



# The 2022 China report of the *Lancet* Countdown on health and climate change: leveraging climate actions for healthy ageing

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## Executive summary

A health-friendly, climate resilient, and carbon-neutral pathway would deliver major benefits to people's health and wellbeing in China, especially for older populations, while simultaneously promoting high-quality development in the long run.

This report is the third China *Lancet* Countdown report, led by the *Lancet* Countdown Regional Centre based in Tsinghua University. With the contributions of 73 experts from 23 leading institutions, both within China and globally, this report tracks progress through 27 indicators in the following five domains: (1) climate change impacts, exposure, and vulnerability; (2) adaptation, planning, and resilience for health; (3) mitigation actions and health co-benefits; (4) economics and finance; and (5) public and political engagement. From 2021 to 2022, two new indicators have been added, and methods have been improved for many indicators. Specifically, one of the new indicators measures how heat affects the hours that are safe for outdoor exercise, an indicator of particular relevance given the boom in national sports triggered by the summer and winter Olympics. Findings in this report, which coincide with the UN Framework Convention on Climate Change 27th Conference of the Parties (COP27) hosted in Egypt (where much attention is being focused on adaptation for clinically vulnerable populations), expose the urgency for accelerated adaptation and mitigation efforts to minimise the health impacts of the increasing climate change hazards in China.

## Another worsening year of health threats from climate change in China

With record-high national average temperatures and increasing frequencies of extreme weather events, people in China are increasingly threatened by the health risks imposed by a changing climate. In 2021, compared with the 1986–2005 average, people in China had an average of 7.85 more heatwave days (which led to an extra of 13 185 heatwave-related deaths; indicator 1.1.1), and a loss of 0.67 more hours of safe outdoor physical exercise per day (indicator 1.1.3). The loss of 33 billion heat-related potential working hours resulted in a loss of 1.68% of gross domestic product (GDP) in 2021, which reversed the

declining trend in lost working hours since 2018 (indicator 4.1.2). The rising temperature also caused the annual average exposure to wildfire to increase by 60.0% between 2017–21 compared with the 2001–05 average. Despite yearly downward fluctuations from 2019 to 2020, extreme rainfalls (indicator 1.2.2) and the disease burden of dengue (indicator 1.3) showed an increasing trend since the year 2000, compared with historical baseline periods.

## Growing recognition and uneven progress in actions

The recognition of the association between climate and health continues to increase in academic and political communities. Notably, climate-related content was explicitly included in the annual work priorities in the Healthy China Action report in 2022, echoing the policy recommendations given in the 2021 China *Lancet* Countdown report. The National Climate Change Adaptation Strategy 2035 also included more concrete and comprehensive provisions related to the health risks of climate change, representing a major step forward compared with the previous strategy issued in 2013. From 2020 to 2021, the coverage of climate and health in Chinese scholar websites grew by 14.2% (indicator 5.3) and, for government websites, grew by 2.8 times (indicator 5.4).

However, there has been mixed progress in the actions on climate adaptation and mitigation. From 2021 to 2021, driven by the response to the repeated waves of COVID-19, most provinces' capacity to detect, prepare, and respond to health emergencies increased (indicator 2.2.1). The collaborations between health and meteorological sectors were also deepened (indicator 2.3). In 2021, compared with levels measured in 2020, the capacity for low-carbon electricity increased by 13% and the capacity for renewable electricity increased by 17.6% (indicator 3.1). Employment in China's renewable sector has accounted for 40% of worldwide renewable energy employment since 2012, reaching 4.7 million people in 2020, already exceeding levels of employment in fossil fuel extraction industries by more than 1.5 million. Nevertheless, the absence of a stand-alone health adaptation plan at the national level, and the lack of a comprehensive assessment of the health impacts of climate change, indicate that progress is still

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scattered rather than organised. The ongoing investment in new coal (indicator 4.2.1), the record-breaking coal consumption (indicator 3.1), the remaining large amount of fossil-fuel subsidies, as well as the weak carbon market (indicator 4.2.3) in 2021 all point to the necessity for cleaner air and a healthier future in China, where over 41% of people are still exposed to annual average particular matter (PM<sub>2.5</sub>) concentrations of over 35 µg/m<sup>3</sup> in 2021 (indicator 3.3). Meanwhile, along with the crisis in Ukraine and the related energy crisis, which is causing more countries to reverse their promises to cut fossil fuel use, these situations also pose serious concerns on billions of fossil-fuel-related assets during the transition to a zero-carbon economy.

### Older populations: vulnerable and overlooked

Compared with younger age groups, people aged over 65 years are more vulnerable to the health risks of climate change. This age group incurred 76·0% of heatwave-related deaths in 2021 (indicator 1.1.1). Because of the rapid population ageing, the total exposure of this age group to wildfires increased more than in the all-age group for 2017–21 compared with the historical average for 1986–2005 (142·3% vs 60·0%; indicator 1.1.2). Similarly, the increase in total exposure of older populations was larger than the increase in exposure of the all-age group during 2016–20 than exposure measured at historical baseline (1986–2005) for both extreme rainfall (263·6% vs 53·8%) and drought (–54·6% vs –73·2%; indicator 1.2.2). In addition, rates of mortality that were attributable to indoor air pollution were 4·7 times higher among older populations than in the all-age group (indicator 3.2).

Despite being more clinically vulnerability and facing greater risks, older populations are marginally represented in the media's coverage of health and climate change (indicator 5.1.1 and 5.1.2), and they are seldom mentioned in the growing coverage of climate and health from government websites (indicator 5.4). In the 14th Five-Year Plan For Healthy Ageing report published in March, 2022, climate change was absent from the policy document. Moreover, older age groups showed less individual engagement in climate change and health than other age groups (indicator 5.2).

Tailored measures can substantially improve the health and wellbeing of older populations. For example, as older populations are more likely to choose solid fuels as their indoor energy source, providing them with intelligible and tailored information can help reduce millions of deaths related to indoor air pollution in China (indicator 3.2). Without timely and targeted mitigation and adaptation actions, the ageing of China's population might offset the progress already made (indicator 3.3).

In 2020, older people represented 13·5% of the total population in China; a proportion that is expected to increase to 26·1% in 2050. Given their susceptibility

to climate-related risks, as well as their higher dependency on health-care systems, it is important to better protect older age groups from the health risks associated with climate change both by incorporating health concerns into climate actions and by addressing climate risks in health strategies.

### Accelerated and more ambitious actions are urgently needed

Despite growing awareness of the link between climate change and health from different actors in Chinese society, current progress is not sufficient for China to achieve green recovery and protect its citizens from the growing health threats of climate change. Therefore, we propose five policy recommendations to achieve this goal:

#### 1. Increase adaptation across governmental departments and accelerate investment in climate resilience

With near-term increases in multiple climate hazards now unavoidable, adaptation across governmental departments and investment in climate resilience must be substantially increased to protect the health of Chinese populations. These changes will require strengthening the leadership of the Ministry of Ecology and Environment to facilitate faster climate adaptation, as well as enhancing cross-departmental coordination (such as the cooperation between the Ministry of Ecology and Environment, the National Health Commission, the National Bureau of Disease Control and Prevention, the China Meteorological Agency, and the Ministry of Housing and Urban-Rural Development). Chinese leaders need to invest more in climate resiliency from the early stage of urban planning to urban renewal and take climate risks into account when constructing healthy cities.

#### 2. Develop a stand-alone Health National Adaptation Plan for climate change

With the guidance from a more robust, multisectoral, and coherent National Climate Adaptation Strategy (ie, the National Climate Change Adaptation Strategy 2035), a stand-alone, Health National Adaptation Plan for climate change to better protect public health must be developed. Leaders must strengthen the response of local efforts to national plans, for example, by establishing a nation-wide heat and cold and health early warning system with regional characteristics. Leaders must also include quantitative goals and define clear responsibilities for different departments and divisions to ensure that the climate adaptation strategies can be translated into detailed implementation plans. Moreover, leaders must establish stringent and periodic evaluation mechanisms to track the progress and performance of the National Climate Change Adaptation Strategy 2035, as well as the Health National Adaptation Plan, to help ensure the success of building a climate-resilient society.

### 3. Prioritise climate change in health policies, with a focus on the wellbeing of vulnerable populations

Leaders must increase awareness within the health-care sector of the threats to health that climate change will bring, particularly in people who are most clinically vulnerable, such as older populations, people with disabilities, people with underlying diseases, and people who might need help at the community level. Leaders should include climate change health impact prevention and treatment as one of the key responsibilities of the new National Bureau of Disease Control and Prevention. Leaders should also include climate change as a major health threat in the specific work plan of the 14th Five-Year Plan For Healthy Ageing report in China. Specifically, leaders should (1) provide clinically vulnerable populations with targeted meteorological and early warning information services; (2) issue guidelines or standards for safe outdoor physical activity under heat stress for different groups of people as soon as possible; (3) provide community-based health education for older populations; (4) establish a regional health and ageing dataset for intervention purposes; and (5) build a joint prevention and treatment initiative between Centers for Disease Control and Prevention (CDC), Red Cross Society of China, community hospitals, and local hospitals.

### 4. Accelerate coal reduction and integrate health considerations into China's pathway to carbon neutrality

Leaders must strictly control the capacity of coal-fired power generation and accelerate the pace of coal reduction (especially in the household sector). These actions are imperative for China to achieve a carbon neutral pathway that maximises the health benefits to the population, including through cleaner air, energy security, and social stability. Leaders should also integrate health considerations into climate actions, which are essential for delivering health benefits and co-benefits, avoiding unintended harms, and improving the wellbeing of the population.

### 5. Promote a low-carbon economy

Leaders should keep encouraging renewable energy generation and consumption. Fossil fuel subsidies must be redirected as funds to promote the development of China's low-carbon economy. With the continuous declining marginal cost of renewable energy, this form of energy represents a favourable opportunity for China's investment layout in a low-carbon economy. Leaders should further increase employment in renewable sectors by providing skill training and stimulate enterprises' awareness of emission reduction with national emission trading, which are essential for assuring a smooth energy transition and for strengthening the green economy.

China faces several challenges, including pandemic control, economic recovery, and addressing climate change, all of which potentially threaten people's health

and livelihoods. Pursuing a climate-resilient and carbon-neutral transition will help to tackle these intertwined challenges. At a time of rapid population ageing, climate actions could be leveraged for healthy ageing, but this will require a fast and coordinated transition from all stakeholders.

## Introduction

In 2021, climate change continued to threaten the health and wellbeing of Chinese people, with record-high national average temperatures and an increased frequency of extreme weather events.<sup>1</sup> Health risks were exacerbated by an ageing population and by the impact of COVID-19 on the health-care system. Older people (people aged 65 years and older) are more clinically vulnerable to the health threats from climate change and are more dependent on a functioning health-care system than younger age groups. In 2021, older people comprised 14·2% of the total population in China.<sup>2</sup> This share is expected to grow to 26·1% in 2050,<sup>3</sup> leading to an even greater proportion of older people than in most countries. Therefore, timely and effective actions for health adaptation that are tailored for these clinically vulnerable people, as well as actions towards climate change mitigation, are paramount for China to reduce the health impacts from climate change and to build a climate-resilient and low-carbon society.

Positive policy actions are starting to emerge. For the first time, the Healthy China Action Promotion Committee added "promoting actions to address health impacts of climate change" in its annual work priorities in 2022,<sup>4</sup> as had been suggested in the 2021 China *Lancet* Countdown report.<sup>5</sup> China's National Climate Change Adaptation Strategy 2035 was announced in 2022, with more comprehensive and practicable action plans laid out in the public health subsection. However, climate change and health considerations were absent from the Healthy Ageing Strategy announced in March 2022. This omission exposes a concerning lack of understanding within the health sector of the extent to which climate change is becoming the defining factor of China's public health profile. Around the world, academic and policy-making communities are increasingly advocating the integration of climate concerns into health policies.

The 2022 China Report of the *Lancet* Countdown is the third annual report led by Lancet Regional Centre in Asia,<sup>5,6</sup> presenting progress in climate change and health interlinkages through 27 indicators across five sections: 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). Two new indicators (indicator 1.1.3: heat and physical activity and indicator 1.4: population exposure to sea level rise) have been added into this report, while most of the pre-existing indicators have undergone methodological improvements. When possible, indicators explore the

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For more on China's National Climate Change Adaptation Strategy 2035 see <https://www.mee.gov.cn/xxgk2018/xxgk/xxgk03/202206/W020220613636562919192.pdf>

**Panel 1: The 2022 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 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

**Mitigation actions and health co-benefits**

- 3.1: energy systems and health
- 3.2: clean household energy\*
- 3.3: air pollution, transport, and energy\*

**Economics and finance**

- 4.1: health and economic costs 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

**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

\*Indicator is further discussed specifically with regard to people aged 65 years and older in text.

particular climate-change-related health risks posed to people aged 65 years and older, the health co-benefits of climate actions to this vulnerable group through reduced air pollution, and their engagement in the climate-health issue.

**Section 1: climate change impacts, exposures, and vulnerability**

This section tracks the health risks of climate change with six indicators covering 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). When possible, the specific risks and effects on people aged 65 years and older are explored for each indicator.

**Indicator 1.1: health and heat**

*Indicator 1.1.1: heatwave-related mortality*

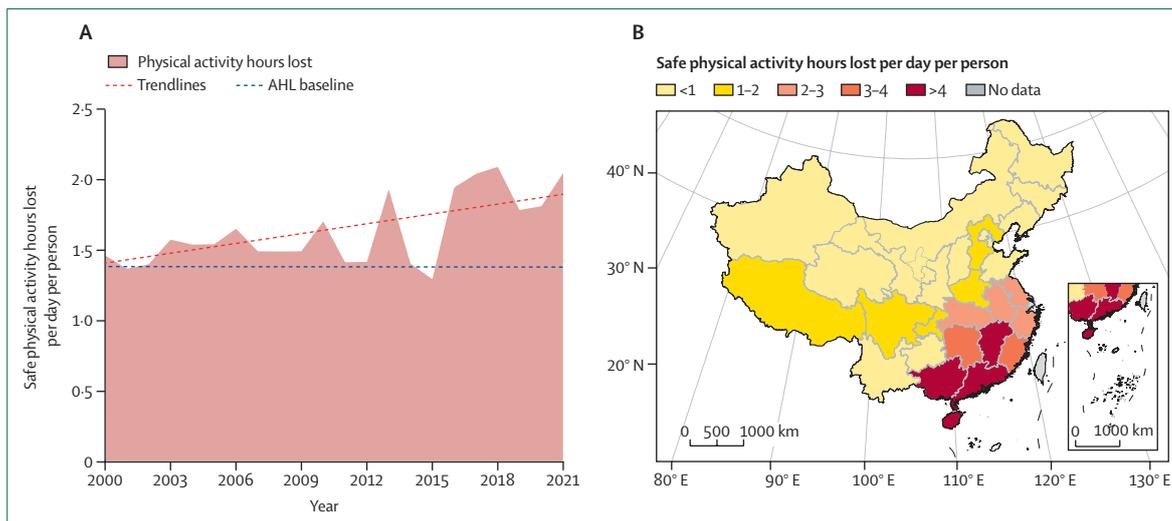
Exposure to consecutive days of heat beyond a particular threshold can lead to a notable increase in the risk of death.<sup>7</sup> This indicator tracks non-accidental heatwave-related deaths, with particular consideration of the impacts on older populations, by using age-specific dose–response relationships (appendix p 1). In 2021, heatwave exposure was 113% (or 7.85 days) higher than

the baseline (1986–2005) average, and the related deaths increased by 13 185 (115%), leading to an estimated 24 966 deaths. With China’s population rapidly ageing, the proportion of deaths in people aged 65 years and older continues to increase from 61.1% (in 1986–2005) to 78.4% (in 2017–21). Among all 31 provinces, heatwave-related deaths in older people were highest in Guangdong (which accounted for 14.9% of total deaths in 2021), followed by Henan (13.9%), and Shandong (10.7%).

*Indicator 1.1.2: change in labour capacity*

Heat stress can reduce the labour capacity of the working-age population and lead to losses in wages and economic output.<sup>8</sup> Compared with the average in baseline years (1986–2005), potential work hours lost (PWHL) due to heat exposure increased by 2.2 billion hours (or 7.1%) in 2021, reaching 33 billion hours and representing 1.4% of the total national work hours. The PWHL in construction and manufacturing sectors continued to increase in 2021, which were 4.1 times (for construction) and 2.2 times higher (for manufacturing) than the baseline period. PWHL in the top ten highest-scoring provinces (ie, provinces with the highest number of PWHL) accounted for 80% of total national losses in 2021 as a result of both rising temperature and concentration of labour-intensive sectors.

See Online for appendix



**Figure 1: Average hours of safe physical activity lost per person per day due to high heat index (2000–21)**

(A) The trend of annual potential activity hours lost per person per day in China from 2000 to 2021. The horizontal dashed line shows the mean of the 1986–2005 baseline period. (B) Potential activity hours lost per person per day in different provinces in 2021. AHL=activity hours lost.

### Indicator 1.1.3: heat and physical activity

Physical activity can benefit mental health and reduce the burden of non-communicable diseases, such as cardiovascular diseases, diabetes, and cancer.<sup>9,10</sup> The participation of Chinese people in sports has continued to rise since the Beijing 2008 Summer Olympics, and the 2022 Winter Olympics is also likely to increase physical activity.<sup>11,12</sup> However, physical activity in high heat and humidity can pose risks of exertional heat stress and potentially lethal heat stroke.<sup>13–16</sup> Rising temperatures can also reduce the hours available for safe outdoor physical activity.<sup>17</sup>

This new indicator evaluates heat stress with a heat index,<sup>18</sup> which combines temperature and humidity, and estimates the number of hours per day (activity hours lost [AHL]) when the heat index exceeds a preassigned threshold. The threshold is set as 33°C, above which experts in China, the USA, and Australia advise against outdoor physical activities because of the high risk of heat illness,<sup>14,19,20</sup> and above which deaths from hyperthermia are likely to increase.<sup>21</sup> In 2021, AHL reached 2.04 hours in all age groups, and 1.99 hours in people older than 65 years, representing an increase of 48.2% (0.7 hours) for all age groups, and 41.2% (0.6 hours) in people older than 65 years, compared with the baseline period (1986–2005; figure 1). People in south central China were affected the most, with 3.94 hours lost in 2021, and had the highest annual average growth rate (2.1%) during 2000–21. Within this region, Guangdong, Hunan, and Guangxi were the most affected, accounting for 40.5% (total population) and 36.8% (older population) of total AHL in China. If this trend continues, the AHL per person per day in south central China is estimated to rise to 7.1 hours in 2050 (appendix pp 6–9).

### Indicator 1.2: health and extreme weather events

#### Indicator 1.2.1: wildfires

Climate change is increasing wildfire-related health risks.<sup>22</sup> This indicator monitors the annual average number of days that people are exposed to wildfire using satellite observations and population data and, new to this report, providing a breakdown of age-group specific exposure. In 2017–21, in the all-age group, the national annual average wildfire exposure increased by 60.0% compared with the average recorded for 2001–05, while the growth was 142.3% (compared with 2001–05) for people aged over 65 years. This increase was mainly due to the increased proportion of older populations. Meanwhile, exposure to wildfires increased in 25 provinces, with particularly large increases in Jilin, Qinghai, and Chongqing. In 19 provinces, exposure to wildfires in older people in 2017–21 increased by more than 100% compared with levels of exposure measured in the same group for 2001–05.

#### Indicator 1.2.2: extreme rainfall and drought

Extreme rainfall poses immediate dangers, as well as long-term negative effects that result from displacement and deterioration of living conditions,<sup>23</sup> whereas prolonged drought affects human health by reducing water supply and agriculture yield.<sup>24</sup> In this report, new data and methods were used to map extremes of precipitation across China, including extreme rainfall and meteorological drought (appendix pp 18–21). Compared with baseline years (1986–2005), Qinghai, Sichuan, and Heilongjiang had the largest increase in extreme rainfall events during 2000–2020, while Tibet, Xinjiang, and Sichuan recorded the largest increase in drought occurrence (appendix p 21). In 2016–20, the average exposure to extreme rainfall and drought per person increased by 71.6%, reaching 0.14 events.

Although the per-person exposure to extreme rainfall was similar for people aged 65 years and older and people in the all-age group, the growth rate of total exposure for the older age group was larger (263·6%) than all-age group (53·8%) in 2016–2020 compared with levels recorded at historical baseline (1986–2005). This result was mainly driven by the rapid ageing trend. The unprecedented extreme rainfall in Henan province in 2021 affected 14·79 million people,<sup>25</sup> and might exacerbate the current upward trend. For drought exposure, the per person exposure in 2016–20 decreased by 76·6% from the 1986–2005 average, reaching 0·2 months. The rate of decline of total exposure of older people to drought was slightly smaller (–54·6%) than the all-age group (–73·2%).

#### Indicator 1.3: climate-sensitive infectious diseases

Dengue fever is one of the most rapidly spreading climate-sensitive diseases in the world, and older populations are at an increased risk of developing severe dengue.<sup>26,27</sup> This indicator tracks the vectorial capacity for its transmission by *Aedes aegypti* and *Aedes albopictus*, the population's susceptibility to dengue, and the disease burden of dengue in China.

The vectorial capacity for dengue transmission has substantially increased in 19 provinces in China during 2004–20 because of changing climatic conditions (appendix p 27). In the three provinces with both *A aegypti* and *A albopictus* distribution (Guangdong, Yunnan, and Hainan), the average susceptibility to dengue fever in 2016–2020 increased slightly compared with that in 2011–15. Moreover, the disability-adjusted life years of dengue declined sharply from 883 person-years in 2019 to 31 person-years in 2020. This change is believed to be due to the strict border restrictions and quarantine policies that were in place during COVID-19.<sup>28</sup> Dengue fever is one of the most serious mosquito-borne diseases in China,<sup>29</sup> whereby the highest number of severe symptoms and deaths occur in older populations. In addition, as a representative of other important climate-sensitive vector-borne diseases, the incidence and epidemic area of severe fever with thrombocytopenia syndrome, which most commonly affects older people who are farmers,<sup>30</sup> is increasing<sup>31</sup> and needs further exploration.

#### Indicator 1.4: population exposure to regional sea level rise

The average regional sea level (RSL) in Chinese coastlines has risen about 0·12 m between 1980 and 2020.<sup>32</sup> Rises in sea level due to global warming could threaten the health and wellbeing of people living in coastal areas through increased flooding, saltwater intrusion, and increased risk of infectious disease transmission.<sup>33</sup>

This new indicator tracks population exposure to risk of RSL rise in China using sea level projections,<sup>34</sup> coastal elevation data,<sup>35</sup> and gridded population data.<sup>36</sup> It is predicted that more than 156 000 (95% CI 59 800–339 000)

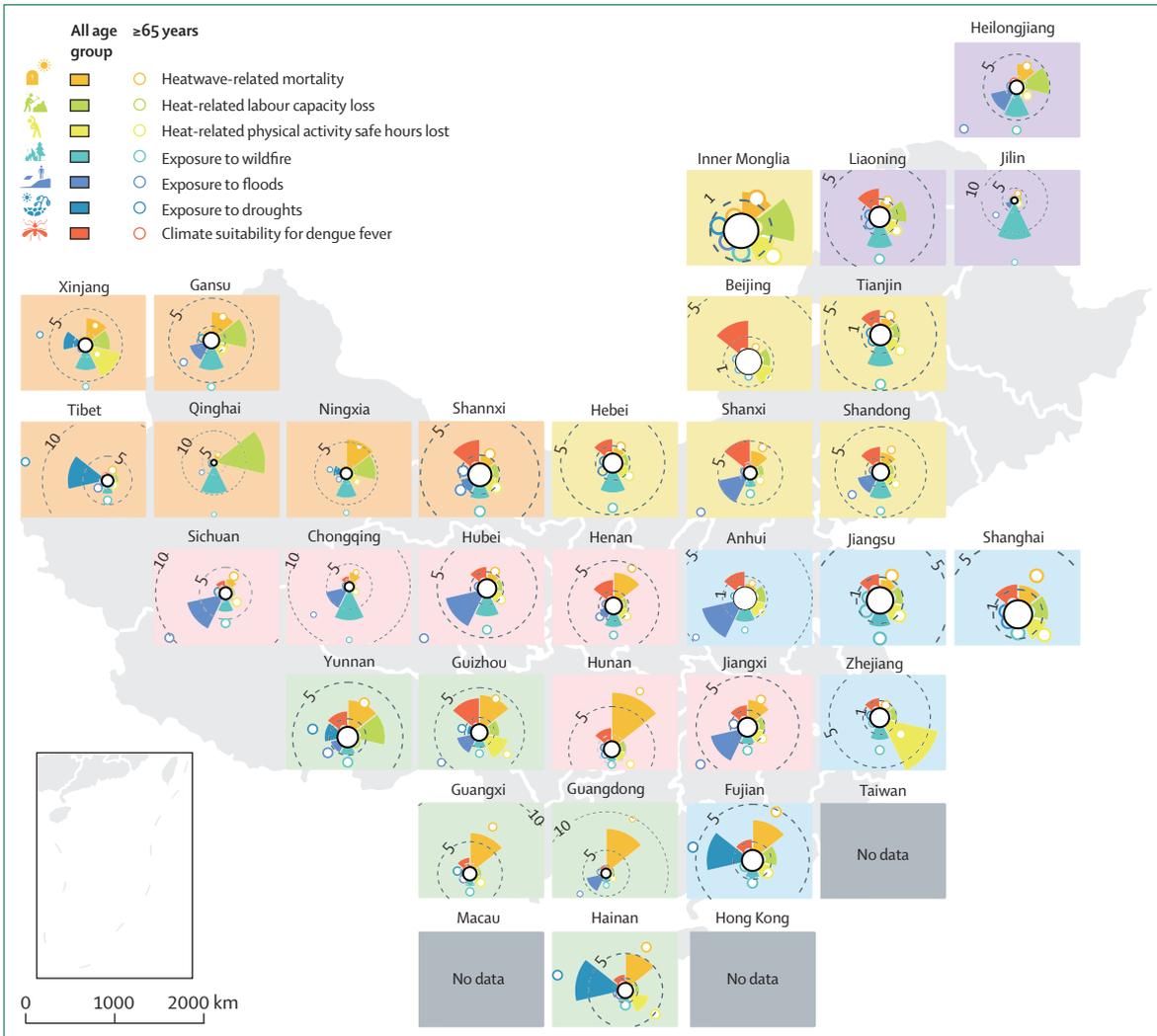
people who are currently (as of 2022) living in coastal areas will be below average RSLs under high-emission scenarios (Shared Socioeconomic Pathway 5 and Representative Concentration Pathway [SSP5]–8·5) by the year 2060 (RSL forecasted at 0·31m [0·1–0·5]) and 855 000 (287 000–1 873 000) people are currently living in areas that will be below average RSL by the year 2100 under this same scenario (RSL forecasted at 0·8m [0·5–1·2]). Considering a low-warming scenario (SSP1–1·9), over 207 000 (25 800–712 000) people are currently settled in areas that would be below average RSL (forecasted at 0·4 [0·1–0·7] m) by the year 2100. Guangdong and Jiangsu provinces have the largest populations settled in low-lying areas and account for over 64% of the total population settled in areas that will be under RSLs in China under all scenarios (appendix pp 32–33).

Unless rapid adaptation or relocation of coastal population occurs, under all scenarios, about 12% of the population that will be living in areas below future RSLs will be people aged 65 years and older. Considering their lower capacity and willingness to migrate,<sup>37</sup> older populations living in coastal areas might be more susceptible than younger groups to the increased risk of RSL rises, and tailored adaptation strategies will be needed even with stringent mitigation measures.

To conclude, the findings in this section reaffirm that climate change continues to threaten the health and wellbeing of Chinese populations, with different regions facing unique health threats (figure 2). At the national level, and compared with the historical average, in 2021, the rising temperatures resulted in an increase in heatwave-related mortality of 115%, the potential hours of labour decreased by 7·1%, and wildfire exposure increased by 62·7%, while the number of hours available for safe physical activity fell by 48·2%. The health risk of climate change on physical activity in all age populations should be carefully considered, as rising temperatures increase the risk of heat-related illnesses from outdoor physical activity, and could substitute outdoor activity into indoor sedentary lifestyles. Older people are more exposed to climate change-related health hazards than the all-age population in most provinces (figure 2) and account for over 70% of the heatwave-related mortalities. Given that near-term increases in multiple climate hazards are unavoidable, timely responses to adapt to and mitigate these health risks are urgently needed.

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

In 2021, the increased frequency of extreme weather events across China caused unignorable health impacts, which were compounded by the simultaneous shock of COVID-19, stressing the importance and urgency of implementing adaptation measures across the whole population. There are encouraging signs of emerging health adaptation measures in China. For example, in 2022, for the first time, the Healthy China Action



**Figure 2: Health risks associated with climate change in each province in China in 2021 compared with historical baseline averages**  
 The values of the bar and plot in each provincial figure represent the ratio of latest year values to historical baseline values. The baseline period and the latest period can be found in the appendix (p 142).

Promotion Committee explicitly mentioned “promoting actions to address health impacts of climate change” in its annual work priorities, reflecting the increasing awareness of the climate-health linkages in the health-care sector. Panel 2 distinctly compares the latest National Strategy on Climate Adaptation with the previous one, making further recommendations to better protect public health from climate change in China.

This section explores progress towards health adaptation across three domains: adaptation planning and assessment (indicator 2.1), adaptation delivery and implementation (indicators 2.2.1, 2.2.2, and 2.2.3), and climate information services for health (indicator 2.3).

**Indicator 2.1: adaptation planning and assessment**

As China still does not have a stand-alone national health adaptation plan, this indicator tracks health

adaptation and assessment progress in each province. Adapting the 2021 WHO Climate and Health Country Profile Survey to the China context, we conducted a survey in June, 2022, and received responses from 20 of 31 provincial Centers for Disease Control and Prevention (CDCs) in mainland China (appendix pp 33–46). Follow-up calls were made to ensure the credibility and accuracy of the findings. A comprehensive assessment of the health effects, clinical vulnerability, and adaptation to climate change was conducted in the whole province of Guangdong, and in a few cities in Jiangsu, Shandong, Xinjiang, and Zhejiang provinces. A lack of government funding support (70%) was still identified as the most important constraint to developing an adaptation plan. Although most provinces stated they have established climate-sensitive disease surveillance systems and early warning systems for extreme

For more on **The National Climate Change Adaptation Strategy 2035** see <https://www.mee.gov.cn/xxgk2018/xxgk/xxgk03/202206/W020220613636562919192.pdf>

**Panel 2: The National Climate Change Adaptation Strategy 2035**

After the first National Climate Adaptation Strategy was published in 2013, the second strategy (The National Climate Change Adaptation Strategy 2035) was announced in 2022 under the leadership of Ministry of Ecology and Environment. The goal of this strategy is to help China build a climate-resilient economy and society by the year 2035.

Similarly to the first adaptation strategy, public health is covered as a subsection in the second adaptation strategy. Despite the absence of a stand-alone national adaptation plan for health, the National Strategy on Climate Adaptation 2035 represents notable progress in protecting public health in three ways:

First, more comprehensive work priorities with performance evaluation mechanisms are mandated. Two work priorities (advancing health risk assessment and improving the monitoring and early-warning system of climate-sensitive diseases) that were already mentioned in the 2013 strategy were again included in this update. In addition, two new work priorities were added to the 2022 strategy: increasing the climate resilience of health-care systems and promoting health adaptation actions across society. The 2022 strategy also requires setting up a new performance evaluation mechanism to track the progress of these work priorities. The more comprehensive mandates facilitate translating the results of the health impact assessment into adaptation actions, and to make sure that their progress aligns with the goals.

Second, in the 2022 strategy, timelines and progressive goals are set for the first time. The strategy mandates establishing a campaign to advance health impact assessment research and to promote health adaptation actions. For the first time, the campaign is associated with clear timelines and progressive goals, which makes the implementation path clearer than in the previous strategy.

Third, region-specific health risk assessment guidelines and location-specific adaptation action advice are now required. The strategy mandates the production of guidelines to assess the health impact of different climate hazards, to carry out region-specific health risk assessments, and to provide the recommended adaptation actions for different locations (eg, urban and rural areas, schools, hospitals, and nursing homes for older people). These mandates will improve local capacity to carry out climate-change-related health risk assessments and will accelerate the progress of assessment across the country. They will also increase the feasibility of the suggested adaptation actions.

Despite progress, most of the key goals in the public health subsection are qualitative (although progressive), which will make the evaluation of progress and performance challenging. Therefore, the National Bureau of Disease Control and Prevention in China should formulate a stand-alone national adaptation plan for health with quantitative goals that are based on these national-level strategies and work priorities so that progress can be monitored effectively.

weather events, they still lack response plans or programmes to address extreme-weather-related health risks.

Addressing health risks from climate change has been added to the annual work priorities in the Healthy China Action Promotion report in 2022, reflecting a growing emphasis on climate change of some policy makers from health sectors. However, the significance of climate change has not been recognised by all health policy makers. For example, there is no mention of climate change in the 14th Five-Year Plan On Healthy Ageing report proposed in March, 2022, reflecting a lack of awareness of the impact of climate change on the health of older populations.

**Indicator 2.2: adaptation delivery and implementation**

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

This indicator created a multi-level index to track the capacity of provinces to respond to public health emergencies, combining 20 indicators covering risk exposure and preparedness, health emergency detection and early warnings, and medical resources (appendix pp 51–60). From 2019 to 2020, the capacity scores improved in all provinces, and the national average score increased from 56.2 to 73.0, partly as a result of the

strengthening of the health system following the outbreak of COVID-19. Provinces in east and southwest China made the fastest progress, mainly because of their efforts to develop more stringent standards in hygiene, disinfection, and infectious disease control practices, as well as increasing medical and hygiene expenditure, strengthening disease risk control measures, and promoting medical informatisation, all measures that can better prepare health systems to respond to climate-change-related health emergencies.

*Indicator 2.2.2: air conditioning—benefits and harms*

Although household air conditioning is very effective at preventing heat-related health impacts, it also drives an increase in electricity demand and additional carbon and particulate matter emissions.<sup>38</sup> This indicator tracks air conditioner ownership, the heatwave-related deaths that might have been prevented through air conditioning use, and air-conditioning-related carbon emissions in China. The number of air conditioning units owned per 100 households in China rose from 18.3 in the year 2000, to 115.6 in 2019, and to 117.7 in 2020. Assuming air conditioning units were effectively used during heatwaves, it is estimated that they helped to avert an estimated 23 300 heatwave-related deaths in China in 2020, 77% of which were of people aged 65 years or

For more on the **14th Five-Year Plan On Healthy Ageing report** see [http://www.gov.cn/zhengce/zhengceku/2022-03/01/content\\_5676342.htm](http://www.gov.cn/zhengce/zhengceku/2022-03/01/content_5676342.htm)

older. However, this use of air conditioning also contributed to an estimated 300 million tons of CO<sub>2</sub> emissions, which was approximately six times higher than in 2000. To achieve the carbon neutrality goal, the energy efficiency of air conditioning units must be rapidly improved, and other climate-friendly heat adaptation measures (eg, personal cooling strategies and increased urban green spaces) prioritised and rapidly rolled out.<sup>35</sup> Green energy generation and thermal energy storage technology (eg, ice thermal energy storage) must be also considered in the future development.<sup>39</sup>

#### Indicator 2.2.3: urban green space

Urban green spaces can provide benefits to physical and mental health through direct and indirect pathways,<sup>40,41</sup> and have been associated with reducing overall mortality.<sup>42</sup> Most of the Chinese population now live in cities or in places experiencing peri-urbanisation. Green spaces can lower local temperatures<sup>43</sup> and reduce air pollution.<sup>44</sup>

This indicator monitors urban green space cover using the normalised difference vegetation index (NDVI,<sup>45</sup> appendix pp 62–66) and gridded population data to calculate population-weighted NDVI as a proxy for green space exposure. Changes in mortality attributable to changes in urban green space exposure were calculated while taking into account the relative risk reduction associated with it, as previously published.<sup>42</sup> In 2021, three provinces had very high levels of urban greenness, seven had high levels of urban greenness, and nine had moderate levels of urban greenness. 12 provinces or municipalities (Guizhou, Yunnan, Shaanxi, Shandong, Beijing, Tianjin, Hebei, Gansu, Shanxi, Inner Mongolia, Ningxia, and Tibet) saw an increase in urban green space over the past decade, while the area of urban green space decreased in one province (Zhejiang in southeast China). The overall green space change during 2011 to 2021 is estimated to have averted 22 893 (95% CI 16 691–36 330) deaths in China.

#### Indicator 2.3: climate information services for health

This indicator tracks the interdepartmental collaborations between meteorological and health departments through data sharing and collaboration using data collected through an annual survey conducted by the *Lancet* Countdown Asia group, as well as through a search for official news releases. Among the 29 provincial meteorological departments that responded to the survey, 27 claimed to have provided meteorological data to the public health sector, up from 21 in 2020. According to the survey, only one meteorological department indicated that climate information that was tailored to older populations was provided. According to the news releases, different local meteorological bureaus (including province-level, city-level, or county-level) in 21 out of 31 provinces reported the existence of a collaboration (or indicated to have signed collaboration agreements) with local health-related

departments or organisations to provide them with climate information services (appendix p 67).

To conclude, according to the indicators tracked in this section, there has been positive progress in health adaptation measures in China in 2021, including the more comprehensive climate-health work priorities in the newly launched national adaptation strategy (panel 2), enhanced cross-sector collaborations, and growing health emergency management across China. These trends reflect the increased priority of climate and health issues in the policy agenda from both health and climate sectors, and echo the policy recommendations made in the previous two reports of the *Lancet* Countdown in China. However, more resources and attention need to be directed to adaptation efforts from all sides of society, especially from the perspectives of investment and risk-reducing effects, as well as mitigation measures, which could have complicated benefit-cost relations with climate adaptation measures. Current adaptation efforts are not targeting clinically vulnerable groups, such as older populations, which could jeopardise their effectiveness to protect the health of Chinese populations.<sup>46</sup> Therefore, rapid acceleration for adaptation efforts and enhanced support for vulnerable groups are urgently needed.

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

After making the carbon neutrality pledges in 2020, the Chinese Government announced a so-called 1+N policy framework in 2021 to help achieve these pledges.<sup>47</sup> If the potential health co-benefits of mitigation actions are prioritised in the implementation of this framework, it will further benefit the low-carbon transition, and substantially improve the life expectancy and welfare of Chinese people.<sup>48</sup> This section tracks China's progress on transitioning towards low carbon energy systems, climate change mitigation (indicators 3.1–3.2), and pollution abatement, together with its associated health implications (indicator 3.3).

#### Indicator 3.1: energy systems and health

This indicator shows progress in, and challenges associated with, renewable electricity development, coal phase-down, and carbon intensity in China. In 2021, the capacity of low-carbon energy (ie, solar, hydro, wind, and nuclear energy) continued to grow, reaching 1.08 terawatts (representing 13% more than that recorded for 2020 and 45.4% of the national power capacity). Similarly, renewable electricity (ie, solar, hydro, and wind) also continued to grow, reaching 1.02 terawatts (representing 13.3% more than that recorded in 2020 and 43.2% of the national power capacity).<sup>49</sup> Meanwhile, low-carbon electricity (ie, solar, hydro, wind, and nuclear) generation increased by 288.2 terawatt hours in China in 2021, which was equivalent to 2 times the low-carbon electricity generated in the UK in 2020.<sup>50</sup> However, driven by the fast

economic reactivation that followed the peak of the COVID-19 pandemic, coal consumption in China rose by 3.7% from 2020 to 2021, reaching a new peak. China's CO<sub>2</sub> emissions from fossil fuel use and cement production increased by 5.7% in the same period, reaching 11.1 billion tons in 2021. With gross domestic product (GDP) increasing by 8.1% in 2021, carbon intensity per unit of GDP reduced by 2.3% compared with 2020.

### Indicator 3.2: clean household energy

In 2019, using data from the global burden of diseases study,<sup>51</sup> the consumption of solid fuels in the household sector is estimated to have caused over 2.3 million deaths worldwide, and 36 300 deaths in China. At 258 deaths per million people, mortality was 48 times higher in China than in other high-income countries. Therefore, increasing the use of clean energy in the household sector in China will have substantial health implications. Although coal is still reported as the preferred energy source as the substitution of biomass for residents in rural areas,<sup>52</sup> there are positive signs of progress as coal use in the household sector continues to decrease, with a 14.5% decline in use (per capita) during 2018–19. Similarly, between 2018 and 2019, per capita use of natural gas increased by 6.3% and per capita use of electricity increased by 4.7%. However, using raw data collected from CHARLS,<sup>53</sup> it is estimated that 47.5% of older people chose solid fuels as their energy sources for cooking in rural areas, which was 11.4% higher than people younger than 65 years and 20.6% higher than people younger than 50 years. This difference is mainly because of the lower price of these fuels, which makes it difficult for older people to stop using these fuels for heating and cooking.<sup>54–56</sup> In addition, because of their tendency to spend more time indoors than younger people, mortality related to household air pollution of solid fuels in people older than 65 years was 5.7 times higher than in the whole population, and 13.4 times higher in people older than 65 years. Promoting knowledge and disseminating information on the risks of the use of fuels in the home among older populations can help to reduce mortality related to indoor air pollution. Policy and publicity are key to promoting clean energy use among older populations, particularly those in rural areas.<sup>57,58</sup>

### Indicator 3.3: air pollution, transport, and energy

From 2020 to 2021, efforts to improve air quality in China led to a reduction of 4.7% in ambient PM<sub>2.5</sub> concentrations, and a 1.9% decrease in ozone concentrations in Chinese cities. The improvement of emission standards for major vehicle categories strongly contributed to this progress. As a result, the emission intensity of nitrogen oxide, PM<sub>2.5</sub>, hydrocarbon, and CO from passenger cars and trucks declined substantially from 2020 to 2021. However, the corresponding emission intensity of passenger

transport (emission per passenger kilometre travelled) increased in this period because transport demand reduced faster than emissions during COVID-19. The contribution of vehicle emissions to ambient ozone concentrations remained at 30% in 2018,<sup>59</sup> exposing the need for further efforts to reduce emissions in the transport sector (eg, by promoting truck-to-rail policies;<sup>60</sup> appendix pp 86–87).

During 2015–20, the number of older people who were exposed to annual average PM<sub>2.5</sub> concentrations over 35 µg/m<sup>3</sup> decreased by 22%. However, the size of the older populations exposed to average annual PM<sub>2.5</sub> concentrations above 5 µg/m<sup>3</sup> increased by 33%. Meanwhile, the number of older people exposed to ozone concentration above 100 µg/m<sup>3</sup> increased by more than 38% (appendix p 81). The rising proportion of older people in China was partly responsible for this increase, which rose from 10% in 2015 to 13.5% in 2020.

Between 2019 and 2020, a policy called the Three-Year Action Plan for Winning the Blue Sky Defense Battle (2018–20)<sup>61</sup> led to 14 600 fewer premature deaths. 30% of the reduction in premature deaths occurred in south central China, 28% occurred in east China, and 16% occurred in north China (as estimated using the greenhouse gas–air pollution interactions and synergies model, appendix pp 83–85).<sup>1,2</sup> Premature deaths that were attributable to air pollution from the household, industry, and agriculture sectors had the largest reductions, mainly as a result of the implementation of ultra-low air pollution emission standards and of a chemical fertiliser and pesticide use policy.<sup>62</sup> However, the emissions from the waste sector caused more premature deaths in 2020 than in 2019. Despite the notable health benefits of cleaner air, progress towards improving air quality in China has been insufficient so far, with over 41% of people being exposed to annual average concentrations of PM<sub>2.5</sub> of over 35 µg/m<sup>3</sup> in 2021.

To conclude, the indicators in this section track China's progress on climate change mitigation and the health benefits that are associated with a reduction in air pollution. The CO<sub>2</sub> emissions from fossil fuel use and cement production increased rapidly after COVID-19, to a level 5.7% higher than in 2020. The delay in decarbonisation threatens China's carbon neutrality goals and contributes to exacerbated health risks from climate change. In addition, despite the notable health co-benefits from the air pollution control policy in China, progress towards cleaner ambient air quality and household energy use have been insufficient. With populations ageing, there is an urgent need to rapidly reduce exposure to air pollution for all age groups to reduce adverse health outcomes during old age and to promote healthy ageing.<sup>63</sup> Achieving these goals demands more ambitious climate policies and more stringent clean-air policies that are closely coupled in China to help achieve the air quality

target set by WHO. Specifically, more efforts need to be done to ensure that coal consumption in China peaks as soon as possible, and that short-term investments align with the long-term carbon neutrality goal. This green recovery pathway will help carbon neutrality, air quality improvements, and healthy ageing goals to be achieved in a synergistic manner.

## Section 4: economics and finance

Transitioning to a zero-carbon economy requires large financial investments.<sup>64,65</sup> However, having a zero-carbon economy would offer net economic benefits by reducing near-term and long-term climate impacts, creating green jobs, and contributing to healthy ageing.<sup>65,66</sup> In this section, seven indicators have been designed to track the progress of the health-related economic costs of climate change (indicators 4.1.1–4.1.4) and progress towards the transition to zero-carbon economies (indicators 4.2.1–4.2.3) in China. The data in this section are all presented in the 2020 value of US\$.

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

#### *Indicator 4.1.1: economic costs of heat-related mortality*

This indicator estimates the economic costs of heatwave-related mortality of working-age people (aged 15–64 years) using the same methods used in the 2021 report (appendix p 88).<sup>67</sup> The overall economic costs of heatwave-related mortality of working-age people in 2021 were \$109.4 million, about five times higher than the costs in 2002, and 14.4% higher than those in 2020. About 74% of the overall costs were due to indirect impacts; the largest indirect costs were found in the manufacturing industry (52%), followed by the service industry (38%). Using provincial-level data up to 2017, the three provinces with the greatest costs were Gansu (\$8.0 million), followed by Henan (\$7.6 million) and Inner Mongolia (\$6.7 million; differences with results from the 2021 report<sup>6</sup> are explained in the appendix [pp 89–90]).

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

Based on the potential heat-related labour productivity losses estimated in indicator 1.1.2, this indicator quantifies the economic costs of heat-related labour productivity losses at the national and provincial level. It is a measure of the reduction in national or provincial GDP due to the work hours lost and the consequent business interruption cascading through the interdependencies between sectors and regions. The economic costs of heat-related labour productivity losses were found to rebound slightly to \$285.8 billion (representing 1.68% of GDP) in 2021 after 2 years of declines since 2018. The three provinces that had the greatest economic costs in 2021, relative to their GDPs, were Hainan (4.75%), Guangxi (3.86%), and Jiangxi (3.33%).

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

This indicator monitors the economic costs associated with PM<sub>2.5</sub>-related premature deaths, using the same method as in indicator 4.1.2 (appendix pp 97–98). Although the absolute national economic costs increased slightly by 3% (from \$9.00 billion to \$9.24 billion during 2015–20), the relative costs as a percentage of China's GDP declined from 0.07% to 0.06% in the same period. Progress towards air pollution control seen since the year 2015 continued during 2020.<sup>6</sup> The manufacturing and service industries still accounted for most (an increase from 90% in 2015 to 92% in 2020) of total costs. The three provinces that had the greatest economic costs in 2020, relative to their GDPs, were Xinjiang (0.27%), Heilongjiang (0.26%), and Hebei (0.12%). Although not included in this indicator, which only focuses on the premature deaths of working-age people, extra economic costs are expected to occur because of the increasing needs for health-care services from the ageing population, as acute impacts of air pollution could be more felt by clinically vulnerable populations, and the symptomatology of chronic exposure to air pollution becomes more pronounced in older age.<sup>68–70</sup>

#### *Indicator 4.1.4: economic costs due to climate-related extreme events*

This indicator updates the economic losses due to climate-related disasters that occurred from 2019 to 2021. The national economic losses due to climate-related extreme events declined to \$59.8 billion (0.35%) in 2021 after a peak in 2020 (\$66.4 billion; 0.45%). The three provinces that had the greatest economic losses in 2019, relative to their GDPs, were Jiangxi (2.61%), Heilongjiang (2.04%), and Zhejiang (1.19%). In 2021, the compound events of extreme flooding and the coronavirus epidemic in Zhengzhou city (Henan province) caused \$19.6 billion of direct and indirect economic losses nationwide, equivalent to nearly a third of the national total losses (panel 3).

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

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

This indicator monitors investments in new thermal power generation and low-carbon energy in China, following the same methods used in the 2021 report.<sup>5</sup> Although the new capacity of thermal power generation continued declining, reaching 46.3 gigawatts in 2021 (18% less than 2020 [56.6 GW]), the investment in new thermal power generation in China reversed the previous declining trend, increasing from \$8.86 billion in 2020 to \$10.68 billion in 2021,<sup>75</sup> resulting in a 4% rise of installed capacity of coal-fired power units. If the construction of all planned coal-fired power units that were commissioned from 2020 to 2030 in China went

**Panel 3: Estimated economic losses of extreme rainfall and the COVID-19 epidemic in Zhengzhou in 2021**

From July 17 to July 23, 2021, Henan province (central China) was hit by unprecedented levels of heavy rainfalls and floods, and its capital city Zhengzhou had extensive casualties and property damage.<sup>71</sup> The event was listed as the deadliest natural disaster in 2021 in China.<sup>72</sup> The situation was further worsened in Zhengzhou by a local coronavirus epidemic a week later,<sup>73</sup> which affected the progress of the post-flood recovery and compounded climate risks.

- Extreme rainstorm (July 20, 2021)
- The first case of COVID-19 reported (July 30, 2021)
- Recovery of subways hit by floods suspended (Aug 5, 2021)
- COVID-19 control measures lifted (Aug 28, 2021)

Using similar methods as indicator 4.1.4, the total economic losses of these events were estimated to be US\$19.6 billion, equivalent to 0.12% of China's gross domestic product in 2021,<sup>74</sup> excluding health costs. Although the flood-induced direct damage only occurred in Zhengzhou, the indirect losses occurred across other regions due to supply chain disruptions

(appendix p 107). Although almost a third (29%) of direct losses happened in Zhengzhou's real estate industry, the indirect losses were bigger in Zhengzhou's non-metallic mineral product (13%), food and tobacco (10%), and transportation services (10%). In regions outside Zhengzhou, the agriculture, mining, petroleum and coking, chemical products, accommodation and restaurants, and financial services were the most heavily affected sectors by these events. Among them, the agriculture in Henan (except Zhengzhou) had the greatest indirect loss, at \$0.4 billion. This case study shows how devastating an extreme climate event can be, both to lives and economies, and how the confluence of different risks, such as the collision between an epidemic and extreme weather, can further aggravate socioeconomic consequences. The huge economic costs of these events show the value of risk assessment, planning, and the implementation of early and adequate adaptation and mitigation actions towards climate change.

ahead, the stranded asset losses would be \$451 billion during 2020 to 2045.<sup>76</sup> Investment in low-carbon energy (including biomass) reached new heights of \$123 billion in 2021, 3.8% higher than that in 2020. The ratio between investment in low-carbon energy (including hydro, wind, solar, biomass, and nuclear power) and new thermal power kept growing in 2021, from 1:1 in 2008 to 9.5:1 in 2020, and further to 11.5:1 in 2021. The top three investors in low-carbon energy in 2021 were Sichuan (\$7.48 billion), Shandong (\$6.99 billion), and Hebei (\$6.02 billion).

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

This indicator monitors employment in renewable energy sectors and fossil fuel industries using data from the International Renewable Energy Agency (IRENA), Global Economic Data, Indicators, Charts & Forecasts (CEIC) Data, and the Chinese National Bureau of Statistics,<sup>77-79</sup> as in the 2021 report.<sup>6</sup> In contrast to the decreasing trend in the total number of people employed in China (from 754.5 million people in 2019 to 750.6 million people in 2020), the number of people employed in the renewable energy sector increased (from 4.4 million in 2019 to 4.7 million in 2020). With employment in the hydropower industry increasing by 45% in 2020, the number of people employed in renewable energy was 1.5 million more than the number of people employed in fossil fuel extraction industries (appendix p 113). If the world followed the 1.5°C pathway by the year 2050, employment in the global renewable energy sector would grow to 43.3 million jobs over the next three decades.<sup>78</sup> China has occupied around 40% of total renewable energy employment worldwide since 2012,<sup>78</sup> and the number of people employed in the

renewable energy sector of China will reach 17.1 million if this share stays constant.

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

This indicator tracks the value of fossil fuel consumption subsidies, the share of total global subsidies,<sup>80</sup> and the coverage and strength of carbon pricing in China (data and methods are described in the appendix [pp 114–117]). Between 2019 and 2020, fossil fuel subsidies in China declined by 25% to \$25.5 billion. Subsidies to fossil fuel electricity reduced substantially, from \$15.2 billion to \$3.8 billion, while subsidies to oil products slightly increased, from \$18.8 billion to \$21.7 billion. In the global ranking of fossil fuel subsidies per capita, China moved from 87th to 88th position in 2020 (from \$24.2 per capita to \$18.1). And in the global ranking of fossil fuel subsidies per unit of GDP, China dropped from 97th to 100th position in 2020 (from 0.24% to 0.17%, appendix p 116). Despite this progress, further accelerating phasing down the rest of fossil fuel subsidies is highly recommended because it could help China to transition towards a low-carbon energy system, improve air quality through less fossil fuel use, and avoid a substantial share of air-pollution-related premature deaths.<sup>81</sup> The national carbon emission trading market in China launched in July, 2021. More than 2000 power generation enterprises, covering 4.6 billion tons of CO<sub>2</sub> (or 41% of China's carbon emissions in 2021) participate in this carbon market, which is the largest in the world. By the end of 2021, the cumulative carbon trading volume reached 178.6 million tons. However, the average carbon price in China was \$6.93,<sup>82</sup> which was much lower than the average carbon price of the EU Emissions Trading System in 2021 (\$63.47). This price implies that

the current emission cap is not stringent enough and the carbon market is still in too early a phase to have an important role in China's pathway to carbon neutrality.

To conclude, despite the downward trend of economic losses due to climate-related extreme events in 2021, with accelerated climate warming and climate-related extreme events, the health and economic costs of climate change as a whole are highly likely to increase in the near future.<sup>83–85</sup> China is at a critical period of heated discussions and designs towards the path to carbon neutrality. Compounded by the continued investment in new coal, the cuts in fossil fuel subsidies are not sufficient enough to protect Chinese people from the health risks related to the use of fossil fuels, and might lead to large amount of fossil fuel-related assets becoming stranded during the transition to a zero-carbon economy.<sup>86</sup> Meanwhile, the market could miss the long-term objectives with short-term policy volatility. The missteps would further increase the future financial and economic risks. Economic markets cannot solve climate change alone. Authorities must continue to provide direction. Accelerating the pace of fossil-fuel subsidy reduction and redirecting these funds to promote the development of China's low-carbon economy could protect present and future economic prosperity, and a healthy future. China's low-carbon green transition is a process that involves balancing energy security risks, financial and economic risks, and the co-benefits of reducing climate-associated harms to public health as a whole.<sup>87</sup>

## Section 5: public and political engagement

An awareness of the links between climate and health is essential for driving accelerated climate action that protects the health of Chinese populations. In a year marked by carbon neutrality commitments, extreme weather events, and COVID-19 in China, this section tracks engagement in climate change and health across varying parts of society, including the media (indicator 5.1), individuals (indicator 5.2), academia (indicator 5.3), and the public sector (indicator 5.4).

### Indicator 5.1: media coverage of health and climate change

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

Seven media Weibo accounts (@People's Daily, @Xinhuanet, @The Beijing News, @The Paper, @HealthTimes, @China Science Daily, and @China Meteorological News) were selected for this report, covering government media, commercial media, and professional media in China. From 2010 to 2021, there was an average of 1131 posts per year discussing climate change across all seven accounts, of which 132 (11.7%) were related to health. From 2021 to 2022, the number of posts covering climate change increased by 8%, reaching 1733 posts. This increase was mainly driven by the coverage

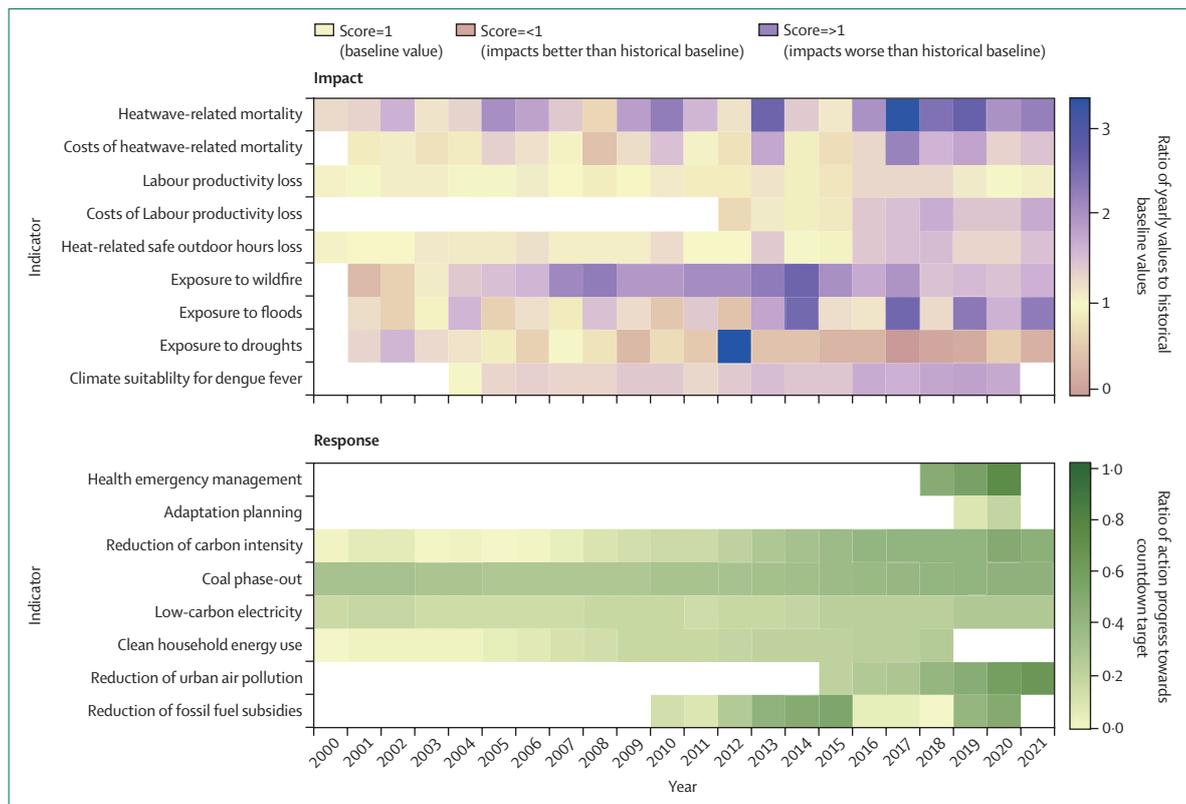
of extreme weather events that occurred during the summer. Among them, only 138 (8.0%) posts were health-related, representing a 68% reduction from 2020. Only nine posts covering health and climate mentioned older populations, and all of them provided reminders of the health risks to these populations of extreme heat and cold during summer and winter, but only three provided specific guidance on how they could protect themselves from the risks.

#### Indicator 5.1.2: newspaper coverage of health and climate change

As the most widely-used source of information, the mainstream media can influence the social media agenda, shape public perceptions, and facilitate public engagement.<sup>88–91</sup> This indicator tracks media coverage of health and climate change in Chinese provincial newspapers from 2008 to 2021, using 34 high-circulation and influential newspapers (appendix pp 122–127). During 2008–21, an average of 24 312 articles per year were published discussing climate change, of which about 1375 (6%) articles per year were related to human health. Continuing an upward trend, newspaper coverage of climate change spiked in 2021, with 36 477 articles, representing a 37% increase nationwide from 2020. Meanwhile, health and climate change coverage remained high, although the number of articles covering these topics in 2021 (2335 articles) was slightly lower than its peak in 2020, which coincided with the outbreak of the COVID-19 pandemic. Older age groups were marginally represented in news articles on health and climate change, with only 30 (less than 1%) of the 2335 articles mentioning older age groups in 2021.

### Indicator 5.2: individual engagement in health and climate change

This indicator uses search queries in Baidu, the most popular Chinese search engine, which accounted for 83.97% of the market share in China in 2021, to track individual engagement in health and climate change. The indicator was improved in 2022, whereby Baidu is now able to stratify search queries by age groups and incorporate keywords related to extreme weather events and population ageing (appendix pp 127–135). In 2021, queries related to climate change rose by 77.5% compared with 2020. Although the share of climate and health co-queries remains low (only 4.71 out of 1000 climate change queries), the total number of co-queries grew by 48.2% from 2020. This trend could be driven by governmental climate and health policies, COVID-19, and extreme weather events. Henan province and its nearby provinces Shaanxi and Shanxi, which had extreme rainfall events in 2021, had a higher proportion of climate change queries than other areas in China. Although ageing was a topic of increasing interest from 2018 to 2021, people seldom searched population ageing with climate change, reflecting little engagement with



**Figure 3: Overview of impacts and responses tracked in the 2022 Chinese Report of the Lancet Countdown**  
 For impacts indicators, the value is indexed as the ratio of the yearly value to historical baseline value. For response indicators, the value is indexed from 0 to 1, with 0 representing the worst actions in the past two decades, and 1 representing the best possible or interim policy target. The colour in each block represents the countdown to the policy targets; the darker the colour, the closer to the target. The standardisation method used to generate the indicator values is available in the appendix (pp 142–44).

the compounding links between ageing and climate change. Compared with other age groups, older people were less prone to co-search climate and health, suggesting that this age group had less awareness and knowledge of climate-health risks.

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

This indicator tracks the engagement of Chinese scholars in climate and health research in journals published in English (with data from Scopus, MEDLINE, and Web of Science Core Collection databases)<sup>92</sup> and Chinese journals (with data obtained from the China National Knowledge Infrastructure database), as well as relevant studies on China. From 2020 to 2021, the number of peer-reviewed scientific articles on climate and health from Chinese scholars increased by 14.2%. From 2009 to 2021, Chinese scholars published 2499 articles in English and 990 articles in Chinese related to climate and health. The publication of articles on climate change and health in English increased by over 20% per year between 2009 and 2020, while the articles in a Chinese language peaked in 2018 then remained steady during 2019–21. The contribution of

Chinese scholars to all articles on climate and health published in English globally increased from 3% in 2009 to 16% in 2021, suggesting an increasing attention of Chinese researchers to this issue.

Among all the articles in English on climate and health, the articles on China increased drastically, from 33 (6% of all articles) in 2009 to 617 (19%) in 2021. Over 75% of the climate and health studies focused on health impact assessment, and about 10% covered climate change mitigation and adaptation.

**Indicator 5.4: government engagement in health and climate change**

This indicator analyses the coverage of climate change and health in articles and documents published in the official websites of four Chinese Government departments: 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 2008–21, an average of 1504 documents published per year related to climate change, of which about 68 (4.5%) per year also covered human health.

From 2020 to 2021, the number of climate-related articles and documents grew by 1·83 times, and the number of climate-and-health-related articles and documents grew by 3·7 times. These increases were mainly driven by the articles related to carbon peaking and carbon neutrality policies. Issues around ageing were seldom mentioned in the content related to climate and health, with only six articles and documents on average per year doing so.

To conclude, compared with 2020, the engagement on health and climate issues from the individuals, scholars, and public sectors continue to grow rapidly. However, coverage decreased in social media and remained stable in newspapers. Therefore, it is important to break barriers between the general public and professionals by communicating academic knowledge and policy attempts to the public through multiple channels including popular media. Additionally, older populations received marginal attention on this issue in media coverage, although they are more vulnerable to the health threats of climate change than younger populations.<sup>93</sup>

### Conclusion of the 2022 China report of the *Lancet* Countdown on health and climate change

In this report we found that, across every indicator within section 1, the health impacts of climate change in 2021 were above historical baseline levels (figure 3), and most exceeded levels measured in 2020. Due to rising temperatures, heat-related health impacts increased from 2020 to 2021, increasing heat-related mortality, reducing labour capacity, and undermining the capacity to partake in physical activity. In addition, exposure to wildfire, extreme drought, and extreme rainfall also increased in different regions across China. Economic losses from heat-related labour losses reached 1·68% of GDP in 2021, the first increase since 2018. The vectorial capacity of dengue transmission also increased as a result of changing climatic conditions and showed an increasing trend since 2004 compared with historical baseline periods.

Since 2020, progress has been made towards increasing climate change adaptation for health. This progress was particularly evident in the areas of adaptation planning, cross-sectorial collaborations, and health emergency management, which reflected the increased priority of climate and health issues in the governmental agenda and echoed policy suggestions made in the previous two *Lancet* Countdown China reports. However, the inputs and attention to adaptation are still insufficient compared with the increasing health risks posed by climate change.

By contrast to the stagnant trend of low-carbon employment around the world in recent years, China's employment in renewable energy has continued to grow since 2012, accounting for 40% of the global share. In 2020, the employment in renewable energy reached 4·7 million people, representing 1·5 million more people than those employed in the fossil fuel extraction industry.

Conversely, the continued increase in the installed capacity of coal-fired generation and the insufficient reduction in fossil-fuel subsidies is a misstep on the road towards low-carbon development. This negative trend could endanger public health and increase future financial and economic risks.

In most provinces, people aged 65 years and older are facing higher health risks of climate change than the general population. However, older people are marginally represented in media coverage and policy design, and show less engagement with climate and health issues than younger age groups. Without timely mitigation and adaptation actions, the ageing of China's population might offset the benefits of China's clean energy transition and reverse the declining trend of air-pollution-related deaths in the coming years.

In a year marked by climate extremes, carbon neutrality commitments, and repeated waves of COVID-19, public health and climate change are receiving growing attention from key actors in society. However, the absence of rapid responses, especially those tailored to clinically vulnerable populations such as older people, jeopardises efforts towards delivering green COVID-19 recovery and sustainable development. Drawing from the evidence in this report, we call for a greater emphasis on accelerated adaptation and mitigation efforts to minimise the health impacts of the increasing climate change hazards, with particular focus on vulnerable groups such as the elderly. Protecting the Chinese populations from a rapidly changing climate will require a faster and more coordinated transition towards low-carbon, resilient societies from all stakeholders.

#### Contributors

The work for this paper 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 structure and concepts of the overall paper and provided input and expertise to the relevant sections. Authors contributing to working group 1 were: CH (who was the lead for working group 1), YB, NC, HC, LC, HJ, QL, XiaL, ZhaL, SL, XT, YY, FY, JY, LZ, RZ, and QZ. Authors contributing to working group 2 were: CR (who was the lead for working group 2), WD, WF, XF, YG, JHua, HH, LL, BL, HM, and QW. Authors contributing to working group 3 were: ShaoZ (who was the lead for working group 3), BC, XC, TG, GK, HLin, H Liu, ZhuL, CL, ZLuo, WM, WS, LW, WW, DZ, and HZ. Authors contributing to working group 4 were: HD (who was the lead for working group 4), DG, YH, XinL, YX, YZ, and ShanZ. Authors contributing to working group 5 were: JS (who was the lead for working group 5), MC, BD, LJ, QJ, SW, JZha, and JZho. WC, CZ, ShiZ, JHuang, XJ, TL, MR, CW, BX, XY, LY, MF-CCF, YL, and PG contributed to coordination, strategic direction, and editorial support. WC had full access to all the data included in the paper. All authors had access to all data reported. WC, CZ, and SZ (ShiZ), accessed and verified the data.

#### Declaration of interests

We declare no competing interests.

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References

- 1 China Meteorological Administration. China climate bulletin. 2022. [http://www.cma.gov.cn/zfxgk/gknr/qxbg/202203/t20220308\\_4568477.html](http://www.cma.gov.cn/zfxgk/gknr/qxbg/202203/t20220308_4568477.html) (accessed April 30, 2020).
- 2 National Bureau of Statistics. Annual data of population. 2021. <https://data.stats.gov.cn/easyquery.htm?cn=C01> (accessed Aug 10, 2022).
- 3 United Nations. Annual total population (both sexes combined) by five-year age group, region, subregion and country, 1950–2100 (thousands). New York, NY: United Nations, 2019.
- 4 Healthy China Action Committee. Health China Action 2022 Work Priorities. 2022. <http://www.nhc.gov.cn/guihuaxxs/s7788/202204/67cb879e0afd44ba916912367de56170.shtml> (accessed April 30, 2022).
- 5 Cai W, Zhang C, Zhang S, et al. The 2021 China report of the *Lancet* Countdown on health and climate change: seizing the window of opportunity. *Lancet Public Health* 2021; 6: e932–47.
- 6 Watts N, Amann M, Arnell N, et al. The 2020 report of the Lancet Countdown on health and climate change: responding to converging crises. *Lancet* 2021; 397: 129–70.
- 7 Xu Z, FitzGerald G, Guo Y, Jalaludin B, Tong S. Impact of heatwave on mortality under different heatwave definitions: a systematic review and meta-analysis. *Environ Int* 2016; 89–90: 193–203.
- 8 Parsons LA, Shindell D, Tigchelaar M, Zhang Y, Spector JT. Increased labor losses and decreased adaptation potential in a warmer world. *Nat Commun* 2021; 12: 7286.
- 9 White RL, Babic MJ, Parker PD, Lubans DR, Astell-Burt T, Lonsdale C. Domain-specific physical activity and mental health: a meta-analysis. *Am J Prev Med* 2017; 52: 653–66.
- 10 Kyu HH, Bachman VF, Alexander LT, et al. Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013. *BMJ* 2016; 354: i3857.
- 11 Bauman AE, Kamada M, Reis RS, et al. An evidence-based assessment of the impact of the Olympic Games on population levels of physical activity. *Lancet* 2021; 398: 456–64.
- 12 Yang F, Wu B, Zhang X, Wang F. Trend of sports activities of the aged in China: 14th five-year plan and medium and long-term development forecast. *China Sport Science and Technology* 2022; 58: 18–23.
- 13 Heat Stroke Expert Group of the Whole Army, People's Liberation Army Professional Committee of Critical Care Medicine. Expert consensus on diagnosis and treatment for heat stroke in China. *Medical Journal of Chinese PLA* 2019; 40: 181–96.
- 14 Heat Stroke Expert Group of the Whole Army, People's Liberation Army Professional Committee of Critical Care Medicine. Expert consensus on emergency diagnosis and treatment of heat stroke. *Zhonghua Jizhen Yixue Zazhi* 2021; 11: 1290–99.
- 15 Yankelson L, Sadeh B, Gershovitz L, et al. Life-threatening events during endurance sports: is heat stroke more prevalent than arrhythmic death? *J Am Coll Cardiol* 2014; 64: 463–69.

- 16 McGeehin MA, Mirabelli M. The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. *Environ Health Perspect* 2001; 109 (suppl 2): 185–89.
- 17 An R, Shen J, Li Y, Bandaru S. Projecting the influence of global warming on physical activity patterns: a systematic review. *Curr Obes Rep* 2020; 9: 550–61.
- 18 Steadman RG. The assessment of sultriness. Part I: a temperature-humidity index based on human physiology and clothing science. *J Appl Meteorol Climatol* 1979; 18: 861–73.
- 19 Chalmers S, Jay O. Australian community sport extreme heat policies: limitations and opportunities for improvement. *J Sci Med Sport* 2018; 21: 544–48.
- 20 Heat Index National Weather Service. 2019. <https://www.weather.gov/jetstream/hi> (accessed April 12, 2022).
- 21 Grundstein AJ, Ramseyer C, Zhao F, et al. A retrospective analysis of American football hyperthermia deaths in the United States. *Int J Biometeorol* 2012; 56: 11–20.
- 22 Xu R, Yu P, Abramson MJ, et al. Wildfires, global climate change, and human health. *N Engl J Med* 2020; 383: 2173–81.
- 23 Paterson DL, Wright H, Harris PNA. Health risks of flood disasters. *Clin Infect Dis* 2018; 67: 1450–54.
- 24 Ault TR. On the essentials of drought in a changing climate. *Science* 2020; 368: 256–60.
- 25 Disaster investigation team of the State Council. Investigation report on the July 20 heavy rain in Zhengzhou, Henan Province. 2021. <https://www.mem.gov.cn/gk/sgcc/tbzdsdgcdbg/202201/P020220121639049697767.pdf> (accessed April 26, 2022).
- 26 Qiyong L. Impact of climate change on vector-borne diseases and related response strategies in China: major research findings and recommendations for future research. *Chin J Vect Biol Control* 2021; 32: 1–11.
- 27 Lin RJ, Lee TH, Leo YS. Dengue in the elderly: a review. *Expert Rev Anti Infect Ther* 2017; 15: 729–35.
- 28 Xiao J, Dai J, Hu J, et al. Co-benefits of nonpharmaceutical intervention against COVID-19 on infectious diseases in China: a large population-based observational study. *Lancet Reg Health West Pac* 2021; 17: 100282.
- 29 Qiyong L. Dengue fever in China: new epidemical trend, challenges and strategies for prevention and control. *Chin J Vect Biol Control* 2020; 31: 1–6.
- 30 Liu K, Zhou H, Sun RX, et al. A national assessment of the epidemiology of severe fever with thrombocytopenia syndrome, China. *Sci Rep* 2015; 5: 9679.
- 31 Qiyong L. Reported cases of vector-borne diseases in China, 2005–2020: Epidemic trend, challenges in prevention and control, and related coping strategies. *Chin J Vect Biol Control* 2022; 33: 1–7.
- 32 Ministry of Natural Resources of the People's Republic of China. China sea level Bulletin 2020. Beijing: Ministry of Natural Resources of the People's Republic of China, 2020.
- 33 Hauer ME, Fussell E, Mueller V, et al. Sea-level rise and human migration. *Nat Rev Earth Environ* 2020; 1: 28–39.
- 34 Fox-Kemper B, Hewitt HT, Xiao C, et al. Ocean, cryosphere, and sea level change. In: Masson-Delmotte V, Zhai P, Pirani A, et al, eds. *Climate Change 2021: the physical science basis contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change*. Cambridge: Cambridge University Press, 2021.
- 35 Kulp SA, Strauss BH. CoastalDEM: a global coastal digital elevation model improved from SRTM using a neural network. *Remote Sens Environ* 2018; 206: 231–39.
- 36 Doxsey-Whitfield E, MacManus K, Adamo SB, et al. Taking advantage of the improved availability of census data: a first look at the gridded population of the world, version 4. *Pap Appl Geogr* 2015; 1: 226–34.
- 37 O'Neill MS, Carter R, Kish JK, et al. Preventing heat-related morbidity and mortality: new approaches in a changing climate. *Maturitas* 2009; 64: 98–103.
- 38 Wan H, Cao T, Hwang Y, Radermacher R, Andersen SO, Chin S. A comprehensive review of life cycle climate performance (LCCP) for air conditioning systems. *Int J Refrig* 2021; 130: 187–98.
- 39 Jay O, Capon A, Berry P, et al. Reducing the health effects of hot weather and heat extremes: from personal cooling strategies to green cities. *Lancet* 2021; 398: 709–24.

- 40 Kinay P, Ji JS. Reporting evidence of greenness co-benefits on health, climate change mitigation, and adaptation: a systematic review of the literature. *Environ Res: Climate* 1: 012002.
- 41 James P, Banay RF, Hart JE, Laden F. A review of the health benefits of greenness. *Curr Epidemiol Rep* 2015; 2: 131–42.
- 42 Rojas-Rueda D, Nieuwenhuijsen MJ, Gascon M, Perez-Leon D, Mudu P. Green spaces and mortality: a systematic review and meta-analysis of cohort studies. *Lancet Planet Health* 2019; 3: e469–77.
- 43 Zhang H, Liu L, Zeng Y, Liu M, Bi J, Ji JS. Effect of heatwaves and greenness on mortality among Chinese older adults. *Environ Pollut* 2021; 290: 118009.
- 44 Ji JS, Zhu A, Lv Y, Shi X. Interaction between residential greenness and air pollution mortality: analysis of the Chinese Longitudinal Healthy Longevity Survey. *Lancet Planet Health* 2020; 4: e107–15.
- 45 Didan K. MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006. 2015. <https://lpdaac.usgs.gov/products/mod13q1v006/> (accessed May 13, 2022).
- 46 Ji JS, Zhu A, Bai C, et al. Residential greenness and mortality in oldest-old women and men in China: a longitudinal cohort study. *Lancet Planet Health* 2019; 3: e17–25.
- 47 Embassy of the People's Republic of China in the United States of America. China's "1+N" Policy Framework. [http://us.china-embassy.gov.cn/eng/zt/climatechange/202111/t20211117\\_10449121.htm](http://us.china-embassy.gov.cn/eng/zt/climatechange/202111/t20211117_10449121.htm) (accessed April 25, 2022).
- 48 Zhang S, An K, Li J, et al. Incorporating health co-benefits into technology pathways to achieve China's 2060 carbon neutrality goal: a modelling study. *Lancet Planet Health* 2021; 5: e808–17.
- 49 China Electricity Council. 2021 national electric power industry statistical express. *China Electricity Council* 2022; <https://www.cec.org.cn/detail/index.html?3-306014=> (accessed April 30, 2022).
- 50 International Energy Agency. Electricity and heat database. Paris: International Energy Agency. <https://www.iea.org/data-and-statistics/data-product/electricity-information> (accessed April 15, 2022).
- 51 Institute for Health Metrics and Evaluation. Global Burden of Disease Study (GBD) 2019. <http://ghdx.healthdata.org/gbd-2019> (accessed Feb 28, 2022).
- 52 Wang J, Zhou Z, Zhao J, Zheng J, Guan Z. Towards a cleaner domestic heating sector in China: current situations, implementation strategies, and supporting measures. *Appl Therm Eng* 2019; 152: 515–31.
- 53 Zhao Y, Strauss J, Chen X, et al. China health and retirement longitudinal study wave 4 User's guide. National School of Development, Peking University, 2020: 5–6.
- 54 Gheewala SH, Damen B, Shi X. Biofuels: economic, environmental and social benefits and costs for developing countries in Asia. *Wiley Interdiscip Rev Clim Change* 2013; 4: 497–511.
- 55 Giri M, Goswami B. Determinants of household's choice of fuel for cooking in developing countries: evidence from Nepal. *Journal of Development Policy and Practice* 2018; 3: 137–54.
- 56 Hou B, Liao H, Wang J-W, Wang F, Zhang H. Cooking fuel decision-making and family structure: a field study in China. *Environ Sci Pollut Res Int* 2019; 26: 24050–61.
- 57 Wu S. Household fuel switching and the elderly's health: evidence from rural China. *Energy* 2022; 240: 122785.
- 58 Cao Z, Meng Q, Gao B. The consumption patterns and determining factors of rural household energy: a case study of Henan Province in China. *Renew Sustain Energy Rev* 2021; 146: 111142.
- 59 Luo Z, Wang Y, Lv Z, et al. Impacts of vehicle emission on air quality and human health in China. *Sci Total Environ* 2022; 813: 152655.
- 60 Bickford E, Holloway T, Karambelas A, et al. Emissions and air quality impacts of truck-to-rail freight modal shifts in the Midwestern United States. *Environ Sci Technol* 2014; 48: 446–54.
- 61 State Council of China. The State Council rolls out a three-year action plan for clean air. 2018. [http://english.mee.gov.cn/News\\_service/news\\_release/201807/t20180713\\_446624.shtml](http://english.mee.gov.cn/News_service/news_release/201807/t20180713_446624.shtml) (accessed April 3, 2022).
- 62 Ministry of Agriculture and Rural Affairs of the People's Republic of China. The action plan for zero growth of chemical fertilizer use by 2020 and the action plan for zero growth of pesticide use by 2020. [http://www.moa.gov.cn/nygbg/2015/san/201711/t20171129\\_5923401.htm](http://www.moa.gov.cn/nygbg/2015/san/201711/t20171129_5923401.htm) (accessed May 1, 2022).
- 63 Liu Y, Tong D, Cheng J, et al. Role of climate goals and clean-air policies on reducing future air pollution deaths in China: a modelling study. *Lancet Planet Health* 2022; 6: e92–99.
- 64 Tay A. By the numbers: China's net-zero ambitions. *Nature* 2022; published online April 5. <https://doi.org/10.1038/d41586-022-00802-3>.
- 65 Nahm JM, Miller SM, Urpelainen J. G20's US \$14-trillion economic stimulus reneges on emissions pledges. *Nature* 2022; 603: 28–31.
- 66 Institute of Climate Change and Sustainable Development of Tsinghua University et al. China's Long-Term Low-Carbon Development Strategies and Pathways. 2022. <https://www.efchina.org/Attachments/Report/report-lceag-20210711/China-s-Long-Term-Low-Carbon-Development-Strategies-and-Pathways.pdf> (accessed April 20, 2022).
- 67 Xia Y, Li Y, Guan DB, et al. Assessment of the economic impacts of heat waves: A case study of Nanjing, China. *J Clean Prod* 2018; 171: 811–19.
- 68 Sabatini D. Air pollution and elderly. In: Capello F, Gaddi AV, eds. *Clinical handbook of air pollution-related diseases*. Cham: Springer International Publishing, 2018: 187–214.
- 69 Guan N, Huang X, Li T. Air quality and health care expenditure: evidence from Chinese middle-aged and elderly samples. *China Econ Quarterly* 2021; 21: 775–96.
- 70 Li S, Chen L, Chen S, Wu S, Guo Y. Acute effects of hourly particulate-matter air pollution on 24 h ambulatory blood pressure in Chinese elderly individuals: a prospective panel study. *Lancet* 2017; 390: S86.
- 71 Global Times. Zhengzhou Party chief demoted, among 97 held accountable for failing duties in deadly downpour. 2022. <https://www.globaltimes.cn/page/202201/1246589.shtml> (accessed March 10, 2022).
- 72 Navarre B. 10 of the deadliest natural disasters in 2021. 2021. <https://www.usnews.com/news/best-countries/slideshows/here-are-10-of-the-deadliest-natural-disasters-in-2021?slide=9> (accessed March 10, 2022).
- 73 Global Times. China's flood-hit Zhengzhou expands lockdown area amid new COVID-19 surge. 2021. <https://www.globaltimes.cn/page/202108/1230521.shtml> (accessed March 10, 2022).
- 74 Hu Y, Yang L, Guan D. Assessing the economic impact of "natural disaster-public health" major compound extreme events: a case study of the compound event of floods and COVID epidemic in Zhengzhou China [in Chinese]. *China Journal of Econometrics* 2022; 2: 257–90.
- 75 National Energy Administration. 2021 national power industry statistics. <https://www.seetao.com/details/137081.html> (accessed May 28, 2022).
- 76 Zhang W, Zhou Y, Gong Z, et al. Quantifying stranded assets of the coal-fired power in China under the Paris Agreement target. *Clim Policy* 2021; published online July 15. <https://doi.org/10.1080/14693062.2021.1953433>.
- 77 IRENA. Renewable energy and jobs—annual review 2021. [https://pact-for-skills.ec.europa.eu/community-resources/publications-and-documents/renewable-energy-and-jobs-annual-review-2021\\_en](https://pact-for-skills.ec.europa.eu/community-resources/publications-and-documents/renewable-energy-and-jobs-annual-review-2021_en) (accessed April 22, 2022).
- 78 CEIC. China employment in fossil fuel extraction ceic global economic data, indicators, charts & forecasts. <https://www.ceicdata.com/zh-hans/china/no-of-employee-by-industry-monthly/no-ofemployee-petroleum-coking-nuclear-fuel> (accessed March 15, 2021).
- 79 China National Bureau of Statistics. National Data 2021. 2022. <https://data.stats.gov.cn/easyquery.htm?cn=C01> (accessed May 15, 2022).
- 80 IEA. Fossil Fuel Subsidies Database. Paris: International Energy Agency, 2022. <https://www.iea.org/data-and-statistics/data-product/fossil-fuel-subsidies-database> (accessed May 13, 2022).
- 81 Gordeljevic V. Hidden price tags, how ending fossil fuel subsidies would benefit our health. 2017. [http://www.env-health.org/IMG/pdf/appendix\\_calculations.pdf](http://www.env-health.org/IMG/pdf/appendix_calculations.pdf) (accessed May 17, 2022).
- 82 Wind Information Co. L. Shanghai. Wind Economic Database 2021.; 2022. <https://www.wind.com.cn/en/data.html> (accessed April 21, 2022).
- 83 Jiang T, Su B, Huang J, et al. Each 0.5° C of warming increases annual flood losses in China by more than US \$60 billion. *Bull Am Meteorol Soc* 2020; 101: E1464–74.

- 84 Knittel N, Jury MW, Bednar-Friedl B, Bachner G, Steiner AK. A global analysis of heat-related labour productivity losses under climate change—implications for Germany's foreign trade. *Clim Change* 2020; **160**: 251–69.
- 85 Zhongming Z, Wei L. Climate change 2022: impacts, adaptation and vulnerability—summary for policymakers released. 2022. <https://www.wind.com.cn/en/data.html> (accessed May 10, 2022).
- 86 Fabian N. Economics: support low-carbon investment. *Nature* 2015; **519**: 27–29.
- 87 Tian J, Yu L, Xue R, Zhuang S, Shan Y. Global low-carbon energy transition in the post-COVID-19 era. *Appl Energy* 2022; **307**: 118205.
- 88 Boykoff MT. Media and scientific communication: a case of climate change. *Spec Publ Geol Soc Lond* 2008; **305**: 11–18.
- 89 Barkemeyer R, Figge F, Hoepner A, Holt D, Kraak JM, Yu P-S. Media coverage of climate change: an international comparison. *Environ Plan* 2017; **35**: 1029–54.
- 90 Boykoff MT. Who speaks for the climate? Making sense of media reporting on climate change. Cambridge: Cambridge University Press, 2011.
- 91 Gavin NT. Addressing climate change: a media perspective. *Env Polit* 2009; **18**: 765–80.
- 92 Berrang-Ford L, Sietsma AJ, Callaghan M, et al. Systematic mapping of global research on climate and health: a machine learning review. *Lancet Planet Health* 2021; **5**: e514–25.
- 93 Suzman R, Beard JR, Boerma T, Chatterji S. Health in an ageing world—what do we know? *Lancet* 2015; **385**: 484–86.

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