts between 2010 and 2024: official (@People's Daily and @Xinhua News), commercial (@The Beijing News and @The Paper), and professional media (@Health Times). From 2010 to 2024, climate change-related posts increased from 99 to 2108 annually, while the share of health-related content peaked at 17% (583 from 1884) in 2020 but dropped to 4% (84 from 2108) in 2024. In 2024, total climate posts decreased by 19·5% (2108 *vs* 2618) from 2023, and health-climate posts declined by 21·0% (124 *vs* 157). Summer accounted for 47·2% of seasonal coverage, dominated by extreme heat, heavy rainfall, and typhoons. Official media emphasised policies and disaster response, commercial outlets focused on breaking events, and professional media provided expert insights. In 2024, semantic analysis showed greater prominence of action-oriented terms, including "early warning" and "emergency response" within the climate-health discourse.

Indicator 5.1.2: newspaper coverage of health and climate change

With both print and online versions, mainstream newspapers play a crucial role in shaping public and political responses to climate change.[1] This indicator tracks climate and health coverage in 34 major provincial newspapers across China from 2008 to 2024, with a focus on regional differences. On average, 27 026 articles covered climate change annually, with 1475 articles (5·5%) addressing health. In 2024, coverage increased to 42 931 articles—a 10% increase from 2023—although growth has slowed since the COVID-19 pandemic. Health-related articles peaked at 2766 in 2020 and declined to 1650 in 2024, slightly less than 2023 levels. In 2024, Shandong (2421 articles), Heilongjiang (1753 articles), and Jiangsu (1715 articles) led in overall climate reporting, while Jiangsu (72 articles), Heilongjiang (60 articles), and Shaanxi (60 articles) topped coverage on health and climate change in 31 mainland China provinces. These disparities highlight the need for more balanced media engagement on climate-health topics nationwide.

Indicator 5.2: individual engagement in health and climate change

From 2022 to 2024, individual engagement (ie, the proportion of Chinese users searching climate change and health-related keywords on Baidu, China's largest search engine) with climate change and health declined. Climate change queries fell by 8·97% in 2023 and by another 32·93% in 2024, which might reflect public desensitisation due to the normalisation of extreme weather events. Provincially, arid northern regions showed more engagement—Inner Mongolia and Gansu had query rates of 33·12% and 25·89% higher than the national average, possibly due to greater local climate impacts. City-level analysis reveals that larger cities (urban populations of more than 5 million) had higher engagement, with query rates 9·95% more than smaller cities and 6·59% higher than the national average. These trends highlight growing disparities in public attention and suggest the need for targeted communication strategies to sustain public awareness and action on climate-health issues.

Indicator 5.3: coverage of health and climate change in scientific journals

This indicator monitors scientific articles on climate change and health published in both English and Chinese journals. Data from 2009 to 2024 were obtained from OpenAlex and Baidu Scholar. The research methodology and keyword aspects of data acquisition for this study have not changed from last year. Between 2009 and 2024, there are 51 294 English-language papers related to climate change and health, of which 4942 are related to China, accounting for 9·34% of the total. During this period, 1731 Chinese-language papers were identified. The number of articles published in both English and Chinese declined in 2024 compared with 2023, decreasing from 613 English articles to 444, and 337 Chinese articles to 290. This decrease represents

Panel 3: **City-level climate and health research in China**

To understand the state of the research on climate and health at city level in China, we reviewed Chinese climate-health research articles published between 1991 and 2024 (see appendix pp 162–63). Urban-scale climate-health research in China grew substantially, with an average annual increase of 18·4%. Early studies (1993–2005) mainly focused on traditional air pollution indicators, such as sulphur dioxide and total suspended particulate, examining their associations with acute health outcomes, including respiratory diseases and mortality. In recent years, however, research has shifted towards broader climate-related exposures, such as extreme heat, $PM_{2·5}$, humidity, and wind speed, and their effects on cardiovascular and respiratory diseases, and general health risks. This shift reflects intensified global climate change, progress in China's environmental governance, and evolving public health policy priorities. Notably, meteorological factors have gained increasing prominence.

The geographical distribution of studies is highly concentrated in China's three major urban clusters: the Beijing–Tianjin–Hebei Urban Agglomeration, the Pearl River Delta, and the Yangtze River Delta. In Beijing, studies primarily examined temperature, $PM_{2·5}$, and relative humidity, with health outcomes focusing on respiratory and cardiovascular diseases. Shanghai's research emphasised temperature, humidity, and extreme heat in relation to mortality and respiratory illnesses. In Tianjin, the focus was on PM_{10} and extreme temperatures, with ischaemic stroke and mortality as key outcomes.

The most frequently analysed meteorological variables were: temperature, $PM_{2·5}$, humidity, relative humidity, and wind speed. The most studied health outcomes included general health risks, respiratory diseases, mortality, and cardiovascular diseases.

The current research landscape reveals notable mismatches between study focus and actual urban needs. First, there is a geographical mismatch: the most heavily studied cities—Beijing, Shanghai, and Tianjin—are not necessarily those facing the most acute or rapidly escalating climate-health risks. In fact, nearly all Chinese cities have fast-growing risks, with many underrepresented cities showing three to four major risk factors that have not yet been adequately addressed in the literature. Second, a mismatch exists in the coverage of risk factors. Current research predominantly concentrates on heat-related and humidity-related risks (which are often linked), and wind speed, while emerging threats related to extreme weather events—eg, droughts, wildfires, and compound heatwaves—are among the most rapidly increasing and socially salient risks, yet remain overlooked in existing city-level studies. Third, the scope of health outcomes lacks coherence and consistency. While some studies adopt general or non-specific definitions of health risk, others narrowly focus on the incidence of a single disease, with little attention given to comprehensive burden-of-disease assessments, such as disability-adjusted life-years of years of life lost. These discrepancies highlight the need to recalibrate research priorities to better align with the dynamic and heterogeneous climate-health risk profiles of Chinese cities.

a reduction of 27·6% for English articles and 14·0% for Chinese articles relative to their 2023 publication volumes. Moreover, this year, we have considered China's city-level climate and health research. Panel 3 provides an overview of Chinese scientific literature on urban climate-health risks, revealing research oversights.

Indicator 5.4: government engagement in health and climate change response

This indicator monitors government engagement in health and climate change in 2023–24. The data covers policy documents published online in December, 2024, on five national-level administrations, namely, the Ministry of Ecology and Environment of the People's Republic of China, the National Health Commission of the People's Republic of China, the Ministry of Housing and Urban-Rural Development, the National Development and Reform Commission, and the National Disease Control and Prevention Administration. Systematically collected keywords related to key topics were extracted from the official websites. The analysis showed that in 2024, 2443 articles were related to climate change and 464 (19·0%) related to a topic on climate and health. The number of articles related to climate change increased by 10·3% compared with 2023.

Conclusion

From 2023 to 2024, coverage of climate change and health declined across media channels, with mass media showing a sharper drop than professional outlets. Discussions shifted toward proactive topics, such as early warnings and emergency response, which echoes our findings on rising economic losses from climate extremes and evidence that city-level actions (panel 2) can yield benefit–cost ratios up to 9:1, underscoring the urgency of targeted urban climate-health policies and investments.

Conclusion of the 2025 China report of the *Lancet* Countdown on health and climate change

In 2024, climate-related health threats in China intensified, with eight (61·5%) of 13 tracked risks reaching record highs (figure 3). Heatwave-related deaths surpassed 20 100—1·7 times the historical average—causing $42·7 million in economic losses among working-age adults (indicators 1.1.1 and 4.1.1). Heat stress led to 40·1 billion work hours lost, equivalent to $282·6 billion or 1·77% of GDP (indicators 1.1.2 and 4.1.2). Daily outdoor activity was reduced by 2·52 h, and warmer nights caused 1383 min of sleep loss per person annually (indicators 1.1.3 and 1.1.4). Compound heatwave exposure increased by 197·9%

(indicator 1.1.5), while wildfire exposure increased by 61·8%, which was higher than early-2000s levels (indicator 1.2.1). Risks from extreme rainfall and drought also grew, with excess diarrhoea risk up 3·0% and 1·9%, respectively (indicator 1.2.2).

Despite progress, mitigation needs to accelerate to meet China's climate goals. Carbon dioxide emissions increased by 0·5% in 2024, with coal still contributing to 64·9% of the energy mix (indicator 3.1). Solar and wind power expanded by 42·6% and 24·9%, and carbon pricing grew 43·4% (indicators 3.1 and 4.2.3). However, coal investments surged 52·4%, underscoring the need to prevent high-carbon lock-in (indicator 4.2.1). Adaptation showed gains: provinces with health plans increased from five to 19 (indicator 2.1), and emergency systems and nature-based solutions, such as urban greening, helped reduce heat deaths (indicators 2.2.1–2.2.3). Yet, uneven capacity remains, especially in susceptible areas.

City-level risks are more unequal than provincial averages suggest. In 2024, 107 cities had wildfire exposure far higher than provincial levels (indicator 1.2.1), and five cities accounted for nearly 15% of heatwave deaths

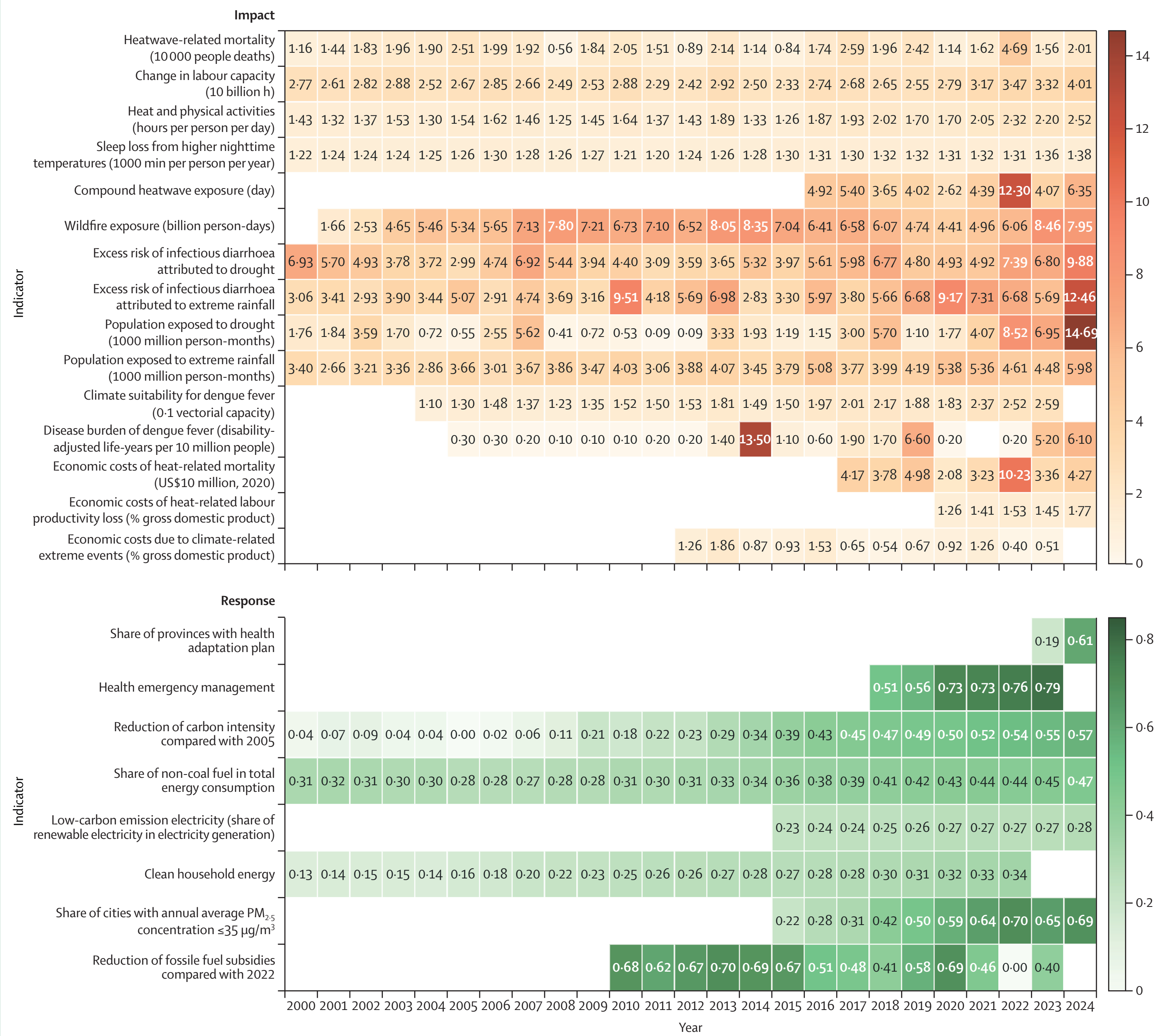

***Figure 3:* An overview of impacts and responses tracked in the 2025 China report of the *Lancet* Countdown on health and climate change**

The colour in each block represents the level of impacts and responses. The darker the colour, the more severe the impacts and the more effective the responses.

(indicator 1.1.1). Coastal and southern cities face high compound heatwave, night heat stress, and dengue risks. Some cities' climate health costs exceed 4·9% of local GDP (indicator 4.1.4). Although cities, such as Shanghai and Chongqing, have advanced renewable energy and carbon pricing (indicators 3.1 and 4.2.3), many high-risk cities remain under-researched and under-supported.

Intensifying climate-health threats demand that cities lead coordinated action. Accelerating a fair, low-carbon transition and bolstering health-centric adaptation are crucial for safeguarding public health and urban resilience. Although a detailed city typology was beyond this Countdown's scope, future targeted research to develop context-specific policies and inclusive planning to ensure equitable outcomes are essential to this effort, offering a valuable and actionable blueprint for other nations facing similar challenges.

Contributors

The 2025 China report of the *Lancet* Countdown on health and climate change is an academic collaboration that builds upon the work of the 2015 *Lancet* Commission on health and climate change and the *Lancet* Countdown: tracking progress on health and climate change, specifically in the Chinese context. This 2025 China report is the annual update of the *Lancet* Countdown on health and climate change and was conducted by five working groups 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. Authors contributing to Working Group 1 are CHu (lead), YB, LC, LF, HK, GL, QL, ZhaL, XL, ZeL, SL, WM, GM, FY, RZ, ZZ, and QZ. Authors contributing to Working Group 2 are CR (lead), WF, JHua, HH, JSJ, TL, BLin, YLi, BLu, XT, QinW, QioW, MY, ZY, and YZ. Authors contributing to Working Group 3 are ShaoZ (lead), BC, GK, HualL, HuanL, ZhuL, CL, YM, RS, YW, YY, DZ, and HZ. Authors contributing to Working Group 4 are YH (lead), DG, CHo, BLi, ZM, JSh, HW, ShanZ, and MZ. Authors contributing to Working Group 5 are JSu (lead), XH, Q J, YS, WW, SW, HX, JZha, and JZho. The coordination, strategic direction, and editorial support for this Countdown was provided by WC, CZ, ShiZ, JC, PG, JHuan, XJ, JK, WL, YLu, MR, MW, CW, BX, XY, and LY.

Declaration of interests

We declare no competing interests.

Acknowledgments

We thank the National Key R&D Program of the Ministry of Science and Technology, together with the National Natural Science Foundation of China, and the Youth Innovation Team of China Meteorological Administration for their financial and strategic support. We thank the projection authors for developing and making the sea level rise projections available, multiple funding agencies for supporting the development of the projections, and the NASA Sea-Level Change Team for developing and hosting the Intergovernmental Panel on Climate Change Assessment Report 6 Sea-Level Projection Tool. We are grateful for the technical support from Yufu Liu and Zheng Tao (Tsinghua University); Mingyu Li (Peking University); Liang Zhao (Chinese Academy of Sciences); Renjie Chen and Jiangdong Liu (Stanford University); Jiacan Yuan and Hu Jin (Fudan University); Baichao Zhang (China Meteorological Administration); Xinlu Sun and Heran Zheng (University College London); Chao Jiang (Green Hospital Committee China Association of Building Energy Efficiency); Kunli Tang and Xueyuan Wang (Zhejiang Gongshang University); Zhenghong Zhu (Sun Yat-sen University); Wenxuan Dong (Tsinghua University); Lu Liang (University of California, Berkeley); Hanyi Wu (Tsinghua University); and Xinyu Yang and Runli Hui (Renmin University of China). The funding sources provided financial and strategic support only. They had no role in the study design, data collection, data analysis, interpretation, or manuscript preparation.

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

References

1 Burkart KG, Brauer M, Aravkin AY, et al. Estimating the cause-specific relative risks of non-optimal temperature on daily mortality: a two-part modelling approach applied to the Global Burden of Disease Study. *Lancet* 2021; **398:** 685–97.
2 Xi D, Liu L, Zhang M, et al. Risk factors associated with heatwave mortality in Chinese adults over 65 years. *Nat Med* 2024; **30:** 1489–98.
3 Cheng L, Gu K, Zhao L, et al. Projecting future labor losses due to heat stress in China under climate change scenarios. *Sci Bull* 2023; **68:** 2827–37.
4 WHO. Global action plan on physical activity 2018–2030: more active people for a healthier world. June 1, 2028. https://www.who.int/publications/i/item/9789241514187 (accessed March 1, 2025).
5 Sallis JF, Cerin E, Conway TL, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. *Lancet* 2016; **387:** 2207–17.
6 Boakye K, Bovbjerg M, Schuna J Jr, et al. Urbanization and physical activity in the global Prospective Urban and Rural Epidemiology study. *Sci Rep* 2023; **13:** 290.
7 Romanello M, Walawender M, Hsu SC, 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.
8 Romanello M, Napoli CD, 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.
9 GBD 2021 Diarrhoeal Diseases Collaborators. Global, regional, and national age-sex-specific burden of diarrhoeal diseases, their risk factors, and aetiologies, 1990–2021, for 204 countries and territories: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet Infect Dis* 2025; **25:** 519–36.
10 Wang P, Asare E, Pitzer VE, Dubrow R, Chen K. Associations between long-term drought and diarrhea among children under five in low- and middle-income countries. *Nat Commun* 2022; **13:** 3661.
11 Nguyen AT, Grembi JA, Riviere M, et al. Influence of temperature and precipitation on the effectiveness of water, sanitation, and handwashing interventions against childhood diarrheal disease in rural Bangladesh: a reanalysis of the WASH Benefits Bangladesh trial. *Environ Health Perspect* 2024; **132:** 47006.
12 Messina JP, Brady OJ, Golding N, et al. The current and future global distribution and population at risk of dengue. *Nat Microbiol* 2019; **4:** 1508–15.
13 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.
14 Ni H, Cai X, Ren J, et al. Epidemiological characteristics and transmission dynamics of dengue fever in China. *Nat Commun* 2024; **15:** 8060.
15 Muis S, Verlaan M, Winsemius HC, Aerts J, Ward PJ. A global reanalysis of storm surges and extreme sea levels. *Nat Commun* 2016; **7:** 11969.
16 Wang Z, Calautit J, Tien PW, et al. An occupant-centric control strategy for indoor thermal comfort, air quality and energy management. *Energy Build* 2023; **285:** 112899.
17 Fan Y, Wang Z, Li Y, Wang K, Sun Z, Ge J. Urban heat island reduces annual building energy consumption and temperature related mortality in severe cold region of China. *Urban Clim* 2022; **45:** 101262.
18 Piticar A, Cheval S, Frighenciu M. A review of recent studies on heat wave definitions, mechanisms, changes, and impact on mortality. *Forum geografic* 2019; **XVIII:** 96–114.
19 He B-J, Wang J, Zhu J, Qi J. Beating the urban heat: situation, background, impacts and the way forward in China. *Renew Sustain Energy Rev* 2022; **161:** 112350.
20 Degirmenci K, Desouza KC, Fieuw W, Watson RT, Yigitcanlar T. Understanding policy and technology responses in mitigating urban heat islands: a literature review and directions for future research. *Sustain Cities Soc* 2021; **70:** 102873.

21 Lee ACK, Jordan HC, Horsley J. Value of urban green spaces in promoting healthy living and wellbeing: prospects for planning. *Risk Manag Healthc Policy* 2015; **8:** 131–37.

22 van den Berg M, Wendel-Vos W, van Poppel M, Kemper H, van Mechelen W, Maas J. Health benefits of green spaces in the living environment: a systematic review of epidemiological studies. *Urban For Urban Green* 2015; **14:** 806–16.

23 Iungman T, Cirach M, Marando F, et al. Cooling cities through urban green infrastructure: a health impact assessment of European cities. *Lancet* 2023; **401:** 577–89.

24 Yu Z, Yang G, Lin T, et al. Exposure ecology drives a unified understanding of the nexus of (urban) natural ecosystem, ecological exposure, and health. *Ecosyst Health Sustain* 2024; **10:** 0165.

25 General Office of the State Council. Work plan to accelerate the establishment of a dual-control system for carbon emissions. July 30, 2024. https://www.gov.cn/zhengce/content/202408/content_6966079.htm (accessed March 10, 2025).

26 State Council. 2024–2025 energy conservation and CO_2 reduction plan. May 23, 2024. https://www.gov.cn/zhengce/zhengceku/202405/content_6954323.htm (accessed March 5, 2025).

27 Yun X, Shen G, Shen H, et al. Residential solid fuel emissions contribute significantly to air pollution and associated health impacts in China. *Sci Adv* 2020; **6:** eaba7621.

28 WHO. Air pollution attributable death rate (per 100 000 population, age-standardized), household. 2025. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/household-air-pollution-attributable-death-rate-(per-100-000-population-age-standardized) (accessed March 20, 2025).

29 National Bureau of Statistics of China. China statistics yearbook 2023. 2023. https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm (accessed March 25, 2025).

30 Yu Xie JH. An Introduction to the China Family Panel Studies (CFPS). *Chin Sociol Rev* 2014; **47:** 3–29.

31 Yang Y, Xue J, Qian J, Qian X. Mapping energy inequality between urban and rural China. *Appl Geogr* 2024; **165:** 103220.

32 State Council. National population development plan (2016–2030). 2017. https://www.gov.cn/zhengce/content/2017-01/25/content_5163309.htm (accessed March 15, 2025).

33 WHO. WHO global air quality guidelines: particulate matter (PM2·5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Sept 22, 2021. https://iris.who.int/bitstream/handle/10665/345329/9789240034228-eng.pdf?sequence=1 (accessed March 11, 2025).

34 Wang Y, Zhao Y, Liu Y, et al. Sustained emission reductions have restrained the ozone pollution over China. *Nat Geosci* 2023; **16:** 967–74.

35 Liu Y, Geng G, Cheng J, et al. Drivers of increasing ozone during the two phases of clean air actions in China 2013–2020. *Environ Sci Technol* 2023; **57:** 8954–64.

36 Qin M, She Y, Wang M, et al. Increased urban ozone in heatwaves due to temperature-induced emissions of anthropogenic volatile organic compounds. *Nat Geosci* 2025; **18:** 50–56.

37 WHO. Air quality, energy and health science and policy summaries. 2025. https://cdn.who.int/media/docs/default-source/air-pollution-documents/air-quality-and-health/who_sps_draft_27_3.pdf?sfvrsn=bb5924ba_3&download=true (accessed March 22, 2025).

38 Center for Statistical Information of National Health Commission of the People's Republic of China. Statistical information center. 2024. http://www.nhc.gov.cn/mohwsbwstjxxzx/tjzxtjcbw/tjsj_list.shtml (accessed March 17, 2025).

39 Organisation for Economic Co-operation and Development . Progress in national climate policy efforts remains insufficient to achieve 2030 targets. Nov 7, 2024. https://www.oecd.org/en/about/news/press-releases/2024/11/progress-in-national-climate-policy-efforts-remains-insufficient-to-achieve-2030-targets.html?utm_source=chatgpt.com (accessed Aug, 7 2025).

40 Africa UNECA. Only 13 of the 195 parties to the Paris agreement communicated their NDC 3·0 by the deadline of 10 February 2025. Feb 13, 2025. https://www.uneca.org/stories/only-13-of-the-195-parties-to-the-paris-agreement-communicated-their-ndc-3.0-by-the-deadline (accessed Aug 6, 2025).

41 Vaughan A. Six months out from COP30, only 21 countries have submitted updated climate targets. May 9, 2025. https://www.iied.org/six-months-out-cop30-only-21-countries-have-submitted-updated-climate-targets (accessed Aug 6, 2025).

42 Zhang F, Yang C, Wang F, Li P, Zhang L. Health co-benefits of environmental changes in the context of carbon peaking and carbon neutrality in China. *Health Data Science* 2024; **4:** 0188.

43 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.

44 Zhang S, An K, Li J, et al. Incorporating health co-benefits into technology pathways to achieve China's 2060 carbon neutrality goal: a modelling study. *Lancet Planet Health* 2021; **5:** e808–17.

45 Li M, Zhang D, Li C-T, Mulvaney KM, Selin NE, Karplus VJ. Air quality co-benefits of carbon pricing in China. *Nat Clim Chang* 2018; **8:** 398–403.

46 Xing J, Lu X, Wang S, et al. The quest for improved air quality may push China to continue its CO_2 reduction beyond the Paris Commitment. *Proc Natl Acad Sci USA* 2020; **117:** 29535–42.

47 Lin Z, Wang P, Ren S, Zhao D. Comprehensive impact assessment of carbon neutral pathways and air pollution control policies in Shaanxi Province of China. *Resour Conserv Recycl Adv* 2023; **18:** 200143.

48 Zhang S, Wu Y, Liu X, et al. Co-benefits of deep carbon reduction on air quality and health improvement in Sichuan Province of China. *Environ Res Lett* 2021; **16:** 095011.

49 Yang X, Lin W, Gong R, Zhu M, Springer C. Transport decarbonization in big cities: an integrated environmental co-benefit analysis of vehicles purchases quota-limit and new energy vehicles promotion policy in Beijing. *Sustain Cities Soc* 2021; **71:** 102976.

50 Qian F, Da C, Lu C, et al. Assessment of co-benefits from on-road vehicle electrification in Suzhou City, China. *Urban Clim* 2024; **56:** 102069.

51 Xue X, Ren Y, Cui S, Lin J, Huang W, Zhou J. Integrated analysis of GHGs and public health damage mitigation for developing urban road transportation strategies. *Transp Res Part D Transp Environ* 2015; **35:** 84–103.

52 Pan R, Liang Y, Li Y, Zhou K, Miao J. Environmental and health benefits of promoting new energy vehicles: a case study based on Chongqing City. *Sustainability* 2023; **15:** 9257.

53 Peng LLH, Jim CY. Economic evaluation of green-roof environmental benefits in the context of climate change: the case of Hong Kong. *Urban For Urban Green* 2015; **14:** 554–61.

54 Global Center on Adaptation. Adapt now: a global call for leadership on climate resilience. Sept 13, 2019. https://gca.org/wp-content/uploads/2019/09/GlobalCommission_Report_FINAL.pdf (accessed Oct 12, 2025).

55 Ding H, Yu T, Xi W, et al. Accelerating climate-resilient infrastructure investment in China. 2021. https://wri.org.cn/en/research/accelerating-climate-resilient-infrastructure-investment-china (accessed Oct 12, 2025).

56 Li Z, Wang X, Liu X, et al. Evaluation of the effect of meteorological risk forecasting service intervention on acute onset and medical expenses of patients with COPD in Pudong New Area of Shanghai. *Shanghai Journal of Preventive Medicine* 2024; **36:** 197–202.

57 Menghan W. Research on the evaluation of the application effect of the heat health risk early warning model in three cities in China. PhD thesis, Hebei University, 2024.

58 He C, Zhang Y, Schneider A, et al. The inequality labor loss risk from future urban warming and adaptation strategies. *Nat Commun* 2022; **13:** 3847.

59 Chu BW, Luo JF, Wang KX, Xing ZC, Wang HK. Substantial increase of heat-induced labor and economic loss in China under rapid economic and environmental temperature growth. *Adv Clim Chang Res* 2024; **15:** 708–16.

60 Zhao MZ, Yan B, Cai WJ, Zhang C. Projection of trade-offs of commercial air conditioning: increasing carbon emission and reducing heat exposure. *Appl Energ* 2025; **382:** 125332.

61 Guan D, Wang D, Hallegatte S, et al. Global supply-chain effects of COVID-19 control measures. *Nat Hum Behav* 2020; **4:** 577–87.

62 Cai W, Zhang C, Zhang S, et al. The 2021 China report of the *Lancet* Countdown on health and climate change: seizing the window of opportunity. *Lancet Public Health* 2021; **6:** e932–47.

63 Wind. Shanghai: wind economic database, 2025. https://www.wind.com.cn/index.html (accessed Oct 14, 2025).

64 National Development and Reform Commission. Coal power decarbonization Retrofit and Construction Action Plan (2024–2027). July 15, 2024. https://www.ndrc.gov.cn/xxgk/zcfb/tz/202407/t20240715_1391663.html (accessed Oct 14, 2025).

65 Hexun. What are the reasons behind the rise in coal prices? How does this increase impact the energy market? Oct 13, 2024. https://funds.hexun.com/2024-10-13/214938109.html (accessed Oct 14, 2025).

66 International Renewable Energy Agency. Renewable energy and jobs: annual review 2024. https://www.ilo.org/sites/default/files/2024-10/IRENA-ILO%20Renewable%20energy%20and%20jobs_2024.pdf (accessed March 21, 2025).

67 Circular Economy Innovation Communities. China monthly. 2024. https://www.ceicdata.com/zh-hans/china/no-of-employee-by-industry-monthly (accessed Feb 22, 2025).

68 Cai W, Zhang C, Zhang S, 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.

69 International Carbon Action Partnership. Emissions trading worldwide: status report 2024. April 10, 2024. https://icapcarbonaction.com/en/publications/emissions-trading-worldwide-2024-icap-status-report (accessed Oct 14, 2025).

70 International Carbon Action Partnership. Emissions trading worldwide: 2024 ICAP status report. April 10, 2024. https://icapcarbonaction.com/en/publications/emissions-trading-worldwide-2024-icap-status-report (accessed Oct 14, 2025).

71 Wang K, Lu C. Review and outlook of global and China's carbon markets. *Bei Jing Li Gong Da Xue Xue Bao* 2025; **27:** 19–36.

72 Mi Z, Zhang Y, Guan D, et al. Consumption-based emission accounting for Chinese cities. *Appl Energy* 2016; **184:** 1073–81.

73 Mi Z, Zheng J, Meng J, et al. Economic development and converging household carbon footprints in China. *Nat Sustain* 2020; **3:** 529–37.

74 Pan X, Ma X, Zhang Y, et al. Implications of carbon neutrality for power sector investments and stranded coal assets in China. *Energy Econ* 2023; **121:** 106682.

75 Wang R, Cai W, Cui RY, et al. Reducing transition costs towards carbon neutrality of China's coal power plants. *Nat Commun* 2025; **16:** 241.

76 Ding Y, Li M, Abdulla A, Shan R, Gao S, Jia G. The persistence of flexible coal in a deeply decarbonizing energy system. *Environ Res Lett* 2021; **16:** 064043.

77 Mi Z, Guan D, Liu Z, et al. Cities: the core of climate change mitigation. *J Clean Prod* 2019; **207:** 582–89.

78 Lin BB, Ossola A, Alberti M, et al. Integrating solutions to adapt cities for climate change. *Lancet Planet Health* 2021; **5:** e479–86.