The 2023 China report of the *Lancet* Countdown on health and climate change: taking stock for a thriving future

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Executive summary

With growing health risks from climate change and a trend of increasing carbon emissions from coal, it is time for China to take action. The rising frequency and severity of extreme weather events in China, such as record-high temperatures, low rainfall, severe droughts, and floods in many regions (along with the compound and ripple effects of these events on human health) have underlined the urgent need for health-centred climate action. The rebound in the country's coal consumption observed in 2022 reflected the great challenge faced by China in terms of its coal phase-down, over-riding the country's gains in reducing greenhouse gas (GHG) emissions. Timely and adequate responses will not only reduce or avoid the impacts of climate-related health hazards but can also protect essential infrastructures from disruptions caused by extreme weather. Health and climate change are inextricably linked, necessitating a high prioritisation of health in adaptation and mitigation efforts. The 2023 China report of the *Lancet* Countdown continues to track progress on health and climate change in China, while now also attributing the health risks of climate change to human activities and providing examples of feasible and effective climate solutions.

This fourth iteration of the China report was spearheaded by the *Lancet* Countdown regional centre in Asia, based at Tsinghua University in Beijing, China. Progress is monitored across 28 indicators in five domains: from climate change impacts, exposures, and vulnerability (section 1); to the different elements of action, including adaption (section 2) and mitigation, and their health implications (section 3); to economics and finance (section 4); and public and political engagement (section 5). This report was compiled with the contribution of 76 experts from 26 institutions both within and outside of China. The impending global stocktake at the UN Framework Convention on Climate Change 28th Conference of the Parties (COP28), the UN initiative on early warning systems (which pledged to ensure the world was protected by the end of 2027), and China's action plans to reduce air pollutants and GHGs illustrate that global climate action has moved from talk to concrete plans. These initiatives could deliver major health benefits, but none of them explicitly list health as a policy target or indicator. The results of the global stocktake could guide health-focused and feasible interventions. The first Health Day and climate-health ministerial meeting that will be hosted at COP28 underline the trend to mainstream health in the global climate change agenda. Health risks arising from human-induced climate change, and production-based and consumption-based CO_2 and ambient particulate matter ($PM_{2·5}$) emissions (indicator 4.2.4) indicate the urgent need for mitigation by identifying human contributions to carbon emissions and climate change. Early warning systems for health risks (indicator 2.4) and the city-level human comfort index provide bottom-up examples of adaptation practices.

Humans at the centre: stocktaking the health impacts of climate change and human contributions to rising health hazards

The record-breaking heat and droughts of 2022 were associated with increased adverse health outcomes. Wildfire exposure increased by 54% (indicator 1.2.1) compared with the historical baseline and heatwave-related mortality increased by 342% (indicator 1.1.1). Heat-related work loss increased by 24% (indicator 1.1.2), safe outdoor physical activity loss increased by 67%, and the resulting hours available for safe outdoor activities decreased by 9·6% (indicator 1.1.3). Human-caused climate change was responsible for 49·4% of heatwave-related mortality, 30·9% of heat-related labour productivity loss, 98·8% of populations affected by drought, and 7·6% of populations affected by flood in the previous 20 years. Heat-related economic loss also broke all previous records, with costs of heat-related labour productivity loss reaching 1·91% of gross domestic product (GDP; US$313·5 billion; indicator 4.1.2). Future concerns must not be overlooked: in the case of future sea level rise, the ratio of exposed populations to the total population in coastal provinces is expected to be 7·7% in 2050 and 12·9% in 2100 under high emission scenarios (indicator 1.4)—putting these populations at risk from the hazards of coastal erosion, floods, and water and land salinification, and at risk of physical harm on coastal infrastructure.

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Steady improvements with little emphasis on health

Growing capacity building to adequately respond to public health emergencies (indicator 2.1.1), expanding coverage of early warning systems (indicator 2.3), and improvements in cross-sectoral information sharing (indicator 2.2) all exemplify China's steady progress in climate change adaption, which involves responses to health risks that are imminent or have already occurred. In response to rising temperatures, use of air-conditioning increased, providing heat protection. However, this use also contributed to increased GHG emissions. Meanwhile, there was no substantial increase in urban green space coverage, which can provide sustainable cooling, while also delivering direct benefits to people's physical and mental health.

Transitions in the energy system coupled with air quality control measures have considerably lowered GHG emissions and air pollution in the past 10 years. Indeed, between 2015 and 2020, improvements in $PM_{2\cdot5}$ air pollution reduction resulted in 282 400 deaths avoided, and 1·5% less CO_2 was emitted in 2022 than in 2021 as a result of substantial reductions in emissions from industrial processes. However, as electricity generation from hydropower and other low-carbon energy sources was threatened by extreme weather events in 2022, coal power was used to fill the gap and secure the energy supply. Consequently, since 2011, coal consumption has grown by the second largest rate (4·3%), posing a persistent health risk related to air pollution. Hence, there is an urgent need to diversify China's energy mix and increase access to diverse sources of renewable energy as safe and stable alternatives to coal power generation. Without a health-centred focus, China risks bypassing the energy transition and getting stuck in a high-carbon entrapment.

With the impacts of climate change on health becoming increasingly visible, the coverage of climate change and health grew substantially from 2021 to 2022 on Weibo and among individual users of Baidu. However, engagement from professional channels such as newspapers, academic journals, and government websites on the climate change–health nexus has remained practically unchanged over the past 2 years, and health was rarely mentioned or prioritised in current mitigation and adaptation actions. Current early warning systems are mainly based on meteorological signals, such as extreme heat, ignoring health implications. Although there is a health section in the National Adaptation Strategy 2035, the absence of a stand-alone nationwide health adaptation strategy exposed the low priority of health in the country's adaptation agenda. Meanwhile, the ratio of public engagement (media, academic, and government) on climate and health to public engagement on climate-only items has grown very slowly over the past 20 years, also implying the low prioritisation of health by the public climate change agenda.

Exploring future opportunities for health-centred responses

Since the first report in 2020, the China reports of the *Lancet* Countdown have been taking stock of progress on climate change and health and reporting findings that have helped to inform and accelerate further policy progress. Issues around climate change and health have been increasingly prominent in relevant policies at both national, regional, and sectoral levels, such as the climate content in health policies such as the annual working priorities of Healthy China. However, overall progress has so far been poor. Therefore, we present five evidence-informed policy recommendations to harness opportunities to deliver a safer, healthy future for people in China:

1. Increase investment and research in renewable energy to avoid the lock-in effects of coal power

Investing in renewable energy infrastructure can reduce GHG emissions and promote energy diversity and resilience. Research and development efforts on grid integration and energy storage can enhance the efficacy, reliability, and affordability of renewable technologies, making them more accessible for widespread adoption. By prioritising these investments, China can cut its long-term reliance on coal power, and pave the way for a cleaner, more sustainable energy system that mitigates climate change and fosters a healthier environment for present and future generations.

2. Harness the synergies in actions to reduce carbon and air pollutants

By capitalising on the interconnections between carbon reduction and improved air quality, China can protect human health, enhance environmental wellbeing, and build resilient communities for generations to come. Transitioning to cleaner and renewable energy sources, promoting energy efficiency in all sectors, and implementing sustainable transportation systems are all components of this strategy. In addition, imposing stringent emission standards for industries, promoting reforestation and conservation actions, and promoting sustainable agricultural practices all contribute to the reduction of carbon emissions and air pollutants.

3. Establish meteorology-informed early warning systems for health

China should develop a population health-oriented meteorological early warning system that accounts for climate health hazards. Such a system will enable the issuing of warnings when climate characteristics or conditions have health concerns and the implementation of targeted and preventive actions for these concerns. Creating an advanced early warning system that provides comprehensive protection for the health of vulnerable populations, such as older people, children, pregnant women, and patients suffering from chronic diseases, can help reduce the toll of climate-related hazards in China.

4. Promote research on the compound and cascading effects of extreme weather events and efficient response strategies

Characterising the interconnected and complex nature of extreme weather events, such as heatwaves, floods, and cyclones can help inform health-protective mechanisms targeted at protecting vulnerable populations, crucial infrastructure, and ecosystems susceptible to cascading climate effects. In addition, charaterising the interactions between sectors such as water, energy, or agriculture and health enables the development of comprehensive response strategies. There is a need for empirical research on the health effects of response strategies such as enhanced early warning systems, improved infrastructure resilience, community preparedness and response plans, and the implementation of nature-based solutions. By promoting relevant research, China can increase its understanding of the compound and cascading effects of extreme weather events and develop effective strategies to mitigate their effects, safeguard lives, and nurture resilient societies.

5. Develop health adaptation guidelines tailored to different actors

These guidelines should provide specific recommendations and strategies for various stakeholders, including local governments, health-care systems, communities, and individuals. Local governments can launch local health adaptation plans and vulnerability maps that reflect local contexts. Health-care systems should develop protocols and training programmes to enhance their capacity to respond to climate-related health challenges. Communities can be empowered through education and awareness campaigns that promote climate-resilient practices and the protection of vulnerable populations. Individuals can be provided with practical guidance on adapting their lifestyles to reduce the health risks associated with climate change. By tailoring guidelines to different actors, China can foster a coordinated and comprehensive approach to health adaptation, ensuring the wellbeing and resilience of communities in the face of a changing climate.

2023 is a crucial moment; the *Lancet* Countdown's stocktake on health and climate change helps identify and define opportunities for accelerated climate action. Looking back at the causes and impacts of climate change in China highlights the need for urgently accelerating mitigation and adaptation efforts. Extreme weather events are stifling mitigation work, and a positive reaction to climate change will enable China to speed up mitigation measures, lead the zero-carbon transition, and deliver immediate health benefits to its people.

Introduction

2022 was a year of dangerous weather conditions for Chinese people, with the second highest national average temperature on record, the lowest precipitation since 2012, a long drought across summer and autumn in the southern region, and extreme rainfall and flooding in the Hunan and northeastern regions.[1] Over 900 million people in China (65%) were affected by a scorching heat that lasted for over 70 days in the summer of 2022.[2] Such hazards have triggered compound and cascading impacts on human health in both the short term and the long term, requiring more flexible and timely adaptation responses. Taking the consecutive heat and drought in Sichuan last summer as an example, the substantial increase in heat stroke incidence was a short-term and direct health impact, whereas the electricity and water supply shortages due to low water levels were long-term and indirect threats for human health and wellbeing.[3,4] Furthermore, China's coal power generation rebounded in 2022, largely to maintain a stable supply of energy when low-carbon electricity generation was threatened by extreme weather events. Therefore, increasing numbers of extreme weather events in the country highlight the need for urgent mitigation and adaptation.

In the meantime, global climate policy is entering a new era, with opportunities to accelerate action and implementation. The clock is ticking, and the health impacts of anthropogenic climate change are becoming more prominent, highlighting the need for mitigation of anthropogenic GHG emissions. The UN's global stocktake process marks a worldwide opportunity for reflection, accounting, and renewed ambition for action incentives and evidence-based solutions. The Chinese Government has launched several policies that will undoubtedly protect human health from climate change, such as the Synergising the Reduction of Pollution and Carbon Emissions Implementation Scheme.[5] Although the announcement of the first Health Day, which will be hosted at COP28, marked the rising political profile of health in climate change issues, health is not explicitly listed as a target in climate policies. It is crucial that health is sufficiently prioritised in governmental climate action, to ensure health co-benefits from climate actions.

The 2023 China report of the *Lancet* Countdown is the third annual update, tracking progress in climate and health across five sections through 28 indicators: 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). To better capture the role of human emissions and present solution opportunities, this year's report includes two new indicators and two new panels. A panel exploring the attribution of health risks from climate change to human-induced changes in climatic conditions (panel 2, figure 1) and an indicator monitoring the attribution of production-based and consumption-based CO_2 and $PM_{2.5}$ emissions (indicator 4.2.4) emphasise the urgency of mitigation actions. Indicators tracking the

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Panel 1: **The 2023 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
- 1.2: health and extreme weather events
  - 1.2.1: wildfires
  - 1.2.2: flood 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 delivery and implementation
  - 2.1.1: detection, preparedness, and response to health emergencies
  - 2.1.2: air-conditioning—the benefits and harms
  - 2.1.3: urban green space
- 2.2: climate information services for health
- 2.3 early warning services for health risks*

Mitigation actions and health co-benefits

- 3.1: energy system and health
- 3.2: clean household energy
- 3.3: air pollution, transport, and energy

Economics and finance

- 4.1: the economic impact of climate change and its mitigation
  - 4.1.1: economic costs of heat-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 ambient particulate matter ($PM_{2.5}$) emissions*

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 in the 2023 China report.

progress of early warning services for health risks (indicator 2.4) and the city-level human comfort index (panel 3) monitor progress on local solutions for adaptation. Where possible, the methodologies of other indicators have been improved on from last year's report with either updated data or methodologies.

Section 1: climate change impacts, exposures, and vulnerability

Anthropogenic climate change is causing substantial health threats to people in China through various pathways. This section monitors the health risks of climate change with six indicators that cover heat and health (indicators 1.1.1–1.1.3), health and extreme weather events (indicators 1.2.1–1.2.2), climate-sensitive infectious diseases (indicator 1.3), and rising sea levels (indicator 1.4). Whenever possible, the impacts or risks that can be attributed to human-induced climate change are identified (panel 2).

Indicator 1.1: health and heat

Indicator 1.1.1: heatwave-related mortality

In 2022, China saw the most severe heatwave since records began in 1961 in terms of intensity, duration, and the area affected. Exposure to extreme temperatures can overload the body's thermoregulatory and circulatory systems, which can induce heat-related diseases, aggravate underlying conditions, and even lead to premature death.[8,9] The record-breaking heatwave contributed to the average number of heatwave days experienced by each Chinese person reaching 21·0 days in 2022, which was 293% (or 15·6 days) higher than the historical baseline (1986–2005) average. Consequently, heatwave-related mortality was estimated to reach a record high of about 50 900 deaths in 2022, more than twice the number in 2021. The annual average mortality over the past 5 years (2018–22) was 169% higher than the historical baseline, highlighting the pressing health threats from heat under a changing climate. Of the 31 provinces, heatwave-related deaths were highest in Henan, followed by Shandong, Jiangsu, and Sichuan, which accounted for 15·5%, 8·7%, 8·5%, and 8·1% of total deaths in 2022, respectively.

Indicator 1.1.2: change in labour capacity

Excessive heat can cause severe physiological strain to workers and lead to reduced labour productivity.[10] In 2022, potential work hours lost due to heat exposure reached 38·3 billion hours, nearly 1·2 times the baseline average (1986–2005). Agricultural and construction workers had a potential work hours lost value that was 24·6-times greater than that of service workers, mainly because they are engaged in more physically demanding labour with higher metabolic rates, making them more susceptible to loss of labour capacity due to heat exposure. Guangdong and Henan had the biggest losses in China because of their higher temperature exposure, larger population sizes, and high proportions of outdoor workers, underlining the importance of workplace-specific adaptation measures in these areas.

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***Panel 2:* The health impacts attributed to human-induced climate change in China**

Climate change is an important source of threats to human health. Quantifying the impacts that are the result of human activities can help policy makers and the public better understand the urgency of climate action. Following the methodology of Vicedo-Cabrera and colleagues,[6] this year's report calculated the proportion of heatwave-related mortality (indicator 1.1.1), change in labour capacity (indicator 1.1.2), exposure to warming (indicator 1.1.4), and extreme rainfall and drought (indicator 1.2.2) attributable to human-induced climate change. Factual and counterfactual scenarios from climate models (appendix pp 116–17) were used to calculate the contribution of human-induced climate change on overall effects. Factual scenarios represent the compound forcing of anthropogenic and natural climate change, whereas counterfactual scenarios only include natural forcing. We quantified the contribution of human-induced forcing by subtracting the counterfactual scenario from the factual scenario.

Nationally, the proportions of several major climate-related risks attributable to anthropogenic emissions have been high over the past 20 years. Compared with the baseline period (1986–2005), the average summer population-weighted temperature increased by 0·185°C and decreased by 0·062°C in 2000–20 under the factual and counterfactual scenarios, respectively, with the anthropogenic impact accounting for 133% of the temperature increase. Average annual heatwave-related mortality during 2000–20 was 12 798 people and 6473 people for the factual and counterfactual scenarios, respectively, with 49·4% of heatwave-related mortality attributable to anthropogenic climate change. 24·9 billion and 17·2 billion working hours were lost annually during 2000–20, respectively, under factual and counterfactual scenarios due to high temperatures, with anthropogenic factors accounting for 30·9% of the total work hours lost. In addition to influencing heat-related outcomes, human factors also accelerate other climate hazards. For example, the average population affected by drought is 146·3 and 1·7 (per 100 000 population per year) for 2000–20 under the factual and counterfactual scenarios, respectively. Therefore, 98·8% of this exposure to drought can be attributed to anthropogenic climate change.

At the provincial level, the contribution of anthropogenic climate change to the indicators varies considerably (figure 1). The provinces with the highest proportions of annual average heatwave-related deaths attributable to anthropogenic climate change in 2000–20 were Guangdong Province (67·0%), Fujian (60·3%), Hainan (59·3%), Hunan (59·7%), and Shanghai (60·2%). The contribution of anthropogenic climate change is generally higher in the southern region of China than in the northern and western regions, with provinces such as Qinghai (97·4%), Yunnan (56·7%), and Xinjiang (58·8%) having much higher attributable portions than the national annual average anthropogenic attribution rate of heat-related work hours lost in 2000–20. However, the total potential working hours lost in these provinces is minimal and has little effect on the overall national results. The provinces with the greatest amount of potential work hours lost are mainly located in south, east, and central China. Most of the anthropogenic climate change impact contributions are between 20% and 30% in these regions, with the contributions in Fujian (42·9%), Guangdong (39·0%), Hainan (35·9%), and Zhejiang (36·6%) all exceeding 30%.

Indicator 1.1.3: heat and physical activity

Doing physical activity in high temperatures and humidity can increase the risk of exertional heat stress and can lead to lethal heat stroke,[11,12] but allocating inadequate time for physical activity is associated with increased cardiovascular diseases, diabetes, or cancer.[13–15] For people who engage in physical activity, high temperatures can present an acute health risk. This indicator tracked the number of safe physical activity hours lost per day when a heat index, which combines temperature and humidity, exceeded a threshold of 33°C.[16] China experienced 2·32 activity hours lost per person per day in 2022. South central China was the most affected region, with 3·67 activity hours lost in 2022. This is an increase of 0·94 hours (67·8%) for China and 1·21 hours (49·4%) for south central China compared with the baseline averages (1986–2005). As a result, the hours available for safe outdoor activities decreased by 9·6% in China. 3 of the 5 years with the most hours of safe physical activity lost in China from 1986 to 2022 have occurred since 2018; in south central China, 4 of the 5 years with most hours lost occurred after 2018.

Indicator 1.2: health and extreme weather events

Indicator 1.2.1: wildfires

While the number of global wildfires has been increasing due to climate change,[17] wildfires in China have garnered substantial interest from both domestic and international research and media communities. Of note is the Chongqing Forest fire of 2022, which was probably precipitated by a combination of elevated temperatures and low humidity. In addition to causing injuries and death, wildfires also threaten land carbon sinks.[18] This indicator monitors the annual average number of days people were directly exposed to wildfire each year with satellite observations and population data. In 2018–22, the national annual average wildfire exposure increased by 33·65% compared with 2001–05. Meanwhile, the exposure days per person grew in 23 provinces, with particularly big absolute increases in Hebei (0·22 billion person-days) and Heilongjiang (0·21 billion person-days).

Indicator 1.2.2: extreme rainfall and drought

This indicator tracks the temporal change in extreme rainfall and drought throughout China during the past

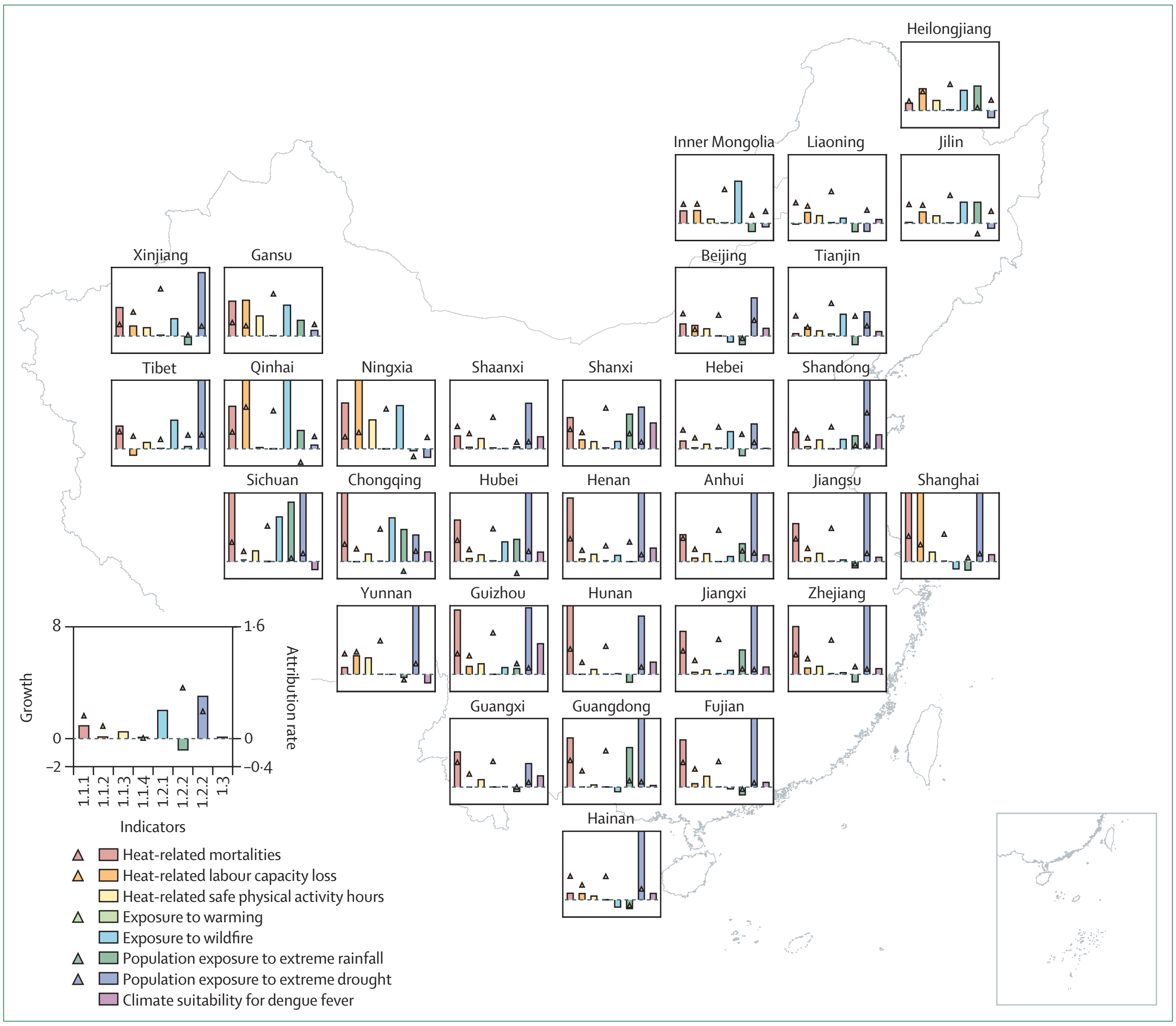

Figure 1: **Growth rates of climate-related health risks and attribution rates of human-induced forcing on health risks in each Chinese province**
The bars represent the growth of climate-related health risks from the historical baseline (mostly 1986–2005) to the current level (mostly in 2022) on the left y axis. The triangles represent the annual average attribution rates of human-induced forcing of climate-related health risks in 2000–20 on the right y axis.

decades. This year, the methodology has been refined to align with the global report of the *Lancet* Countdown, which uses the standardised precipitation evapotranspiration index (SPEI) to define drought (an SPEI value <–1·5 indicates a drought event) by accounting for precipitation, temperature, and evaporation.[19] Compared with the baseline years (1986–2005), the land area annually affected by extreme rainfall in China varied less substantially than the area affected by drought between 2000 and 2022. Areas with a net increase in drought incidence saw on average 3 extra months of drought than in the baseline years. The size of the population exposed to extreme rainfall events increased by 23·0% in 2000–22 compared with the baseline (appendix p 18). Gansu, Qinghai, and Sichuan had the largest increase in extreme rainfall events during 2000–22, whereas Tibet, Xinjiang, and Sichuan recorded the largest increase in drought occurrence (appendix p 20).

See Online for appendix

Indicator 1.3: climate-sensitive infectious diseases

Dengue fever is one of the most rapidly spreading climate-sensitive diseases in the world and has a considerable impact on public health.[20,21] This indicator includes the vectorial capacity for the transmission of dengue by *Aedes aegypti* and *Aedes albopictus* mosquitos, human population vulnerability, and the disease burden of dengue in China.

The vectorial capacity for dengue transmission increased in 17 provinces in China between 2004 and 2021 due to changing climatic conditions (appendix pp 25–26). The average vulnerability to severe dengue outcomes increased by over 10% in 17 provinces, between 2010–15 and 2016–21. The disability-adjusted life-years of dengue declined sharply, from 883 person-years in 2019 to 2 person-years in 2021, because of the strict border restrictions and quarantine policies put in place during the COVID-19 pandemic.[22]

Panel 3: **Moving from provincial-level indicators to city-level indicators—the example of city-level body comfort days**

Given the vast territorial area in China and the heterogeneity in climate and socio-economic status among cities, improving the spatial resolution of monitoring efforts from the provincial level to the city level would help people have a deeper understanding of how climate is changing in their specific regions and how trends are affecting their health, and provide more targeted and practical policy recommendations.

Tracking the number of body comfort days in Chinese cities, a metric developed by the China Meteorological Agency (CMA), is a potential new indicator for future China reports of the *Lancet* Countdown. It was briefly reported annually in the China Climate Bulletin, an official CMA publication that summarises the climate in different seasons and different regions in China. Before the number of body comfort days was calculated, the CMA developed a body comfort index, which combined daily temperature, humidity, and wind speed data from each city level with detailed meteorological observation data owned by the CMA (see appendix pp 45–46 for detailed formulas to calculate the body comfort index).[7] When the body comfort index of 1 day is between 59 and 70, the day is defined as a body comfort day; otherwise it is not.

In 2022, the ratio of comfort days to all days in the year in most of China's cities was between 20% and 40%. Southwestern cities, such as Simao, had higher comfort ratios, usually above 60%, whereas in cities in remote and arid inland regions, the comfort day ratio was as low as 10%. In cities, such as Beijing and Shanghai, the comfort day ratio was between 20% and 30%. Generally, the comfort day ratio is positively related to the population density, probably because people tend to live in cities with more comfortable climates.

However, 196 of 337 cities (58%) had fewer comfort days in 2022 than the 1986–2005 average, most of which are densely populated. Liupanshui, Ruili, and Nujiang, which are in remote southwestern mountainous areas, experienced the greatest loss of comfort days in 2022 compared with the historical baseline (1986–2005), with 98 days, 42 days, and 34 days lost, respectively, owing to rising temperatures in humid locations. The number of comfort days lost in densely crowded cities such as Beijing, Shanghai, and Zhengzhou was 14 days, 7 days, and 17 days, respectively, which is substantial when compared with their historically low comfort days (roughly 100 days in 1986–2005). Meanwhile, some cities experienced an increase in their comfort days ratios. For example, compared with 1986–2005, the number of human comfort days in Lingzhi and Kunming, cities with cold climates, increased by 15 days and 35 days, respectively.

This city-level information can help residents learn how to reduce their exposure to non-comfort days. It could also stimulate city managers to maintain or even increase the number of body comfort days in their cities with more effective climate change adaptation or mitigation measures. In the future, despite methodological challenges, more efforts will be given to improve the spatial resolution of the existing indicators in sections 1 and 2 from the provincial level to the city level where possible.

Indicator 1.4: population exposure to regional sea level rise

Regional sea level rise poses substantial risk to coastal residents, including from increased flooding, erosion, storm surges, and saltwater intrusion.[23,24] This indicator predicts population exposure to future regional sea level rise along the Chinese coast. In addition to regional sea level projections, new factors were taken into account in this report to estimate population exposure, including extreme sea level (ie, the occurrence of exceptionally high local sea surfaces due to short-term phenomena, including storm surges, tides, and waves) and population changes under three future climate and socioeconomic scenarios (shared socioeconomic pathways [SSPs]; appendix p 26).

The total Chinese population exposed to floods due to the present sea level rise and the 100-year return period of extreme sea level is 42 071 641 people. This number is projected to reach its peak roughly in the middle of this century before declining under all scenarios, as anticipated decreases in the population offset the effects of sea level rise. However, the ratio of the exposed population to the total population in coastal provinces is projected to increase compared with the baseline period (1995–2014) across all three scenarios (eg, the median estimation under the intermediate Shared Socioeconomic Pathway 2 [SSP2]–4·5 scenario for the present 100-year return period extreme sea level is 6·9% in 2050 and 9% in 2100), indicating a greater impact from future sea level changes on Chinese coastal communities (appendix p 28). The exposure varies by province. The most affected province is projected to be Jiangsu, where about 22·4% of the total population is projected to be threatened by floods at the level of 100-year extreme sea level under the very high SSP5–8·5 scenario in 2050 and 34·9% of the population in 2100.

Conclusions

Record high temperatures and drought in 2022 led to a substantial increase in related human exposure and health risks. Compared with the historical baseline (1986–2005), heatwave-related deaths, heat-related loss of potential work hours, and heat-related loss of time for safe outdoor physical activity increased by 342%, 24%, and 67%, respectively, and wildfire exposure increased by 54%. Over the past 20 years, more than 40% of heatwave-related mortalities, 25% of heat-related labour productivity loss, 98% of drought exposure, and 58% of flood exposure could be attributed to anthropogenic climate change. Although some Chinese people are aware of the health risks of extreme weather events, they have not linked them to anthropogenic climate change. Thus, the media and scientists need to explain this connection to the public to encourage them to support reducing global warming to protect themselves (section 5). Without strict emission reductions, climate change will threaten the Chinese public health system. For example, achieving the target of 1·5°C of warming will prevent tens of thousands of deaths in China.[25] Thus, China needs strict climate change mitigation regulations to reduce health risks, highlighting the urgent need for both adaption (section 2) and mitigation (section 3).

Section 2: adaptation, planning, and resilience for health

Extreme weather events in China in 2022 had substantial health impacts, particularly as the country faced its most severe drought and longest heatwave in six decades.[26] Both active adaptation, which involves pre-emptive planning to avoid future health risks, and passive adaptation, which responds to imminent risks, are needed. The UN recommends early warning systems as effective measures to save both lives and livelihoods from extreme weather events. China has implemented the real-time release of early risk warning information and corresponding public health services in some pilot provinces and cities. To measure progress in health adaptation to climate change, a new indicator on early warning services for health risks (indicator 2.3) has been added to this section alongside indicators on adaptation delivery and implementation (indicator 2.1.1, 2.1.2, and 2.1.3) and climate information services for health (indicator 2.2).

For more on **14th Five-Year Plan** see https://www.gov.cn/zhengce/content/2022-01/24/content_5670202.htm

Indicator 2.1: adaptation delivery and implementation

Indicator 2.1.1: detection, preparedness, and response to health emergencies

This indicator uses a multi-level index to measure the capacity of provinces to respond to public health emergencies, combining 22 indicators covering risk exposure and preparedness, health emergency detection and early warnings, and medical resources (appendix pp 31–34). Considering the impact of the growing older population and societal forces on public health emergencies, two indicators have been added to this year's report. From 2020 to 2021, the national average index score slightly increased from 73·00 to 73·54, with 18 of 31 provinces improving their capacity scores. For this index, a score of 100 represents the best possible performance in 2018. Values greater than 100 represent a better performance than the best registered performance in 2018. Beijing maintains its top position nationwide with a score of 104·9. Hubei, which has recovered from the impact of COVID-19, was the province with the most progress (value increased by 5·00 points) and performed even better than in 2019. Hubei was followed by Guangdong (increased by 2·47 points), Henan (increased by 2·34 points), and Fujian (increased by 2·27 points). These improvements are probably due to substantial efforts in strengthening the pharmaceutical industry, increasing health-care spending, or promoting social work in the health sector. However, the emergency response capacity of some provinces is facing challenges due to ageing populations, insufficient social expenditure, and recurrent outbreaks of COVID-19. Sichuan (decreased by 3·14 points), Tianjin (decreased by 2·52 points), and Hunan (decreased by 3·88 points) experienced rises of infectious diseases and, during the epidemic, there was some confusion in their data management, including the crash of their health code systems.

Indicator 2.1.2: air-conditioning—the benefits and costs

According to data from the Chinese Statistical Yearbook, the number of air-conditioning units owned per 100 households in China was 131·2 in 2021, a more than six-fold increase from 2000. The use of air-conditioning is effective for preventing heat-related mortality and we estimate that over 23 000 Chinese heatwave-related deaths were averted by air-conditioning in 2021. However, air-conditioning also leads to adverse health outcomes, by increasing urban heat due to the emission of heat waste, and $PM_{2·5}$ pollution and GHG emissions due to its high energy consumption. In China, air-conditioning contributed to an estimated 8600 deaths attributable to ambient $PM_{2·5}$ exposure in 2019, and to 0·3 gigatonnes (Gt) of CO_2 emissions in 2021. Following the Chinese Government's introduction of relevant policies, such as the State Council's 14th Five-Year Comprehensive Work Plan for Energy Conservation and Emission Reduction, more eco-friendly air-conditioning technologies are being promoted, to avoid the harmful health impacts of air pollution and rising temperatures. However, testing the effects and effectiveness of this policy will require more time.

Indicator 2.1.3: urban green space

Urban green spaces offer numerous benefits to health, including reducing ambient temperatures. Living near green spaces can help mitigate the impacts of heat waves on urban residents.[27] We measured green space with the normalised difference vegetation index (NDVI) and satellite imagery. We calculated population densities to measure the population-weighted NDVI (or green space exposure) in urban areas. Then, we evaluated the potential effect on mortality attributable to changes in urban green space exposure for urban areas within provinces (appendix pp 39–40). In 2022, two provinces had a very high level of urban greenness, 11 had high levels, and ten had moderate levels. Southern latitudes tended to have higher levels of green space, and urban green space in most Chinese cities showed an upward trend over the past decade. In 2022, five provinces or municipalities had lower greenness levels than in the

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past decade, whereas 12 provinces saw an increase of over 10% in greenness compared with the past decade. When looking at adults and taking relative risk into account, the overall green space changes from 2011 to 2022 are estimated to have averted 38 195 (95% CI 28 039–59 747) adult deaths in China.

Indicator 2.2: climate information services for health

Effective climate change adaptation that protects health needs interdepartmental collaboration. This indicator includes two sub-indicators. The first sub-indicator tracks which provincial meteorological departments provide climate and weather information or products to the public health sector, and the second tracks which provincial meteorological departments and public health departments have officially collaborated to provide information. The results of the Annual Provincial Survey on Climate Change Assessment and Information Services, which was initiated by the *Lancet* Countdown China in 2021,[28] show that in 28 of 30 responding provinces, meteorological data are shared with health-related departments. According to official releases, further collaborations between meteorological bureaus at the province, city, or county level and health-related agencies have been found in 22 provinces. These collaborations include data sharing, emergency responses, early warnings, and scientific research for climate-related and weather-related health risks.

Indicator 2.3: early warning services for health risks

Early warning systems for health risks are important adaptation tools that provide timely and accurate information to decision makers and the public.[29] This indicator was added this year to track the progress of early warning systems for health risks at both the provincial and city level in China. The number of provinces and cities across China that issued early warnings for health risks related to climate change increased from two provinces and two cities in 2020 to six provinces and 24 cities in 2021, and eight provinces and 27 cities in 2022. The types of early warning considered included ambient air quality health index warnings, heat-health early warnings, and cold-health early warnings.[30] Warnings can be issued daily. Warning levels are automatically estimated by the warning systems on the basis of a pre-designed algorithm and the monitoring or prediction of daily temperatures and concentrations of air pollutants. When given thresholds are exceeded, warnings are released to the public with some tips for health protection. The early warning health risk information is mainly released by local centres for disease control through their official websites, mobile apps, and WeChat official accounts. The population covered by warning services for heat and cold is much smaller than the population covered by warning systems for air pollution (31·85 million people *vs* 183·33 million people in 2022).

Conclusion

In 2022, China steadily intensified its passive adaptation actions on risk response: the national health emergency response score rose from 73·00 in 2020 to 73·54 in 2021; health risk early warnings expanded to cover eight provinces and 27 cities, shielding 183·33 million people; and interdepartmental collaborations strengthened with meteorological data being shared across 28 of 30 provinces. However, the country has not yet done enough in terms of active adaptation measures: air-conditioning ownership increased to 131·2 units per 100 households in 2021, averting 23 000 heatwave-related deaths but contributing to 8600 deaths linked to $PM_{2·5}$ pollution in 2019 and 0·3 Gt of CO_2 emissions in 2021. Expanding urban green spaces has been pivotal, leading to 38 195 fewer adult deaths between 2011 and 2022. Both active and passive adaptation require top-level planning, so a national health adaptation plan of action remains a strong need for future adaptation action in China.

Section 3: mitigation actions and health co-benefits

In 2022, there were efforts from the Chinese Government to extend the so-called 1+N policy framework, aimed at achieving its carbon peaking and carbon neutrality pledges. In this policy, the 1 refers to the long-term strategy tackling climate change, whereas the N refers to the various policies ensuring emissions peak before 2030.[31,32] A new policy, the Implementation Plan for Synergistically and Effectively Promoting Pollution Control and Carbon Emission Reduction, was released in June, 2022.[33] This policy recognises the potential of interventions aimed at reducing GHG emissions to also reduce conventional environmental pollutants. This section tracks China's progress on transitioning to a low-carbon energy system, climate change mitigation (indicators 3.1–3.2), pollution abatement, and the associated health effects by regions and sector or fuel types (indicator 3.3).

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. This year, an in-depth analysis on the reasons behind coal use change was added. In 2022, the carbon intensity (kg CO_2/US$) of the Chinese energy system decreased by 4·4% compared with 2021, driving a 1·5% decrease in CO_2 emissions despite a 3% increase in GDP (appendix pp 49–50). The decrease in CO_2 emissions in China in 2022 mainly came from a substantial decline in emissions from the industrial sector due to improved energy efficiency and renewable energy generation,[34] rather than from a coal phase-down. In fact, coal consumption increased by 4·3% in 2022 (the second highest annual growth rate since 2011), mainly attributable to the soaring demand from the electricity and heat generation sectors. China's coal consumption in 2022 also increased in response to the economic recovery from the COVID-19 pandemic, and the impact of extreme weather events on other sources of energy generation. With national GDP growing by 3% and exports increasing by 10·5% compared with 2021 (39·1% higher than that of 2019 before the pandemic),[35,36] a rapid increase was seen in the demand for electricity. Meanwhile, widespread and extended periods of extreme heat and drought not only led to a rapid increase in household electricity demand, but also a substantial decrease in hydropower generation capacity.[37] Indeed, hydropower electricity generation decreased by 30% in September, 2022, on a year-on-year basis.[38] Although 8·5% more electricity was produced by low-carbon sources (ie, hydrological, wind, solar, and nuclear) in 2022 than in 2021 (an increase of 231·8 terawatt hours [TWh]),[34] total electricity consumption (324·4 TWh more than in 2021)[37] surpassed the renewable energy generation capacity, pushing China to use coal to meet domestic energy needs.

Indicator 3.2: clean household energy

The Chinese Government has implemented a series of powerful residential energy transition initiatives to address severe air pollution and reduce carbon emission.[39] From 2010 to 2020, China's domestic energy consumption per capita increased by 67·0%, and the share of solid, highly polluting fuels (eg, coal) in total energy use decreased by 60·4%, accompanied by a 33·8% decrease in their absolute use. Meanwhile, the shares of electricity and natural gas (ie, clean fuels at point of use) use increased by 39·8% and 26·3%, respectively, accompanied by 111·0% and 133·5% increases in their absolute use.[40] However, a WHO report[41] shows that the mortality rate attributable to household air pollution in China was 50·7 deaths per 10 000 population in 2019. Energy costs in rural areas grew at an average annual rate of 6·5% from 2013 to 2017, twice as much as the rate in urban areas (3·0%). The highest growth rate was among poor rural households (annual rate of 10·7%), followed by rural middle-income households (annual rate of 5·6%). Notably, households switching to cleaner fuels are dominated by low-income groups (ie, households with low or extremely low incomes), with a share of about 60%. This finding also helps explain the reason that households with clean stoves in previous studies tend to also use solid fuel stoves,[42] namely because the use of free or inexpensive solid fuels and biomass fuels facilitates lower household energy costs. This implies that support and carefully designed policies should be given to low-income groups in rural areas to facilitate a low-carbon and healthy transition.

Indicator 3.3: air pollution, transport, and energy

From 2021 to 2022, the average level of $PM_{2·5}$ in Chinese cities decreased by 4·2% (appendix p 61). In more than 70% of cities, the annual average concentrations of $PM_{2·5}$ were below 35 μg/m³ (ie, below WHO interim target 1 of $PM_{2·5}$ concentrations). However, concentrations are still substantially above the 5 μg/m³ maximum concentration recommended by WHO.[43] Ozone pollution has worsened in Chinese cities and ozone concentrations increased by 8·5% from 2021 to 2022 (appendix p 61). This indicator uses the greenhouse gas and air pollution interactions and synergies (also known as GAINS) model to estimate premature deaths related to ambient $PM_{2·5}$ from different sectors and fuel types and found that some 282 400 of premature deaths were avoided between 2015 and 2020 due to the implementation of the Three-Year Action Plan for Winning the Blue Sky Defense Battle.[44] Coal substitution and the implementation of ultra-low emission standards have led to a substantial reduction in premature deaths, especially for households (which avoided 72 600 premature deaths), power sectors (which avoided 36 600 premature deaths), and industry (which avoided 23 600 premature deaths). The household sector was associated with the greatest number of avoided premature deaths in the north of China (28 900 deaths) due to the adoption of coal-to-electricity and coal-to-gas actions (appendix p 66).

Upgrading emission standards in transportation is estimated to have resulted in 42 100 fewer premature deaths across China. However, the emission intensity of passenger transport has continued to rebound since the COVID-19 outbreak in 2020. By the end of 2022, the emission intensities of carbon monoxide, hydrocarbons, nitrogen oxides, and particulate matter from passenger transport rose by 150%, 164%, 178%, and 152%, respectively, compared with 2019 pre-pandemic levels. In 2020, the adoption rate of new-energy vehicles for passenger transport in Shanghai, Tianjin, and Beijing exceeded 5%. Shifting transport modes (eg, road-to-rail or road-to-sea) and implementing electric vehicles will be essential for delivering environmental and health benefits.

Conclusion

Changing the energy mix and instituting air pollution control measures led to substantial decreases in the emission of air pollutants, including GHG and particulate matter from emissions from industry energy usage, residential energy usage, and transportation. However, the highest rate of increase in coal consumption since 2011 showed a warning sign that without an ambitious response to climate change, progress on mitigation could be seriously impeded by extreme weather, resulting in a forced increase in the use of fossil fuels. China still faces many challenges in its pursuit of a zero-emission transition, including how to secure a reliable supply of electricity generated by zero-emission sources and how to overcome technical barriers in energy storage and long-distance power grid transmission to support the large-scale development of renewable electricity. China urgently needs to find solutions for these challenges to avoid the lock-in effect and stranded asset risks associated with continued investment in coal,[45] and short-term and long-term health risks. The promotion of China's electric vehicles requires considerations around battery resources and the power supply of urban electric vehicles, which are needed for a transition in the most effective and balanced way.

Section 4: economics and finance

To match the urgency of limiting global warming to 1·5°C, a sharp increase in the development of and investment in renewable energy is still needed.[46] This section tracks the progress of eight indicators, focusing on the health-related economic costs of climate change (indicators 4.1.1–4.1.4) and the transition to zero-carbon economies (indicators 4.2.1–4.2.4) in China. A new indicator (4.2.4) was introduced to reveal the flow of CO_2 and $PM_{2·5}$ emissions in China's trade and to call for interprovincial and international cooperation to mitigate climate change and combat air pollution. 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 the methodology of this indicator was improved to use the advanced adaptive regional input–output (also known as ARIO) model to estimate the total economic cost associated with the loss of workers from the heatwave-related mortality of working-age people at the national and provincial level (appendix pp 67–69).[47] This year's indicator was also updated to evaluate the economic cost of the proportion of the heatwave-related mortality of working-age people that is specifically attributable to human-induced climate change. In 2022, the national economic costs of heat-related mortality among working-age people reached a new high ($0·59 billion), 0·32-times greater than in 2017. Despite a decrease of 8·3% in heatwave-related mortality among working-age individuals in 2021 compared with 2017, the total economic losses associated with this mortality have increased by 17%. This effect can be attributed to alterations in the geographical pattern of mortality, leading to a redistribution of labour loss among various sectors. Notably, sectors crucial to China's economy (information technology services, architecture, and chemical products) have encountered a higher degree of loss. The indirect costs were found to be 7·33-times greater than direct costs in 2022. Although some provinces gained economic benefits through multiregional trade, costs were found in 80·6% of provinces. The three provinces with the greatest costs in 2022 were Shaanxi ($0·16 billion; 0·038% of GDP) followed by Guangdong ($0·10 billion; 0·006% of GDP) and Gansu ($0·08 billion; 0·055% of GDP).

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

This indicator evaluates the total economic costs of heat-related labour productivity loss in China over the past decade (2013–22). The national economic costs of heat-related labour productivity loss reached a new record high in 2022, amounting to $313·5 billion (1·91% of national GDP). 2022 was the first time that the national costs exceeded $300 billion, indicating the devastating economic toll of heat on China, and highlighting the need for further effective measures to mitigate the negative impacts on labour productivity. In 2022, the central and southeastern regions of China experienced higher economic costs (relative to regional GDPs) than other regions due to extreme heat, with the provinces of Hainan (4·29% of GDP), Anhui (3·55% of GDP), Jiangxi (3·51% of GDP), and Hubei (3·17% of GDP) having the highest costs.

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 in 2020 with the latest population census data of China.[48] The national economic costs of $PM_{2·5}$-related premature deaths declined from $7·87 billion (0·07% of GDP) in 2015 to $7·57 billion (0·05% of GDP) in 2020 (decreasing by 3·79%), indicating promising progress in China's efforts to tackle air pollution. The secondary (including manufacturing, mining, and construction) and tertiary (including transport, wholesale, retail, catering, and other services) industries incurred most of the economic costs, accounting for 50% and 34% of costs, respectively, in 2020 (see appendix pp 75–76 for the classification of industries). The northwestern regions of China experienced greater negative economic effects from the health impacts of $PM_{2·5}$ pollution than other regions. The two provinces that suffered the greatest economic costs in 2020, relative to their GDPs, were Gansu (0·23% of GDP) and Shaanxi (0·20% of GDP).

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

This indicator estimates the economic losses due to climate-related disasters with the latest released versions of China's 2018 and 2020 input–output tables. Disaggregation of direct damage into industrial and residential sectors is also improved by accounting for different land use types, sourced from the China Urban Construction Statistical Yearbooks.[49] National economic losses due to climate-related extreme events declined for the second consecutive year, to $52·0 billion (0·32% of GDP) in 2022, after peaking at $99·4 billion (0·68% of GDP) in 2020. Disaster-induced direct damage has caused extensive indirect economic losses (at a ratio of 1 to approximately 0·76) through the trade connections between sectors and regions. Although the secondary and tertiary industries accounted for a major part (roughly 61%) of the direct damage, the primary industry suffered the largest indirect losses (roughly 63%) (appendix pp 81–82). In 2020, economic losses from extreme weather events in China were spatially dispersed at the provincial level, with the provinces of Anhui (5·37%), Jiangxi (5·07%), and Gansu (4·22%) experiencing the greatest economic losses relative to their GDPs.

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 investments in new fossil fuel power generation and low-carbon energy in China, with the same methodologies employed in previous reports. The new, additional capacity of thermal power generation declined from 56·6 gigawatts (GW) in 2020 to 46·3 GW in 2021 and 44·7 GW in 2022. However, investment in new thermal power generation in China increased by 25·9% (from $10·7 billion in 2021 to $13·5 billion in 2022) because the unit cost of installing new capacity increased by 40·0%. On the other hand, the new, additional capacity of renewable energy increased by 15·4% compared with 2021, reaching 148·9 GW in 2022. Investment in renewable energy increased correspondingly (by 11%), from $76·0 billion in 2021 to $84·4 billion in 2022. This investment is leading to a higher return of new capacity, with the output–investment ratio increasing from 1·3 GW per $1 billion in 2021 to 2·0 GW per $1 billion in 2022. The lower return rate than thermal power (4·2 GW per $1 billion) might discourage investment, but financial supports through policy implementation should be effective at addressing this barrier. The new capacity of solar energy soared, reaching 87·4 GW in 2022, with a growth rate of 59·1%. Furthermore, the increasing unit cost of additional thermal power capacity might partly explain the decrease in the ratio between investment in low-carbon energy (including hydrological, wind, solar, and nuclear power) and thermal power from 11·5 to 1 in 2021 to 7 to 1 in 2022. At the provincial level, the top three provinces for renewable energy investment in 2022 were Hebei ($7·6 billion), Shandong ($7·3 billion), and Guangdong ($5·1 billion).

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

This indicator tracks employment in renewable energy sectors and fossil fuel extraction industries with the same data source as in last year's report.[50–52] In 2021, the number of people employed in renewable energy increased to 5·1 million from 4·7 million in 2021, accounting for 42% of employees in the renewable energy sector worldwide.[51] Conversely, employment in high-carbon industries has continued to decline since 2013. The number of people employed in the coal sector decreased to 3·4 million in 2021, half the number employed in 2013.[53] The proportions of total global workers in the hydropower, solar photovoltaic power, and total renewable energy sectors employed in China were as high as 37%, 77%, and 42% in 2021, respectively (appendix pp 86–87). Jiangsu, Zhejiang, Yunnan, Inner Mongolia, Ningxia, and Xinjiang benefited the most from the employment gains of the booming solar photovoltaic industry because the bulk of China's photovoltaic supply chain capacity is located in these provinces.

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

This indicator includes several sub-indicators: the value of fossil fuel subsidies in China; China's share of total global subsidies (data from the International Energy Agency);[54] and the strength of carbon pricing in China. After decreasing in 2018–20, fossil fuel subsidies increased by 125% in 2021, reaching $49·6 billion. This increase was largely because the global energy crisis increased the gap between the fuel market price and the price actually paid by consumers, which fossil fuel consumption subsidies aimed to lessen.[55] Subsidies to fossil fuel electricity generation increased substantially from $3·7 billion in 2020 to $28·7 billion in 2021, due to the electricity shortage crisis in China.[56] In 2021, fuel subsidies per capita and fossil fuel subsidies as a share of GDP in China increased substantially, from $18·1 to $35·0 per capita, respectively, and from 0·17% to 0·61% of GDP, respectively. However, China's global ranking by these metrics dropped from 27th to 31st and from 32nd to 33rd, respectively, out of the 41 countries in the International Energy Agency database.[54]

The eight pilot carbon emissions trading markets in China[57] all increased their carbon prices from 2021 to 2022, with an 18% increase in the average carbon price (from $6·9 in 2021 to $8·2 in 2022). However, despite this increase, the Chinese average carbon price was far below the global average carbon price in 2022 ($32).[58] In order to achieve carbon neutrality, China should not only accelerate its pilot policy but also expand its scope.

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

This new indicator investigates CO_2 and $PM_{2·5}$ emissions generated by the production of goods and services traded between China's provinces, to understand the environmental impact of one region's consumption on the regions where products and services were originally produced.[59,60] In 2017, 24·3% of China's CO_2 emissions were attributed to the net trade of goods and services between China's provinces, and 15·0% were from the net production of goods and services exported to other countries. The figures for $PM_{2.5}$ emissions were 23·9% and 13·7%, respectively. Provinces with higher GDPs per capita had larger consumption-based emissions than production-based emissions, and vice versa. In Beijing, the consumption-based CO_2 and $PM_{2.5}$ emissions were 2·18-times and 2·90-times higher than its production-based emissions in 2017, respectively. On the other hand, the production-based CO_2 and $PM_{2.5}$ emissions of Inner Mongolia were 1·81 times and 1·55 times its consumption-based emissions, respectively.

Emissions embodied in net exports flowed from western and central China to more developed provinces in the east (figure 2). In the less developed northwest provinces, 20·3% (306·8 megatonnes [Mt]) of production-based CO_2 emissions were caused by the production of goods and services that were ultimately consumed in other regions of China. By comparison, the more developed provinces on the south coast had the largest carbon emissions embodied in net imports (134·26 Mt). The central and central coast provinces had the largest $PM_{2.5}$ emissions embodied in net exports (216·33 kilotonnes [Kt]) and net imports (221·53 Kt), respectively. Consumption-based emissions show that less developed inland regions are bearing a high proportion of production-related emissions, often for products that are then used in more developed coastal regions, highlighting the need for interprovincial cooperation to mitigate climate change and combat air pollution.

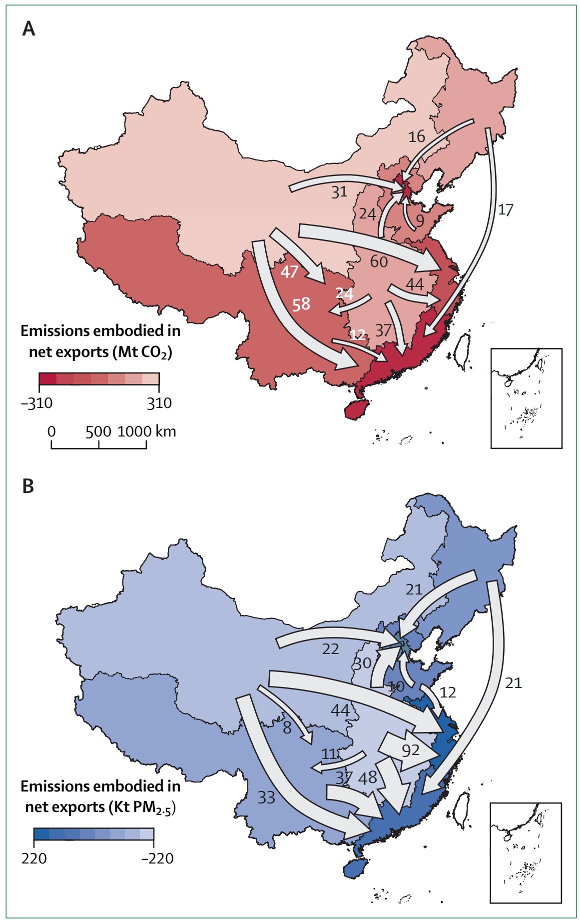

***Figure 2:* Net flow of CO_2 and $PM_{2.5}$ emissions in domestic trade among regions of China in 2017**

Net flow of (A) CO_2 emissions and (B) $PM_{2.5}$ emissions. The direction of an arrow from one region to another indicates the flow of emissions embodied in net exports from one region to another. The width of (and numbers for) each arrow indicate the volume of the net flow of emissions embodied in trade. Kt=kilotonnes. Mt=megatonnes. $PM_{2.5}$=ambient particulate matter.

Conclusion

Despite more stringent policies and better preparation driving down the economic costs of air pollution and climatic extremes, the economic losses caused by heatwave-related mortality and heat-related labour productivity loss both reached new records in 2022. Without more ambitious and rapid actions, these climate change-related economic losses will continue growing in the future. Furthermore, China has not yet managed to cut its dependency on fossil fuels. The conflict between Russia and Ukraine, unfavourable economic conditions, and technological barriers, led to an increasing unit price of fossil fuels and greater fossil fuel subsidies in 2022. To achieve its carbon neutrality goal, the energy system in China needs to phase out 85% of fossil fuels in 30 years.[61] Therefore, continued investment in fossil fuel could result in both economic and climate risks. To accelerate the low-carbon transition and protect human health from worsening climate conditions, fossil fuel subsidies should be re-allocated towards key low-carbon technologies, including energy storage, long-distance power transmission, and carbon capture and storage. Reducing CO_2 and $PM_{2.5}$ emissions embodied in international and interprovincial trade would also be important in speeding up the transition. Climate change presents severe economic threats, with tipping points amplifying irreversible damages that are not currently covered by our indicators. Without action, it is estimated that China might lose 3·55% of its GDP by 2050 due to these risks; yet by transitioning to a low-carbon economy, these potential losses can be limited to 1·6% by 2050.[62]

Section 5: public and political engagement

Public and political engagement is crucial for raising awareness, driving policy changes, and promoting actions on climate change and health. Efforts from different actors in society can collectively contribute to a healthier and sustainable future. This section tracks engagement with climate change and health by different segments of society, including media coverage through social media and newspapers (indicator 5.1), individuals (indicator 5.2), academia (indicator 5.3), and the government (indicator 5.4).

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 tracks the coverage of health and climate change on Weibo, the most popular social media platform for engagement on public affairs among Chinese residents.[63,64] Posts from seven media Weibo accounts were selected (@People's Daily, @Xinhuanet, @The Beijing News, @The Paper, @HealthTimes, @China Science Daily, and @China Meteorological News), covering official, commercial, and professional media in China. From 2010 to 2022, there was an average of 1424 posts per year discussing climate change across all seven accounts, of which 121 (8·54%) were related to health. The ratio of posts on both health and climate change to all posts on climate change reached an all-time high of 9% in 2022, an increase from 3% in 2010. Compared with 2021, the number of posts related to climate change and health in 2022 increased by 109% (288 posts *vs* 138 posts).

Indicator 5.1.2: newspaper coverage of health and climate change

As mainstream media, newspapers in both print and online versions play a crucial role in informing and shaping public and political responses to climate change.[19] This indicator tracked the coverage of health and climate change from 2008 to 2022 in all provincial-level administrative divisions in China, with content analysis of 34 official provincial newspapers. Across the 2008–22 period, an average of 25 172 articles per year were published discussing climate change, with an average of 1449 articles (6%) per year referring to human health. The upward trend in newspaper coverage of climate change continued in 2022, reaching 37 207 articles. Coverage of health and climate change in 2022 included 2490 articles, which was slightly lower than the spike of 2766 articles observed in 2020.

Indicator 5.2: individual engagement in health and climate change

The aim of this indicator is to track individual engagement with health and climate change topics. This indicator uses query data from Baidu, the most widely used Chinese search engine. Co-queries related to climate change and health increased by 669·75% in 2022 compared with the average of the previous 5 years (2017–21), indicating the growing interest of users about the health and climate change nexus. Potential contributing factors include more governmental climate and health policies, the COVID-19 pandemic, and increased media coverage of the topic. People with higher levels of education are more likely to engage in co-searches around climate change and health; there were 129·25% more queries by people with a bachelor's degree or higher than by people with lower educational qualifications. Users in arid regions in northern and western China, and areas with hot summers (eg, Hubei, Hunan, and Jiangxi), had higher proportions of climate-change-related queries.

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

This indicator tracks the number of scientific articles related to climate change and health in China published in both English and Chinese journals. Data from 2009–22 were obtained from OpenAlex and Baidu Scholar for English and Chinese articles, respectively.[65,66] From 2009 to 2022, English journals worldwide published 22 151 articles related to climate change and health, of which 3150 articles were related to China, accounting for about 14·22% of the total. Publication of articles on climate change and health in China grew drastically, with articles in English-language journals increasing by more than six-fold (500 articles *vs* 66 articles) and articles in Chinese-language journals increasing by 117% (102 articles *vs* 47 articles) from 2009 to 2022. The number of articles on climate change in Chinese journals remained steady throughout the past decade with growth since 2019 mainly driven by articles related to extreme weather events and climate actions such as mitigation and adaptation (appendix p 112).

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 four official websites of the Chinese Government, including the China Meteorological Administration, the National Development and Reform Commission, the National Health Commission of the People's Republic of China, and the Ministry of Ecology and Environment of the People's Republic of China. During 2008–22, an annual average of 1519 articles were related to climate change, and roughly 92 articles (6·1%) related to a topic on climate and health.

Conclusion

This section clearly shows that there is already social concern about climate change in China and that media, academic, public, and governmental coverage of climate change has steadily increased over the past decade. Encouragingly, people's interest in climate change is growing, and media communication on climate change is helping disseminate information. However, there is a clear scarcity of attention to the relationship between health and climate change, especially in newspapers.

Conclusion of the 2023 China report of the *Lancet* Countdown on health and climate change

The 2023 China report of the *Lancet* Countdown found that the health impacts of rising temperatures have been

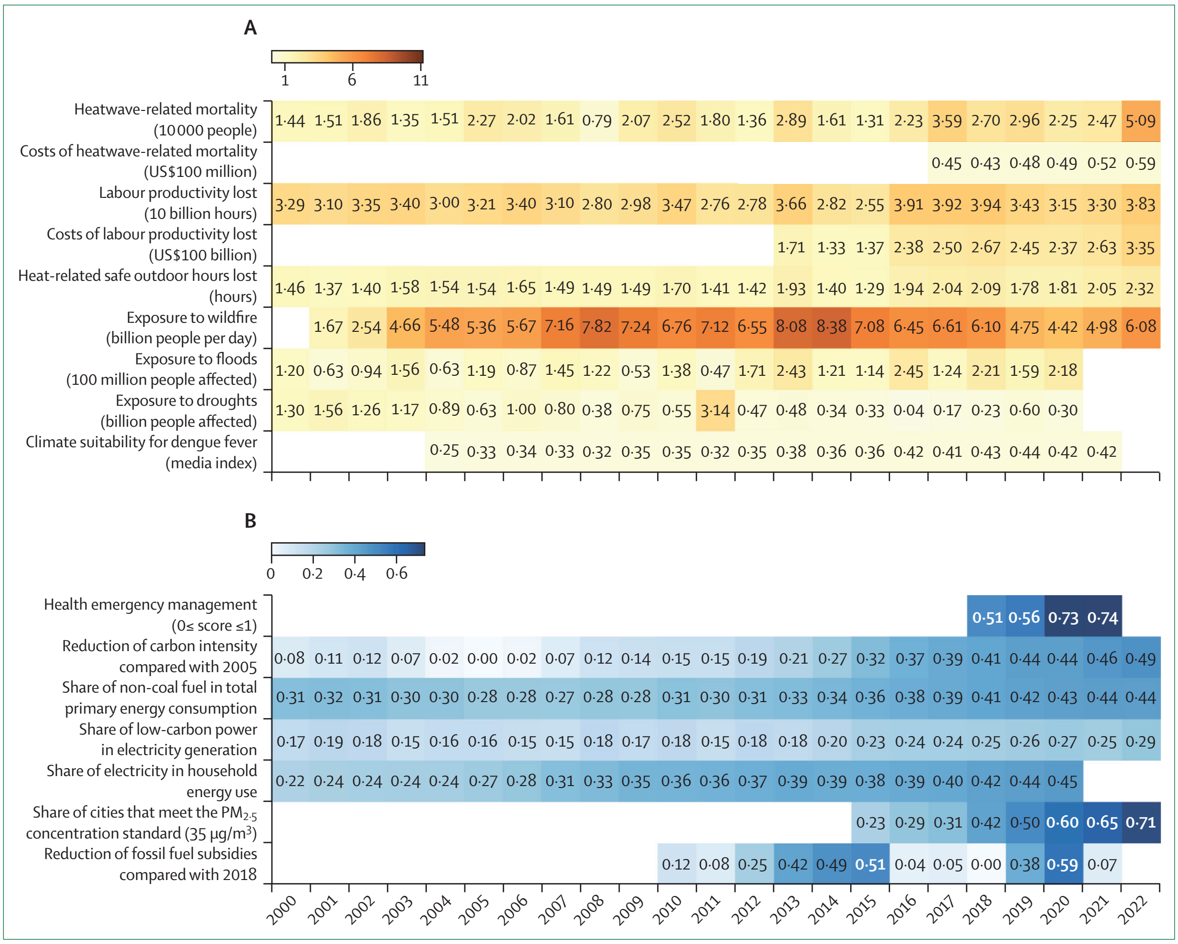

Figure 3: **An overview of the impacts and responses tracked in the 2023 China report of the *Lancet* Countdown**
(A) The absolute value of each indicator. (B) The change in indicators tracking responses. The value is indexed from 0 to 1, with 0 representing the worst actions in the past two decades, and 1 represents the best possible policy response. The colour in each block represents the magnitude of impacts and responses. The darker the colour, the more severe the impacts and the more effective the responses.

substantial in the past 10 years (figure 3) and that progress on adaptation and mitigation have been steady but too slow to meet the urgency of the problem. Rapidly growing awareness from individuals and scholars is not being fully translated into engagement by newspapers and governments or accelerated action.

Record-breaking heat and drought in China in 2022 led to increased exposure to climate-related hazards and increased health risks. Compared with the historical baseline, time for safe outdoor physical activity decreased by 67%, wildfire exposure increased by 54%, heat-related loss of potential work hours increased by 24%, and heatwave-related mortality increased by 342%. In the past 20 years, human-caused climate change has contributed to almost 49·4% of heatwave-related deaths, 30·9% of heat-related labour productivity loss, 98·8% of population exposure to droughts, and 7·6% of population exposure to floods. Economic losses related to heat have also broken all previous records. Without timely interventions, economic losses due to climate change are anticipated to keep increasing in the future. The alarming upward trend of health risks, combined with the high proportion attributable to human emissions, calls attention to the urgent need for mitigation and adaptation.

The conflict between Russia and Ukraine, unfavourable economic conditions, and technological barriers have all contributed to China's continuing dependence on fossil fuels. Implementing new interventions and strategies to reduce local reliance on fossil fuels remains imperative for responding to climate change, protecting human health, and enabling a sustainable economy. An estimated 282 400 lives were saved between 2015 and 2020 thanks to mitigation actions to minimise air pollutants. Emissions of CO_2 from industrial processes fell by 1·5% in 2022 compared with 2021. However, the fastest rate of increase in coal consumption since 2011 revealed that progress on mitigation could be seriously impeded by extreme weather, fluctuations in fossil fuel prices and supplies, and insufficient renewable energy supplies, highlighting the need for sustainable, robust renewable energies as an alternative. In 2022, fossil fuel subsidies increased in response to the rising cost of fossil fuels, which the conflict between Russia and Ukraine triggered. China's energy grid must eliminate 85% of fossil fuel use within 30 years if it is to reach its objective of carbon neutrality.[67] The economy and the environment are already being impacted by climate change and will be at greater risk if investments in fossil fuels continue to rise.

2023 is a milestone year for both stocktaking and outlooks. Looking back at the causes and damages of climate change in China reaffirms the urgency of climate change mitigation and the importance of adaptation. Despite the potential gains for health and economics, progress on mitigation is being delayed by extreme weather events and global events and crises. We highly recommend that policy makers increase investment in renewable energy, synchronise carbon and air pollution reduction efforts, build meteorology-informed early warning systems for health, promote research on the compound effects of extreme weather events, and formulate tailored health adaptation guidelines for different stakeholders. At this pivotal moment, it is crucial to build on the work of the global stocktake to assess progress and barriers and seize opportunities for enhanced climate action.

Contributors

The 2023 Chinese report of the *Lancet* Countdown on health and climate change is an academic collaboration, which builds on 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 context of China. The work for this report was conducted by five working groups, which were responsible for the design, drafting, and review of their individual indicators and sections. All authors contributed to the overall paper structure and concepts and provided input and expertise to their relevant sections. The authors who contributed to working group 1 were CH (who was the lead for working group 1), YB, NC, HC, LC, QL, XL, ZhaL, YLi, WM, XT, YY, FY, JY, LZ, and RZ. The authors who contributed to working group 2 were CR (who was the lead for working group 2), XD, WF, XF, YG, JHua, HH, JSJ, TL, LL, BLi, BLu, and QW. The authors who contributed to working group 3 were ShaoZ (who was the lead for working group 3), BC, TG, GK, HLin, HLiu, ZhuL, CL, ZheL, LW, DZ, and HZ. The authors who contributed to working group 4 were HD (who was the lead for working group 4), DG, YH, ZM, JSh, XS, YX, YZ, ShanZ, MZ, and ZZ. The authors who contributed to working group 5 were JSu (who was the lead for working group 5), MC, XH, QJ, YS, WW, SW, HX, JZha, and JZho. The coordination, strategic direction, and editorial support for this Countdown were provided by ShiZ, WC, CZ, JHuan, XJ, MR, MW, CW, RW, BX, XY, LY, YLu, and PG.

Declaration of interests

We declare no competing interests.

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