The 2024 China report of the *Lancet* Countdown on health and climate change: launching a new low-carbon, healthy journey

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Executive summary

2023 was a landmark year for climate change globally, across Asia, and within China. Global average temperatures were 1·45°C higher than the pre-industrial average, making it the warmest year on record since 1850. In Asia, 2023 was the second-hottest year documented. China recorded its highest-ever average temperature at 10·71°C (0·82°C above the 1981–2010 average), had its second-lowest rainfall since 2012, and endured notable flood and drought events.

In a world rapidly approaching the long-term goal of Paris Agreement to "hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1·5°C", the importance of action and implementation is urgent. As the world's largest emitter of greenhouse gases, a powerhouse for renewable energy deployment, and one of the nations most affected by climate-related health risks, China's proactive role in addressing climate change and its health risks is crucial both locally and globally.

This is the fifth annual China report of the *Lancet* Countdown on health and climate change, the flagship report for tracking progress, or lack thereof, on climate change and health in China. Over the years, what began as the marginal effort of a few dedicated individuals has grown into a considerable movement at the forefront of global climate and health discourse. The report is led by the *Lancet* Countdown Asia Centre, with contributions from 77 experts across 26 institutions. Progress is assessed with 31 indicators across five domains: climate change impacts, exposures, and vulnerability (section 1); adaptation actions (section 2); mitigation efforts and their health implications (section 3); economic and financial aspects (section 4); and public and political engagement (section 5). This year, the report adopts a forward-looking perspective, including projections of health risks associated with climate change, and tracks the concerning trends in compound exposure, highlighting the importance of ongoing adaptation efforts. Additionally, two new indicators have been introduced: stranded coal assets from the low-carbon transition (indicator 4.2.5) and health-care sector emissions (indicator 3.4). Both indicators underscore the need for mitigation actions to safeguard the health of people in China. Wherever possible, we have aligned our indicators with the UN Framework Convention on Climate Change 28th Conference of the Parties (COP28) discussions and enhanced them with updated data and improved methodologies.

A steep climb in climate-health risks

The health of individuals and communities is society's most valuable asset. However, the worsening climate because of delayed climate action is not only increasingly putting people's health and lives at risk; it is also harming the economic and social systems that underpin health and wellbeing.

Similar to others countries, China is faced with an increase in health threats from hot and dry weather conditions, such as heatwaves, droughts, and wildfires. In 2023, the average number of heatwave exposure days per person reached 16 days, over three times the historical average (1986–2005), which resulted in a 1·9 times surge in heatwave-related deaths (indicator 1.1.1). In addition, the higher temperatures resulted in a 24% increase in potential work hours lost (indicator 1.1.2), and a 60% rise in reduced time for safe outdoor activities (indicator 1.1.3) compared with historical averages. The occurrence of compound hot–dry days also skyrocketed, with 30 times as many days in 2023 as in 1986–2005, presenting untracked potential health risks. Indeed, drought exposure grew over 900% compared with the baseline, leading to a 15·1% higher excess risk of drought-related infectious diarrhoea from 2013–22 (indicator 1.2.2), and with the compound effect of hot and dry weather, wildfire exposure increased 43·9% compared with 2001–04 (indicator 1.2.1). Reversing the trend of previous years, 2023 saw 21 provinces experience a decrease in their urban greenspaces (indicator 2.2.2), which could be related to years of widespread and persistent droughts, indicating the effects of climate change on adaptive capacities.

The health effects of climate change brought economic consequences as well. The national economic cost due to heat-related labour capacity loss reached a new high of

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US$283·4 billion, equating to 1·65% of gross domestic product (GDP; indicator 4.1.2), and economic losses from climate-related extreme events jumped considerably to $77·1 billion (0·45% of GDP), around 1·5 times that of 2022 (indicator 4.1.4). In 2023, the direct national economic costs of heatwave-related mortality among working-age individuals climbed to $61·3 million, up 23·1% from 2022 (indicator 4.1.1).

A bumpy road to accelerated climate actions

Along with the rapidly increasing health risks from the warming climate and extreme climate events, engagement within the intersection between climate change and health has markedly grown in China since the 2000s, including public and professional sectors (indicators 5.1–5.4). China released its first Health National Adaptation Plan for setting goals, frameworks, and guidelines for health adaptation actions by 2030 (indicator 2.1). Climate information services for health and health-risk early warning services are becoming more refined, diversified, and increasingly widespread (indicators 2.3–2.4). Several policies to tackle this crucial issue have been advanced in 2023, including the completion of a policy framework construction to realise the carbon peaking and carbon neutrality goals, a shift of policy focus from controlling overall energy consumption to controlling overall carbon emissions, and the launch of two pilot initiatives to assess environmental-health and climate-health risks and advance adaptation measures in selected areas. As a result, the renewable energy capacity in China increased by 302·2 gigawatts (GW) in 2023, representing more than half of the global increase for the year, which elevated the country's total renewable capacity to a record 1450 GW and exceeded coal power installations (1390 GW) for the first time (indicator 4.2.1).

Despite progress, the transition away from fossil fuels in China is on a bumpy road. In 2023, coal consumption rose by 4% compared with 2022 (indicator 3.1.2), which was the largest annual growth rate since 2011. Per capita CO_2 emissions in China reached a new record-high and overtook Japan to become the highest in Asia for the first time in 2023. Furthermore, the CO_2 emissions from China's health-care sector alone amounted to 240 million tons in 2020 (indicator 3.4). From 2022 to 2023, in line with increased coal consumption, the number of cities exceeding WHO's annual average $PM_{2·5}$ concentration threshold increased from 98 to 117 $PM_{2·5}$, as did the number surpassing the ozone threshold (from 243 to 256 $PM_{2·5}$) posing an immediate risk to human health and underscoring the implications of delaying a fair energy transition (indicator 3.3).

The challenges faced by China are multifaceted. To meet the 2°C–1·5°C climate goals, China's carbon emissions have to decrease annually by 6–9% from 2030 to 2060, an unprecedented rate of reduction, particularly given that emissions are still rising. Additionally, extreme weather events, such as droughts and water shortages in the southwest, have led to a decrease in renewable energy usage and an increase in the annual operational hours per plant of coal power plants by 76 hours, reaching 4466 hours in 2023 (indicator 3.1). This increase reversed the recent decline in coal power generation, highlighting the obstacles in shifting towards low-carbon development. Furthermore, China's investment in coal and fossil fuel subsidies continues to rise, and carbon pricing remains at a somewhat low and stagnant level, creating a less favourable market incentive for the transition to renewable energy (indicator 4.2.3). As a result, China's emissions have continued to rise, making reaching its climate goals, and a healthy future for Chinese people, increasingly challenging.

An urgent need for healthier and equitable future

Although already dangerous, recent health risks might be just a glimpse of even worse ones to come. By the 2060s (2051–70), annual average heatwave-related mortality, heat-related labour productivity loss, and wildfire-related deaths are projected to increase by 183–275% (indicator 1.1.1) and 28–37% (indicator 1.1.2) compared with the 1986–2005 average. Additionally, annual excess risk of dengue fever incidence is projected to increase by 15·3–15·5% from 2013–19 levels (indicator 1.3). Coastal regions, home to nearly half of China's population and 60% of its GDP, face threats from rising sea levels, with potential exposure rates increasing up to 10·2% depending on emissions scenarios (indicator 1.4). China's reliance on coal poses not only health threats, but also economic risks, including stranded coal assets from the low-carbon transition, which are projected to cost $10·6 billion by 2030, even if China plans no new coal-fired units (indicator 4.2.5).

Widening health disparities represent another potential adverse consequence of delayed climate action. In 2023, heatwave exposure remarkably surpassed national averages in the lower-income provinces of Gansu and Ningxia with poor infrastructure and adaptation measures, leading to increased mortality (indicator 1.1.1). Low-income areas, such as Jilin, Heilongjiang, and Liaoning also faced higher economic costs due to heatwave exposure (indicator 4.1.1). Additionally, these provinces, which typically have cooler summer temperatures, score lower in their ability to manage health emergencies (indicator 2.2.1) and have substantially fewer air conditioners per 100 households compared with the national average (indicator 2.2.2). This situation could worsen with future climate warming, underscoring the urgent need for enhanced adaptation and heat protection strategies.

Transitioning to renewable energy in China offers opportunities to drive sustainable economic growth, improve public health, and enhance regional equity. Initiatives like the Three-Year Action Plan for Winning the Blue Sky Defense Battle have prevented over 312 500 air pollution-related premature deaths in polluted areas (indicator 3.3). Investments in renewables, especially in underserved regions—eg, Xinjiang that leads all

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provinces with $6·6 billion invested (indicator 4.2.2)—boost job creation and enhance local health and economic conditions, demonstrating the potential for a fair and equitable transition nationwide.

Charting a healthy low-carbon path beyond COP28

As the world prioritised climate and health at COP28, China is transitioning to a unified strategy, including new policies to address air pollution, advancing adaptation measures, and developing renewable energies. Despite facing unprecedented threats from climate change, the need remains for China to steer towards a healthy, equitable, and low-carbon future. This report outlines crucial actions to protect the health and wellbeing of current and future generations in China:

1. Establish an effective inter-departmental coordination mechanism for responding to health risks from climate change

China should implement a ministerial coordination mechanism at the national level to coordinate resources, such as data, funding, and the infrastructure needed to address the health risks of climate change, drawing on practices similar to the USA Office of Climate Change and Health Equity. China should also explore best practices for establishing local coordination mechanisms, leveraging current pilot initiatives similar to the Environmental and Climate-Health Risks Assessment pilots led by the National Disease Control and Prevention Administration and the Advancing Adaptation Measures Cities Pilot led by the Ministry of Ecology and Environment.

2. Accelerate the implementation of the control of overall carbon emissions at the regional level

With national policies now issued, regions need to quickly expand renewable energy, reduce the carbon intensity of energy, and enhance carbon emissions control to avoid future risks of stranded assets and health damages.

3. Advance climate and health-friendly investment and financing

China will need to cut fossil fuel subsidies and increase financial support for essential mitigation and adaptation technologies. Funding for adaptation technologies should cover mechanisms for the Health National Adaptation Plan actions; early warning systems; and research on impact assessments, compound risks, adaptation, and pilot construction. Mitigation technology should include enhancing research and development, ensuring energy security with technological innovation, and increasing the climate resilience of energy systems to hasten the transition away from coal.

4. Develop a low-carbon health-care system

Setting comprehensive sustainability and low-carbon standards for health-care facilities and practices with reference to international guidance, initiating pilot projects to explore innovative low-carbon solutions within the medical sector, and compiling a catalogue of low-carbon products for use in health-care settings would all help towards the goal of a low-carbon future.

5. Provide high-quality health meteorological services

Current tailored weather-related health services should be expanded to other parts in China. These services should offer personalised warnings that consider the specific geographical location, the prevalent diseases in the area, and individual susceptibilities. Developing sophisticated early warning systems that use the latest meteorological and medical research can forecast potential health risks from various weather events. Implementing these services should involve collaboration between meteorological, environmental, and health departments to ensure that accurate, timely, and relevant information reaches the public.

China is increasingly integrating climate and health policies and coordinating across local, provincial, national, and international levels to prioritise a health-centred response. In 2023, the first official Health Day at COP28 underscored the need to prioritise health in climate negotiations. The COP28 UAE Climate and Health Declaration outlined essential steps for enhancing health co-benefits, adapting climate health strategies, and boosting health-care resilience and emission reduction. Following these initiatives, China aims to lead health-centred climate actions, serving as a model for other Asian and low-income and middle-income countries and advancing towards a healthy, sustainable future.

Introduction

In 2023, the global average temperature rose 1·45°C above pre-industrial levels, the highest on record.[1,2] China faced its own climatic extremes, recoding the highest average temperature (10·71°C), second-lowest level of rainfall, and widespread droughts since 1951.[3] Beijing's summer rainfall exceeded all historical records, marking the highest in 140 years.

In 2023, at The Conference of the Parties 28 (COP28), among unprecedented climate challenges, nations pledged to triple renewable energy usage by 2030 and reduce fossil fuel dependence. The summit introduced the first official Health Day and climate and health ministerial meeting. The COP28 UAE Declaration on Climate and Health was adopted by 149 countries, including China. Discussions on the Global Goal on Adaptation concluded with a strategic framework emphasising health as a key objective.[4] The pledges at COP28 highlighted the urgent need to incorporate health into action plans and expedite implementation.

Finalised in 2023, the 1+N carbon peaking and neutrality policy system sets an overarching strategy ('1') and various supporting sectoral and regional policies ('N'). China's quantified targets for mitigation efforts have shifted from the control of overall energy

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***Panel 1:* The 2024 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 activities
- 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 green space
- 2.3: climate information services for health
- 2.4: health risk early warning system

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: health-care sector emissions*

Economics and finance

- 4.1: the economic impact 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 mortality
  - 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 CO_2 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: media 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

*New indicators added in 2024.

consumption to the control of overall carbon emissions, highlighting China's increased support for renewable energy and stronger commitment to carbon mitigation. Meanwhile, China introduced two local pilot policies related to health adaptation actions: the Environmental and Climate-Health Risks Assessment pilots led by the National Disease Control and Prevention Administration and the Advancing Adaptation Measures Cities pilot led by the Ministry of Ecology and Environment, both facilitating local cross-departmental collaboration and health adaptation strategy development. In September 2024, led by the National Disease Control and Prevention Administration, China released its first Health National Adaptation Plan,[5] which will guide the country's actions against health risks from climate change until 2030.

Despite progress, the health threats of climate change are still rising, with per capita greenhouse gas (GHG) emissions increasing 218% since 2000. The increase in coal consumption by 5·6% in 2023 is a complex outcome of extreme weather, heightened energy demand, economic conditions, and policy influences, challenging the country's ability to meet its climate pledges and secure a safe and liveable future for its citizens.

As the fourth annual update, the 2024 China Report of the *Lancet* Countdown offers the most up-to-date stocktake of climate and health in China and presents a forward-looking analysis of the climate-health nexus across 31 indicators and five domains: climate change impacts, exposures, and vulnerability; adaptation, planning, and resilience for health; mitigation actions and health co-benefits; economics and finance; and public and political engagement (panel 1). Indicators exposing present and projected health risks linked to climate change (figure 1) and compound exposure risks reveal concerning trends. The report also introduces two new indicators: one highlighting stranded coal assets from the low-carbon transition (indicator 4.2.5; figure 2) and health-care sector emissions (indicator 3.4). This report aligns indicators with COP28 themes and updates them with the latest data and refined methodologies wherever feasible.

Section 1: climate change impacts, exposures, and vulnerability

Comprehensively tracking health risks from climate change is crucial. This section examines trends of health risks in four areas: heat (indicators 1.1.1–1.1.3),

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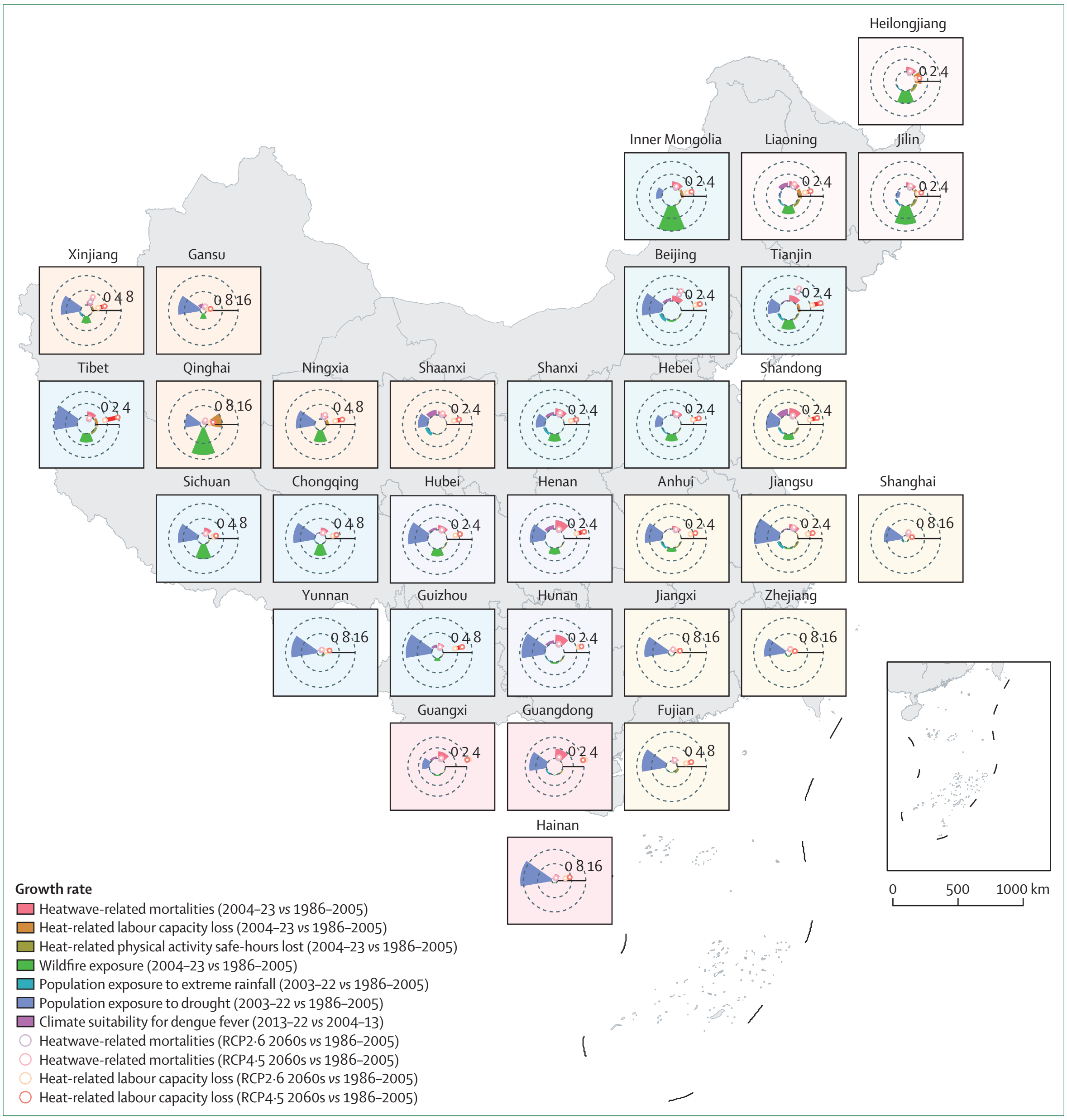

Figure 1: **Future and current growth rates compared with historical baselines of climate health risks in different provinces**
The values of the bars in each provincial figure represent the growth rates of climate health risks compared with the historical baseline (mostly 1986–2005 averages) to current levels (mostly 2004–2023 averages). The circles represent the growth rates of climate health risks from historical baseline to projected future average in the 2060s (2051–2070 average), and the methods summary can be found in the appendix (p 133).[6,7] The background of the figure is coloured by regional groupings of provinces as following: northeastern China (Heilongjiang, Jilin, and Liaoning), northern China (Inner Mongolia, Beijing, Tianjin, Shanxi, and Hebei), eastern China (Shandong, Anhui, Jiangsu, Shanghai, Jiangxi, Zhejiang, and Fujian), central China (Hubei, Henan, and Hunan), northwestern China (Xinjiang, Gansu, Qinghai, Ningxia, and Shaanxi), southwestern China (Tibet, Sichuan, Chongqing, Yunnan, and Guizhou), and southern China (Guangxi, Guangdong, and Hainan). Carbon emissions under scenario RCP4·5 is higher than that for scenario RCP2·6; therefore, most risks are higher with scenario RCP4·5. RCP=representative concentration pathway.

extreme weather (indicators 1.2.1–1.2.2), climate-sensitive infectious diseases (indicator 1.3), and rising sea levels (indicator 1.4). New for this report, it explores human exposure to compound extremes and includes forecasts of China's major climate health risks up to the 2060s (appendix p 133), displayed in indicators 1.1.1, 1.1.2, 1.2.1, and figure 1.[6–8]

Indicator 1.1: health and heat

Indicator 1.1.1: heatwave-related mortality

2023 marked the warmest year globally, with China recording its highest area-weighted temperature since 1951 at 10·71°C. Heatwave exposure days per person soared to 16 days, over three times the historical average (1986–2005) and nearly double the previous year. Heatwave-related

See Online for appendix

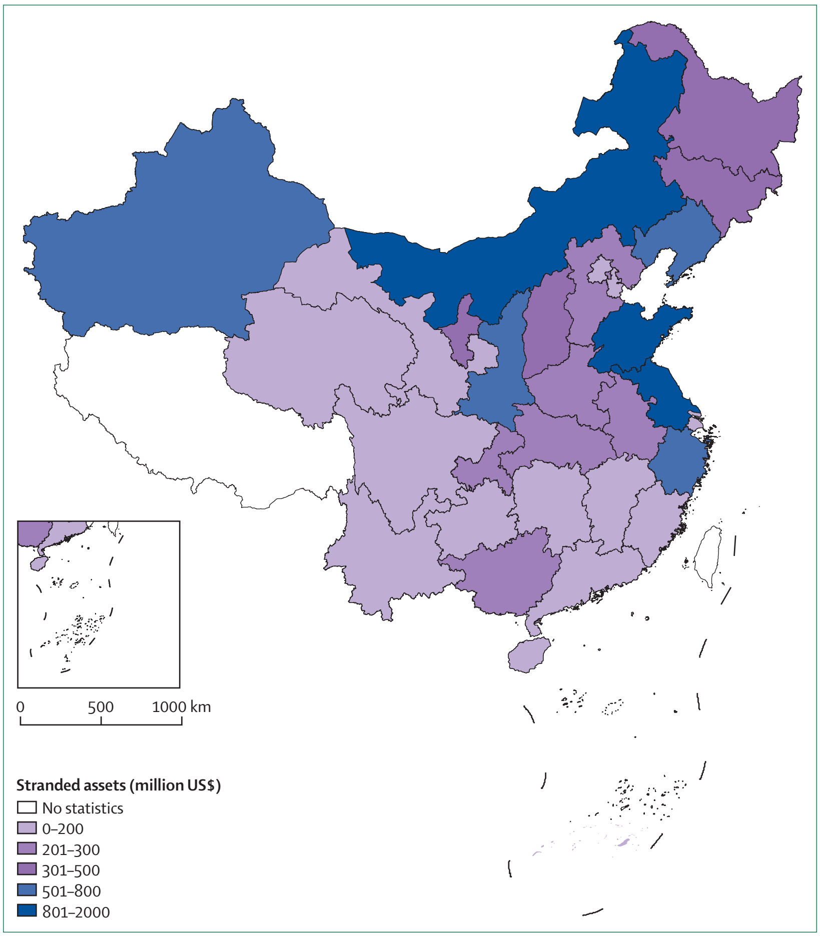

Figure 2: **Potential stranded assets of coal-fired power plants in China by province in 2030**

deaths in China increased by 1·9 times from 2019–23 compared with 1986–2005, totalling about 37 254 deaths in 2023. Unlike previous trends that saw southern regions affected more, 2023 had notable deaths in cooler northern, northeastern, and northwestern areas, now facing rapid heatwave increases. For example, deaths in Beijing were 6·4 times, Ningxia 4·9 times, Gansu 4·1 times, and Liaoning 4·2 times higher than their historical averages. These statistics highlight the need for climate policies to focus on regions without sufficient cooling infrastructure. By the 2060s, annual heatwave-related mortality is expected to reach 29 000 to 38 000 in China, an increase of 183–275% from historical levels, with most provinces seeing more than double the fatalities.[6]

Indicator 1.1.2: change in labour capacity

Heat stress at work directly threatens occupational health and productivity, resulting in reduced work time and economic output.[9,10] Compared with the average in baseline years (1986–2005), the potential work hours lost due to heat stress increased by 24·1% in 2023, reaching 36·9 billion hours, equivalent to the average income of 12·6 million people. The potential work hours lost was most prominent in the southern, eastern, and central regions, with Guangdong and Henan provinces accounting for 11·8% and 9·5% of total losses, respectively. Agricultural and construction sectors have the largest potential work hours of 23·8 and 6·9 billion hours lost in 2023, respectively. Heat-related potential work hours lost are projected to increase by 28–37% during 2051–70 compared with the historical baseline, with the largest growth in northeastern provinces that are typically cool regions, highlighting the urgency for protective adaptation measures.[7] COP28 emphasised the need to protect workers' rights among a changing climate;[11] some workplace adaptations, such as flexible working hours, heat stress monitoring, and access to cooling centres, could serve as models for areas newly experiencing these challenges.

Indicator 1.1.3: heat and physical activity

Rising global temperatures pose risks to safe physical activity.[12] Reduced physical activity can lead to sedentary behaviours and increased chronic diseases in the long term,[13,14] and thereby reduce physical and psychological wellbeing. This indicator tracks potential safe physical activity-hours lost due to high heat index. Chinese people had a 60% increase in activity-hours lost in 2023 compared with the baseline (1986–2005), averaging 2·20 activity-hours lost per person per day. China's available safe activity hours dropped by 0·82 h per person per day in 2023 compared with the baseline. South-central China, with around 400 million people affected, had a record high of 4·10 activity-hours lost per person per day in 2023, nearly double the national average.

Indicator 1.2: health and extreme weather events

Indicator 1.2.1: wildfires

Wildfires can affect human health through burns, loss of crucial infrastructure, and air pollution.[15] Wildfires in China have been increasing since 2020, particularly affecting the densely populated eastern regions. The annual person-days of wildfire exposure from 2019 to 2023 were 43·9% higher than during 2001–05, with exposure in 2023 being the highest since 2000. Among 31 provinces, 24 (70·6%) reported rising exposure, with 16 (51·6%) provinces, mostly in the southwest and northwest, experiencing over 100% increases. China has relocated forest and grassland fire reporting from the China Forestry Yearbook to the Emergency Management Yearbook, indicating a shift from hazard control towards comprehensive disaster management, enabling higher resilience against potential future health threats from wildfire. Wildfire-related deaths are projected to rise by 28–36% to 110 000–117 000 annually by the 2030s compared with the 1986–2005 average.[8]

Indicator 1.2.2: extreme rainfall and drought

Over the past decades, the frequency of extreme rainfall and drought has greatly increased, with considerable health effects.[16] In 2024, extreme rainfall has been redefined by the 99th percentile of precipitation from 1986–2005, aligning with the 2023 global report of the *Lancet* Countdown.[16] Simultaneously, this indicator tracks health effects, focusing on infectious diarrhoea risks. In 2022, the population exposed to drought increased sharply and was more than nine-times greater than in baseline years (1986–2005; appendix p 15), while exposure to extreme rainfall fluctuated with no clear national trend.

Infectious diarrhoea causes 1·32 million cases annually in China, ranking second among class C infectious diseases.[17] Extreme rainfall and droughts can escalate the incidence of this condition by contaminating water supplies and disrupting sanitation systems.[18–20] The attributable excess risk of infectious diarrhoea has been quantified using exposure–response curves.[21] Compared with baseline years, the annual average excess risk of infectious diarrhoea associated with extreme rainfall grew by 2·41% during 2013–22, especially in northwestern and eastern China (appendix p 15). The risk related to drought increased by 15·1%, with greatest increases in Ningxia, Shanxi, and Tibet (appendix p 15).

Indicator 1.3: climate-sensitive infectious diseases

Dengue fever, a climate-sensitive disease, has seen two outbreaks in mainland China since 2010.[22,23] This indicator assesses the impact of climate change on dengue spread via three sub-indicators: vectorial capacity of *Aedes aegypti* and *Aedes albopictus* for dengue fever transmission, population vulnerability, and China's dengue disease burden.

From 2004 to 2022, dengue vector transmission capacity increased across 17 eastern provinces, with the highest transmission in southern China, particularly Hainan, Guangxi, and Guangdong (appendix pp 16–25). Vulnerability to dengue rose in 15 provinces, especially in the central region, compared with the 2010–2015 average. In 2022, dengue's disability-adjusted life-years were low at 21 person-years, down from 883 in 2019, partly due to COVID-19 policies; however, the proportion of patients older than 60 years increased from 10·5% in 2020 to 15·4% in 2022. Despite the drop in disability-adjusted life-years, increased vector capacity and vulnerability indicate a high risk of future epidemics. By the 2060s, the excess risk of dengue is projected to rise by 15·3–15·5% from the 2013–19 average, with spikes of 30–60% in provinces such as Hainan, Guangdong, Jiangsu, and Shanxi.[21]

Indicator 1.4: population exposure to regional sea level rise

Coastal areas in China, account for 46·35% of the population and 60·12% of gross domestic product (GDP), are increasingly susceptible to storm surges and saltwater intrusion.[24,25] This indicator predicts future population exposure to regional sea level rise along the coast of the Chinese mainland and the assessments includes hydrological connections and coastal defences to improve exposure estimates.

By 2100, 4·4%, 5·7%, and 9·2% of the coastal populations are projected to be exposed to sea level rise under various emission scenarios (shared socioeconomic pathways [SSP]1–1·9: low, SSP2–4·5: moderate, and SSP5–8·5: high) considering 50-year flood. The exposed ratios will go to 5·2%, 6·5%, and 10·2% for 100-year flood. Under each scenario, the most affected provinces will be Zhejiang and Jiangsu. Zhejiang and Jiangsu are the most at risk, with up to 27% (25% 50-year flood) of Zhejiang's population facing inundation under the high scenario considering 100-year flood. Mitigation could considerably reduce exposure, with the largest decreases in Jiangsu by up to 14·0%, Zhejiang by 9·0%, and Tianjin by 7·6% under the low scenario compared with the high scenario (appendix p 27).

Conclusion

In 2023, China faced extreme hot and dry weather conditions, with record high temperatures and the second-lowest precipitation since 2012.[3] These conditions led to a rise in heatwave-related deaths (309% increase), work hours lost (24% increase), and reduced time for safe outdoor activities (60% increase) from the 1986–2005 average. Importantly, compound extreme weather events might present more considerable threats to human health than isolated occurrences (panel 2). Exposure to compound hot–dry days surged over 30 times, elevating untracked health risks. During 2013–2022, the excess risk of infectious diarrhoea due to extreme rainfall rose by 2·4%, and drought-related risks increased by 15·1% from the 1986–2005 average. Dengue vulnerability also heightened in 15 provinces in 2016–2022 from the 2010–15 average. Future projections indicate escalating health risks: by the 2030s, wildfire-related risks could increase by 28–36% to 110 000–117 000 deaths annually; by the 2060s, heatwave-related deaths and work hour losses could climb by 183–275% and 28–37%, respectively from the 1986–2005 average. By 2100, 5·2–10·2% of the coastal population could face threats from sea level rise. The ongoing and anticipated rise in climate-related health risks highlight the urgent need for protective health actions (section 2), robust adaptation, and strong mitigation efforts (section 3).

Section 2: adaptation, planning, and resilience for health

Health adaptation efforts have received increased attention globally with the Global Goal on Adaptation framework;[39] multiple adaptation-related goals in the COP28 UAE Declaration on Climate and Health;[4] and the endorsement of initiatives related to forest, green spaces,[40] and global cooling.[41] This section monitors China's efforts in adaptation planning and assessment (indicator 2.1), adaptation delivery and implementation

Panel 2: **Population exposure to compound extreme weather events in China**

With global warming and rapid urbanisation, emerging extreme events and their co-occurrences will pose an accelerated threat to human health,[26–28] particularly for the older population.[6,29,30] Compound extreme events pose more severe risks for human health when compared with individual events.[31,32] During compound hot–dry events, high heat stress and the absence of available freshwater might have negative effects on human health and could even lead to death.[33,34] China was hit by record-breaking compound hot–dry events in the summer of 2022, which affected more than 900 million people.[33] Extreme heat often occurs concurrently with a high ozone concentration; both heat and ground-level ozone have adverse effects on the human cardiovascular and respiratory systems and increases the risk of premature deaths.[35,36] A study in Europe showed that daily excess deaths were nearly two-times greater during compound hot-ozone pollution events than in each single event.[37] Compound hot-ozone pollution events have become one of the most impactful compound events across the world,[38] but little research of their health impact (eg, population exposure) has been conducted in China. Considering the high health impact and urgency, compound hot–dry events and compound hot-ozone pollution events have been selected to analyse the population exposure during the past 30 years to help with mapping spatiotemporal exposure patterns and informing targeted policy recommendations.

Temperature and precipitation data from the National Climate Center and population data from Tsinghua University have shown a substantial increase in population exposure to compound hot–dry days from 1986 to 2022 in China. The average exposure was approximately 697 million person-days during the historical baseline period (1986–2005), and this value increased to 21 billion person-days in 2022, a 30-fold increase. The per capita exposure days were estimated to be about 16·5 days in 2022, which was about 29-fold larger than the historical baseline period. The exposure to compound hot-dry days occurred more frequently in northern China (ie, Heilongjiang, Inner Mongolia, and Xinjiang) and the Yangtze River basin of China (ie, Xizang, Yunnan, Guizhou, Hunan, Jiangxi, and Sichuan). Before 1998, exposure existed in only several of the aforementioned provinces. After 1998, exposure to compound hot–dry days increased, with more than 15 (48·4%) of 31 provinces in the analysis showing large population exposure. This increase accelerated after 2013, and in 2022, the total population exposure to compound hot–dry days was the largest ever, with eight provinces having more than 30 days per capita.

Using ozone concentration and temperature data from the European Centre for Medium-Range Weather Forecasts Reanalysis (version 5), population exposure to compound hot-ozone pollution days was analysed. During the historical baseline (1986–2005), the average annual exposure to compound hot-ozone pollution days was approximately 3·55 billion person-days. The total population exposure exceeded the average value of baseline after 1999. 2001 saw the greatest exposure with 12·64 billion person-days, nearly 14-fold larger compared with the historical baseline. This remarkable increase of compound hot-ozone pollution days was mainly caused by the growth of the population, the number of motor vehicles, and the development of industrial production. There were 3·0 per capita exposure days during the baseline period, which increased to 6·7 days in 2023. During the historical baseline period, regions with large populations had a high total exposure, mainly in northeastern China, such as Hebei, Shandong, Liaoning, and Henan. Meanwhile, the exposure days per capita were larger in northwestern China, namely in Ningxia, Gansu, Qinghai, and Xinjiang. During 1986–2023 (excluding 2003, 2010, and 2021), the total population exposure in Hainan Province was 0. During the past decade (2014–2023), the total population exposure in Shandong, Hebei, and Henan were the top three of all provinces, while the largest increases from the historical average were in Shanghai at 425%, 313% in Xinjiang, and 265% in Tianjin.

The exposure to compound extreme events has substantially increased in recent years, especially in the populated areas of China, such as the Yangtze River basin and the Bohai Sea Ring area. Population exposure to compound hot–dry days shows the most remarkable changes compared with the historical baseline in Henan, Sichuan, and Shandong. With climate change and an aging population, the adverse effects from compound extreme events will be further amplified. Existing research focused on compound events themselves or exposure to compound events, and quantitative assessment that comprehensively considered hazards, exposure, and susceptibility to compound risks is still restricted. Detailed country-level and region-level risk analysis is in urgent need to help establish the spatiotemporal patterns of people affected by compound extreme events and understand unbalanced patterns and the associated health risks.

(indicators 2.2.1–2.2.3), climate information services for health (indicator 2.3), and health risk early warning services (indicator 2.4).

Indicator 2.1: adaptation planning and assessment

This indicator tracks both national and provincial progress in health adaptation and assessment in China. In September 2024, China released its first National Climate Change Health Adaptation Action Plan (2024–2030). Led by the National Disease Control and Prevention Administration and jointly issued with 12 other ministries, the plan sets phased goals: by 2025, it aims to establish interdepartmental coordination, and improve monitoring systems and indicators. By 2030, key regions and sectors will see enhanced health adaptation capacity and public health system resilience, with a climate adaptation-friendly environment for public health broadly established across society. As of March 2024, a survey by China's Center for Disease Control and Prevention (CDC) revealed that of 29 (93·5%) of 31 provinces that responded, only five (16·1%) provinces (Tianjin, Shaanxi, Jiangsu, Guangxi, and Chongqing) have implemented health adaptation policies or measures in 2023, still a notable improvement from only one (3·2%) province in 2021. Comprehensive assessments of health impact, vulnerability, and adaptation were conducted in Hunan Province, parts of Beijing, and several cities across Jiangsu, Jiangxi, Shandong, Guangdong, Hainan, and Zhejiang. In total, covering both province-level and city-specific assessments, 20 (64·5%) provinces conducted health impact assessments of climate change, 12 (38·7%) conducted vulnerability assessments, and seven (22·6%) conducted adaptation assessments, with a 44% increase in health risk impact assessments since 2022. Challenges include a 76% lack of multisectoral cooperation, with 69% of provinces without adequate risk assessment technologies and 66% facing insufficient government funding.

Indicator 2.2: adaptation delivery and implementation

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

This indicator assessed provinces' emergency response readiness via a composite index of 23 sub-indicators covering risk preparedness, health emergency detection, early warnings, and medical resources (appendix pp 42–46). For this report, a new sub-indicator on coverage rate of basic medical insurance in the total population was introduced to better assess medical resources. In 2022, the national average index score improved by 2·10, from 73·45 to 75·55, reflecting a steady improvement in China's public health and emergency response capabilities. Growth in developed areas, such as Zhejiang, Beijing, and Shanghai, was driven by higher public health standards, government support, and pharmaceutical industry development. Growth in low-income regions, such as Tibet, Xinjiang, and Qinghai, was primarily due to infrastructure development. The rapid improvement in underserved areas has helped reduce regional disparities, as evidenced by the decreased variance from 2018 to 2022 (appendix p 52).

Indicator 2.2.2: air conditioning—benefits and harms

In 2022, China averaged 133·9 air-conditioning units per 100 households, with notable regional variations. High-income provinces such as Guangdong (229 units), Jiangsu (218 units), and Zhejiang (218·8 units) had higher penetration compared with cooler, lower-income regions such as Qinghai (1·6 units), Ningxia (17·5 units), and Gansu (10 units; appendix pp 53–54). Approximately 70% of Chinese households have air conditioning, which helped prevent about 45 000 heatwave-related deaths in 2022—nearly double the figure from 2021. However, air conditioning also exacerbates climate change and air pollution indirectly, causing 9300 deaths attributable to $PM_{2.5}$ exposure in 2021 and generating 0·33 gigatonnes of CO_2 in 2022. China is pursuing sustainable cooling for all with passive cooling technologies,[42] increasing active cooling efficiency,[43] and promoting climate-friendly refrigerants,[44] echoing the Global Cooling Pledge at COP28 to reduce cooling-related emissions by 68% by 2050.[41]

Indicator 2.2.3: urban green space

Living in greener environments is associated with better mental health and reduced all-cause mortality.[45,46] This indicator measures greenness level using the population-weighted normalised difference vegetation index and assesses the impact of urban green space on mortality across province. In 2023, 21 (67·7%) of 31 provinces noted over a 10% decline in greenness from the 2012–22 average, with substantial reductions in the dry, drought-prone northern region.[47] Severe droughts in 2023 further diminished vegetation health in northern China, as satellite data indicated poor vegetative conditions (appendix pp 57–58).[48] In addition to unfavourable natural conditions, post-pandemic economic slowdown has stalled the development of large-scale urban green spaces and reduced maintenance standards for existing ones, potentially contributing to the decline in overall greenness. In 2023, only two provinces had very high levels of urban greenness, while nine had exceptionally low levels, showing a pattern of decreasing greenness from south to north (appendix p 56). The reduction in green spaces between 2013 and 2023 is estimated to have been associated with 27 360 adult deaths in China (95% CI 20 657–40 496; appendix pp 54–55).

Indicator 2.3: climate information services for health

Meteorological departments in nearly all Chinese provinces share data with health departments, but this does not always result in public services. Consequently, this indicator no longer tracks data-sharing status, but instead focuses on the specific types of health meteorological services offered by provincial meteorological administrations, including early warnings for heatstroke, cardiovascular and respiratory diseases, and mosquito bites. A survey by the Public Meteorological Service Center of the China Meteorological Administration received valid responses from all 31 provinces. In 2023, seven (22·6%) provinces offered heatstroke weather forecasts, four (12·9%) for cardiovascular issues, five (16·1%) for respiratory conditions, and one (3·2%) for mosquito bite risks (appendix pp 59–60). Some provinces also issued alerts tailored to susceptible groups, such as Shanghai's forecasts for children's asthma environmental risks. These targeted warnings, distributed via multimedia platforms, are essential for adapting to the increasing health risks posed by adverse weather.

Indicator 2.4: health risk early warning services

Early warning systems for health risks are important adaptation tools that provide timely and accurate information to decision makers and the public. This indicator tracks the progress of early warning systems for health risks offered by provincial and city-level CDCs, based on a nationwide survey by the Chinese CDC. Health risk early warnings related to climate change cover high temperatures (heatwaves), low temperatures (cold waves), and health tips for flood disasters. The reach of these warnings has expanded from five provinces and 24 cities in 2022 to seven provinces and 28 cities in 2023. These warnings are primarily distributed via official websites, mobile apps, and WeChat accounts of local CDCs, with the population covered by these services rising from 129·81 million in 2022 to 193·94 million in 2023.

Conclusion

In 2022, China advanced in adaptation actions, increasing its national health emergency response score from 73·54 in 2021 to 75·55 in 2022, with reduced regional disparities. Coverage of health early warning services expanded in 2023, offering more detailed and diverse health meteorological warnings. People in cooler areas are still susceptible to 2023's severe heatwaves due to the absence of air conditioning, but in high-income provinces, the massive use of air conditioning increased carbon emissions and pollution-related deaths. The 2023 drought harmed the vegetation, and urban green spaces reduced in 21 provinces. The introduction of health adaptation pilots in 2023 and the Health National Adaptation Plan in 2024 encouraged cross-departmental collaboration and localised actions, but these efforts need feasible guidelines and increased financial support to be effective.

Section 3: mitigation actions and health co-benefits

In 2023, China completed its carbon peaking and neutrality policy framework,[49] with all provinces and 12 key sectors (such as energy, buildings, and transport) announcing low-carbon development plans.[50–52] Additionally, a new policy shift in July 2023 prioritised controlling total carbon emissions over total energy consumption,[53] reflecting China's increased focus on climate change mitigation. Considering China's 31% contribution to global GHG emissions and its rising per capita CO_2 levels surpassing Japan's for the first time in 2023,[54] tracking policy implementation is crucial to identify possible solutions to fully realise expected effects. Hence, this section tracks the country's progress in transitioning to a low-carbon energy system and clean household energy (indicators 3.1–3.2), improving air quality and its health effects (indicator 3.3). Additionally, a new indicator (3.4) is introduced to monitor carbon emissions from the health-care sector and is an important contributor to the country's carbon footprint.[55,56]

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. We provide an in-depth analysis of the reasons behind coal use change. In 2023, the carbon intensity (kg CO_2 per US$) of the Chinese energy system decreased by 2·5% compared with 2022, albeit with a 2·6% increase in CO_2 emissions and a 5·2% increase in GDP (appendix pp 65–66). The increase in CO_2 emissions in China in 2023 mainly came from a surge in emissions from fossil fuel consumption. Oil and natural gas consumption increased by 9·1% and 7·2%, respectively, in 2023.[57] While the share of coal has declined over the past two decades, it still accounts for 55·3% of China's total energy consumption.[57] Efforts to reduce the share of coal consumption have been completely offset by a 5·7% increase in total energy demand, which has a growth rate rarely higher than GDP. China's coal consumption increased by 5·6% in 2023 due to energy-intensive economic growth, driven by coal power generation and the clean energy manufacturing boom, particularly in the production of solar photovoltaic power and batteries.[58] The rapidly growing energy demand and the issues related to the dispatchability of renewable energy have further exacerbated these challenges.[59] Furthermore, with coal still representing the most available source of energy in China, its consumption might also increase to ensure energy security during extreme climate events, with record-low hydropower operating rates caused by droughts and the increasing energy demand during extreme heatwaves in north China in 2023.[60,61] Additionally, extreme weather events, such as droughts and water shortages in the southwest, have led to a decrease in renewable energy usage and an increase in the annual operational hours per plant of China's coal power plants with a capacity of 6000 kilowatts or more by 76 hours, reaching 4466 hours in 2023.[62] These trends underscore the importance of reducing the reliance on coal power by transitioning to cleaner, locally-generated renewable energy. Encouragingly, in 2023, renewable power generation (hydropower, wind power, and solar power) continued to grow, reaching 2436 terawatt hours (7·4% more than that of 2022), accounting for 26·8% of national power generation. Meanwhile, nuclear power generation grew to 433 terawatt hours (3·7% more than that of 2022), accounting for 4·8% of national power generation. Generally, low-carbon (renewable power and nuclear power) generation accounted for 31·5% of national power generation.

Indicator 3.2: clean household energy

The transition from highly polluting solid fuels (eg, coal or solid biomass) to clean energy (eg, photovoltaics)

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addresses both air quality improvement and GHG emission reduction goals and can increase energy access and independence in remote areas. Accompanying fast economic growth and development, China's per capita residential energy consumption has increased by 75·09% from 2010 to 2021. The share of coal use has decreased by 64·72%, accompanied by a 38·2% decrease in absolute use, but still makes up 8·8% of the total household energy use. Meanwhile, the share of electricity is increasing by 29·59%, accompanied by a 127% increase in absolute use, making up 22·3% of the total household energy use in 2021.[63] Heating constitutes around 50% of the primary energy consumption in buildings in China,[64] but the inefficient use of solid fuels such as coal worsens carbon emissions and air pollution, also posing health risks. In 2016, inefficiently combusted solid fuels (eg, scattered coal) continued to dominate household heating in China, especially in rural areas of northern China,[65] which is why clean heating technology was prioritised in China's 2017 national strategy.[66] As of 2021, over 26 million rural households have participated in the clean energy substitution programme,[67] reducing scattered coal usage by over 150 million tons, substantially cutting $PM_{2·5}$ levels by over one-third, and improving air quality.[68] By July 2022, clean heating expanded to cover 1·56 billion m², accounting for 73·6% of all building areas requiring heating. In 2022, the clean heating rate in northern China exceeded 75% in regions participating in the clean energy substitution programme.[69] Government financial subsidies fund this clean energy substitution programme,[70] but strain local finances, especially in economically underdeveloped areas. Exploring sustainable economic incentive mechanisms such as carbon trading markets is crucial for long-term progress.

Indicator 3.3: air pollution, transport, and energy

This indicator tracks air pollution changes in China due to pollution control policies in key sectors. The indicator also uses the Greenhouse Gas and Air Pollution Interactions and Synergies model to estimate changes in premature death attributable to $PM_{2·5}$ exposure. This report includes analysis of specific mortality causes and how China's carbon-neutral policies could alleviate future burden of cardiovascular disease.

Following 7 years of consistent decline, since 2015, $PM_{2·5}$ concentrations in Chinese cities had a notable rebound in 2023, rising 5·5% from 2022 levels but still 13·5% below pre-pandemic levels. This rebound is attributed to increased pollutant emissions from the gradual resumption of economic activities post-pandemic, rising temperature effects leading to a rise in secondary organic aerosols,[71] and intensified east Asian winter monsoons with increased nationwide sand and dust events.[72] The number of cities exceeding WHO's $PM_{2·5}$ interim target (35 µg per m³) grew from 98 to 117 (5·9%) in 2023, while those surpassing the ozone concentrations threshold (160 µg per m³) increased from 243 to 256 (4·9%).[73]

We estimate that the Three-Year Action Plan for Winning the Blue Sky Defense Battle could have prevented 312 500 premature deaths between 2015 and 2021 (appendix 78–79). Stroke accounts for 49·8% of total prevented premature deaths as the largest contribution, followed by ischaemic heart disease (24·7%), and chronic obstructive pulmonary disease (20·5%). The 2021 Global Burden of Disease study shows that stroke and coronary heart disease accounted for approximately 22·16% (2·6 million) and 16·73% (1·9 million) of total mortality in China, respectively.[74] Under a carbon-neutral scenario (SSP1–19), in 2060, the short-term $PM_{2·5}$-related excess incidence of stroke and coronary heart disease (3352 cases) is projected to decrease by 90% compared with a medium-emissions scenario (SSP2–45, 34 485 cases).[75] Therefore, achieving carbon neutrality is an important health interventions in China.[76]

From 2011 to 2019, transportation policies jointly reduced long-term $PM_{2·5}$-attributed premature deaths by over 50 000. COVID-19 restrictions on movement initially increased passenger transportation emission intensity,[77,78] but after declaring the pandemic's end in late 2022, travel rebounded, resulting in a 42% decrease in passenger transportation emission intensity (for carbon monoxide, nitrogen oxides, hydrocarbons, $PM_{2·5}$, and PM_{10}) compared with 2022. China's vehicle emission control policies (eg, National VI policies, license plate restrictions, odd-and-even license plate rule, and a high rate of vehicle electrification) have proven highly effective and their success in megacities can guide other regions.[79]

In 2023, freight emission intensity decreased by 21%, notably in key freight hubs such as Shandong province, while private vehicle emission intensity (0·5–5 ton per vehicle, depending on the region) also decreased, particularly at the lowest level in megacities such as Beijing and Shanghai, showcasing effective control policies.

Indicator 3.4: health-care sector emissions

The health-care sector aims to protect health, but is paradoxically a considerable contributor to climate change. This new indicator measures China's health-care and social work sector's carbon emissions using environmentally-extended input–output analysis with expenditure and CO_2 emission data from the Carbon Emission Accounts & Datasets Multi-Regional Input–Output Table of 2020.[80] Since health-care and social work are combined into one sector in the industry classification of the China Multi-Regional Input–Output Table, the carbon accounting object of this indicator is both the health-care and social work sector, not only the health-care sector. The CO_2 emissions from China's health-care and social work sector was 240 million tons CO_2 equivalent (tCO_2e) in 2020. Per capita emissions in 2020 is lower than than the global average of 0·28 tCO_2e.[81] The carbon emissions from health-care facilities are generally lower during the pandemic because of the considerable drop in health-care facility visits (11·2% decrease from the previous year).[82] As health-care visits and emissions potentially increased post-COVID, a low-carbon transformation is essential, offering substantial health benefits while promoting climate action. China's health-care sector should enhance carbon emission reduction efforts with operational and service model optimisations.

Conclusion

Despite of the considerable strides made in renewable energy development and in the low-carbon transition of key energy demand sectors (eg, household and transport), the progress in China's energy supply sector has fallen short of the ideal level in 2023. The shortage of climate-friendly technologies to ensure energy security again hindered the progress in coal phase-down and carbon emissions reduction. Assuming China's CO_2 emissions remain constant from 2023–30, China's emission would need to decline by 11–35% on an annual basis from 2031–50 to comply with the country's carbon budget compatible with 2°C and 1·5°C targets.[83] Meeting such a goal requires urgent acceleration of the development and deployment of renewable energy, advancement of energy storage and power grid technologies, and improvements in climate resilience of the current energy supply system. Additionally, implementing regional carbon emissions control is crucial.

Section 4: economics and finance

This section provides crucial information about the economic and financial implications of the health effects of climate change and the progress of climate action. From assessing the health and economic costs of climate-related events (indicators 4.1.1–4.1.4) to scrutinising investments in renewable energy and fossil fuel subsidies (indicators 4.2.1–4.2.4), these indicators provide essential data to inform discussions and negotiations on health and climate change. A new indicator (4.2.5) is introduced in this report to estimate the scale of stranded assets in China's coal-fired power generation sector and the related financial risks of investing in coal. All data are presented in 2020 and US$.

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

Indicator 4.1.1: economic costs of heatwave-related mortality

Using the Adaptive Regional Input–Output model, this indicator assesses the economic costs of heatwave-related mortality among working-age individuals (15–64 years) nationally and provincially (appendix pp 84–86).[84] A new, detailed analysis multiplies the heatwave-related mortality rate by workers' compensation based on the updated 2020 input–output table. A notable 50·5% increase in working-age mortality contrasted with a 1·2% decrease in overall mortality in 2023. Direct national economic costs surged to $61·3 million, up by 23·1% from 2022, while total costs, including indirect ones, rose to $137 million (up by 17·4%). Lower-income provinces, such as Jilin, Heilongjiang, and Liaoning, with weaker industrial ties with other provinces, had higher mortality rates, exacerbating spatial economic inequality. In 2023, Inner Mongolia ($20·80 million, 0·0073% of GDP), Gansu ($16·0 million, 0·011% of GDP), and Xinjiang ($13·10 million, 0·006% of GDP million) incurred the highest total economic costs (appendix pp 84–85).

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

Extreme heat can cause severe physiological strain on workers and reduce labour productivity, leading to considerable economic effects with production and business disruptions.[85] This indicator updates the economic costs of heat-related labour productivity loss during 2020–2023 using the latest 2020 Chinese Multi-Regional Input–Output (MRIO) table.[86] In 2023, the national economic costs of heat-related labour productivity loss reached a new record of $283·4 billion, equivalent to 1·65% of national GDP, marking the second consecutive year exceeding $250 billion. These figures underscore the urgent need for measures to protect workers and reduce productivity losses. The manufacturing and agricultural sectors had the largest direct costs ($66·6 billion and $51·6 billion, respectively) because of the high exposure of workers to extreme heat. However, the services and manufacturing sectors had the greatest indirect costs ($64·5 billion and $44·3 billion, respectively) due to the high dependencies on inter-sectoral trade. The provinces most affected relative to GDP were Hainan (4·13%), Anhui (3·01%), and Jiangxi (3·01%).

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

Exposure to $PM_{2·5}$ pollution harms health and is associated with premature deaths from diseases, including pulmonary and cardiovascular diseases.[87] $PM_{2·5}$-related premature deaths among the working-age population reduce labour availability in production, leading to immediate output losses and subsequent cascading losses. This indicator updates the economic costs of $PM_{2·5}$-related premature deaths in 2021 at the multi-provincial level using the latest 2020 Chinese MRIO table. The national economic costs of $PM_{2·5}$-related premature deaths totalled $7·0 billion in 2021 (0·04% of GDP), representing a decrease of 4·7% compared with 2015. This decrease indicates promising progress in China's efforts to address air pollution. Most costs occurred in secondary (53·2%) and tertiary (37·2%) industries, highlighting the need to focus on mitigating $PM_{2·5}$ effects in these sectors (appendix p 92). Northern and central China suffered more economic consequences from $PM_{2·5}$-related premature deaths than the southern regions, with Hebei and Henan provinces facing the greatest costs relative to their regional GDP (0·09% and 0·08%, respectively).

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

Climate change has intensified the occurrence of extreme weather events, endangering lives and assets.[88] This indicator measures the economic losses of climate-related extreme events, including droughts, floods, hailstorms, thunderstorms, cyclones, blizzards, and extreme low temperatures. In 2023, the national economic losses due to climate-related extreme events grew substantially to $77·1 billion (0·45% of GDP), about 1·5 times that of 2022. Such a rebound is mainly attributable to the increasing effects of floods and typhoons, which highlights an urgent need for effective resilience measures to adapt for extreme weathers and to mitigate the negative economic effects. Among all losses, 58% were caused by direct destruction of physical assets, while 42% were indirect losses due to production and business interruptions. The results update only to 2021 on the provincial scale because of data limitations. Henan faced the highest losses, primarily due to unprecedented catastrophic rainfall and floods in July 2021, which accounted for 18·59% of its GDP. Shanxi (1·51%) and Shaanxi (1·34%), located in the central and western China, also had considerable losses.

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 tracks China's investments in new coal power generation and low-carbon energy. Investments in renewable energy continue to increase, with a considerable 102·8% increase in new capacity from 2022, reaching 302·2 gigawatts (GW) as the total capacity in 2023. The total capacity of renewable energy surpassed coal-fired power for the first time in history in 2023.[89] The capacity of solar and wind energy saw substantial growth rates of 147·1% and 101·1%, respectively, while the new installed hydropower capacity fell from 23·9 GW in 2022 to 10·3 GW in 2023. The Operational Guidance on Energy outlines the transition of coal-fired power to backup energy for peak-load electricity.[90] Due to this shift and hydropower's underperformance from droughts, the new thermal power generation capacity rebounded from 44·7 GW in 2022 to 65·7 GW in 2023. The investment ratio in low-carbon energy (including hydrological, wind, solar, and nuclear power) and thermal power increased, reaching 8·4:1 in 2023, up from 7:1 in 2022. At the provincial level, the top three provinces for renewable energy investment in 2023 were Xinjiang ($6·6 billion), Henan ($5·8 billion), and Shandong ($5·7 billion).

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

This indicator continuously monitors 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[91] and the China Premium Database (CEIC).[92] The employment in fossil fuel extraction industries continued its decline from 3·2 million in 2021 to 3·1 million in 2022. Meanwhile, in 2022, the total workforce in the renewable energy sector expanded to 5·5 million, marking a 1·8% increase from 2021. Notably, approximately 64% of this growth stemmed from the adoption of new technologies, encompassing geothermal energy, ground-based heat pumps, municipal and industrial waste, and ocean energy.

However, solar energy employment showed a slight decline of around 19 000 jobs. This downturn is expected to be temporary given the progress of pursuing carbon neutrality, as solar photovoltaic power industry jobs are projected to reach 3·5 million by 2035, which is an increase of 187% from 2020.[93]

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

This 2024 indicator has been improved with a larger data source from the Fossil Fuel Subsidy Tracker.[94] In 2022, fossil fuel subsidies in China soared to a record $88·7 billion, an increase of 78·2% and accounting for 6·5% of global subsidies, driven by subsidies for electricity and natural gas due to an ongoing energy shortage. Despite this increase, China's global rankings for fossil fuel subsidies per capita fell from 87th to 89th, and subsidies as a share of GDP dropped from 43rd to 102nd of 169 countries in 2022, hinting at the global reliance on fossil fuels. China's eight pilot carbon trading markets maintained stable prices at $8·1 per ton from 2022 to 2023, lagging behind the EU Emissions Trading System.[95] It has been 11 years since launching carbon emissions trading in pilot regional markets in 2013 and 3 years since the launch of national power sector emission trading in 2021. To control carbon emissions more efficiently, it is recommended to expand sectoral coverage and increase carbon price constraints properly while safeguarding energy and industrial security.

Indicator 4.2.4: production-based and consumption-based attribution of CO_2 and $PM_{2·5}$ emissions

This indicator updates the China MRIO table from 2017 to 2020 and examines CO_2 and $PM_{2·5}$ emissions stemming from the production of goods and services exchanged among China's provinces. In 2020, 25·1% of China's CO_2 emissions stemmed from the internal trade of goods and services among its provinces, while 15·0% were from exports to other countries. Similarly, for $PM_{2·5}$ emissions, the figures were 21·8% for internal trade and 15·6% for exports. In the low-income northwest provinces, 25·2% (507·68 megatonnes [Mt]) of production-based CO_2 emissions were embodied in net exports to other regions of China. By comparison, the high-income provinces on the south coast had the largest carbon emissions embodied in net imports of 173·13 Mt. The CO_2 emissions embodied in net trade from northwest provinces were 65·5% higher than that in 2017, indicating that CO_2 emissions are increasingly polarised toward lower-income regions.[86] The central provinces had the largest $PM_{2·5}$ emissions embodied in net exports (145·93 kilotonnes [Kt]), and central coast provinces had the largest $PM_{2·5}$ emissions (167·71 Kt). Both figures were smaller than that in 2017 because of air pollution reduction in China.

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

This new indicator estimates the annual value and spatial distribution pattern of potentially stranded assets in China's coal-fired power generation sector under the carbon allowances limits of the 1·5°C goal of the Paris Agreement.[96,97] With nearly 6000 coal-fired units' data from the Global Energy Monitor, this indicator adopted the Overnight Cost of Capital method[98–101] to estimate the potentially stranded assets at the factory level following the lowest-stranded assets roadmap based on the 1·5°C pathway. Carbon allowance limits for China for 2019–2100 are calculated using the allocation method of fairness principles (historical responsibility, capability to pay, and equal per capita convergence).[102–105] As the main driver of carbon emissions in China's energy sector,[106,107] decision makers should recognise the economic risks associated with increasing coal-fired power capacity and delaying the transition to low-carbon energy systems.

If no new coal-fired units are added in China in 2030, the value of stranded assets in China's coal-fired power generation sector would reach $10·6 billion under the 1·5°C pathway. The three provinces with the highest stranded assets of 2030 would be Shandong ($1837·3 million), Jiangsu ($1464·8 million), and Inner Mongolia ($823·6 million). Of all stranded assets attributed to China's coal-fired power units, 41·9% would occur in eastern China ($4463 million) and 15·3% in northeast China ($1624·6 million). Considering the flexibility retrofit (ie, a decrease in utilisation hours of coal-fired units) scenario, the stranded assets of China in 2030 under the 1·5°C pathway would be $8·6 billion with a 20% reduction in utilisation hours and $6·1 billion with a 30% reduction (appendix pp 106–110).

Conclusion

In 2023, while the economic impact of air pollution-related premature deaths declined due to cleaner energy adoption and stricter controls, the economic costs of heatwave-related mortality and productivity loss surged because of record-breaking heatwaves that surpassed records established the previous year. With records set year on year, it emphasises the urgent need to accelerate low-carbon transformation and advance climate and health-friendly investment and financing. Despite the ongoing rise in investment in low-carbon energy, the continued increase of fossil fuel subsidies and stagnant carbon prices might result in considerable stranded assets and financial risks in the future. China could experience the highest value of stranded asset risks (representing 55% of the global total under 1·5°C targets)[100] and should prioritise a fair transition for the health of its people and its economy.[108]

Section 5: public and political engagement

This section assesses engagement with climate change and health across various societal sectors, encompassing media (indicator 5.1), individuals (indicator 5.2), academics (indicator 5.3), and government (indicator 5.4). This section highlights the crucial role of public and political engagement in accelerating climate action, providing a comprehensive view of the discourse. Wherever possible, the coverage of COP28 and its Health Day was investigated.

Indicator 5.1: media coverage of health and climate change

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

Analysis of seven Weibo accounts, including official (@People's Daily and @Xinhuanet), local (@The Beijing News), commercial (@The Paper), and professional media (@HealthTimes, @China Science Daily, and @China Meteorological News) revealed an increase in coverage from 2010 to 2023. On average, there were 1535 posts yearly on climate change during 2010–23, with 146 (9·51%) concerning health. In 2023, 175 posts about health and climate change received 21 963 retweets, 93 085 likes, and 20 013 comments. 72·57% focused on domestic issues, 24% on other countries, and 3·43% on global topics. Over 65% discussed health impacts from extreme rain and heat in Beijing, Shaanxi, and Yunnan. Despite COP28's Health Day coverage by The Paper and The Beijing News, this news were not posted on their Weibo accounts.

Indicator 5.1.2: newspaper coverage of health and climate change

Mainstream newspapers can influence public and political responses to climate change.[16] This indicator tracks provincial media coverage of health and climate change from 2008 to 2023, analysing 34 major provincial newspapers and paying special attention to COP28. From 2008 to 2023, newspapers featured on average 26 032 articles annually on climate change, with about 6% (1464 articles) annually related to health. Despite a general upward trend of coverage on climate change, the increase from 2022 to 2023 was 5%, which was much lower compared with the 37% annual increase from 2020 to 2021. The peak year for health-related climate change coverage was 2020 during the COVID-19 pandemic. In contrast, 2023 saw a decline in health-related articles, with 1695 articles compared with 2490 in 2022 and 2766 in 2020. COP28 was briefly mentioned in 15 (0·9%) of the 1695 health-related climate change articles in 2023.

Indicator 5.2: individual engagement in health and climate change

This indicator aims to track individual engagement with health and climate change with query data from Baidu, China's most widely used search engine. In 2023, searches for climate change decreased by 8·98%, reverting to 2021 levels. The influence of COVID-19 in 2022 probably heightened awareness of the correlation between health and climate change in China. As the effect diminishes, a corresponding decrease in individual engagement has been observed. Analysis shows that females and individuals with tertiary education are more engaged. Northern China, western China, and the Qing-Zang Plateau show higher engagement compared with other regions. Furthermore, except for Xinjiang and Yunnan, western China had more COP28-related searches, aligning with the region's increased climate change queries.

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

This indicator tracks scientific articles related to climate change and health in China in both English-language and Chinese-language journals. Data from 2009–23 were obtained from OpenAlex and Baidu Scholar, respectively. Between 2009 and 2023, there were 29 826 English-language papers related to climate change and health, of which 3441 are related to China, accounting for 11·54% of the total. In 2023, the number of articles related to China decreased compared with 2022, but still exceeds 400 papers. Meanwhile, the number of Chinese articles showed a considerable increase, with more than three times as many articles as 2022 (337 *vs* 102).

Indicator 5.4: government engagement in health and climate change

This indicator tracks government engagement in climate change and health according to policy text data from the five official websites of the Chinese Government (the China Meteorological Administration, the National Development and Reform Commission, the National Health Commission of the People's Republic of China, the Ministry of Ecology Environment of the People's Republic of China, and the National Disease Control and Prevention Administration). In 2023, an annual average of 2214 articles were related to climate change, and correspondingly, 377 (17%) related to a topic on climate and health. Among the articles that were shown on the aforementioned websites of the Chinese Government, 20 mentioned COP28.

Conclusion

From 2022 to 2023, there was a decline in engagement with climate and health issues among the general public, following a heightened concern over health caused by COVID-19. Meanwhile, engagement from professional communities (ie, academic journals, media, and government websites) increased steadily. Despite COP28's Health Day marking a considerable milestone for climate and health, its coverage was limited, indicating insufficient attention and engagement in the Chinese-speaking world. There remains a disconnect between climate change and health in many sectors in China.

Conclusion of the 2024 China report of the *Lancet* Countdown on health and climate change

The 2024 China report of the *Lancet* Countdown found that health impacts of the rising temperatures have been substantial in recent years (figure 3), and that progress on adaptation has been steady while progress in energy transition and air quality improvement has witnessed a stagnant or even downward trend in 2023.

In 2023, China faced severe health threats from hot and dry climate conditions. The record-breaking heatwaves and temperature rise led to a 309% increase in heatwave-related deaths, considerable losses in work hours, and increased exposure to wildfires. Drought exposure that was seven times higher than baseline, escalated the risk of drought-related health issues such as infectious diarrhoea risks by 15%. Economic effects were profound, with heat-affected labour productivity losses reaching $326·0 billion (1·9% of GDP) and costs from climate-related events at $79·5 billion, marking a 150% increase from the previous year.

In China, progress in addressing climate change and health risks is uneven. National health emergency response preparedness improved, with the score increasing from 73·54 in 2021 to 75·55 in 2022 and with narrowing regional disparities. In 2023, provinces provided various meteorological services for health, including for heatstroke, cardiovascular and respiratory conditions, and mosquito bites. The country made considerable strides in renewable energy, adding 302·2 GW capacity in 2023, surpassing coal for the first time, and employment in the renewable sector grew to 5·5 million, maintaining a growth trend. Challenges persist, particularly in remote, cooler areas where low air conditioning ownership leaves susceptible populations at risk from record heatwaves. Drought has diminished urban green spaces in 21 (67·7%) of 31 provinces, highlighting climate adaptation challenges. The absence of a national health adaptation plan limits strategic direction and financial investment. Coal consumption increased by 4% from 2022 to 2023, marking the highest rise since 2011, and only 24% of rural homes used clean heating in 2023, leading to exposure to indoor air pollution. Moreover, fossil fuel subsidies continue to

Impact

Indicator	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Heatwave-related mortalities (10 000 people deaths)	1·44	1·51	1·86	1·35	1·51	2·27	2·02	1·61	0·79	2·07	2·52	1·80	1·36	2·89	1·61	1·31	2·23	3·59	2·70	2·96	2·25	2·47	5·09	3·73
Cost of heatwave-related mortalitie (US$100 million)																		4·30	4·47	4·81	4·85	5·49	6·32	6·40
Heat-related labour capacity loss (10 billion hours)	3·17	2·99	3·23	3·29	2·89	3·10	3·29	3·00	2·70	2·87	3·35	2·66	2·68	3·53	2·72	2·46	3·77	3·79	3·81	3·31	3·04	3·19	3·78	3·70
Cost of heat-related labor capacity loss (US$100 million)															1·23	1·33	2·28	2·34	2·46	2·28	2·21	2·43	3·12	3·26
Heat-related physical activity safe hours lost (loss of safe hours per day)	1·46	1·37	1·40	1·58	1·54	1·54	1·65	1·49	1·49	1·49	1·70	1·41	1·42	1·93	1·40	1·29	1·94	2·04	2·09	1·78	1·81	2·05	2·32	2·20
Wildfire exposure (billion people per year)		1·67	2·54	4·66	5·48	5·36	5·67	7·16	7·82	7·24	6·76	7·12	6·55	8·08	8·38	7·08	6·45	6·61	6·10	4·75	4·42	4·98	6·08	8·11
Population exposure to extreme rainfall (billion person-events)	2·94	2·94	2·45	2·82	3·52	2·74	3·24	2·82	3·22	3·33	3·04	3·73	2·78	3·59	3·98	3·09	3·44	4·23	3·47	3·55	4·46	4·30	3·39	
Population exposure to drought (10 billion person-months)	0·15	0·14	0·69	0·11	0·06	0·21	0·54	1·13	0·25	0·23	0·13	0·04	0·07	0·76	0·34	0·33	0·33	0·94	0·84	0·60	1·64	1·42	1·66	
Climate suitability for dengue fever (media index)					0·25	0·33	0·34	0·33	0·32	0·35	0·35	0·32	0·35	0·38	0·36	0·36	0·42	0·42	0·44	0·44	0·42	0·42	0·36	

Score: 8 7 6 5 4 3 2 1

Response

Indicator	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Health emergency management (0≤ score ≤1)																			0·51	0·56	0·73	0·73	0·76	
Reduction of carbon intensity (compared with 2005)	0·12	0·15	0·15	0·08	0·06	0·00	0·01	0·05	0·08	0·17	0·12	0·15	0·13	0·19	0·24	0·29	0·33	0·36	0·38	0·40	0·41	0·43	0·46	0·47
Share of non-coal fuel in total energy consumption	0·32	0·32	0·31	0·30	0·30	0·28	0·28	0·27	0·28	0·28	0·31	0·30	0·32	0·33	0·34	0·36	0·38	0·39	0·41	0·42	0·43	0·44	0·44	0·45
Share of renewable electricity in electricity generation	0·17	0·19	0·18	0·15	0·16	0·16	0·15	0·15	0·18	0·17	0·18	0·15	0·18	0·18	0·20	0·23	0·24	0·24	0·25	0·26	0·27	0·27	0·27	0·27
Share of electricity in household energy use	0·11	0·11	0·12	0·12	0·12	0·13	0·14	0·15	0·16	0·17	0·17	0·17	0·18	0·19	0·19	0·18	0·19	0·19	0·20	0·21	0·22	0·22		
Share of cities that meet the $PM_{2·5}$ concentration standard (35 μg per m^3)																0·23	0·29	0·31	0·42	0·50	0·60	0·65	0·71	0·65
Reduction of fossil fuel subsidies compared with 2018											0·52	0·46	0·03	−0·05	−0·03	0·04	0·20	0·12	0·00	0·19	0·30	0·39	−0·11	

Score: 1·0 0·8 0·6 0·4 0·2 0

Figure 3: **An overview of impacts and responses tracked in the 2024 Chinese Report of the *Lancet* Countdown**
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. For impact indicators, the values are absolute values of the indicators, with all indicators sharing the same colour scale shown on the right. For the baseline indicators, a larger number represents a greater impact. For response indicators, the values are normalised from 0 to 1, where 0 represents the action progress in the base year or no action, while 1 represents the best possible action progress.

grow, further complicating the transition to cleaner energy sources. To meet the 2°C or 1·5°C climate goals, China's carbon emissions need to decrease annually by 6–9% from 2030, a rate of reduction unprecedented and fraught with challenges.[109]

Despite these challenges, and amid continued and increasing reliance on fossil fuels, there are signs of progress. By 2023, China had taken considerable steps to increasingly centre health within climate change discourse, emphasising the need for renewable energy at the forefront of a fair transition. This shift promises not only environmental and economic benefits, but also public health benefits, as cleaner air improves health outcomes. Investments in renewables are particularly impactful in China's low-income regions, promoting equitable progress and facilitating an equitable transition by creating jobs and reducing development disparities.

China's post-COP28 actions are key to accelerating global initiatives. China's renewable energy development

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and fossil fuel reduction considerably impact global emissions, while exporting these technologies can help other countries, especially low-income ones, to reduce emissions. China's pilot programmes on adaptation in susceptible regions offer valuable insights for other low-income countries. Achieving a sustainable future, however, requires China to intensify efforts in reducing GHGs and staying on track to restrict global warming to below 1.5°C.

Contributors

The 2024 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. The work presented in this paper 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 report concepts and provided input and expertise to the relevant sections. Working Group 1: CH (as lead), YB, NC, HC, LC, QL, ZhaL, SL, XW, FY, WY, JY, RZ, QiZ, and QiaZ. Working Group 2: CR (as lead), WF, YifH, JHua, HH, JSJ, TL, LL, BLin, YLi, BLu, QuoW, and QinW. Working Group 3: ShaoZ (as lead), BC, GK, HLin, HLiu, ZhuL, CL, ZheL, YM, RS, LW, YY, DZ, and HZ. Working Group 4: HD (as lead), DG, YixH, BLi, ZM, JSh, XS, YX, YZ, ShanZ, MZ, and ZZ. Working Group 5: JSu (as lead), MC, XH, Q J, YS, WW, SW, HX, JZha, and JZho. The coordination, strategic direction, and editorial support for this paper was provided by WC, CZ, ShiZ, JHuan, XJ, MR, MW, CW, BX, XY, LY, YLu, and PG.

Declaration of interests

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