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The 2019 Report of The Lancet Countdown on Health and Climate Change

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List of Abbreviations

A&RCC – Adaptation & Resilience to Climate Change
AAP – Ambient Air Pollution
AUM – Assets Under Management
BEV – Battery Electric Vehicle
CDP – Carbon Disclosure Project
CFU – Climate Funds Update
CO_2 – Carbon Dioxide
COP – Conference of the Parties
COPD – Chronic Obstructive Pulmonary Disease
CPI – Consumer Price Indices
CSD – Climate Sensitive Disease
DALYs – Disability Adjusted Life Years
DPSEEA – Driving Force-Pressure-State-Exposure-Effect-Action
ECMWF – European Centre for Medium-Range Weather Forecasts
EEIO – Environmentally-Extended Input-Output
EEZ – Exclusive Economic Zone
EJ – Exajoule (10*18 joules)
EM-DAT – Emergency Events Database
ERA – European Research Area
ETR – Environmental Tax Reform
ETS – Emissions Trading System

EU – European Union
EU28 – 28 European Union Member States
EV – Electric Vehicle
FAO – Food and Agriculture Organization of the United Nations
FAZ – Frankfurter Allgemeine Zeitung
FISE – Social Inclusion Energy Fund
GBD – Global Burden of Disease
GDP – Gross Domestic Product
GHG – Greenhouse Gas
$GtCO_2$ – Gigatons of Carbon Dioxide
GW – Gigawatt
GWP – Gross World Product
HAB – Harmful Algal Blooms
HFC - Hydrofluorocarbon
HIC – High Income Countries
HNAP – Health component of National Adaptation Plan
HT – Hindustan Times
ICS – Improved Cook Stove
IEA – International Energy Agency
IHR – International Health Regulations
IPC – Infection Prevention and Control
IPCC - Intergovernmental Panel on Climate Change
IRENA - International Renewable Energy Agency
KP – Kaiser Permanente
LMICs – Low- and Middle-Income Countries
LPG – Liquefied Petroleum Gas
Mt – Megaton
$MtCO_2e$ – Metric Tons of Carbon Dioxide Equivalent
MODIS – Moderate Resolution Imaging Spectroradiometer
MRIO – Multi-Region Input-Output
NAP – National Adaptation Plan
NASA – National Aeronautics and Space Administration
NDCs - Nationally Determined Contributions
NHMSs – National Meteorological and Hydrological Services
NHS – National Health Service
NO_x – Nitrogen Oxides
NYT – New York Times
OECD – Organization for Economic Cooperation and Development
PHEV – Plug-in Hybrid Electric Vehicle
$PM_{2.5}$ – Fine Particulate Matter
PV – Photovoltaic
SDG – Sustainable Development Goal
SDU – Sustainable Development Unit
SHUE – Sustainable Healthy Urban Environments
SO_2 – Sulphur Dioxide
SSS – Sea Surface Salinity

241 SST – Sea Surface Temperature
242 tCO_2 – Tons of Carbon Dioxide
243 tCO2/TJ – Total Carbon Dioxide per Terajoule
244 TJ – Terajoule (10*12 joules)
245 ToI – Times of India
246 TPES – Total Primary Energy Supply
247 TWh – Terawatt Hours
248 UHC – Universal Health Coverage
249 UK – United Kingdom
250 UN – United Nations
251 UNFCCC – United Nations Framework Convention on Climate Change
252 UNGA – United Nations General Assembly
253 UNGD – United Nations General Debate
254 USA – United States of America
255 V&A – Vulnerability and Adaptation
256 VC – Vectorial Capacity
257 VLY – Value of a Life Year
258 WHL – Work Hours Lost
259 WHO – World Health Organization
260 WMO – World Meteorological Organization
261 WP – Washington Post
262 YLL – Years of Life Lost

Executive Summary

The Lancet Countdown is an international, multi-disciplinary collaboration, dedicated to monitoring the evolving health profile of climate change, and providing an independent assessment of governments' delivery of their commitments under the Paris Agreement.

The 2019 report presents an annual update of 41 indicators across five key domains: climate change impacts, exposures, and vulnerability; adaptation, planning, and resilience for health; mitigation actions and health co-benefits; economics and finance; and public and political engagement. It represents the findings and consensus of 27 leading academic institutions and UN agencies from every continent. Each year, the methods and data that underpin the Lancet Countdown's indicators are further developed and improved, with updates described at each stage of this report. In order to generate the quality and diversity of data required, the collaboration draws on the world-class expertise of climate scientists, ecologists, mathematicians, engineers, energy, food, and transport experts, economists, social and political scientists, public health professionals, and doctors.

The science of climate change describes a range of possible futures, which are largely dependent on the degree of action or inaction in the face of a warming world. To this end, the policies implemented now will have far-reaching effects in determining these eventualities, with the indicators tracked here monitoring both the present-day effects of climate change, as well as the world's response. Understanding these decisions as a choice between one of two pathways – one that continues with "business as usual" and one that redirects to a future that remains "well below 2°C" – helps to bring the importance of today's decisions, into sharp focus.

Evidence provided by the Intergovernmental Panel on Climate Change, the International Energy Agency, and the US National Aeronautics and Space Administration is helpful in understanding the degree of climate change experienced today and in contextualising these two pathways.

The Impacts of Climate Change on Human Health

The world has so-far observed a 1°C temperature rise above pre-industrial levels, with feedback cycles and polar amplification seeing a rise as high as 3°C in North Western Canada.[1,2] Indeed, eight of the ten hottest years on record have occurred in the last decade.[3] Such rapid change is primarily driven by the combustion of fossil fuels, consumed at a rate of 171,000 kg of coal, 11,600,000 litres of gas, and 186,000 litres of oil per second.[4-6] Progress in mitigating this threat is intermittent at best, with CO_2 emissions continuing to rise in 2018.[7] Importantly, many of the indicators contained in this report suggest the world is following this "business as usual" pathway.

The carbon intensity of the energy system has remained unchanged since 1990 (Indicator 3.1.1), and from 2016 to 2018, total primary energy supply from coal increased by 1.7%, reversing a previous downwards trend (Indicator 3.1.2). Correspondingly, the healthcare sector is responsible for some 4.6% of global emissions, steadily rising across most major economies (Indicator 3.6). Global fossil fuel consumption subsidies increased by 50% over the last three years, reaching a high of almost US$430 billion in 2018 (Indicator 4.4.1).

Here, a child born today will experience a world that is over four degrees warmer than the pre-industrial average, with climate change impacting human health from infancy and adolescence to adulthood and old age. Across the world, children are among the worst affected by climate change. Downward trends in global yield potential for all major crops tracked since 1960 threatens food production and food security, with infants often worst affected by the potentially permanent effects of undernutrition (Indicator 1.5.1). Children are among the most susceptible to diarrhoeal disease and experience the most severe effects of dengue fever. Trends in climate suitability for disease transmission are hence particularly concerning, with nine of the ten most suitable years for the transmission of dengue fever on record occurring since 2000 (Indicator 1.4.1). Similarly, since an early 1980s baseline, the number of days suitable for Vibrio (a pathogen responsible for part of the burden of diarrhoeal disease) has doubled, and global suitability for coastal Vibrio cholerae has increased by 9.9% (Indicator 1.4.1).

Through adolescence and beyond, air pollution – principally driven by fossil fuels, and exacerbated by climate change – damages the heart, lungs, and every other vital organ. These effects accumulate over time, and into adulthood, with global deaths attributable to ambient $PM_{2.5}$ remaining at 2.9 million in 2016 (Indicator 3.3.2) and total global air pollution deaths reaching 7 million.[8]

Later in life, families and livelihoods are put at risk from increases in the frequency and severity of extremes of weather, with women often among the most vulnerable. At the global level, 77% of countries experienced an increase in daily population exposure to wildfires from 2001-2014 to 2015-2018 (Indicator 1.2.1). Perhaps unsurprisingly, India and China sustained the largest increases, with an increase of over 15 million and 10.5 million exposures over this time period. In low-income countries, almost all economic losses from extreme weather events are uninsured, placing a particularly high burden on individuals and households (Indicator 4.1). Temperature rises and heatwaves are limiting the labour capacity of populations at increasing rates. In 2018, 45 billion potential work hours were lost globally compared to a 2000 baseline, and Southern parts of the United States of America lost as much as 15-20% of potential daylight work hours during the hottest month of 2018 (Indicator 1.1.4).

Populations aged over 65 years are particularly vulnerable to the health effects of climate change, and especially to extremes of heat. From 1990 to 2018, populations in every region have become more vulnerable to heat and heatwave, with Europe and the Eastern Mediterranean remaining the most vulnerable (Indicator 1.1.1). In 2018, these vulnerable populations experienced 220 million heatwave exposures globally, breaking the previous record of 209 million set in 2015 (Indicator 1.1.3). Already faced with the challenge of an ageing population, Japan had 32 million heatwave exposures affecting people aged over 65 in 2018, the equivalent of almost every person in this age group experiencing a heatwave. Finally, whilst they are difficult to quantify, the down-stream risks of climate change, such as those seen in migration, poverty exacerbation, violent conflict, and mental illness affect people of all ages and all nationalities.

A business as usual trajectory will result in a fundamentally altered world, with the indicators described above providing a glimpse of the implications of this pathway. Here, the life of every child born today will be profoundly affected by climate change. Without significant intervention, this new era will come to define the health of people at every stage of their lives.

Responding to Climate Change for Health

The Paris Agreement lays out a target of “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C”. In a world that matches this ambition, a child born today would see the phase-out of all coal in the UK and Canada by their 6th and 11th birthday; they would see France ban the sale of petrol and diesel cars by their 21st birthday, and they would be 31 years old by the time the world reaches net zero in 2050, with the UK’s recent commitment one of many to come. The changes seen in this alternate pathway could result in cleaner air, safer cities, and more nutritious food, coupled with renewed investment in health systems and vital infrastructure. It is clear that this second path, which limits global average temperature rise to “well below 2°C” is possible, and would transform the health of a child born today for the better, right the way through their life.

Considering the evidence available in the 2019 indicators, there are signs that the beginning of such a transition may be unfolding. Despite a small increase in coal use in 2018, in key countries such as China, it continued to fall as a share of electricity generation (Indicator 3.1.2). Correspondingly, renewables accounted for 45% of global growth in power generation capacity that year, and low-carbon electricity reached a high of 32% of global electricity in 2016 (Indicator 3.1.3). Global per capita use of electric vehicles grew by an enormous 20.6% between 2015 and 2016, and now represents 1.8% of China’s total transportation fuel use (Indicator 3.4). Improvements in air pollution seen in Europe from 2015 to 2016 could result in a reduction of Years of Life Lost worth €5.2 billion annually if this reduction remained constant across a lifetime (Indicator 4.2). In a number of cases, the savings from a healthier and more productive workforce, with fewer healthcare expenses, will cover the initial investment costs of these interventions. Similarly, more resilient cities and health systems are beginning to emerge. Almost 50% of countries and 69% of cities surveyed reported efforts to conduct national health adaptation plans or climate change risk assessments (Indicators 2.1.1, 2.1.2 and 2.1.3). These plans are now being implemented, with the number of countries providing climate services to the health sector rising from 55 in 2018 to 70 in 2019 (Indicator 2.2) and 109 countries reporting medium to high implementation of a national health emergency framework (Indicator 2.3.1). Growing demand is coupled with a steady increase in health adaptation spending, which represents 5% (£13 billion) of total adaptation funding in 2018 and has increased by 11.8% over the past 12 months (Indicator 2.4). This is in part funded by growing revenues from carbon pricing mechanisms, which saw a 30% increase in funds raised between 2017 and 2018, up to US$43 billion (Indicator 4.4.3).

However, current progress is inadequate, and despite the beginnings of a transition described above, the indicators published in the Lancet Countdown's 2019 report are suggestive of a world struggling to cope with warming that is occurring faster than governments are able, or willing to respond. There are too many missed opportunities to improve public health, and leadership in recognising these links at the UN General Assembly is too often left to Small Island Developing States (Indicator 5.3). Indeed, it is the generation that has led the wave of school climate strikes across the world that will be affected most by climate change.

Meeting this unprecedented challenge will require an unprecedented global response, with bold, new approaches to policymaking, research, and business. It will take the work of the 7.5 billion people currently alive, to ensure that the health of a child born today isn't defined by a changing climate.

Introduction

Human wellbeing, and the stability of local communities, health systems, and governments all depend on how they interface with the changing global climate.[9,10] Across the world, an average temperature rise of 1°C since a pre-industrial baseline[1,2] has already revealed profound impacts, with more severe storms and floods, prolonged heatwaves and droughts, new and emerging infectious diseases,[11-13] and compounding threats to food security. Left unabated, climate change will define the health profile of current and future generations, will challenge already overwhelmed health systems, and undermine progress towards the United Nations (UN) Sustainable Development Goals (SDGs) and universal health coverage (UHC).[14,15]

The Intergovernmental Panel on Climate Change (IPCC)'s recent Special Report on Global Warming of 1.5°C makes the scale of the response required clear: global annual emissions must halve by 2030 and reach net-zero by 2050 in order to limit warming to 1.5°C, whilst recognising that no amount of climate change is considered "safe".[2] Placing health at the centre of this transition will yield enormous dividends for the public and the economy, with cleaner air, safer cities, and healthier diets. Analysis focused on one of these pathways – cleaner air through more sustainable transport and power generation systems – suggests that the economic gains from the health benefits of meeting the Paris Agreement substantially outweigh the cost of any intervention by a ratio of 1.45 to 2.45, resulting in trillions of dollars of savings world-wide.[16] When the health benefits of any increase in physical activity that results from modal shift are taken into account, the economic gains increase significantly.[17] These analyses complement a recent assessment from outside the health sector, which estimates that a robust response to climate change could yield over US$26 trillion and 65 million new low-carbon jobs by 2030, compared to a business-as-usual scenario.[18]

Monitoring this transition from threat to opportunity and demonstrating the benefits of realising the Paris Agreement is precisely why *the Lancet Countdown: Tracking Progress on Health and Climate Change* was formed. As an international, independent research collaboration, the partnership brings together some 27 academic institutions and UN agencies from every continent. The indicators and report presented here represent the work and consensus of climate scientists, geographers, engineers, energy, food and transport experts, economists, social and political scientists, public health professionals, and doctors.

The 41 indicators of the 2019 report span five domains: climate change impacts, exposures, and vulnerability; adaptation planning and resilience for health; mitigation actions and their health co-benefits; economics and finance; and public and political engagement (Panel 1).

Working Group	Indicator	
Climate Change Impacts, Exposures and Vulnerability	1.1: Health and heat	1.1.1: Vulnerability to extremes of heat
		1.1.2: Health and exposure to warming
		1.1.3: Exposure of vulnerable populations to heatwaves
		1.1.4: Change in labour capacity
	1.2: Health and extreme weather events	1.2.1: Wildfires
		1.2.2: Flood and drought
		1.2.3: Lethality of weather-related disasters
	1.3: Global health trends in climate-sensitive diseases	
	1.4: Climate-sensitive infectious diseases	1.4.1: Climate suitability for infectious disease transmission
		1.4.2: Vulnerability to mosquito-borne diseases
	1.5: Food security and under-nutrition	1.5.1: Terrestrial food security and under-nutrition
		1.5.2: Marine food security and under-nutrition
Adaptation, Planning, and Resilience for Health	2.1: Adaptation planning and assessment	2.1.1: National adaptation plans for health
		2.1.2: National assessments of climate change impacts, vulnerability, and adaptation for health
		2.1.3: City-level climate change risk assessments
	2.2: Climate information services for health	
	2.3: Adaptation delivery and implementation	2.3.1: Detection, preparedness and response to health emergencies
		2.3.2: Air conditioning – benefits and harms
	2.4: Spending on adaptation for health and health-related activities	
Mitigation Actions and Health Co-Benefits	3.1 Energy system and Health	3.1.1: Carbon intensity of the energy system
		3.1.2: Coal phase-out
		3.1.3: Zero-carbon emission electricity
	3.2: Access and use of clean energy	
	3.3: Air pollution, energy, and transport	3.3.1: Exposure to air pollution in cities
		3.3.2: Premature mortality from ambient air pollution by sector
	3.4: Sustainable and healthy transport	
	3.5: Food, agriculture, and health	
	3.6: Mitigation in the healthcare sector	
Economics and Finance	4.1: Economic losses due to climate-related extreme events	
	4.2: Economic costs of air pollution	
	4.3: Investing in a low-carbon economy	4.3.1: Investment in new coal capacity
		4.3.2: Investments in zero-carbon energy and energy efficiency
		4.3.3: Employment in low-carbon and high-carbon industries
		4.3.4: Funds divested from fossil fuels
	4.4: Pricing greenhouse gas emissions from fossil fuels	4.4.1: Fossil fuel subsidies
		4.4.2: Coverage and strength of carbon pricing
		4.4.3: Use of carbon pricing revenues
Public and Political Engagement	5.1: Media coverage of health and climate change	
	5.2: Individual engagement in health and climate change	
	5.3: Engagement in health and climate change in the United Nations General Assembly	
	5.4: Engagement in health and climate change in the corporate sector	

Panel 1: The Lancet Countdown Indicators

Strengthening a global monitoring system for health and climate change

This collaboration builds on three decades of work around the world, which has sought to understand and assess the scientific pathways linking climate change to public health.[13] In 2016, the Lancet Countdown launched a global consultation process, actively seeking input from experts and policymakers on which aspects of these pathways could and should be tracked as part of a global monitoring process. A large number of indicators were initially considered, and then narrowed down into the five indicator domains and published, along with a request for further input.[19] The final set of indicators were selected, based on: the presence of credible scientific links to climate change and to public health; the presence of reliable and regularly updated data, available across temporal and geographic scales; and the importance of this information to policymakers.[20]

Overcoming the data and capacity limitations inherent in this field and remaining adaptable to a rapidly evolving scientific landscape has required a commitment to an open and iterative approach. This has meant that the analysis provided in each subsequent annual report replaces analyses from previous years, with methods and datasets being continuously improved and updated. In every case, a full description of these changes is provided in the appendix, which is intended as an essential companion to the main report, rather than a more traditional addendum.

The 2019 report presents 12 months of work refining the metrics and analysis. In addition to updating each indicator by one year, key developments include:

- The strengthening of methodologies and datasets for indicators that capture: heat and heatwaves; labour capacity loss; the lethality of weather-related disasters; terrestrial food security and undernutrition; health adaptation planning and vulnerability assessments; air pollution mortality in cities; household fuel use for cooking; and qualitative validation of engagement from the media and national governments in health and climate change.
- The expansion of geographical and temporal coverage for indicators that capture: marine food security; national adaptation planning for health; health vulnerability assessments; climate information services for health; the carbon intensity of the energy system; access to clean energy; and Chinese media engagement in health and climate change.
- The construction of new indicators that capture: exposure to wildfires; the transmission suitability for cholera; the benefits and harms of air conditioning; emissions from livestock and crop production; global healthcare system emissions; economic cost of air pollution; and individual online engagement in health and climate change.

There is also ongoing work to establish indicators for concepts which are inherently difficult to quantify, such as the mental health effects of climate change. In addition, three indicators included in previous years – covering migration, global health adaptation funding, and academic engagement in health and climate change – are not presented in the 2019 report, as further work is being conducted to improve their methods and to ensure that they are able to be sustainably reproduced into the future. These indicators will be re-introduced in subsequent years.

For the second consecutive year, these changes represent significant updates to a majority of indicators – a pace which will only accelerate as additional funding and capacity from the Wellcome Trust and the Lancet Countdown's partners grow. Going forward, the collaboration will seek to further strengthen its scientific processes, continuously review its indicators, and produce internally coherent frameworks to guide the development of new indicators. To this end, the Lancet Countdown remains open to new input and participation from experts and academic institutions willing to build on the analysis published in this report.

The year in health and climate change

The 2019 report points to a number of worsening human symptoms of climate change. Over 220 million additional exposures to heatwaves (with each exposure defined as one person over 65 exposed to one heatwave) occurred in 2018 compared to a climatological baseline, higher than ever previously tracked (Indicator 1.1.3). This occurred at a time when demographic vulnerability to these extremes continued to increase across every region (Indicator 1.1.1), and the warming experienced by human populations reached four times that of the global average temperature rise (Indicator 1.1.2). Around the world, resultant losses in labour capacity were seen, with a number of the Southern states in the USA losing as much as 15-20% of daylight capacity, for workers in construction and agriculture (Indicator 1.1.4). The effects of this warming extended to other extremes, with 106 countries experiencing a marked increase in the daily population exposures to wildfires when compared to baseline (Indicator 1.2.1). In the case of infectious disease, 2018 was the second most suitable year on record for the transmission of diarrhoeal disease and wound infections from *Vibrio* bacteria, and nine out of the last ten most suitable years for the transmission of dengue fever have occurred since 2000 (Indicator 1.4.1). The distribution of exposure and impact is not equal, with a number of these indicators reporting greater changes in low-income settings in parts of Africa, South East Asia, and the Western Pacific (Indicator 4.1).

Despite this, the carbon intensity of the global energy system has remained flat since 1990 (Indicator 3.1.1), and use of clean fuels for household services is stagnating (Indicator 3.2). Perhaps of greatest concern, total primary energy supply from coal increased by 1.7% from 2016 to 2018, reversing a previously observed downwards trend (Indicator 3.1.2), and CO_2 emissions from the energy sector, far from falling, rose by 2.6% from 2016 to 2018 (Indicator 3.1.1). Global fossil fuel subsidies rose to US$427 billion in 2018, a 33% rise from 2017 (Indicator 4.4.1), and healthcare-associated emissions now represent 4.6% of global emissions, rising across most major economies (Indicator 3.6). Fossil fuel use continues to contribute to ambient air pollution, which resulted in 2.9 million deaths in 2016 (Indicator 3.3.2).

Whilst these emerging health impacts and the lack of a coordinated global response portray a bleak picture, they also mask important trends that lie behind the data. Encouraging reductions in investment in new coal capacity and a fall in coal as a share of total electricity generation continue (Indicators 4.3.1 and 3.1.2). Renewable energy accounted for 45% of total growth in 2018 (Indicator 3.1.3), and low-carbon electricity represented an impressive 32% share of total global electricity generation in 2016 (Indicator 3.1.3). The reduction in air pollution seen in Europe from 2015 to 2016, if held constant across a lifetime, could result in annual reduction in Years of Life Lost valued at €5.2 billion (Indicator 4.2). These changes are reinforced by new commitments from the UK[21] and France[22] to reach net zero by 2050, with others soon expected to follow.

At the same time, the world is beginning to adapt, with almost 50% of countries, and 69% of cities surveyed, reporting the completion or undertaking of a climate change risk assessment or adaptation plan (Indicators 2.1.2 and 2.1.3). Increasingly, these plans are being implemented, with 70 countries providing meteorological services targeted towards the health sector in 2019 and 109 countries achieving medium to high implementation of a national health emergency framework (Indicators 2.2 and 2.3.1).

In the health sector, the UK's Royal College of General Practitioners and Faculty of Public Health divested their fossil fuels investments in 2018, joining a large number of universities, non-governmental organisations and pension funds from across the world (Indicator 4.3.4). Alongside this, new analysis suggests a growing and more sophisticated recognition of the health benefits of the response to climate change in the media (Indicator 5.1).

Many of the trends identified in the 2019 Lancet Countdown report are deeply concerning. Greenhouse gas (GHG) emissions continue to rise. Nevertheless, the continued expansion of renewable energy, increased investment in health system adaptation, improvements in sustainable transport, and growth in public engagement suggests ongoing reasons for cautious optimism. At a time when the UN Framework Convention on Climate Change is preparing to review commitments under the Paris Agreement in 2020, greatly accelerated ambition and action is required in order to meet the world's commitment to remaining "well below 2°C."[23]

Section 1: Climate Change Impacts, Exposures, and Vulnerabilities

Climate change and human health are interconnected in a myriad of complex ways.[13] Building on the Lancet Countdown's previous work, section 1 of the 2019 report continues to track quantitative metrics along pathways of population vulnerability, exposure, and health outcomes that are indeed indicative of the cost to human health of climate change, and thus the urgent need to reduce GHG emissions. The impacts tracked here in turn motivate and guide climate change adaptation (section 2) and mitigation (section 3) interventions.

Changes in warming and weather events are not evenly distributed across the globe, and some populations, including children, the elderly and outdoor workers, are more vulnerable than others. Efforts to track the unequal impacts of climate change are reflected through indicators that, for example, focus on particularly vulnerable populations, and by focusing on low- and middle-income countries experiencing the worst of these effects.

Whilst it is certainly true that the effects of climate change vary by geography and that these effects will not always be negative, it is also true that any so-called 'positives' are often short-term in nature, and quickly overwhelmed and outweighed by other exposures. One such example is seen in Australia, where any benefit that may have been gained from CO_2 fertilisation is both small and largely outweighed by greater climate variation, with crop yields now stalling as harvests are increasingly affected by more frequent drought.[24] Even disregarding the negative effects of temperature change, any CO_2 fertilisation benefits are likely to be short-lived, as rising CO_2 concentrations will negatively affect grain quality.[25-28]

For 2019, a new metric tracking exposure to wildfires has been added (Indicator 1.2.1), as has an expansion of climate suitability of infectious diseases (Indicator 1.4.1), to now include cholera transmission risk. These indicators portray a world which is rapidly warming, where environmental and social systems are already feeling the effects of climate change, and human health is being affected as a result.

Indicator 1.1: Health and heat

The most immediate and direct impact of a changing global climate on human health is seen in the steady increase in global average temperature, and the increased frequency, intensity, and duration of extremes of heat. The pathophysiological consequences of heat exposure in humans are well documented and understood, and include heat stress and heat stroke, acute kidney injury, exacerbation of congestive heart failure,[29] and increased risk of interpersonal,[30] and collective violence.[31] In particular, during periods of extreme heat, young children have a greater risk of electrolyte imbalance, fever, respiratory disease and kidney disease.[32] Here, four indicators are related to heat, tracking the vulnerabilities, exposures, and labour implications of a warming world.

Indicator 1.1.1: Vulnerability to extremes of heat

Headline finding: *Vulnerability to extremes of heat continues to rise among older populations in every region of the world with the Western Pacific, South East Asia and African regions all seeing an increase in vulnerability of over 10% since 1990.*

Certain populations are more vulnerable to the health effects of heat than others. Older populations are particularly vulnerable, especially those with pre-existing medical conditions (such as diabetes and cardiovascular, respiratory, and renal disease).[33] Outdoor workers, while younger and healthier overall, are also vulnerable due to heightened exposure. This indicator presents a heat vulnerability index which ranges from 0 to 100 and includes proportion of the population over 65, prevalence of chronic diseases, and proportion of the population living in urban areas, with the data and methods unchanged from previous years, and provided in detail in the appendix.

Populations over 65, in all regions of the world, are becoming increasingly vulnerable. However, the highest increase from 1990 to 2017 has been seen in the Western Pacific (33.1% to 36.6%) and African (28.4% to 31.2%) regions. Overall, Europe remains the most vulnerable region to heat exposure (followed closely by the Eastern Mediterranean region), due to its ageing population, high rates of urbanisation, and high prevalence of cardiovascular and respiratory disease, and diabetes.

Indicator 1.1.2: Health and exposure to warming

Headline finding: *Human populations are concentrated in the areas most exposed to warming, experiencing a mean summer temperature change four times higher than the global average.*

This indicator compares the population-weighted summer temperature change from a 1986-2005 baseline with the global average summer temperature change over the same period, using weather data from the European Centre for Medium-Range Weather Forecasts (ECMWF),[34] ERA-Interim project and population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[35] Full details are provided in the appendix, along with an explanation of improvements for the 2019 report, which uses higher resolution climate and population data (0.5° grid instead of 0.75° grid).

The population-weighted temperatures continue to grow at a significantly faster pace than the global average, increasing the human health risk. The global average population-weighted temperature has risen by 0.8°C from the 1986-2005 baseline to 2018, compared with a global average temperature rise of 0.2°C over the same period.

Indicator 1.1.3: Exposure of vulnerable populations to heatwaves

Headline finding: *In 2018, 220 million more heatwave exposures affecting older populations were observed, breaking the previous record set in 2015. Japan alone experienced 32 million heatwave exposures, the equivalent of almost every person aged 65 and above experiencing a heatwave in 2018.*

Heatwaves across all of the Northern Hemisphere made headlines in 2018, reaching new highs for a number of countries.[36] The definition of a heatwave, the demographic data[35] and methods used here remain unchanged from previous reports (see appendix).[46] Each heatwave exposure event is defined as one heatwave experienced by one person aged over 65. This indicator was also improved with a higher resolution (0.5° grid instead of 0.75° grid).

Figure 1 presents the change in heatwave exposure events relative to the recent past average. The increase in heatwave exposure events (220 million, which is 11 million more than the 2015 record) is due to a series of heatwaves across India (45 million additional exposures); in central and northern Europe (31 million additional exposures in the EU); and northeast Asia, where the heatwave affected Japan, the Korean peninsula, and Northern China. There were 32 million exposures affecting people aged over 65 in Japan alone, the equivalent of almost every person in this age group experiencing a heatwave in 2018.[37]

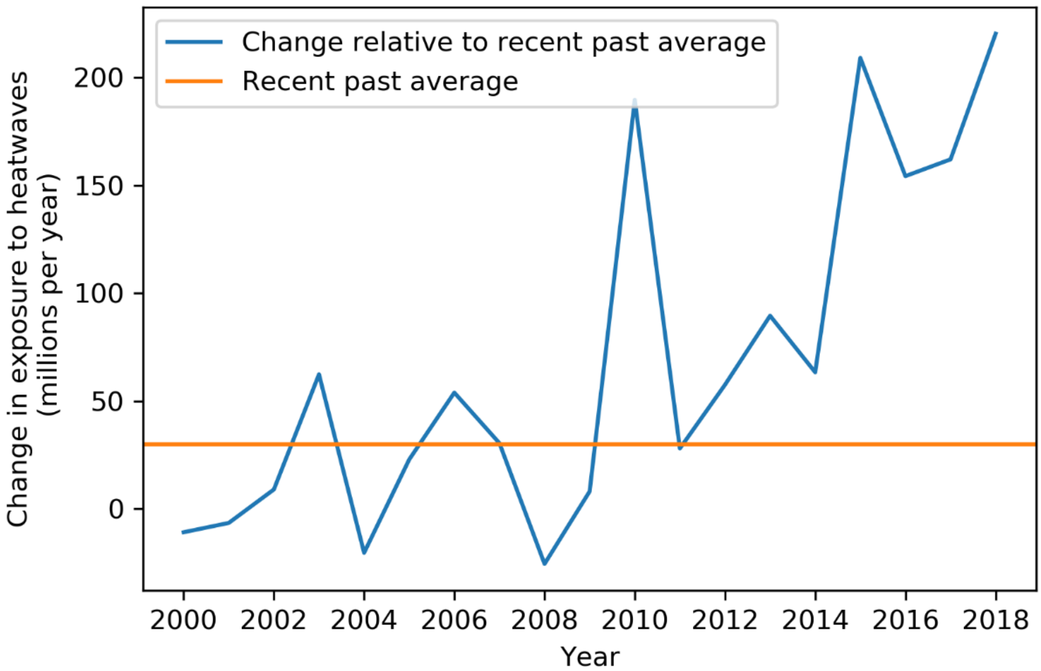


Figure 1: Change in the number of heatwave exposure events in the over 65 population compared with the historical average number of events (1986–2005 average).

Indicator 1.1.4: Change in labour capacity

***Headline finding:** higher temperatures continue to affect people's ability to work. In 2018, due to rising temperatures, there were 45 billion additional potential work hours lost compared with the year 2000.*

People's ability to work is affected by temperature and humidity, which are both captured in the Wet Bulb Globe Temperature (WBGT) measurement. Labour productivity loss estimates for every degree increase of WBGT beyond 24°C range from 0.8% to 5%.[38] Reduced labour productivity is often the first symptom of the health effects of heat, and, if not addressed, may lead to more severe health effects, such as heat exhaustion and heat stroke.

This indicator highlights the important impact of climate change on labour capacity in vulnerable populations.[39] It assigns work-fraction loss functions to different activity sectors (service, manufacturing and agriculture), linking WBGT with the power (metabolic rate) typically expended by a worker within each of these three sectors. This is then coupled with the proportion of the population working within each of these three sectors to calculate potential work hours lost (WHL) by country. This indicator has been improved to include the impact of sunlight on the potential WHL by calculating the increase in WBGT using solar radiation data available from the ERA database, with full methods described in the appendix.[35,40,41]

The global atmospheric temperature and humidity in 2018 were slightly more favourable for work than in 2017, but the upward trend of potential WHL since 2000 remains clear (Figure 2). In 2018, 133.6 billion potential work hours were lost, 45 billion hours more than in 2000.

Figure 3 presents a map of the equivalent potential full-time work lost in the sun and the shade**.** Of note, for 300W work in the shade (typical for manufacturing), over 10% potential daily work hours were lost in densely populated regions such as South Asia. For 400W work in the sun (typical for agriculture and construction), even workers in the Southern parts of the USA (below a latitude of 34˚N, with Texas, Louisiana, Mississippi, Alabama, Georgia, and Florida particularly affected), lost 15-20% of potential daylight work hours in the hottest month in 2018.

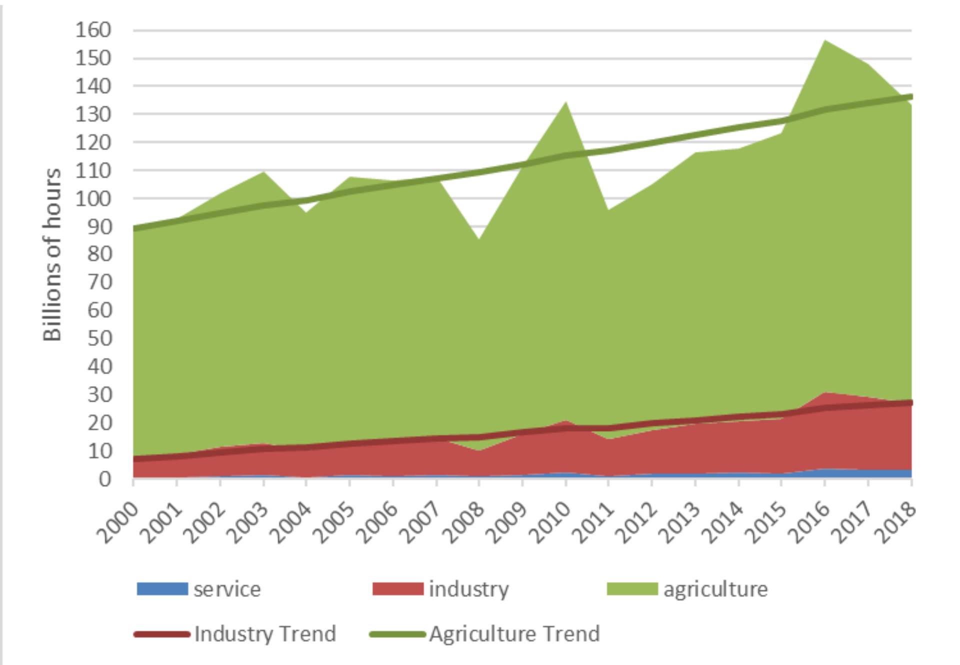


Figure 2: Potential global work hours lost by sector 2000-2018.

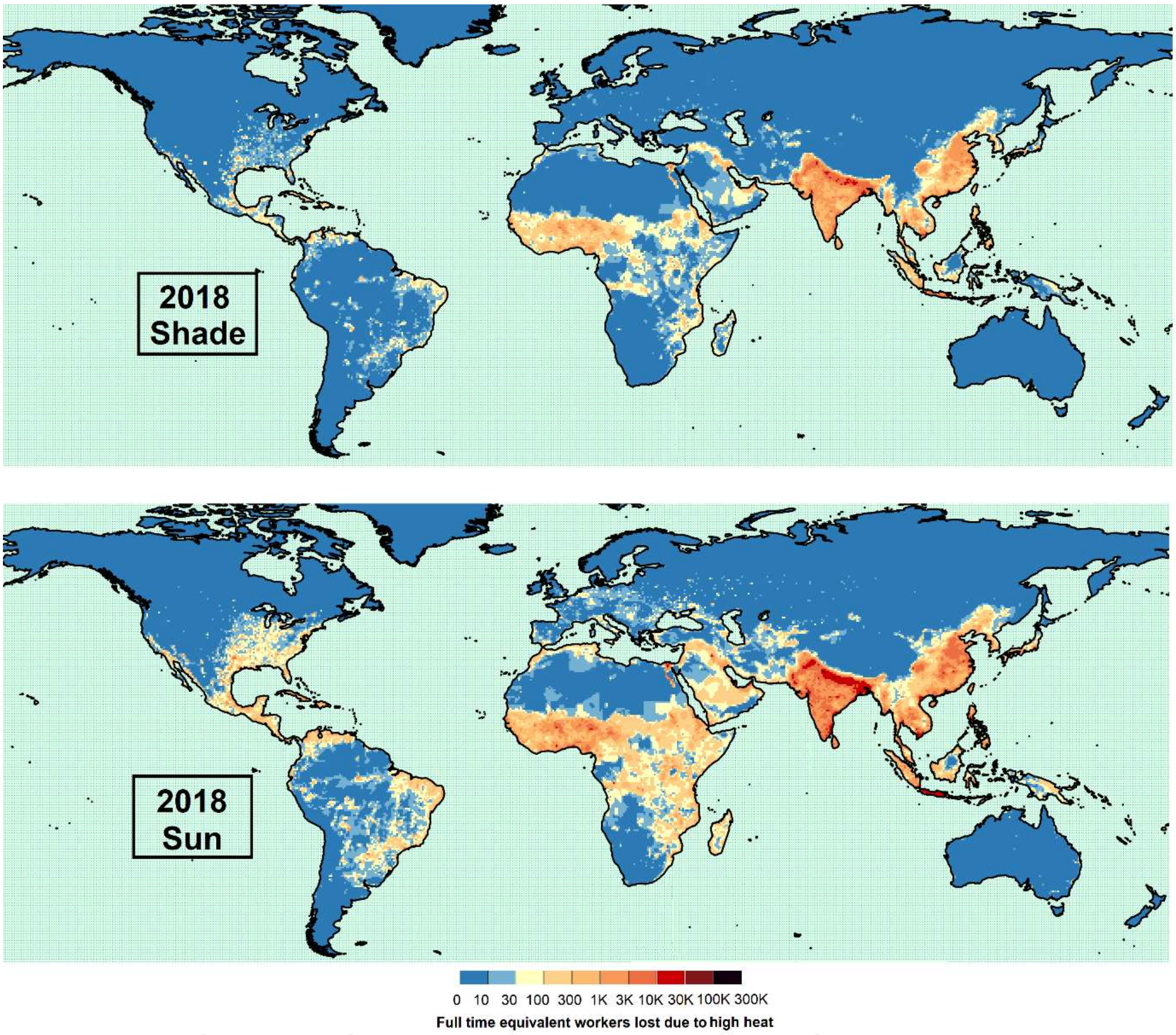


Figure 3: Potential full-time work lost in the sun or in the shade, based on the percent of people working in agriculture (400W), industry (300W) and services (200W) in each grid cell.

Indicator 1.2: Health and extreme weather events

Indicator 1.2.1: Wildfires

Headline finding: *152 out of 196 countries saw an increase in annual daily population exposure to wildfires in 2015-2018 compared to 2001-2004, with India alone experiencing an increase of 21 million annual daily exposures. This not only poses a threat to public health, but also results in major economic and social burdens in both higher- and lower-income countries.*

The health impacts of wildfires range from direct thermal injuries and death, to the exacerbation of acute and chronic respiratory symptoms due exposure to wildfire smoke.[42] Additionally, the global economic burden per person affected by wildfires is over twice that of earthquakes and over 48 times that of floods, although the global number of events and number of people affected by floods are much higher.[43] Furthermore, recent climatic changes, including increasing temperature and earlier snowmelt, contribute to hotter, drier conditions, that increase risk of wildfires. Yet, wildfires remain an important component of many ecosystems, although they can be ecologically harmful through human ignition or where forest management practices do not fully account for periodic, natural burning.

This new indicator represents the change in the average annual number of days people were exposed to wildfire in each country. It was developed using Collection 6 active fire product from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the NASA Terra and Aqua satellites.[44] Fire point locations were matched to a political border shapefile from the Global Burden of Disease (GBD), and consequently joined with population count per square kilometre, taken from NASA SEDAC GPWv4.[35] The result is an annual sum of people experiencing a fire event per day. The mean number of person-days exposed to wildfire was taken for years 2001-2004 (the earliest years for which data with adequate coverage and resolution is available) and compared with the mean from 2015-2018.

Overall, this indicator reports a mean increase of 464,032 person-days exposed to wildfire per year over the period studied, however the change experienced in some countries is far greater than the global increase. India, China, the Democratic Republic of Congo, Mexico, and Iraq sustained the largest increase in the number of person-days impacted by wildfires, with a maximum difference of nearly 21,807,000 person-days in India followed by 17,003,000person-days in China (Figure 4). Countries including Spain, Russia and Uzbekistan saw significant reductions in the number of people affected.

Crucially, this indicator will evolve over time to cover the health risks of wildfire smoke,[42] which can travel far distances and affect areas that are not directly exposed to fires.[45]

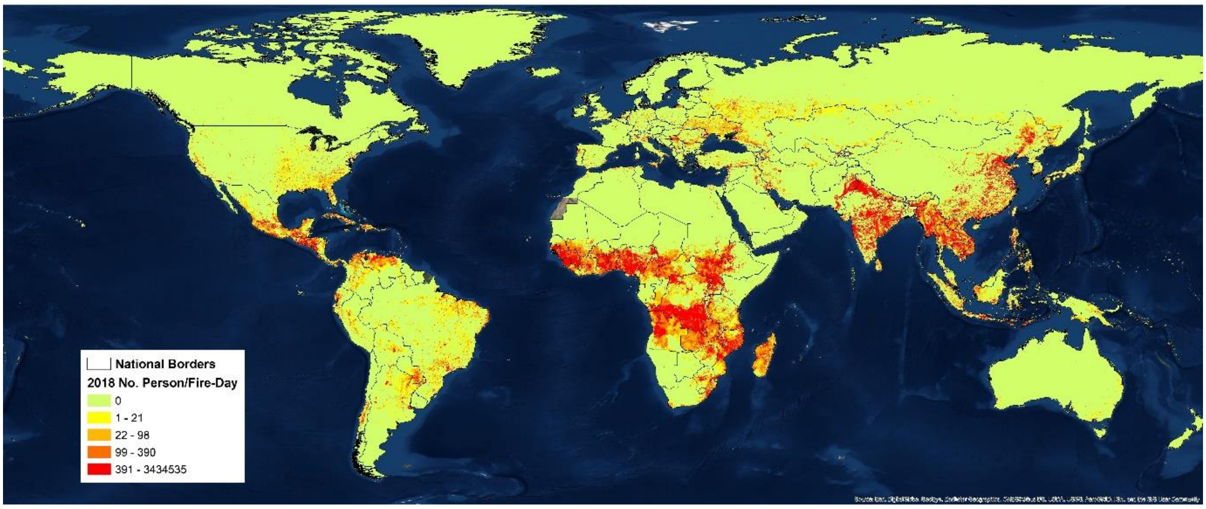


Figure 4: Person days exposed to fire in 2018.

Indicator 1.2.2: Flood and drought

Headline Finding: *Extremes of precipitation, resulting in flood and drought, have profound impacts on human health and wellbeing, with South American and South East Asian populations experiencing long-term increases in both phenomena.*

This indicator tracks exposure to extremes of precipitation, using weather and population data used in previous reports,[20,46] and described in full in the appendix. Analysis across time and space reveals regional trends for drought and extreme heavy rain that are more significant than global trends, reflecting the varying nature of climate change depending on the geographical region.

Floods are particularly problematic for health, resulting in direct injuries and death, the spread of vector- and water-borne disease, and mental health sequelae.[47] Figure 5 provides a global map of extremes of rainfall as a proxy for flood, and demonstrates that South America and South East Asia are experiencing the largest increases.

Prolonged drought remains one of the most dangerous environmental determinants of premature mortality, affecting hygiene and sanitation, as well as resulting in reduced crop yields, food insecurity, and malnutrition.[47] The change in the mean number of severe droughts highlights increased exposure in large areas of South America, Northern and Southern Africa, and South East Asia, with many areas experiencing a full 12 months of drought throughout 2018 (see appendix).

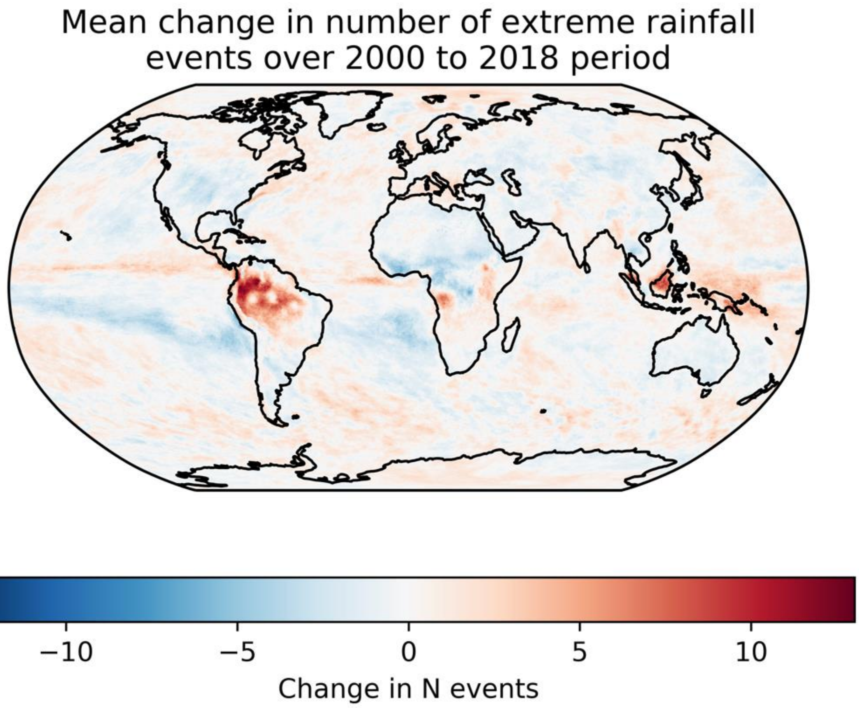


Figure 5: Mean change in number of extreme rainfall events per year over the 2000-2018 period (change calculated relative to mean of 1986-2005).

Indicator 1.2.3: Lethality of weather-related disasters

Headline Finding: *To date, there has been a statistically significant long-term upward trend in the number of flood and storm related disasters in Africa, Asia, Europe, and the Americas since 1990. At the same time, Africa has experienced a statistically significant increase in the number of people affected by these types of disasters.*

This indicator tracks the number of occurrences of weather-related disasters, the number of people affected, and the lethality. These are formulated as a function of the hazard (magnitude and frequency) and the vulnerability and exposure of populations at risk, using data from the Centre for Research on the Epidemiology of Disasters.[48] For the 2019 report, disasters have been separated into two groupings: flood and storm related disasters; and heatwave, extreme temperature and drought related disasters. Further detail of these methods and data are presented in the appendix.

For the heatwave, extreme temperature, and drought related disasters, no statistically significant global trend was identified. One explanation for this could be the geographically local nature of such events. However, in the case of floods and storms, a statistically significant trend in occurrence was identified individually across Africa, Asia, and the Americas. There has also been a statistically significant increase in the number of people affected by floods and storms in Africa, although there was not a statistically significant increase in the lethality of these events.

The relative stability of the lethality and numbers of people affected due to these disasters could be possibly linked to improved disaster preparedness (including improved early warning systems) as well as increased investments in healthcare services, and is discussed further in section 2.[49-51] Importantly, work from the 2015 Lancet Commission demonstrates that a business-as-usual trajectory is expected to result in an additional 2 billion flood-exposure events per year by 2090, which will likely overwhelm health systems and public infrastructure.[13]

Indicator 1.3: Global health trends in climate-sensitive diseases

Headline finding: *Whilst large improvements are occurring in mortality due to diarrhoeal diseases, malnutrition, and malaria, mortality due to dengue is rising in regions most affected by these diseases.*

As described in the preceding indicators, climate change affects a wide range of disease processes. Corresponding health outcomes result from a complex interaction between the direct and indirect effects of climate change and social dynamics, such as population demographics, economic development, and access to health services.[13] This indicator provides a macro view of these interactions, using GBD data to track mortality due to diseases which are sensitive to climate change.[52] Mortality due to earthquake and volcano events is removed from the GBD category of 'forces of nature' to give estimates for weather-related events.

Figure 6 presents global trends in climate-sensitive disease mortality from 1990 to 2017, with all-cause mortality as a reference. Death from diarrhoeal diseases and protein-energy malnutrition has declined considerably over this period in regions most affected (Africa, South East Asia and Eastern Mediterranean). Likewise, Africa has experienced a marked decrease in malaria mortality since the 2000s. Socioeconomic development, improved access to healthcare, and major global health initiatives in sanitation and hygiene, and vector control, have all contributed to these improvements in health outcomes.[13,53] However, mortality from dengue fever continues to rise, particularly in South East Asia.

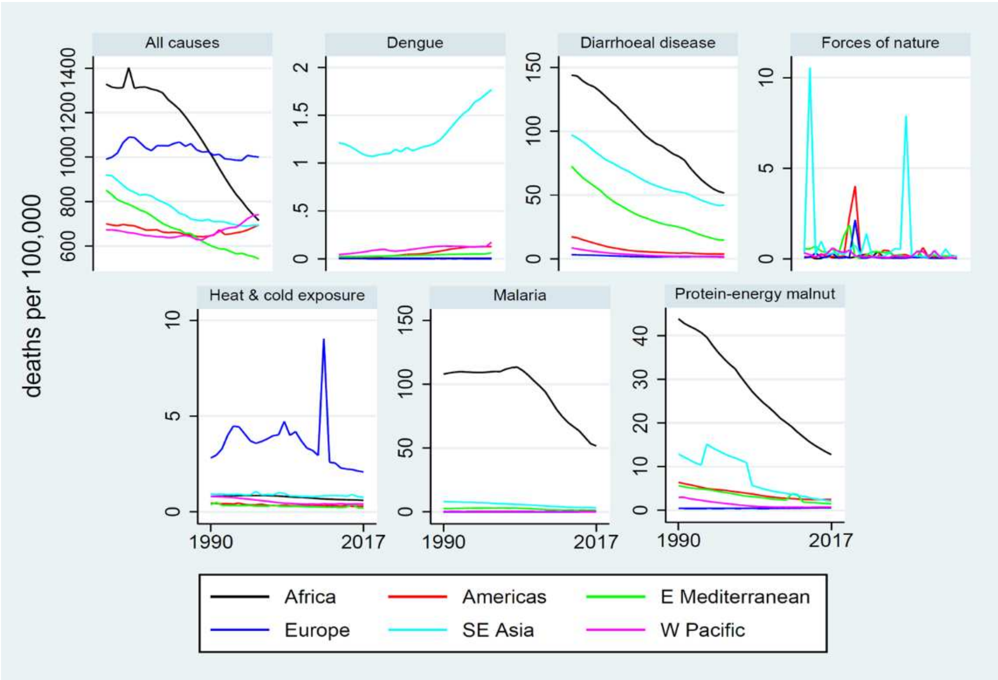


Figure 6: Global trends in all-cause mortality and mortality from selected causes as estimated by the Global Burden of Disease 2017 [52] for the 1990-2017 period, by WHO regions.

Indicator 1.4: Climate-sensitive infectious diseases

Indicator 1.4.1: Climate suitability for infectious disease transmission

Headline Finding: *Due to a changing climate, environmental conditions are increasingly suitable for the transmission of numerous infectious diseases. Suitability for disease transmission has increased for dengue, malaria,* Vibrio cholerae *and other pathogenic* Vibrio *species. The number of suitable days per year in the Baltic for pathogenic* Vibrio *reached 107 in 2018, the highest since records began, and double the early 1980s baseline*.

Climate change affects the distribution and risk of many infectious diseases.[47] The 2019 Lancet Countdown report updates its analysis of dengue virus, malaria and *Vibrio* with the most recently available data, and presents an additional analysis of *V. cholerae* environmental suitability in coastal areas.

Malaria and dengue fever are endemic in many parts of the world and, as described in the previous indicator, continue to contribute substantially to burden of disease, with young children particularly vulnerable. Suitability for transmission of mosquito-borne infectious diseases is affected by factors such as temperature, humidity and precipitation. For dengue, vectorial capacity (VC), which expresses the average daily rate of subsequent cases in a susceptible population resulting from one infected case, is calculated using a formula including the vector to human transmission probability per bite, the human infectious period, the average vector biting rate, the extrinsic incubation period and the daily survival period.[54] For malaria, the number of months suitable for transmission of *Plasmodium falciparum* and *P. vivax* malaria parasites is calculated based on temperature, precipitation and humidity. Climate suitability for both of these mosquito-borne diseases is averaged for the most recent five years for which data is available and compared with a 1950s baseline.

Vibrio species cause a range of human infections, including gastroenteritis, wound infections, septicemia, and cholera. *Vibrio* species are found in brackish marine waters and cases of infections are influenced by sea surface salinity (SSS), sea surface temperature (SST), and chlorophyll-a concentrations.[55-57] Climate suitability for *Vibrio* species was estimated based on SSS and SST globally and focally for two regions (the Baltic and USA Northeast coastlines) in which *Vibrio* (excluding *V. cholerae*) infections are most frequently observed. For pathogenic *Vibrio* species (excluding *V. cholerae*), an average of the five most recent years for which data is available is compared with a 1980s baseline, whereas the new *V. cholerae* specific analysis compares the most recent three years with a 2003-2005 baseline (based on data availability). Full detail on methods can be found in the appendix.

Climate suitability for transmission is rising for each of the pathogens studied. The second highest VC for both dengue vectors was recorded in 2017, with the 2012-2017 average 7.2% and 9.8% above baseline for *Aedes aegypti* and *Aedes albopictus*, respectively (Figure 7). This continues the upward trend of climate suitability for transmission of dengue, with nine of the ten most suitable years occurring since 2000. Malaria suitability continues to increase in highland areas of Africa, with the 2012-2017 average 29.9% above baseline. The percentage of coastal area suitable for *Vibrio* infections in the 2010s has increased at northern latitudes (40-70° N) by 3.8% compared to a 1980s baseline, with 2018 the second most suitable year on record (5% above the baseline) (Figure 8). The area of coastline suitable for *Vibrio* has increased by 31% and 29% for the Baltic and USA Northeast respectively. Additionally, the number of days per year suitable for Vibrio in the Baltic reached 107 in 2018, which is double the early 1980s baseline and the highest on record. Globally, environmental suitability for coastal *V. cholerae sensu lato* has increased by 9.9%, driven by regional increases in Asia, Europe, Middle East, North America, and Northern and Western Africa.

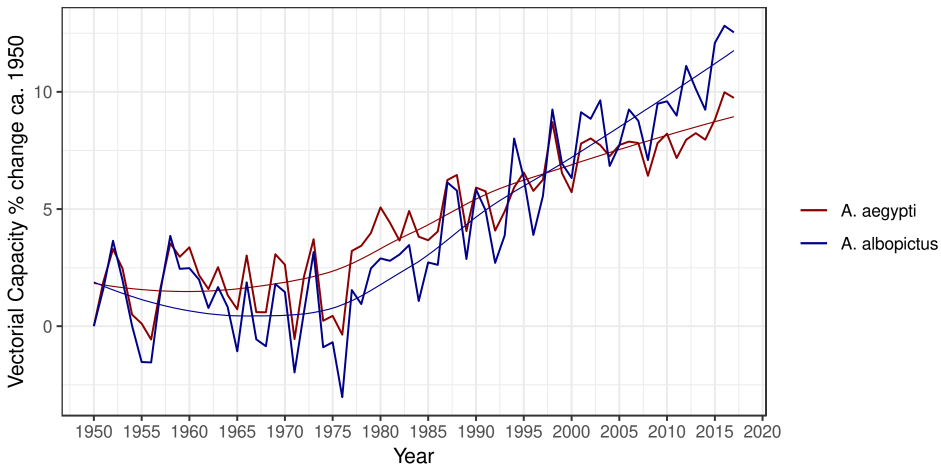


Figure 7: Changes in global vectorial capacity for the dengue virus vectors Aedes aegypti and Aedes albopictus 1950-2017.

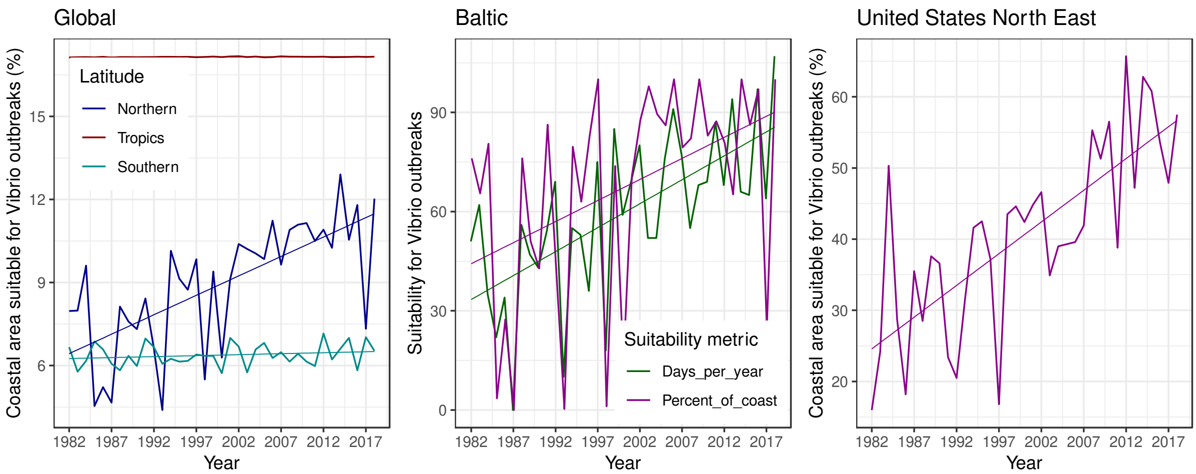


Figure 8: Change in suitability for pathogenic Vibrio *outbreaks as a result of changing sea surface temperatures a) globally, divided into three latitudinal bands (northern latitudes = 40-70°N; tropical latitudes = 25°S-40°N; and southern latitudes = 25-40°S); b) the Baltic and c) United States North East coast.*

Indicator 1.4.2: Vulnerability to mosquito-borne diseases

Headline finding: *Climate change induced risk of mosquito-borne diseases may be offset by improvements in public health systems. Dramatic investments in public health have resulted in a 31% fall in global vulnerability observed from 2010–2017. However, this success is not spread equally, with vulnerability to recurrent dengue outbreaks increasing in the Western Pacific and South East Asia over the same period.*

Whilst the previous indicator describes the influence of climate over the transmission of several infectious diseases, this indicator tracks vulnerability to one of these (dengue). Importantly, population vulnerability to this phenomenon is modulated by human, social, financial, and physical factors as well as to the adaptive capacity of a community.[53,58]

Country-level data relating to surveillance, preparedness and response from the World Health Organization (WHO) International Health Regulations' (IHR) core capacities for the years 2010 to 2017,[59] are used as a proxy for adaptive capacity. *Aedes aegypti* vulnerability is defined by abundance and VC as described in Indicator 1.6.1. This index estimates the population-level risk of exposure to *Aedes* mosquitoes, accounting for the public health core capacity to cope with the potential impacts. A full account of the methods can be found in the appendix.

A contraction of the vulnerability to dengue is observed from 2010 to 2017 in tropical and sub-tropical areas of South America, Africa and Asia. However, this decrease in vulnerability has levelled off in recent years, with a reversing trend in the Western Pacific and South East Asia Regions.

Indicator 1.5: Food security and undernutrition

Indicator 1.5.1: Terrestrial food security and undernutrition

Headline finding: *All major crops tracked – maize, wheat, rice, and soybean – demonstrate that increases in temperature have reduced global crop yield potential.*

Currently, improvements in nutrient and water management, as well as expansion of agricultural area in lower income countries, are causing global food production rise.[60,61] However, the global number of undernourished people appears to have been increasing since 2014, driven by challenges to access, availability, and affordability of food.[62] Undernutrition overwhelmingly affects children under five, causing intrauterine growth restriction, stunting, severe wasting, micronutrient deficiencies and poor breastfeeding.[63] There is growing evidence that crop production is threatened in complex ways by changes in the incidence of pests and pathogens;[64] increasing water scarcity;[65] and increased frequency and strength of extreme weather conditions that can damage or even wipe out harvests.[66]

Crop yield potential was tracked for wheat, rice, soybean, and maize. Change in crop growth duration is used as a proxy for yield potential. It is based on the time taken in a year to accumulate a reference period (1981-2010) accumulated thermal time. A reduction in crop duration means the crop matures too quickly with lower seed yield.[67] This methodology is described in full, in the appendix, alongside a full description of the CRU database used.[44]

Globally, crop yield potential for maize, winter wheat, and soybean has reduced in concert with increases in temperature (Figure 9), challenging efforts to achieve SDG 2 to end hunger by 2030.[66] This data resonates with a meta-analysis of the literature by Zhao et al. (2017).[68] which suggests that global yields of these four key crops are reduced by 6%, 3.2%, 7.4%, and 3.1% globally for each 1°C increase in global mean temperatures.

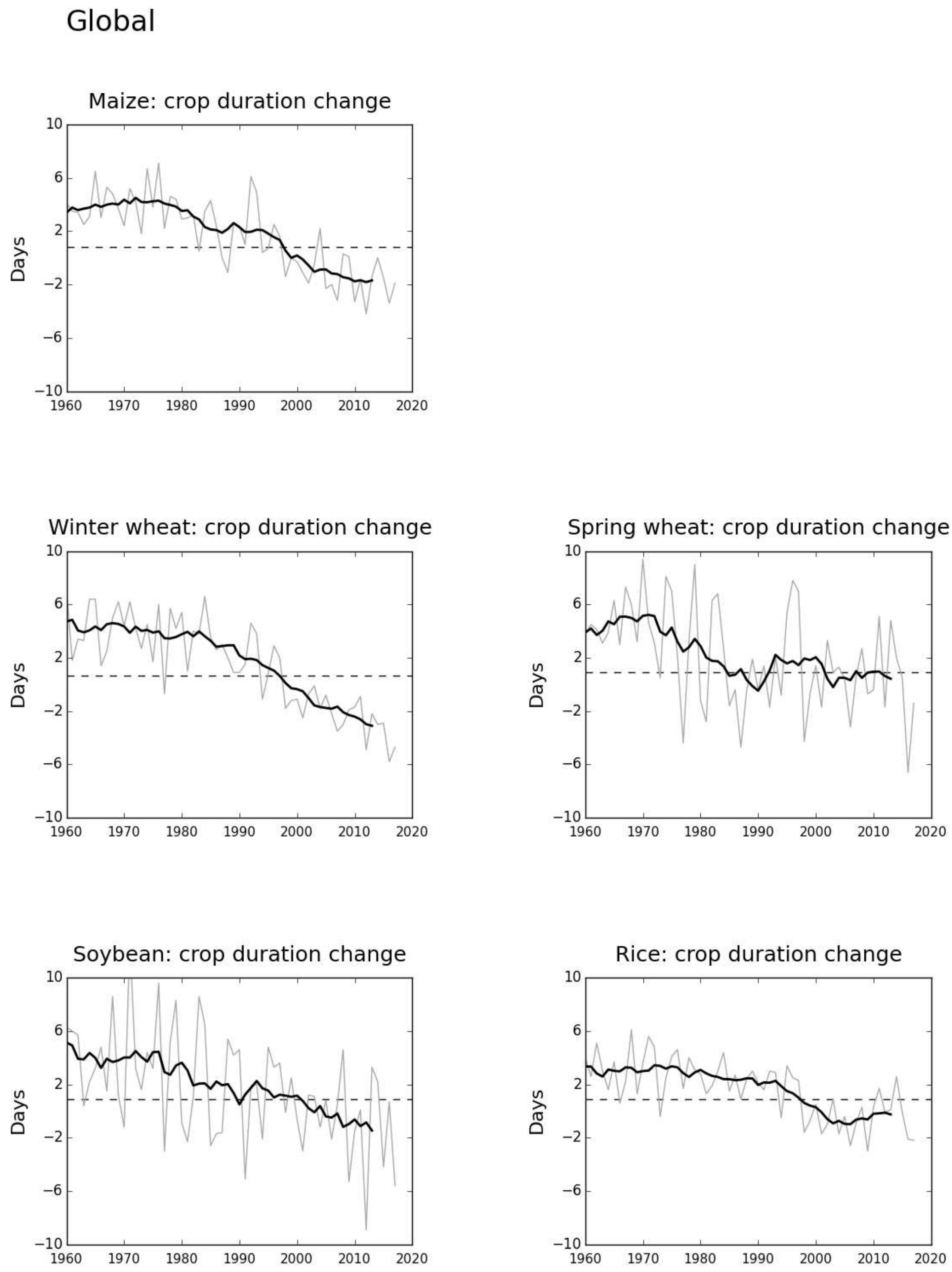


Figure 9: Change in crop growth duration (days) for five crops. The dashed line shows the average change in crop duration compared with the reference period 1981-2010 baseline. Grey line: annual global area-weighted change. Black line: running mean over 11 years (5 years forward, five years backward).

Indicator 1.5.2: Marine food security and undernutrition

***Headline finding:** Between 2003 and 2018, sea surface temperature rose in 34 of 64 investigated territorial waters, undermining marine food security.*

Fish provide almost 20% of their animal protein intake to 3.2 billion people, with a greater reliance on fish sources of protein often in low- and middle-income countries (LMICs), particularly small island developing states (SIDS).[69] Climate change threatens fisheries and aquaculture in a number of ways, including through SST rise, intensity, frequency, and seasonality of extreme events, sea level rise, and ocean acidification.[70] Acute disturbances such as thermal stress lead to impaired recovery of the coral reefs, which threatens marine fish populations and therefore marine primary productivity, a key source of omega3 fatty acids for many populations.[71]

This indicator tracks SST in territorial waters, selected for their geographical coverage and importance to marine food security, using data sourced from FAO, NASA and NOAA with all methods described in full in the appendix.[72-74] This has been further developed and now includes 64 territorial waters (including countries where data is available) located in 16 FAO fishing areas This indicator is complemented by monitoring of coral bleaching due to thermal stress (abiotic indicators), and per-capita capture-based fish consumption (biotic indicator) (see appendix). Between 2003 and 2018, SST has risen in 34 of the 64 territorial waters, with the maximum increase in SST observed over this time being 3.5°C in Finland.

Conclusion

The indicators presented in this section provide evidence of the exposures, vulnerabilities and impacts of climate change on health. They demonstrate worsening exposures and vulnerabilities along a range of temperature and precipitation pathways, the reduction in crop yield potentials, and rises in vectorial capacity for a number of climate-sensitive diseases. As has been stated, it is clear that these effects are felt most acutely by low- and middle-income countries across the world.

Continued work on attribution remains an important consideration here. For example, in earlier reports, migration was addressed, where questions of attribution to climate change remain particularly challenging.[20,46] Irrespective of how climate change migrants are counted,[75] many factors contribute to health risks faced by migration. Health impacts depend on both pre-existing conditions (e.g. mental health and nutritional status, desire or not to migrate, and existing health systems) along with interventions (e.g. healthcare access, provision of food and shelter, and changing health-related resources).

Similarly, in 2018 the links between climate change and mental health were highlighted.[46] Mental health may variously be affected negatively by heatwaves, loss of property and livelihoods due to floods, or climate-induced migration. However, although links between climate and mental health are many and varied, they are highly socially and culturally mediated. Attempting to operationalise such an idea as a single-number indicator linking climate change and mental health outcomes remains elusive, yet quantifying these impacts is of clear importance.[76]

Section 2: Adaptation, Planning, and Resilience for Health

As knowledge of the health consequences of climate change increases, so too does the urgent need to redouble efforts to protect people from adverse effects, particularly given the lack of dramatic material progress on mitigation. Health systems will be placed under increasing and overwhelming pressure, and it is now clear that adaptation is essential, even with the most ambitious mitigation efforts.[58] An adaptation gap is apparent, signalled in some of the impacts discussed above, and the rapid introduction of better-developed and funded adaptation initiatives across all sectors is necessary to close this divide. The health sector was highlighted as one of the top three priority areas for adaptation in an analysis of Intended Nationally Determined Contributions (NDCs) prepared for the Paris Agreement.[77]

By their very nature, adaptation and resilience measures are local and specific to regional hazards and underlying population health needs. Identifying readily available global metrics, with adequate data and proximity to climate change and to health adaptation is particularly challenging.[78-80] Beyond this, evaluating the success of any interventions is difficult, given that the goals of adaptation are inherently long-term, and no counterfactual is readily available. Rising to this challenge, the work in this section has expanded, from the initial three indicators proposed in 2016,[19] to the eight presented here. The structure of these indicators, and this section, builds on the WHO Operational Framework for building climate resilient health systems,[81] monitoring progress across the following selected domains:

- Adaptation planning and assessment (Indicators 2.1.1, 2.1.2 and 2.1.3)
- Adaptive information systems (Indicator 2.2)
- Adaptation delivery and implementation (Indicators 2.3.1 and 2.3.2)
- Adaptation financing (Indicators 2.4.1 and 2.4.2)

True to an iterative approach, many indicators have been further developed. For the indicators evaluating national health adaptation planning and vulnerability mapping (Indicators 2.1.1 and 2.1.2), the number of country respondents have increased from 40 to 101. Additional information on implementation and government funding is included alongside qualitative analysis, undertaken as part of the validation of the self-reported data. A new indicator focuses on air conditioning use as an adaptive measure to heat mortality (Indicator 2.3.2). This is the first of a new suite of indicators under development, which monitor adaptation to a specific exposure pathway, complementing existing work on health adaptation efforts as a whole.

A number of indicators in this section rely on self-reported data in surveys of national and subnational governments to track health adaptation, with clear strengths and limitations to this approach. Self-reported survey data is subject to response and nonresponse error with local verification difficult,[79] however the datasets here – from the WHO and the Carbon Disclosure Project (CDP) – provide the best available information on national- and city-level health-specific adaptation globally. More information on the validation of the national data can be found in the appendix.

Indicator 2.1: Adaptation planning and assessment

Indicator 2.1.1: National adaptation plans for health

***Headline finding**: Recognition of the need for health adaptation to climate change is widespread, and planning is underway. In 2018, half of countries surveyed reported having a national health and climate change plan in place.*

Over the past decade, there has been a steady increase in countries scaling up health adaptation projects to build climate resilience.[82] This indicator, based on data from the 2018 WHO Health and Climate Country Survey Report,[83] tracks the number of countries that have a national health and climate change plan or strategy, current levels of their implementation and the commitment of national health funds for achieving the health adaptation and mitigation priorities outlined by governments in these documents. Importantly, the country response rate has more than doubled, with 101 of the 194 Member States reporting in the 2018 survey compared with 40 reporting in the 2015 survey presented in earlier Lancet Countdown reports.[20]

Global coverage of national adaptation plans for health is growing, with 51 out of 101 countries now having a national health and climate change plan in place. Just over half of these countries report at least a moderate level of implementation of their plans (Figure 10), however challenges to full implementation remain, with less than 20% of countries reporting that action is being taken on a majority of their key priorities. National funding for implementation of health and climate change plans was identified as a central constraint with fewer than 4 in 10 countries reporting to have at least partial funding for the implementation of their main health adaptation and mitigation priorities (Figure 10).

A further analysis of approximately 40 strategies/plans, collected as part of the survey, highlightsthat the comprehensiveness and scope of the national health and climate strategies/plans varied widely, . with only a small number of plans directly linked to the National Adaptation Plan (NAP) process as part of the UN Framework Convention on Climate Change (UNFCCC). Finally, about 30% of the national health and climate change plans were published over five years ago. Opportunities therefore exist in national health and climate planning to update and expand the comprehensiveness of plans and for these to be developed into health components of NAP (HNAPS),[81] thereby anchoring health within national climate processes and potentially strengthening access to international climate finance for health adaptation.

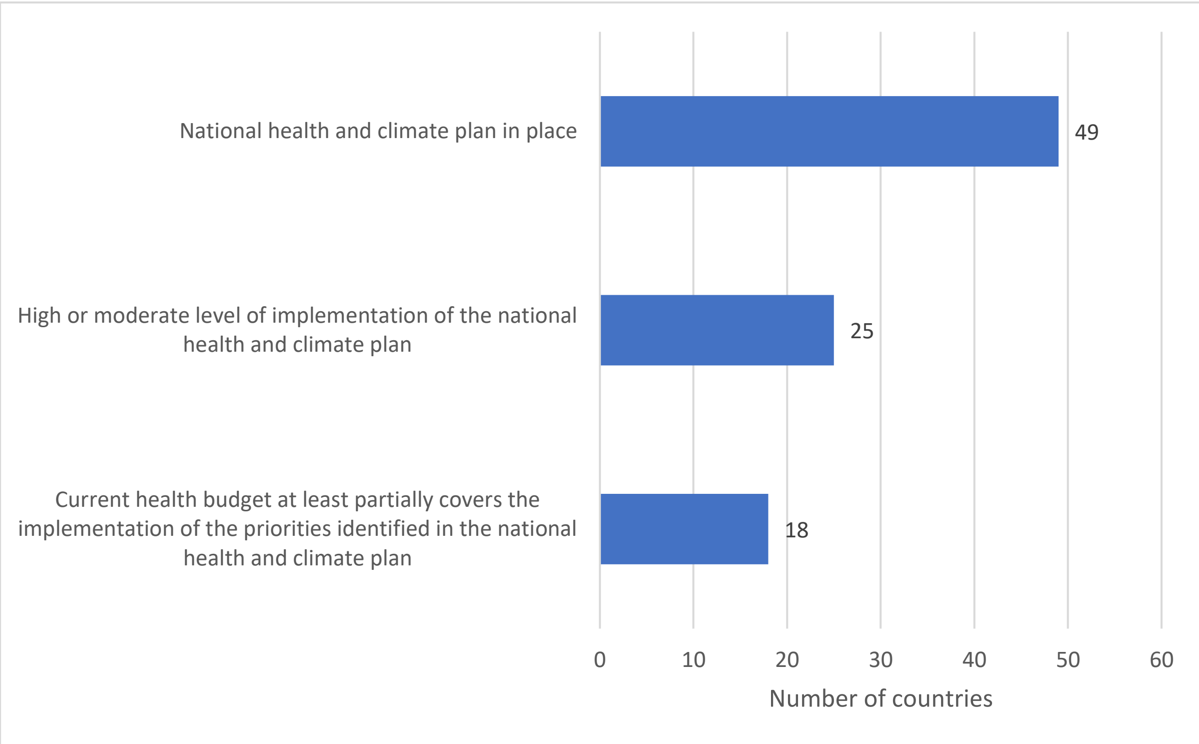


Figure 10: Number of countries with a national health and climate change plan or strategy (n=101).

Indicator 2.1.2: National assessments of climate change impacts, vulnerability, and adaptation for health

***Headline finding:** Of 101 countries surveyed in 2018, 48 indicated that a national assessment of health vulnerability to climate change had been conducted. However, of these, just over 40% reported that assessment findings had influenced the allocation of human and financial resources.*

An adequate health adaptation response requires an assessment of the vulnerability of populations to different kinds of health effects, an assessment of local geographical and meteorological trends, and the corresponding capacity of health services. A health vulnerability and adaptation (health V&A) assessment serves as a baseline analysis, against which changes in disease risks and protective measures can be monitored, and strengthens the case for investment in health protection.[84] As above, data for this indicator is sourced from the 2018 WHO Health and Climate Country Survey Report.[83] Additional information on the survey methods and data can be found in the appendix.

An increasing number of countries are undertaking national V&A assessments for health, the majority of countries indicating that these assessments are having at least some influence over policy prioritisation. However, translating evidence into funding decisions remains an issue, with only about 40% of countries reporting that resource allocation is guided by evidence generated from V&A assessments for health.

Indicator 2.1.3: City-level climate change risk assessments

***Headline finding:** In 2018, 54% of global cities surveyed expected climate change to seriously compromise their public health infrastructure, with 69% of cities actively developing or having completed a comprehensive climate change risk or vulnerability assessment.*

The effects of climate change are experienced locally, with cities and local government forming a crucial component of any health adaptation response. For this indicator, the Lancet Countdown works with the CDP to include data from their annual global survey of cities.[85] Two components of this data are analysed: the number of global cities that have undertaken a city-wide climate change risk or vulnerability assessment; and their perceived vulnerability of critical health infrastructure to climate change. In 2018, 489 cities participated in the survey, with most (61%) coming from high-income countries.

Just over half (52%) of all responding cities have undertaken an assessment and a quarter either have an assessment in progress (17%) or intend to undertake an assessment in the future (7%). This represents a small, but steady increase from 2017.[46] The health impacts of climate change are of increasing concern for cities, with 54% of responding cities noting that critical assets and/or services related to public health would be impacted by climate change, compared with 51% in 2017.[46]

Indicator 2.2: Climate information services for health

***Headline finding:** Progress has been observed in the number of countries providing climate services to the health sector, increasing from 55 in 2018 to 70 in 2019.*

It is essential that meteorological and hydrological services work with health services to monitor and prepare for the climate-related risks to health tracked in section 1.[81] This indicator tracks national climate information services for health, which help monitor and prepare for climate-related health risks, using data reported by national meteorological and hydrological services to the World Meteorological Organization (WMO) Country Profile Database integrated questionnaire.

Seventy national meteorological and hydrological services of WMO Member States reported providing climate services to the health sector, 15 more than reported in the 2018 Lancet Countdown report.[46] Of these, 18 were from Africa, 5 from the Eastern Mediterranean, 22 from Europe, 13 from the Americas, 4 from South East Asia, and 8 from the Western Pacific. Additional detail was provided by 47 respondents, with a number of services working with the health sector and creating products accessible to the health sector. However, whilst climate services can be used for health in a range of ways, including monitoring, provision of early warning systems and forecasting of environmental risks, application of these services to policymaking remains low, with only 4 out of the 47 Member States reporting that climate services are guiding health sector policy decisions and investments plans.

Indicator 2.3: Adaptation delivery and implementation

Indicator 2.3.1: Detection, preparedness and response to health emergencies

***Headline finding:** 109 countries have medium to high implementation of a national health emergency framework, preparing for all public health events and emergencies.*

The International Health Regulations (IHR) are an international legal instrument aimed at helping the global community prevent and respond to acute public health risks.[59] These are assessed through a set of core capacities, reported in an annual survey of State Parties. The survey has been improved from a yes/no questionnaire from 2010 to 2017, to a more detailed tool which assesses the degree of implementation (see appendix). Capacity 8 (C8) of the IHR focuses on countries' national health emergency framework (NHEF), which applies to all public health events and emergencies, covering disease outbreaks, air pollution, extreme temperatures, droughts, floods and storms, as well as societal hazards (such as conflict and financial crisis). The survey includes three components: planning for emergency preparedness and response mechanism; management of health emergency response operations; and emergency resource mobilisation.[86]

In 2018, 182 WHO Member States completed the survey relating to C8. Of these, 109 countries had medium to high implementation of the three components for this core capacity. However, the degree of implementation varied greatly by region, with Africa and

Europe reporting having achieved 21.3% and 75.5% medium-high implementation respectively.

Indicator 2.3.2: Air conditioning – benefits and harms

Headline finding: *Use of air conditioning as an adaptation measure is a double-edged sword: on the one hand, global air conditioning use in 2016 reduced heatwave-related mortality by 23% compared with a world without any air conditioning; on the other hand, it also confers harms, by contributing to climate change, worsening air pollution, substantially adding to peak electricity demand on hot days, and enhancing the urban heat island effect.*

Indoor cooling is an important adaptation to extreme heat, with air conditioning emerging as a primary mechanism. Access to household air conditioning is highly protective against heatwave-related mortality;[87] however it is also associated with substantial indirect harms. On hot days in locations with high air conditioning prevalence, this can account for more than half of peak electricity demand[88] which, if sourced from fossil fuels, contributes to both CO_2 and $PM_{2.5}$ emissions. Additionally, waste heat from air conditioning can paradoxically increase external night time temperatures by more than 1°C.[89] Hydrofluorocarbon (HFC) refrigerants used for air conditioning can escape into the atmosphere where they act as powerful GHGs. In baseline scenarios, these HFC emissions will rise to 1-2 $GtCO_2e$ per year by 2050.[90,91] Consequently, a nuanced approach to heat adaptation must be deployed, which protects vulnerable populations across the world from heat-related morbidity and mortality, whilst minimising the health and other co-harms of air pollution, the urban heat island effect, and worsening climate change.

This new indicator includes four components: the proportion of households using air conditioning; the prevented fraction of heatwave-related mortality attributable to air conditioning use; CO_2 emissions attributable to air conditioning use; and premature mortality from air conditioning attributable $PM_{2.5}$. Unpublished data for household air conditioning use, electricity consumption, and CO_2 emissions was provided by the International Energy Agency (IEA). The prevented fraction,[92] the percent reduction in heatwave-related deaths due to a given proportion of the population having household air conditioning, compared with a complete absence of household air conditioning, was calculated using a relative risk for heatwave-related mortality of 0.23 for having household air conditioning compared with not having household air conditioning,[87] and the proportion of populations with household air conditioning. The air pollution source attribution methods discussed in section 3 (Indicator 3.3.2) were used to calculate deaths due to $PM_{2.5}$ emissions from air conditioning.

Between 2000 and 2016, the world's air conditioning stock (residential and commercial) more than doubled to 1.62 billion units and the proportion of households with air conditioning increased from 21% to 30% (Figure 11). In 2016, this proportion was 4% in India, 14% in the European Union, 58% in China, and ≥90% in the USA and Japan.

Correspondingly, the global prevented fraction of heatwave-related mortality increased from 16% in 2000 to 23% in 2016, ranging from <10% in India, Indonesia, and South Africa to ≥66% in the USA, Japan and Korea. It is important to remember that the relative risk estimate used for these calculations is based on studies focused on European and US populations, and further research is required to fully understand the effect modification across different contexts.[87]

These trends have also been associated with significant harms. In 2016, air conditioning accounted for 10% of global electricity consumption and 18.5% of electricity used in buildings.[93] Under the IEA's baseline scenario, these figures will increase in 2050 to 16% and 30%, respectively.[93] Following the trend in the proportion of households with air conditioning, CO_2 emissions from air conditioning use tripled from 0.35 gigatons in 1990 to 1.1 gigatons in 2016 (Figure 11), and are projected to rise to 2 gigatons in 2050 in the IEA's baseline scenario.[93] In 2016 the number of premature deaths due to $PM_{2.5}$ exposure attributable to air conditioning was 2480 in India, 2662 in China, 1088 in the European Union, and 749 in the USA.

Fortunately, one path forward provides for adaptation against heat-related mortality for those who need it, without the associated harms of GHGs and $PM_{2.5}$ emissions, excessive electricity demand, and undue contribution to the urban heat island effect. Air conditioning use could be reduced by promoting energy efficient appliances and energy efficient building design through strong, enforced building codes.[93] Traditional building designs in tropical and sub-tropical regions reduce thermal stresses by providing shade, thermal mass, insulation, and ventilation.[93] There is great potential to reduce the harms of air conditioning by increasing its efficiency,[93] by generating electricity from non-fossil-fuel sources, and by implementing the Kigali Amendment to the Montreal Protocol to phase-down HFCs.[94]

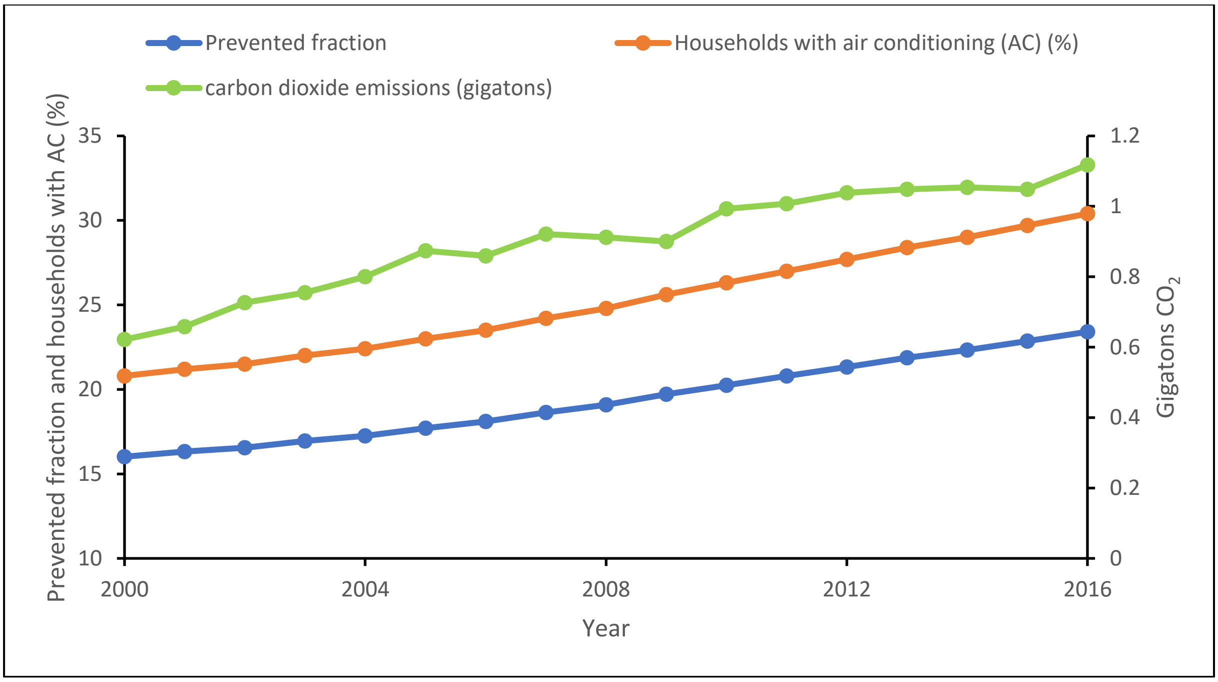


Figure 11: Global proportion of households with air conditioning (orange line), prevented fraction of heatwave-related mortality due to air conditioning (blue line), and CO_2 emissions from air conditioning (green line) 2000-2016.

Indicator 2.4: Spending on adaptation for health and health-related activities

Headline finding: *In 2018, global spending on health adaptation to climate change was estimated to be 5% (£13 billion) of all adaptation spending, and health-related spending was estimated at 13.5% (£35 billion). These estimates represent increases in absolute and relative terms over previous data.*

A higher demand for health adaptation measures requires increased adaptation funding. This indicator tracks adaptation spending, using 2015/16, 2016/17 and 2017/18 data from the Adaptation and Resilience to Climate Change (A&RCC) dataset produced by kMatrix,[95] as described in the 2017 and 2018 reports.[20,46] "Health adaptation" spending is defined as national adaptation spending specifically within the formal healthcare sector, whereas "health-related adaptation" follows adaptation spending in the disaster preparedness and agriculture, in addition to healthcare. Data in this year's indicator covers 191 countries and territories that have data reported in the A&RCC dataset. Per capita values are based on 183 countries with population estimates from the International Monetary Fund (IMF) World Economic Outlook.[96]

Spending on adaptation to climate change in health and healthcare increased by 11.2% in 2017/18, compared to 2016/17 data. This percentage increase is, notably, larger than the change in adaptation spending as a whole (an increase of 6.5% on last year). At the country level, growth of health adaptation spending ranged from 17.5% (United Kingdom) to 10.0% (Latvia). There were lower increases and lower variation in the health-related values, from

11.1% (United Kingdom) to 6.8% (Kazakhstan). Importantly, health still represented a small proportion of total adaptation spend, having grown from 4.6% in 2015/2016 to 5.0% in 2017/2018.

Grouped by WHO Region, the highest percentage change for health adaptation spending is in Europe (12.1%), and the highest per capita spending is in the Americas (£4.2 for health, £11.2 for health-related) (Figure 12). By comparison, in the African, Eastern Mediterranean and South East Asian regions, per capita health adaptation spending is less than £1.

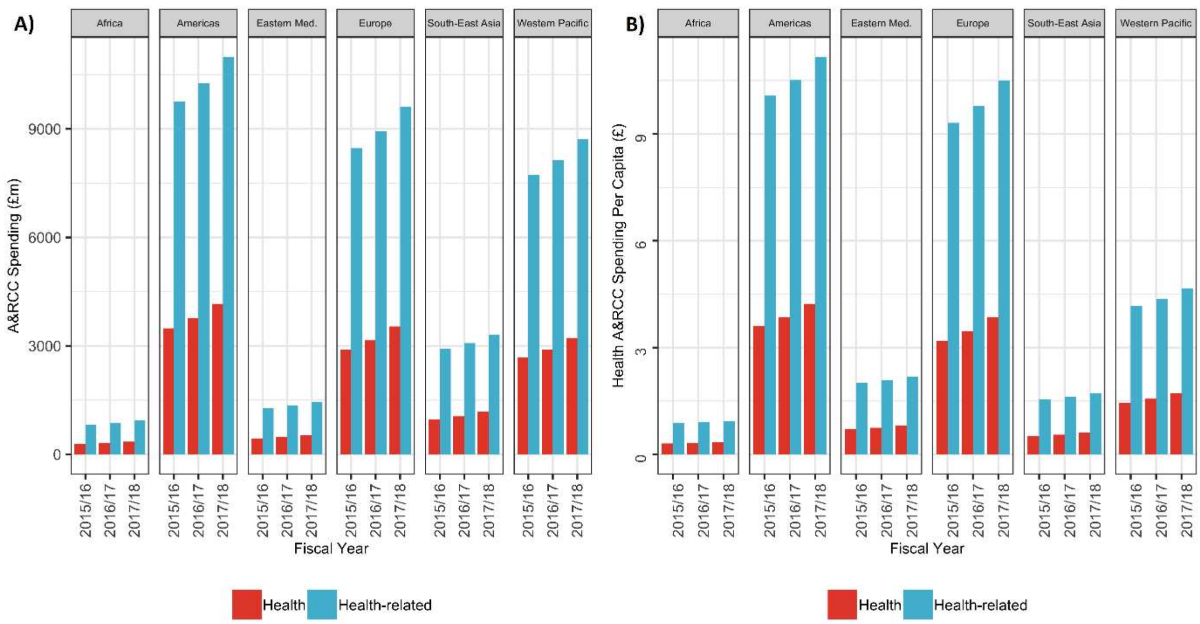


Figure 12: Adaptation Spending for Financial Years 2015/16 to 2017/18. A) Total health and health-related A&RCC spending (£m), B) Health and health-related A&RCC per capita (£). Plots are disaggregated by WHO Region. 'Eastern Med.' denotes the Eastern Mediterranean Region.

Conclusion

Whilst many of the indicators presented in section 2 are moving in a positive direction, the pace of the adaptation response from the health community remains slow. The number of countries with national adaptation plans for health and the number of countries and cities that have assessed health risk and vulnerabilities has increased, along with the spending on health adaptation. Thorough consideration of the best adaptation options is required before implementation goes ahead. For example, the health benefits of adaptation measure such as air conditioning may be counteracted by the harms they cause through a contribution to heat generation, climate change and air pollution (Indicator 2.3.2).

These findings and those from the UN Environment Adaptation reports, show that further work is required globally, both in terms of the planning and implementation of adaptation for health.[97,98]

Section 3: Mitigation Actions and Health Co-Benefits

As section 1 highlighted, the health impacts of climate change are already occurring, and require an urgent response, both in terms of health adaptation (section 2) and also, importantly, in mitigation, in order to minimise future climate change.

In keeping with the Paris Agreement's commitment of "well below 2°C", and to pursue a 1.5°C target, it is necessary for global emissions to peak as soon as possible (some studies suggest 2020) and then follow a steep decline to 2050.[2] However, current mitigation actions and commitments are not consistent with this goal. Indeed, at 53.5 $GtCO_2e$, total global GHG emissions for 2017 were the highest ever recorded.[99] Current commitments under the Paris Agreement are far from sufficient, with 2030 emissions estimated to be lowered by only 6 $GtCO_2e$ - half the reduction required to achieve a 2˚C scenario and one fifth for a 1.5˚C scenario.[97]

Discussions of GHG emissions reductions must be more directly coupled with the positive economic and health benefits that they bring. Mitigation actions improve health in the long term, through avoided climate change, but also in the near term through numerous pathways such as, reductions in risk of respiratory and cardiovascular disease attributable to air pollution,[8] reductions in the risk of diseases related to physical inactivity and obesity due to increased cycling and walking,[100] and a suite of improvements that result from healthier diets.[101]

Section 3 of the 2019 Report of the Lancet Countdown tracks mitigation and its health consequences, by sector:

- Energy (Indicators 3.1.1, 3.1.2, 3.2)
- Air pollution (Indicators 3.3.1, 3.3.2)
- Transport (Indicator 3.4)
- Agriculture (Indicator 3.5)
- Healthcare (Indicator 3.6)

Crucially, it adds two new indicators of great importance to health – emissions attributable to livestock and crops (allowing a more nuanced discussion about the health and climate benefits of reductions in ruminant meat consumption), and emissions from national healthcare systems. This section will continue to expand in future years by monitoring mitigation and health co-benefits in other important sectors including industry, buildings, and land-use.

Overall CO_2 emissions from fossil fuels have risen by 2.6% from 2016 to 2018 (Indicator 3.1.1). Concerningly, coal phase-out has reversed, with a 1.7% increase from 2016 to 2018 seen in total primary energy supply (Indicator 3.1.2). However, more encouragingly, growth in renewables continues apace and comprised 45% of total growth in electricity generation. Currently, modern renewables represent 5.5% of global electricity generation (Indicator 3.1.3), but are predicted to reach 30% by 2023.[102] The implication for air pollution of both of these trends is important. With continued demand for fossil fuels and an increase in coal consumption, ambient air pollution attributable deaths have remained stagnant, resulting in 2.9 million deaths in 2016 (Indicator 3.3.2).

The transport sector is an equally entrenched emitter (Indicator 3.4), with GHG emissions and fuel use maintaining a modest growth trajectory of 0.7% per capita CO_2e in 2016. While there has been a dramatic increase in electric vehicle (EV) use they continue to represent a small proportion of the global fleet. Yet countries such as China have positioned EVs as the future of driving with electricity in transport, with 21.4% growth in per capita usage from 2015 to 2016, rising to 1.8% of total fuel use.

Feeding the global population is a critically important aspect of health and wellbeing along with ensuring economic stability and security. However, the agriculture and food sector are both energy and carbon intense and an important area for climate change mitigation. Global agricultural GHG emissions (Indicator 3.5) have increased between 2000 to 2016 by 14% for livestock and 10% for crops.

The health sector is on the frontline of climate change and plays a vital role in any response. It is also a major contributor to GHG emissions (Indicator 3.6), with global estimates as high as 4.6% of global emissions in 2016.

Indicator 3.1: Emissions from the energy system

Indicator 3.1.1: Carbon intensity of the energy system

Headline Finding: *In 2018, the carbon intensity of the energy system remained flat, at the same level as in 1990. However, GHG emissions from fossil fuel combustion has returned to a growth trajectory, rising by 2.6% from 2016 to 2018. Limiting warming to 1.5°C would require a 7.4% year-on-year reduction from 2019 to 2050.*

In the 2019 Lancet Countdown report, this indicator includes data to 2016, supplemented with additional statistics for global CO_2 emissions from energy combustion for 2017[103] and 2018.[104] It tracks the carbon intensity of the energy system, monitoring the CO_2 emitted per terajoule of total primary energy supply (TPES). TPES reflects the total amount of primary energy used in a specific country, accounting for the flow of energy imports and exports. Key improvements in this analysis are seen in the disaggregation of fuel type, the extension of data back to 1970, and the inclusion of new projections forward to 2050. A full description of the data and methods is provided in the appendix.

Global emissions of CO_2 from fossil fuel combustion, having been flat between 2014-16, have increased to a new high of 33.1 $GtCO_2$ in 2018 (Figure 13).[104] This 2.6% increase over the last two years is due to continued growth in energy demand, mostly from fossil fuels.

The carbon intensity of the energy system will need to reduce to near zero by 2050. In the last 15 years, carbon intensity has largely plateaued, as the growth of low carbon energy has been insufficient to displace fossil fuels. However, recent IEA data suggests that carbon intensity may be starting to reduce, with gas slowly displacing coal (Figure 13).[104]

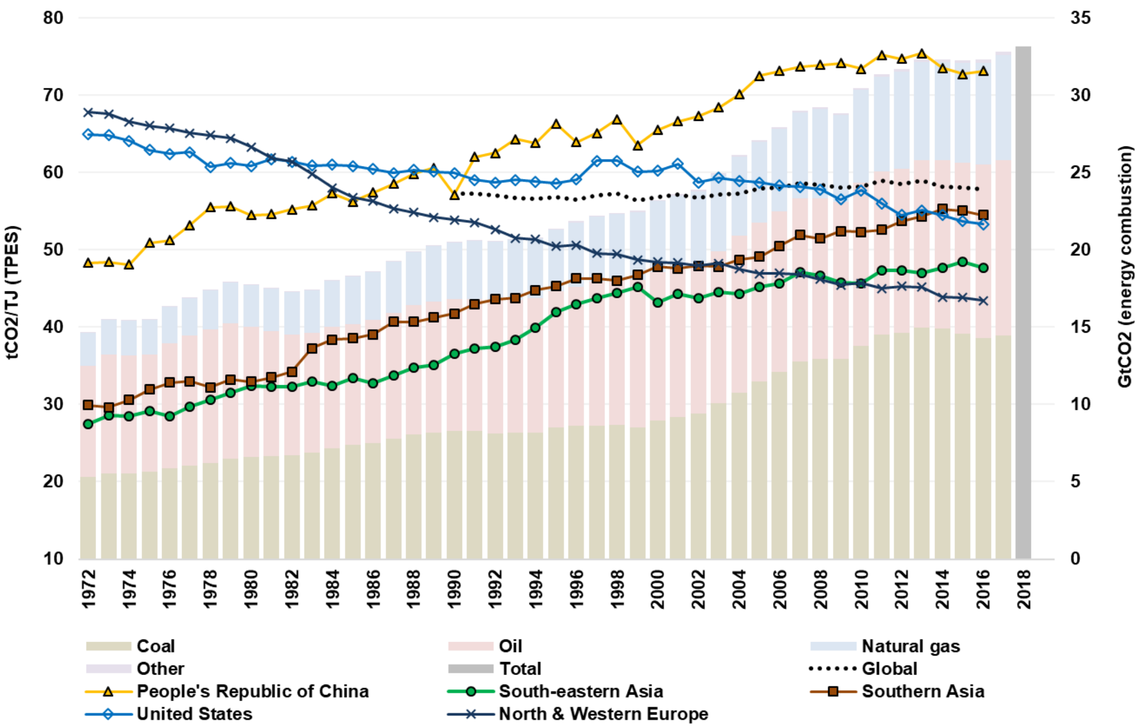


Figure 13: Carbon intensity of Total Primary Energy Supply (TPES) for selected regions and countries, and global CO_2 emissions from energy combustion by fuel type, 1972-2018. Carbon intensity is shown by lines (primary axis) and global emissions by stacked bars (secondary axis). This carbon intensity metric estimates the tonnes of CO_2 for each unit of total primary energy supplied (tCO2/TJ). For reference, carbon intensity of fuels (tCO_2/TJ) are as follows: coal 95-100, oil 70-75, and natural gas 56.

Indicator 3.1.2: Coal phase-out

***Headline Finding:** From 2016 to 2018, TPES from coal increased by 1.7%, driven by growth in China and other Asian countries.*

Coal phase-out is essential, not only as a key measure to mitigate climate change, but also to reduce morbidity and mortality from air pollution.[8] As of December 2018, 30 national governments, along with many sub-national governments and businesses, have committed to coal phase-out for power generation through the Powering Past Coal Alliance.[105] In this year's Lancet Countdown report, this indicator tracks total primary energy supply from coal, plus projections for coal phase-out, using the scenarios that informed the Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C.[2]

Coal has returned to a growth trajectory from 2016 to 2018 (Figure 14), however, due to the overall growth in global energy demand, the share of coal in primary energy supply continues to fall (see appendix). Coal continues to be the second largest contributor to global primary energy supply (after oil) and the largest source of electricity generation (at 38%, compared to gas, the next highest at 23%). Most of the growth in TPES of coal has been in Asia, notably China, India and South East Asia.

Rapidly decreasing coal use to zero is critical to meeting the commitments of the Paris Agreement. For example, nothing short of an 80% reduction in coal use from 2017 to 2050 (a 5.6% annual reduction rate) is consistent with a 1.5°C trajectory (see appendix). However, given that the technology to support coal phase-out exists, this represents a low-hanging fruit for climate change mitigation and a more rapid reduction rate is likely feasible.

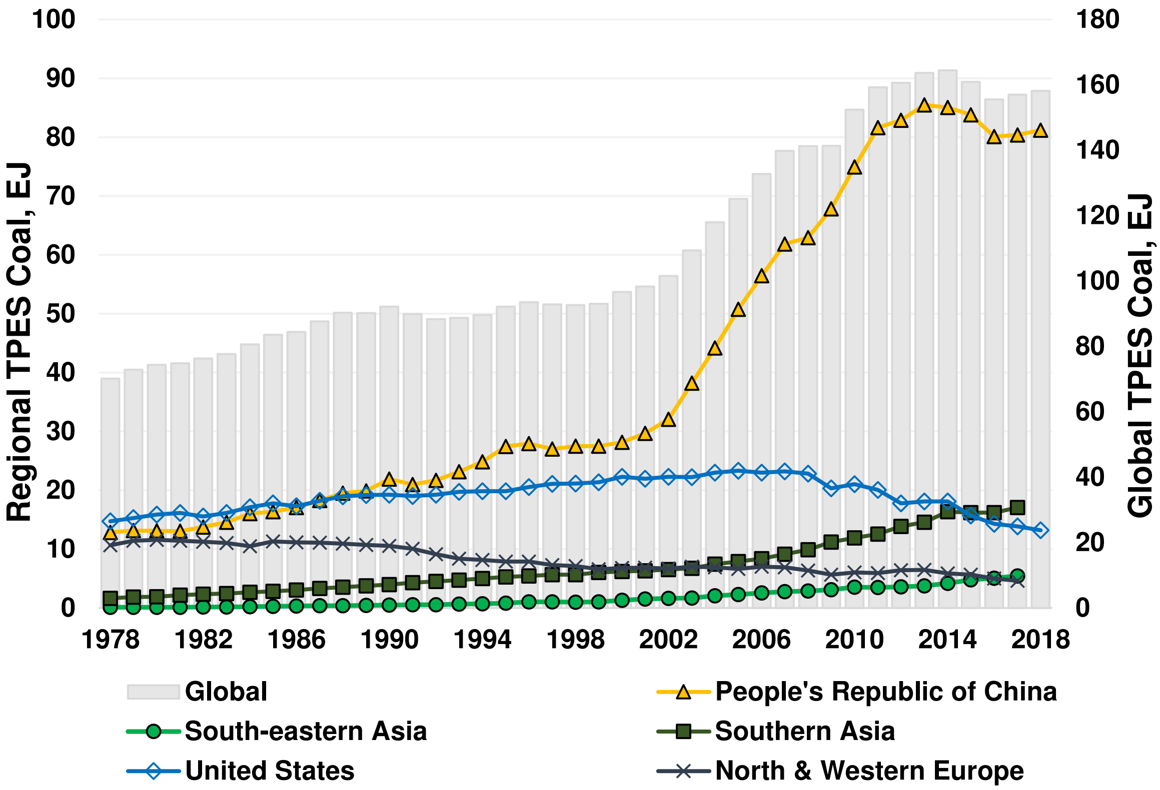


Figure 14: Total Primary Energy Supply (TPES) coal use in selected countries and regions, and global TPES coal, 1978-2018. Regional primary energy supply of coal is shown by the trend lines (primary axis) and total global supply by the bars (secondary axis). Data are shown to at least 2017, and extended to 2018 for selected regions and global supply (where data allows).

Indicator 3.1.3: Zero-carbon emission electricity

Headline Finding: *In 2018, renewable energy continues to account for a large share (45%) of growth in electricity generation, with 27% of growth coming from wind and solar.*

With the power generation sector accounting for 38% of total energy-related CO_2 emissions, it is crucial that renewables displace fossil fuels. This indicator tracks total low carbon electricity generation (which includes nuclear and all renewables, including hydro) and new renewable electricity generation (excluding hydro), using the World Extended Energy Balances dataset from the IEA.[104] Renewable electricity generation was also projected using the scenarios that informed the IPCC Special Report on Global Warming of 1.5°C.[2] A full description of the datasets, methods, and these projections is provided in the appendix.

In 2016, low-carbon electricity globally accounted for 32% of total global electricity generation (Figure 15). As costs continue to fall, solar generation continues to grow at an unprecedented rate of around 30% per annum (but still only accounting for 2% of total global generation).[106]

An assessment of 1.5°C compliant scenarios highlights that generation from new renewables sources (solar, wind, geothermal, wave and tidal) needs to increase by 9.7% per annum, to a level in 2050 that is larger than the total global electricity generation today. Since 1990, the annual growth rate for these renewable sources was over 14%, a very promising trend, but one that must be maintained for a further three decades.

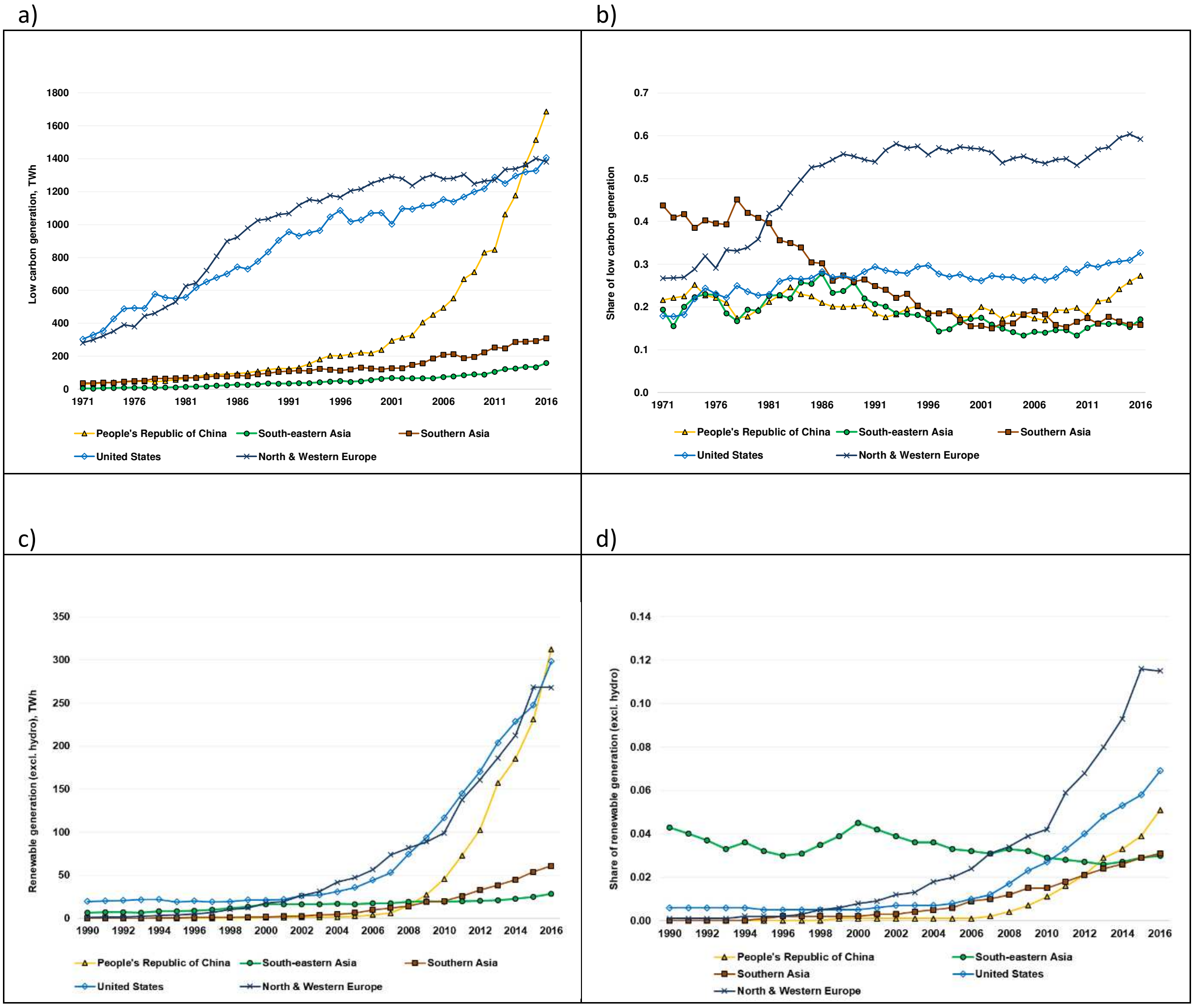


Figure 15: Renewable and zero-carbon emission electricity generation (excluding bioenergy), 1990-2016. a) Electricity generated from zero carbon sources, TWh; b) Proportion of electricity generated from zero carbon sources; c) Electricity generated from renewable sources (excl. hydro), TWh; d) Proportion of electricity generated from renewable sources (excluding hydro).

Indicator 3.2: Access and use of clean energy

***Headline Finding:** Almost 3 billion people live without access to clean fuels and technologies for cooking, and usage remains at just 7.5% of households in low-income countries.*

Globally, it is estimated that 3.8 million deaths per year are attributable to household air pollution,[110] largely due to the use of solid fuels, such as coal, wood, charcoal, and biomass, for cooking. Efforts to provide clean cooking and heating technologies could therefore result in substantial health co-benefits in addition to reducing GHG emissions and short-lived climate pollutants (SLCPs).[107-110] Additionally, universal access to affordable, reliable, sustainable, and modern energy for all is a key determinant of economic and social development and is central to health and well-being.[111,112]

This indicator combines both a top-down and bottom-up approach from both IEA and WHO datasets, capturing total household energy use and household fuel use for cooking respectively.[113,114] The new data on household clean fuel use presented here represents an impressive effort from the WHO, bringing together thousands of national household surveys across three decades and over 140 countries. Full details of the methods, definitions, and data for this indicator are provided in the appendix.

Drawing on this data, use of clean fuels and technologies for cooking for 2015-2017 remains low, at 7.5% in households in low-income countries, and 40% in households in lower-middling income countries (Figure 16). This reflects slow improvement in access to clean cooking fuels and technologies, which has increased by just 1% since 2010, with almost 3 billion people remaining in access-deficit.[115]

Concerningly, although access to electricity has risen from 83% in 2010 to 87% in 2016, residential clean energy usage – which, at point of demand, includes electricity of all sources, solar thermal and geothermal – remains low. In 2016, the global proportion of clean energy use in the residential sector was approximately 24%, up from 17% in 2010.[113] Solid biomass, which contributes to respiratory and cardiovascular disease attributable to household air pollution,[116] is currently estimated to account for 36% of total residential sector energy use.

Future forms of this indicator will work to link residential energy and fuel use to household air pollution morbidity and mortality across the world. Panel 2 provides an example of one possible approach to achieving this, using slum housing in Viwandani in Nairobi, Kenya.

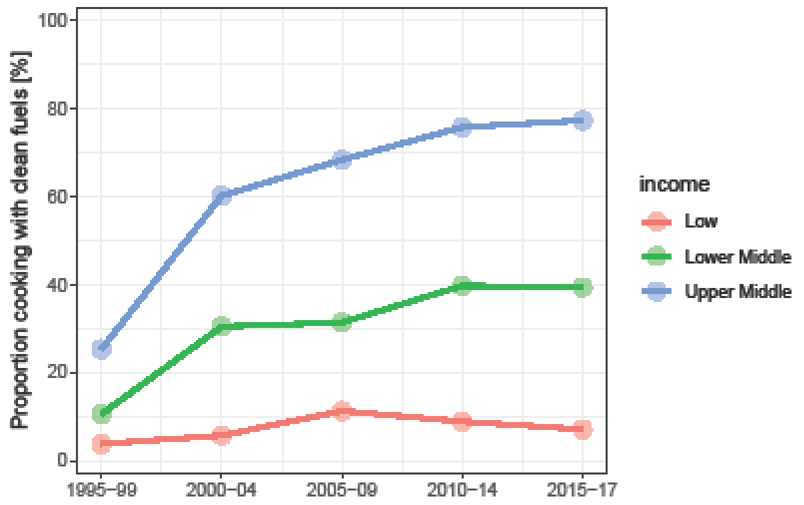


Figure 16: Proportion of clean fuel use for cooking 1995-2017 by World Bank income group.

This case study focuses on indoor exposure to $PM_{2.5}$, the mortality attributable to this exposure, and CO_2e emissions in slum housing in Viwandani, Nairobi, Kenya. In this setting, cooking is done with solid fuels (14.6%), kerosene (72.9%), or electricity (12.5%). Most dwellings lack space heating (84.6%), with the rest using solid fuel heaters from June to August. Houses without electricity use kerosene-burning koroboi lamps for lighting year-round; 8-hour average ambient outdoor pollution levels are around 67µg/m^3.[117]

Current indoor exposure and space heating estimates were estimated using EnergyPlus,[118] calibrated to monitored indoor levels in dwellings using different fuel types and ventilation behaviours.[119] Two scenarios were modelled, involving the following changes in exposure and heating energy consumption:

1) Electrification of all existing stoves, lamps, and heaters using the current electrical network, which was assumed to reduce outdoor pollution by 40% based on the estimated contribution of residential combustion to annual mean air pollution in Nairobi from the GAINS model.[120]
2) Electrification as in (1), but with low energy lighting, and heaters installation extended to all dwellings. Additionally, upgrades to dwelling energy efficiency and airtightness in-line with local sustainable design guidelines.[121]

Current mean 24-hour exposures in Viwandani are estimated to average 60 µg/m^3 with the fuels producing an estimated 425 kg of CO_2e per household year. Electrification was estimated to result in appreciable reduction of both GHG emissions and $PM_{2.5}$ air pollution (and hence $PM_{2.5}$-related premature deaths – see table below). For upgrades to the building envelope and increased electric heating and lighting coverage, the decrease in CO_2e emissions was broadly similar to that for electrification, but with substantially greater reduction in $PM_{2.5}$ concentrations and hence air pollution-related premature deaths. Such wholesale changes, however, do not reduce indoor exposures to less than the WHO-recommended limit of 10 µg/m^3. Therefore, reduction of indoor $PM_{2.5}$ to adequate levels would also necessitate further significant reductions in outdoor ambient levels or the application of additional technologies such as air filtration systems.

Scenario	Annual CO_2e emissions (kg CO_2e/household/year)	Annual average $PM_{2.5}$ air pollution (µg/m^3)	Reduction in air pollution-attributable premature deaths
Current	425	60	--
Electrification	210	31	22%
Upgrading dwellings	211	25	28%

Panel 2: Household air pollution conditions in Nairobi, Kenya

Indicator 3.3: Air pollution, transport, and energy

Exposure to ambient air pollution, most importantly fine particulate matter ($PM_{2.5}$), constitutes the largest global environmental risk factor for premature mortality, causing several million premature deaths due to cardiovascular and respiratory diseases every year.[8,122,123] Over 90% of children are exposed to $PM_{2.5}$ levels above the WHO guidelines,[124] which can affect their health throughout their life, from increased risk of lung damage, impaired lung growth and pneumonia, to subsequent risk of development of asthma and chronic obstructive pulmonary disease.[125] Most of the exposure to $PM_{2.5}$ results from anthropogenic activities, and much of this is associated with combustion of coal and other fossil fuels for electricity generation, industrial production, transport, and household heating and cooking, and therefore $PM_{2.5}$ emissions share many of the same sources as GHG emissions.[126]

Indicators 3.3.1 and 3.3.2 report on source contributions to ambient air pollution and its health impacts, drawing from the GAINS model,[127] which calculates emissions of all precursors of $PM_{2.5}$ on a detailed breakdown of economic sectors and fuels used. Underlying activity data are based on statistics reported by the IEA.[128] A more detailed methodology is provided in the appendix.

Indicator 3.3.1: Exposure to air pollution in cities

Headline finding: *Urban citizens are continuing to be exposed to high levels of air pollution, with 83% of cities exceeding the WHO's recommended safe level. A major share of the pollution is associated with energy use, particularly residential combustion.*

The world is becoming increasingly urbanised, with almost 70% urbanisation of the global population expected by 2050.[129] Due to the concentration of population and emissions, many cities have become hot spots of air pollution. Few cities worldwide have achieved $PM_{2.5}$ concentration levels below the WHO guideline of an annual mean of 10µg/m^3, and many cities exceed this standard several fold.[130] The highest measured concentrations in recent years have been reported in South and East Asia, while big data gaps exist in other world regions. Particularly concerning is the fact that these high concentration levels have been further increasing or stagnant in many regions of the developing world. A positive exception to this trend is China, where many highly polluted cities have experienced strong improvements in air quality in recent years due to ambitious emission control efforts. Cities in Europe and the US have seen slowly decreasing $PM_{2.5}$ levels thanks to effective implementation of air pollution control legislation and regulation.

This analysis estimates source contributions to ambient $PM_{2.5}$ concentration levels in urban areas outside Europe (more than 3,500 cities with over 100,000 inhabitants), with results aggregated to the WHO world regions. It is calculated here that 83% of these cities do not meet the WHO guideline on ambient $PM_{2.5}$.

In most regions, residential combustion of solid fuels for cooking and heating was the dominant source of $PM_{2.5}$ concentrations for 2016. While coal is prominent in some countries, the majority of the burden comes from the use of biomass in traditional stoves, which is often associated with net GHG emissions as well, due to unsustainable harvesting.

Indicator 3.3.2: Premature mortality from ambient air pollution by sector

Headline finding: *In 2016 there were 2.9 million premature deaths due to ambient $PM_{2.5}$ pollution, with global mortality approximately stagnant. On a decadal scale, improvements are seen in some regions due to efficient emission controls, particularly from industrial processes and power generation.*

Knowing the sources of ambient air pollution is essential for designing efficient mitigation measures that maximise benefits for human health and climate. This indicator estimates the source contributions to ambient $PM_{2.5}$ and their health impacts on a global level, quantifying contributions from individual economic sectors and highlighting coal combustion across sectors.

Results for 2016 are similar to the estimates for 2015, with an overall number of premature deaths attributable to ambient $PM_{2.5}$ estimated at 2.9 million. The dominant contribution varies between and within world regions: in Africa household cooking is the overwhelming source; while in other regions industry, traffic, electricity generation, and agriculture play bigger roles (Figure 17). Small decreases are visible in the European Region (mainly from closing of coal power plants) and in the Western Pacific region. These regions have also seen some sustained improvements over the last 10 years, presumably due to implementation of end-of-pipe emission controls on power plants (Western Pacific) and also other emission sectors in Europe. However, worldwide currently still more than 440,000 premature deaths are estimated to be related to coal burning.

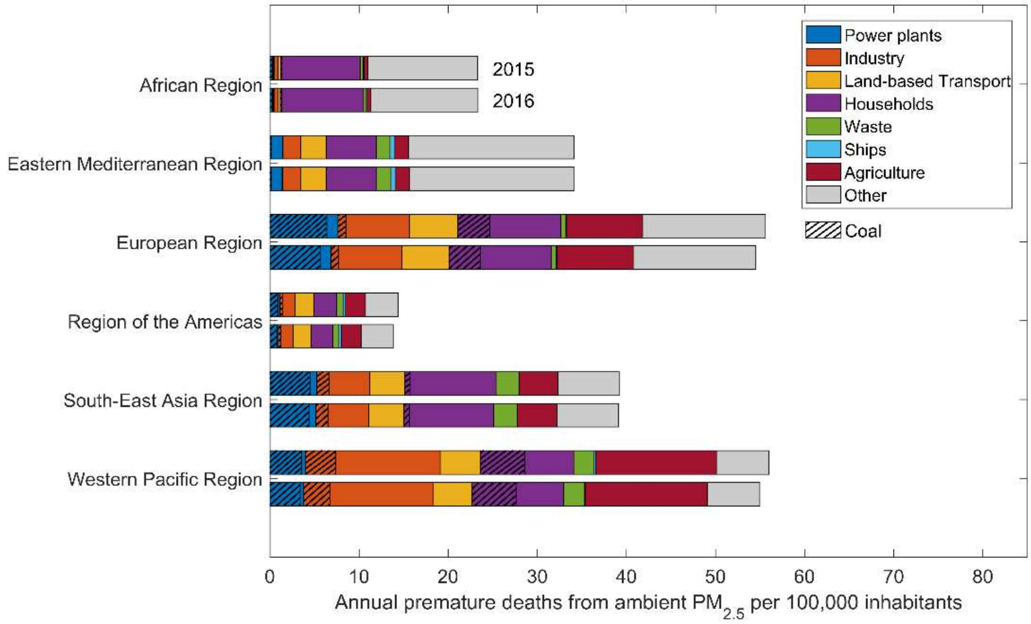


Figure 17: Premature deaths attributable to ambient $PM_{2.5}$ in 2015 (upper bars) and 2016 (lower bars), by economic source sectors of pollutant emissions, for the 2015 population. Coal as a fuel is highlighted by hatching.

Indicator 3.4: Sustainable and healthy transport

Headline Finding: *Global road transport fuel use increased 0.7% from 2015 to 2016 on a per capita basis. Fossil fuels continue to dominate, but their growth is being tempered somewhat by rapid increases in biofuels and electricity.*

As with electricity generation, transition to cleaner fuels for transport is important for climate change mitigation and will have the added benefit of reducing mortality from air pollution.[100] Fuels used for transport currently produce more than half the nitrogen oxides emitted globally and a significant proportion of particulate matter, posing a significant threat to human health particularly in urban areas (Indicator 3.3).[131] Additionally, the health benefits of increasing uptake of active forms of travel (walking and cycling) have been demonstrated through a large number of epidemiological and modelling analyses.[49,100,132-134] Encouraging active travel, in particular cycling, has become increasingly central to transport planning, and there is growing evidence that bikeway infrastructure, if appropriately designed and implemented, can increase rates of cycling.[135] A modal shift in transport could also result in reductions in air pollution from tyre, brake and road surface wear in addition to exhaust related particulates.[136]

Global trends in levels of fuel efficiency and the transition away from the most polluting and carbon-intensive transport fuels are monitored using data from the IEA; specifically, it follows the metric of fuel use for road transportation on a per capita basis (TJ/person) by type of fuel.[46,137] In response to feedback, this year's indicator displays data in three categories of fuel: fossil fuels, biofuels, and electricity.

Globally, per capita fuel use increased by 0.7% from 2015 to 2016 (Figure 18). Although fossil fuels continue to contribute 95.8% of total fuel use for road transport, the use of clean fuels is growing at an increasing rate: fossil fuels grew by 0.5% compared to 3.3% growth in biofuels and 20.6% growth in electricity. In China electricity now represents 1.8% of total transportation fuels use. This is more than any other country and an 80% higher share than that seen in Norway (0.85%), who have committed to having 100% of new vehicles sold being zero-emission by 2025.[138] A growing number of countries and cities have announced plans to ban vehicles powered by fossil fuels and auto-maker Volkswagen has announced that it will stop developing engines that run on petrol or diesel after 2026.[139]

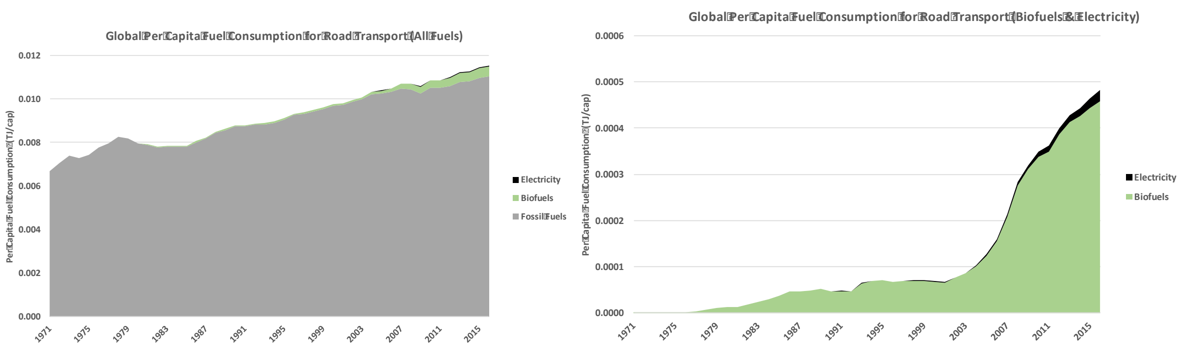


Figure 18: Per capita fuel use by type (TJ/person) for road transport with all fuels (left) and non-fossil fuels only (right).

As an important case study, a number of cities have made considerable progress towards improving levels of cycling. Vitoria-Gasteiz in Spain is notable, where cycling mode share has increased from close to zero to almost 15% in less than a decade.[140] The city's transport policy has strongly promoted cycling though the expansion of the cycle lane network, improved cycle parking facilities and the introduction of safety courses and new cycling regulations as well as communication on the health benefits of cycling.[141] The search for a more comprehensive metric of active transport remains elusive, principally limited by scarcity of data access in this field.

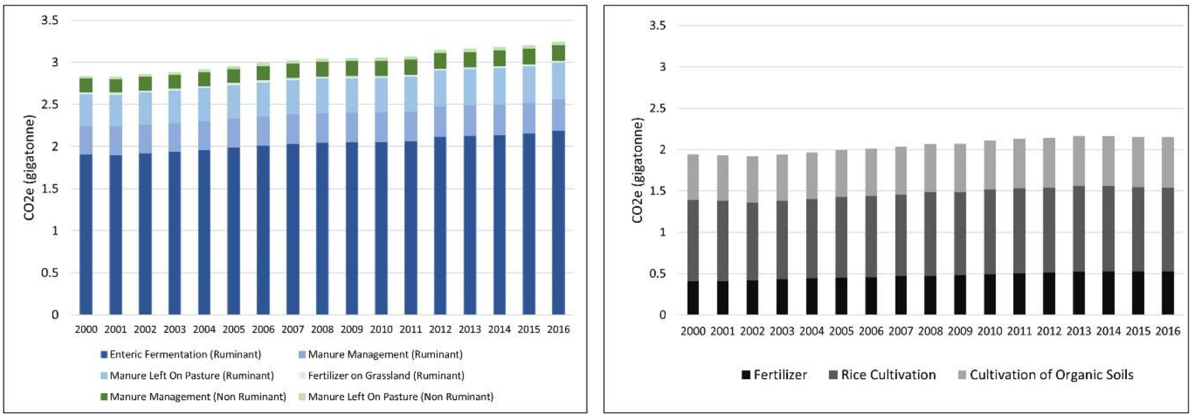
Indicator 3.5: Emissions from livestock and crop production

Headline finding: *Total emissions from livestock and crop production have increased by 14% and 10%, respectively, from 2000 to 2016, with 93% of livestock emissions attributed to ruminants.*

Obesity and undernutrition present two great challenges to global public health, and both these forms of malnutrition share many common systemic drivers with climate change.[142] Current dietary trends are contributing to both non-communicable diseases (NCDs) and GHG emissions, as well as other impacts on the planet, including biodiversity loss and impacts on water and land use.[101] In particular, excess red meat consumption contributes to both the risk of cardiovascular disease and type 2 diabetes as well as GHG emissions.[143] To this end, whilst total emissions from crops and livestock will need to decline significantly in the future, particular attention should be given to capitalising on low-carbon production processes, and reducing the consumption of ruminant meat and other animal source foods, particularly in high income settings.[20,46] Importantly, the nuance and complexity of any such indicator must be stressed, and it is clear that there is no 'one-diet-fits-all' solution.[101]

For the 2019 Lancet Countdown report, this indicator focuses on emissions from livestock and crop production. The new analysis added here provides a novel method of understanding the emissions profile of agricultural groups – for example, ruminant livestock. A full description of the methods and data is provided in the appendix.

Overall emissions from livestock have increased by 14% since 2000 to over 3.2 $GtCO_2e$ in 2016 (Figure 19). Ruminants contribute 93% of total livestock emissions (3 $GtCO_2e$ per year), with non-dairy cattle (used for meat) contributing 62-65% of this (see appendix). However, the largest increase in emissions from 2000 to 2016 has come from poultry, which has an increase in emissions of 58% (rising from 30.6 million tonnes CO_2e in 2000 to 48.5 million in 2016), more than double that of non-dairy cattle.



(a) Emissions from Livestock (b) Emissions from Crop Production

Figure 19: Global livestock (a) and crop (b) GHG emissions annually from 2000-2016, by process.

Total emissions from crop production have increased by 10% since 2000, to around 2 billion tonnes of CO_2e in 2016. Paddy rice cultivation, which releases methane, contributes around half of these emissions (47-50%), with cultivation of organic soils (such as peatlands), and addition of nitrogen fertilisers (synthetic and manure) to soils contributing 27-29% and 21-25% respectively.

Indicator 3.6: Mitigation in the healthcare sector

Headline Finding: *Global healthcare sector GHG emissions were approximately 4.6% of the global total emissions.*

Section 2 makes clear that the healthcare sector is central in managing the health damages of a changing climate, however, it is also a significant contributor of GHG emissions, both directly and indirectly through purchased goods and services. Recent national-level studies for the US,[144] Canada,[145] and Australia[146] have used environmentally-extended input-output (EEIO) modelling, finding that healthcare sector emissions represent between 4-10% of total GHG emissions in those countries. EEIO models have been in wide use since the 1970s,[147] and underpin consumption-based accounting of emissions performed at national and global scales.[148] An important advantage of using EEIO modelling is that estimates of healthcare sector emissions are performed on a life cycle basis, meaning that all emissions are accounted for, from the electricity usage of healthcare facilities, to the energy to produce and transport medical equipment and pharmaceuticals.

National-level studies cannot easily be compared due to differences in how emissions inventories, monetary input-output tables, and health expenditure data are collected in each country. In addition, some portion of healthcare sector emissions in each country is imported from other countries as embodied carbon in traded commodities, thus requiring a global scope and the use of multi-region input-output (MRIO) models that cover more than one country. For this edition of the Lancet Countdown, a standardised, international measure of healthcare sector GHG emissions was created using multiple MRIO models (EXIOBASE, WIOD) that cover 40-47 countries and rest-of-world regions, in combination with WHO health expenditure data for 187 countries, assigned to the MRIO model geographic units.

Figure 20 shows variations in per capita healthcare-related GHG emissions as a function of time, affluence, and the proportion of national economic output spent on healthcare. Per capita, US emissions are significantly higher than those of any other country, and have risen steadily over the study period 2007-2016. However, per capita healthcare emissions of other countries have increased even more significantly, albeit from a lower base, including China (CN, 180%), South Korea (KR, 75%) and Japan (JP, 37%). In contrast, Greece's healthcare GHG emissions showed a marked decrease (GR,-35%), likely reflecting economic hardships in that country. Results using the WIOD MRIO model show similar trends but slightly lower absolute GHG emissions. The lowest per capita emissions modelled were for India (IN) and Indonesia (ID), at less than 1/40th those for the USA. Comparison of emissions per capita and Gross Domestic Product (GDP) per capita show a levelling off trend of healthcare emissions versus affluence, again with the exception of the US.

Overall, healthcare was responsible for approximately 2250 Mt CO2e in 2016, or 4.6% of the global total emissions (excluding land use change). A parallel global analysis using a different MRIO model (EORA) just looking at CO_2 (excluding other GHGs) for 36 countries determined a healthcare contribution of 4.4% to the global total for the countries considered,[149] corroborating the results presented here.

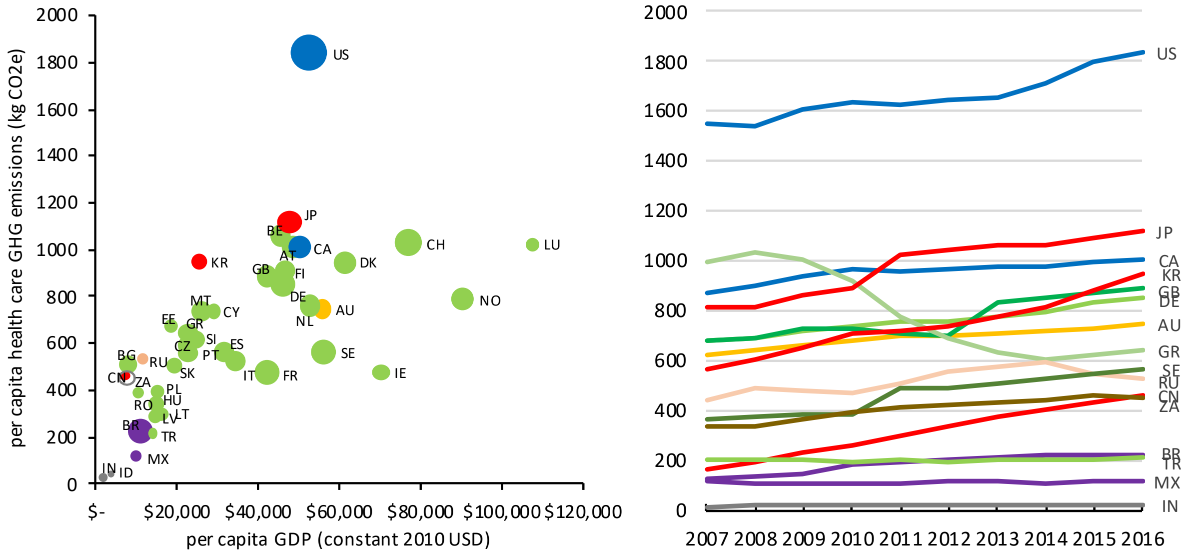


Figure 20: Per capita healthcare GHG emissions by country: (left) as a function of GDP per capita, bubble widths indicate proportion of national spending on healthcare; (right) over time 2007-2016. Colour key: green=Europe, light brown=Africa; grey=South Asia/South East Asia, pink=North/Central Asia, red=East Asia, yellow=Oceania, blue=North America; purple=Latin America. Abbreviations follow ISO two-letter country codes.

Health systems are increasingly faced with the dual challenges of responding to the health impacts of climate change and reducing the contribution of the healthcare sector to GHG emissions. From 2013 to 2018, participants from health systems, health centres and hospitals, from 19 different countries, and representing 9,199 health centres and 1,693 hospitals, have participated in the Health Care Climate Challenge. The Challenge addresses key areas including local climate change risk assessments, health adaptation plans, fossil fuel and renewable energy project investments, and work with government agencies to support GHG emissions reductions and healthcare sector adaptation.

A leader in climate action progress is Kaiser Permanente (KP), one of the largest not-for-profit health systems in the US, serving 12.3 million members. Between 2008 and 2017, KP reduced its operational GHG emissions by 29% while increasing its membership by 36%. As of early 2018, 36 of its facilities hosted onsite solar panels. KP is working to increase its purchasing of renewable electricity to 100% of total usage by 2020. Anesthetic gases account for 3% of KP's GHG emissions. Between 2014 and 2018, KP achieved a 24% reduction in GHG emissions associated with its use of anesthetic gases through progressive elimination of the drug Desflurane.[150]

The largest example of a health system taking steps to reduce GHG emissions and other environmental impacts comes in the form of the UK National Health Service (NHS). A national-level detailed analysis of government funded healthcare, demonstrates that the NHS, public health and social sector in England reduced its GHG emissions (excluding CFCs) by 18.5% from 2007 to 2017, while clinical activity increased by 27.5% over the same time period.[151] Efforts are also being made to reduce water use, plastic waste and air pollution from the NHS.

Panel 3: Healthcare sector response to climate change

Conclusion

The indicators of section 3 present a mix of encouraging and concerning trends. Renewable electricity generation continues to grow, as does access to energy and the rate of electric vehicle sales. However, the carbon intensity of the energy system remains unchanged, with coal supply increasing, reversing the recent trend, and significant effort is required to decarbonise the agricultural and healthcare sectors. The summation of all of this is that GHG emissions continue to rise. Next year (2020) is important for two reasons – it is the year the implementation period of the Paris Agreement begins, and the year most studies suggest global emissions must peak then in order to remain on a 1.5°C pathway. To meet both commitments, a substantially stronger global response is required urgently, to reduce GHG emissions and minimise the future health risks of climate change. The health sector has an important role to play in achieving these goals, both by reducing its own emissions and working with policymakers to help design and implement measures that reduce GHG emissions and maximise health co-benefits.

Section 4: Economics and Finance

Section 4 examines the financial and economic dimensions of the impacts of climate change, and of mitigation efforts required to respond. Although many indicators in this section may appear to be distant from human health, they are key to tracking the low-carbon transition that underpins current and future determinants of human health and wellbeing described in sections 1-3.

The projected economic cost of inaction to tackle climate change is enormous. For example, compared with maintaining a 2°C limit, the costs of 3°C of warming are expected to reach US$4 trillion per year by 2100 (around 5% of total global GDP in 2018), whilst the total economic costs of a 4°C rise are estimated at US$17.5 trillion (over 20% of GDP in 2018).[152]

Investment to mitigate climate change substantially reduces these risks, and generates further economic benefits. For example, the UK's independent Committee on Climate Change calculated that achieving net-zero emissions in the UK in 2050, in line with the more ambitious objective of the Paris Agreement, is likely to require investments of 1-2% of the UK's GDP in 2050. However, if the economic value of co-benefits to human health (and savings to the NHS, for example from reduced air pollution), and the creation of low-carbon industrial opportunities are considered, the economic implications are likely to be positive.[153] Global economic benefits are likely to be maximised (and costs minimised) if strong policy action is taken as soon as possible to accelerate the low-carbon transition.

The nine indicators in this section fall into four broad themes:

- Economic costs of climate change (Indicator 4.1);
- Economic benefits of tackling climate change and air pollution (Indicator 4.2);
- Investing in a low-carbon economy (Indicators 4.3.1, 4.3.2, 4.3.3, and 4.3.4);
- Pricing GHG emissions from fossil fuels (Indicators 4.4.1, 4.4.2 and 4.4.3).

The 2019 report adds an additional indicator tracking the economic value of change in mortality due to air pollution (Indicator 4.2).

Indicator 4.1: Economic losses due to climate-related extreme events

Headline Finding: *In 2018, a total of 831 climate-related extreme events resulted in US$166 billion in overall economic losses. Although most losses were in high-income countries and insured, no measurable losses due to events in low-income countries were covered by insurance.*

The indicators in section 1 presented changes in exposures and resulting health impacts of climate-related extreme events (Indicators 1.2.1, 1.2.2 and 1.2.3). The economic costs of extreme climate-related events may also exacerbate the direct health impacts they produce. This indicator tracks the total annual economic losses (insured and uninsured) across country income groups relative to GDP, resulting from climate-related extreme events.

The data for this indicator is sourced from Munich Re's NatCatSERVICE,[154] with climate-related events categorised as meteorological, climatological, and hydrological events (geophysical events are excluded) as well as data from the World Bank Development Indicator Database.[155] The methodology remains the same as was used in the 2018 Report of the Lancet Countdown,[46] and full methodology, along with data for 1990-2018 can be found in the appendix.

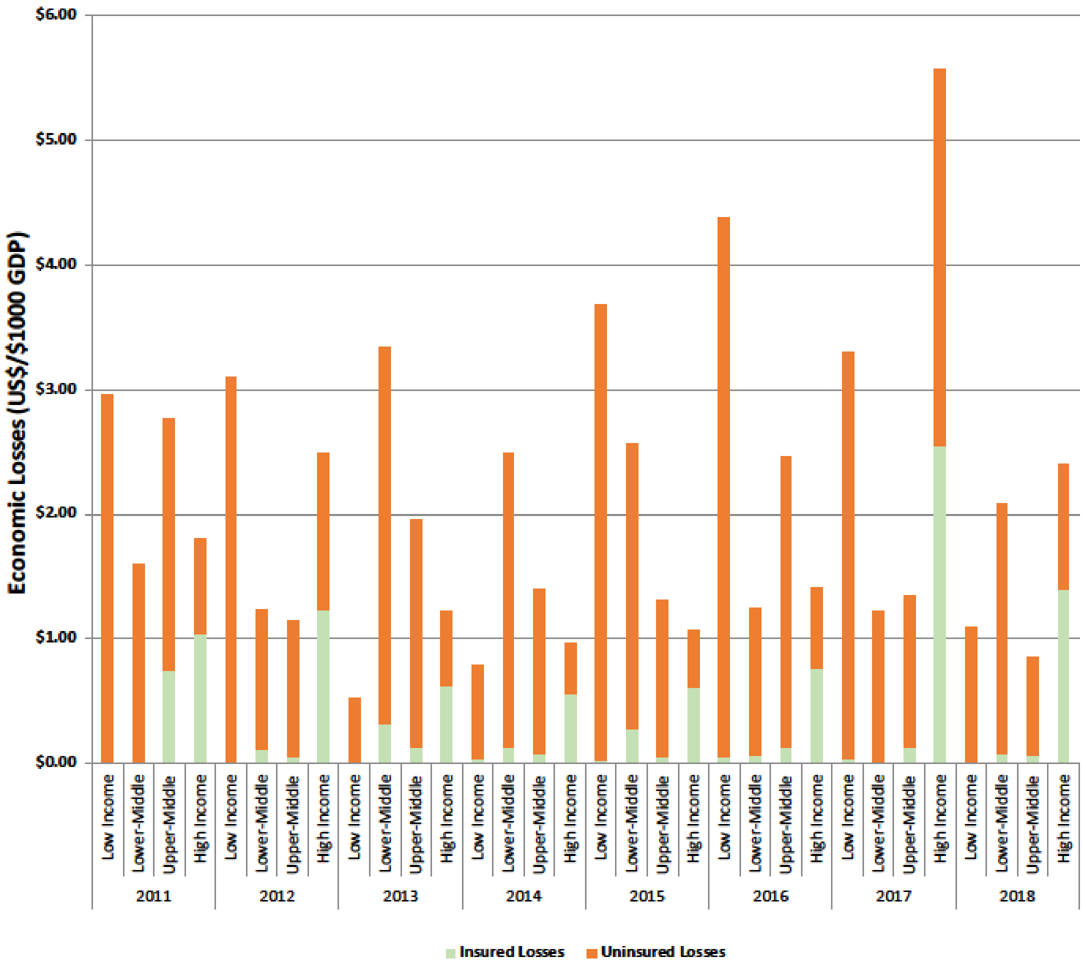


Figure 21: Insured and uninsured Economic Losses from Climate-Related Events Relative to GDP by World Bank income group.

Figure 21 presents both insured and uninsured economic losses due to extreme climate-related events relative to GDP. Absolute global economic losses in 2018 were US$166 billion, around half the value experienced in 2017, but still higher than any other year since 2005. As in previous years, economic losses are highest in high-income countries, but well over half of these losses in high-income countries were insured. By contrast, although in previous years less than 1% of losses in low-income countries were insured (for example, US$20 million of US$1.9 billion losses in 2017), in 2018 not a single event recorded created measurable losses covered by insurance.

Indicator 4.2: Economic costs of air pollution

Headline Finding: *Across Europe, improvements in particulate air pollution from human activity were seen from 2015 to 2016. If the levels of pollution for these two years remained* *the same over the course of a person's life, this difference would lead to an annual average reduction in Years of Life Lost worth €5.2 billion saved.*

Indicator 4.2 is a new indicator for the 2019 report and is the first indicator on the economics of the health co-benefits of climate change mitigation, capturing the economic costs of the impact of air pollution on human health (Indicator 3.3.2). It will be developed into a full suite of metrics over the coming years, with 2019 presenting values for the European Union alone. It places an economic value on the Years of Life Lost (YLL) that result from exposure to $PM_{2.5}$ from anthropogenic sources, for the EU.

This indicator is based on estimates of the total YLL to the 2015 population of EU member states that results from the change in anthropogenic $PM_{2.5}$ exposure experienced from 2015 to 2016, if such emissions and subsequent population exposure were to remain constant over the course of their remaining lifetimes. Each YLL is assigned a 'Value of a Life Year' (VLY) of €50,000, which is the lower bound estimate as suggested by the EU Impact Assessment Guidelines.[156] Complete details for this indicator can be found in the appendix.

As described under Indicator 3.3.2, anthropogenic $PM_{2.5}$ pollution decreased between 2015 and 2016 in Europe, largely due to a reduction in emissions from the power sector. If the population of the EU in 2015 were to experience anthropogenic $PM_{2.5}$ emissions at 2016 levels consistently to 2115, instead of levels experienced in 2015, the total annual average economic value of the reduction in YLLs would be around €5.2 billion. However, even at 2016 levels of anthropogenic $PM_{2.5}$ pollution, the total annual average cost to the 2015 population would still be €129 billion, with the greatest costs generally found in countries with the largest populations. The greatest projected average life lost per person is in Hungary, Romania and Poland (at over 8 months per person), with an EU average of 5.7 months of life lost per person.

For the first iteration of this indicator, it was not possible to calculate annual YLLs attributable to $PM_{2.5}$ exposure in a given year. However, methodological refinements should allow this metric to be reported in the 2020 report.

Indicator 4.3: Investing in a low-carbon economy

Indicator 4.3.1: Investment in new coal capacity

***Headline Finding:** Global investment in new coal-fired electricity capacity declined again in 2018, continuing the downward trend experienced since 2011.*

Whilst Indicator 3.1.2 tracks progress on coal phase-out through the total primary energy supply of coal, this indicator looks to the future of coal-fired power generation through tracking investments in coal-fired capacity.

The data source for this indicator (IEA) remain the same as in the 2017 Lancet Countdown report,[20] however the methodology has altered, and been retrospectively applied to recalculate all data presented. The revised approach considers ‘ongoing’ capital spending, with investment in a new plant spread evenly from the year new construction begins, to the year it becomes operational. Previously, data was presented as ‘overnight’ investment, in which all capital spending on a new plant is assigned to the year in which the plant became operational. Further details are found in the appendix. Data for 2006-2017 using the old methodology are also presented in Figure 22 for comparison.

Whilst TPES for coal increased in 2018 (Indicator 3.1.2), investment in new coal-fired electricity generating capacity continued the downward trend experienced since 2011. Interestingly, this decline was in large part due to reduced investment in the same countries that increased their coal TPES in 2018 (China and India), providing hope for coal phase-out. The number of total Final Investment Decisions (i.e. the decision to begin construction) declined 30% in 2018, with costs and construction times for new plants generally increasing due to larger, more efficient and complex designs, and the use of advanced pollution control systems, in response to concerns over air quality.[157]

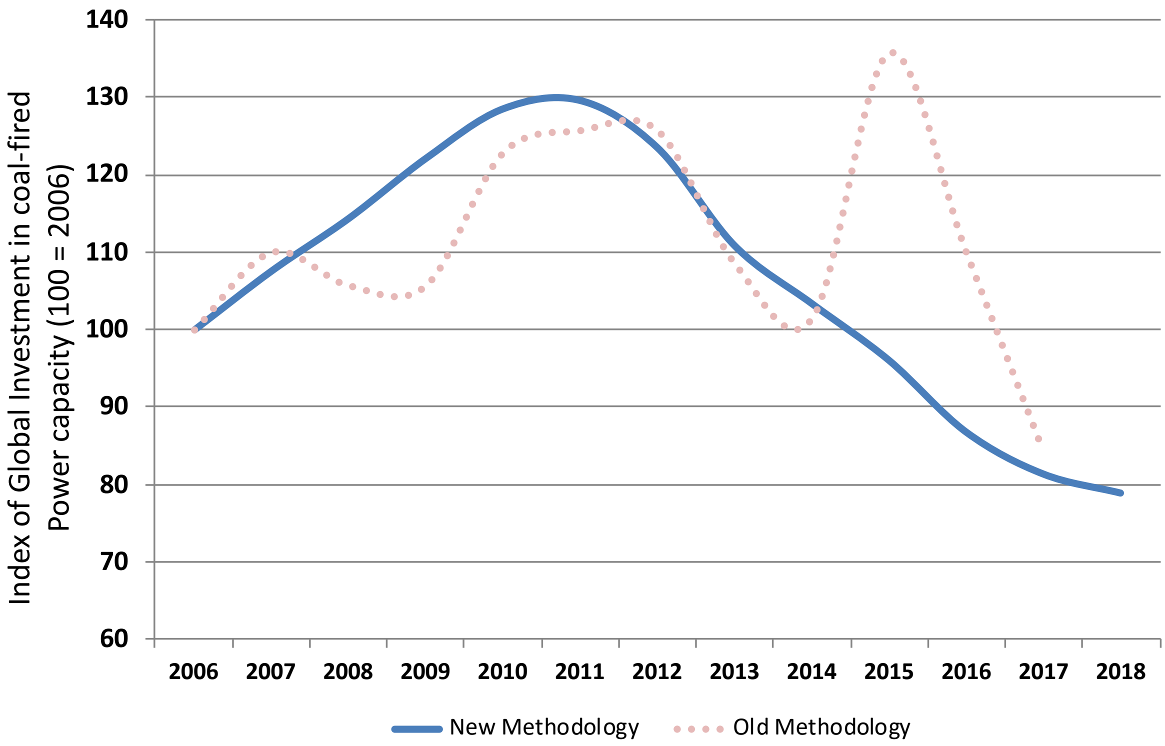


Figure 22: Annual global investment in coal-fired capacity 2006-2018 (an index score 100 corresponds to 2006 levels) (Source: IEA, 2019).[157]

Indicator 4.3.2: Investments in zero-carbon energy and energy efficiency

***Headline Finding:** Trends in energy investments are currently heading in the wrong direction. In 2018, investments in fossil fuels increased, whilst investments in zero-carbon energy decreased.*

Indicator 4.3 monitors global investment in zero-carbon energy, energy efficiency, fossil fuels, and electricity networks. It complements the tracking of zero-carbon electricity generation (Indicator 3.1.3) in section 3 and potentially predicts future trends in this indicator. All values reported are in US$2018, with data sourced from the IEA.[157] The data sources for this indicator remain the same as described in the 2017 Lancet Countdown report,[20] however the methodology has been updated somewhat (see appendix).

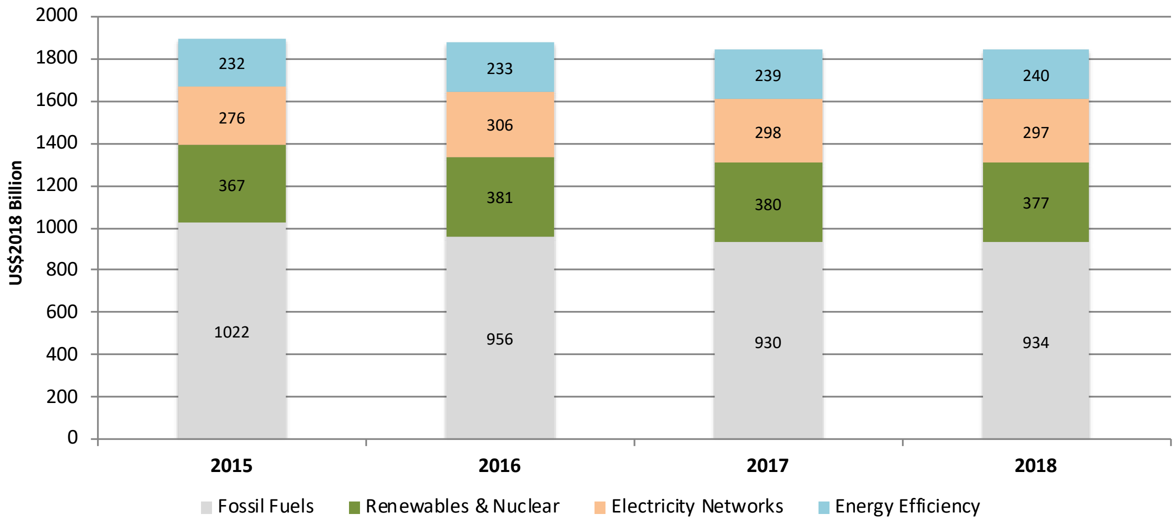


Figure 23: Annual Investment in the Global Energy System.

Total investment in the global energy system remained stable at around US$1.85 trillion in 2018, following a steady decline between 2015 and 2017 (Figure 23). Investment in fossil fuels increased slightly, driven by an increasing oil price, whilst investment in zero-carbon energy slightly decreased, driven by reduced investment in renewable electricity – partly the result of continually declining costs. Investments in energy efficiency and electricity networks remained stable between 2017 and 2018.

In contrast with growth in zero-carbon electricity generation (Indicator 3.1.3), these investment trends are currently not consistent with limiting warming to well below 2°C. The IEA estimate that in order to achieve a pathway consistent with the goals of the Paris Agreement, investment in zero-carbon energy, electricity networks that enable it, and energy efficiency, must collectively grow by two-and-a-half times by 2030 (even with further expected reductions in the cost of such technologies and actions), and account for at least 65% of total annual investment in the global energy system.[157,158]

Indicator 4.3.3: Employment in renewable and fossil fuel energy industries

Headline Finding: *In 2018, renewable energy provided 11 million jobs – an increase of 4.2% from 2017. Employment in fossil fuel extraction industries also increased to 12.9 million – a 2% increase from 2017.*

There are well documented occupational health consequences of working in some key fossil fuel industries, such as risk of injury and respiratory disease as well as risk of damage to hearing and skin.[20] On the other hand, with appropriate planning and policy, the transition of employment opportunities from high to low-carbon industries may yield positive consequences for both the economy and human health.[159]

This indicator tracks global direct employment in fossil fuel extraction industries (coal mining and oil and gas exploration and production) and direct and indirect (supply chain) employment in renewable energy, presented in Figure 24. The data for this indicator are sourced from the International Renewable Energy Agency (IRENA) (renewables) and IBIS World (fossil fuel extraction).[160-162] The data for fossil fuel extraction employment for 2012-2017 differs significantly from that presented in the 2018 Countdown report, due an improved methodology in the data collection and estimation methodology for global coal mining employment by IBISWorld. Similarly, values for Hydropower and Other Technologies for renewable energy employment have been revised, following methodological changes. Further detail is found in the appendix.

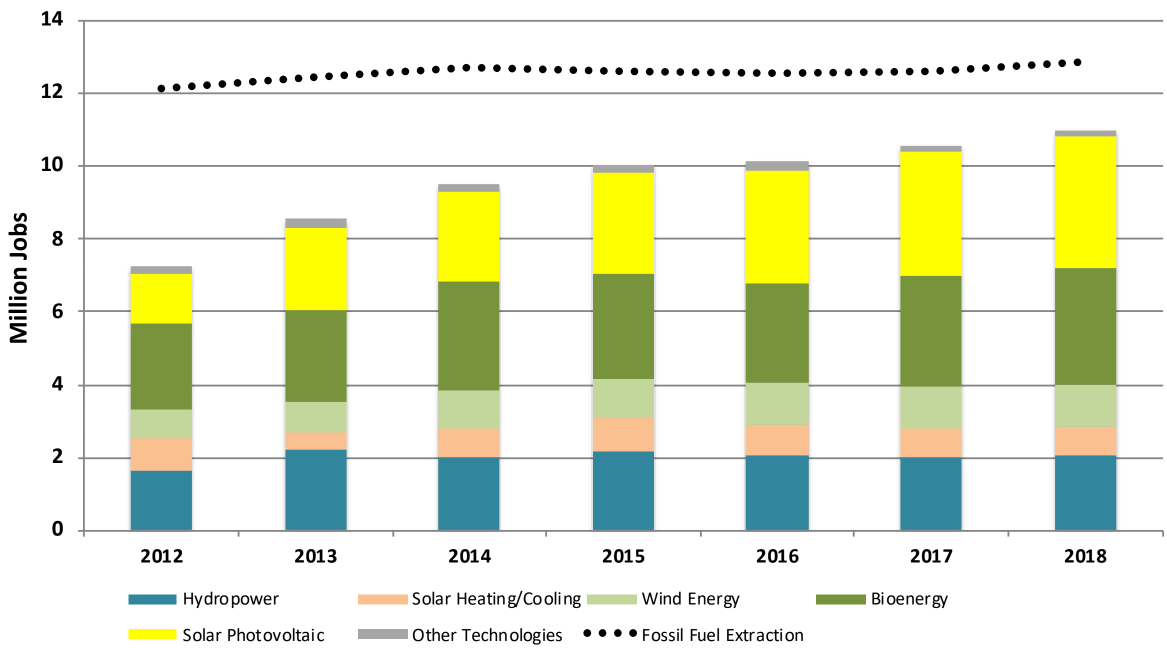


Figure 24: Employment in Renewable Energy and Fossil Fuel Extraction Sectors

In 2018, around 11 million people were employed either directly or indirectly in the global renewable energy industry. This represents a 4.2% increase from 2016, with growth in five out of six categories. Employment related to solar PV grew by over 7%, and remains the largest employer, with China responsible for nearly-two thirds of related jobs. Overall, 32% of global renewable energy jobs are held by women.[162]

Growth in employment in the fossil fuel extractive industries has been driven by both the growth of coal mining in China and other emerging markets (particularly India), despite a decline in many higher-income countries, and the upstream oil and gas industries, following rising prices in 2018. However, it is expected that employment in both industries will decrease in the coming years due to slowing growth in demand for coal in key markets such as China, and a decline in other (particularly high-income) markets, as the transition to low-carbon electricity continues, along with a potential decline in oil and gas prices coupled with increasing efficiency.[160,161]

Indicator 4.3.4: Funds divested from fossil fuels

Headline Finding: *The global value of new funds committed to fossil fuel divestment in 2018 was US$2.135 trillion, of which health institutions accounted for around US$66.5 million; this represents a cumulative sum of US$7.94 trillion since 2008, with health institutions accounting for US$42 billion.*

Originating in the late 2000s, the divestment movement seeks to both remove from the fossil fuel industry its 'social license to operate' and guard against the risk of losses due to 'stranded assets', by encouraging investors to commit to divest themselves of assets related to the industry. The debate on the direct and indirect consequences of these approaches is nuanced and complex, with evidence on their effects only just beginning to emerge.[163]

This indicator tracks the total global value of funds divested from fossil fuels, and the value of divested funds coming from health institutions, using data provided by 350.org,[164] with full methodology described in the appendix.

From 2008 to the end of 2018, 1,026 organisations with cumulative assets worth at least US$7.94 trillion, including 23 health organisations with assets of around US$42 billion, had committed to divestment, including the World Medical Association, the British Medical Association, the Canadian Medical Association, the UK Royal College of General Practitioners, and the Royal Australasian College of Physicians. The annual value of new funds committing to divesting increased from US$428 billion in 2017 to US$2.135 trillion in 2018. However, health institutions have divested at a reduced rate, with just US$866.5 million divested in 2018, compared to US$3.28 billion in 2017.

Indicator 4.4: Pricing greenhouse gas emissions from fossil fuels

Indicator 4.4.1: Fossil fuel subsidies

***Headline Finding:** In 2018, fossil fuel consumption subsidies increased to US$427 billion - over a third higher than 2017 levels, and over 50% higher than 2016 levels*.

Negative externalities, including the various direct and indirect consequences for human health and the natural environment, mean that the true cost of fossil fuels is far greater than their market price.[165] Fossil fuel subsidies (both for their consumption and their extraction) artificially lower prices even further, promoting overconsumption, further exacerbating both GHG emissions and air pollution.

This indicator tracks the value of fossil fuel consumption subsidies in 42 (mostly non-OECD) countries. Although these countries account for a large proportion of such subsidies around the world, they are by no means comprehensive, meaning that the values reported are conservative. The methodology and data source (IEA) for this indicator remains unchanged since the 2017 Lancet Countdown report,[46] and is described there and the appendix. Data for 2008 and 2017, which was previously not available, is now included.

Whilst fossil fuel subsidies declined between 2012 and 2016, this trend was reversed in both 2017 and 2018, reaching US$319 billion and US$427 billion, respectively (Figure 25). The values presented above do not include the economic value of the unpriced negative externalities. If these were to be included, the IMF estimated that in 2017 global subsidies to fossil fuels increase to US$5.2 trillion – equivalent to 6.3% of Gross World Product (GWP).[166]

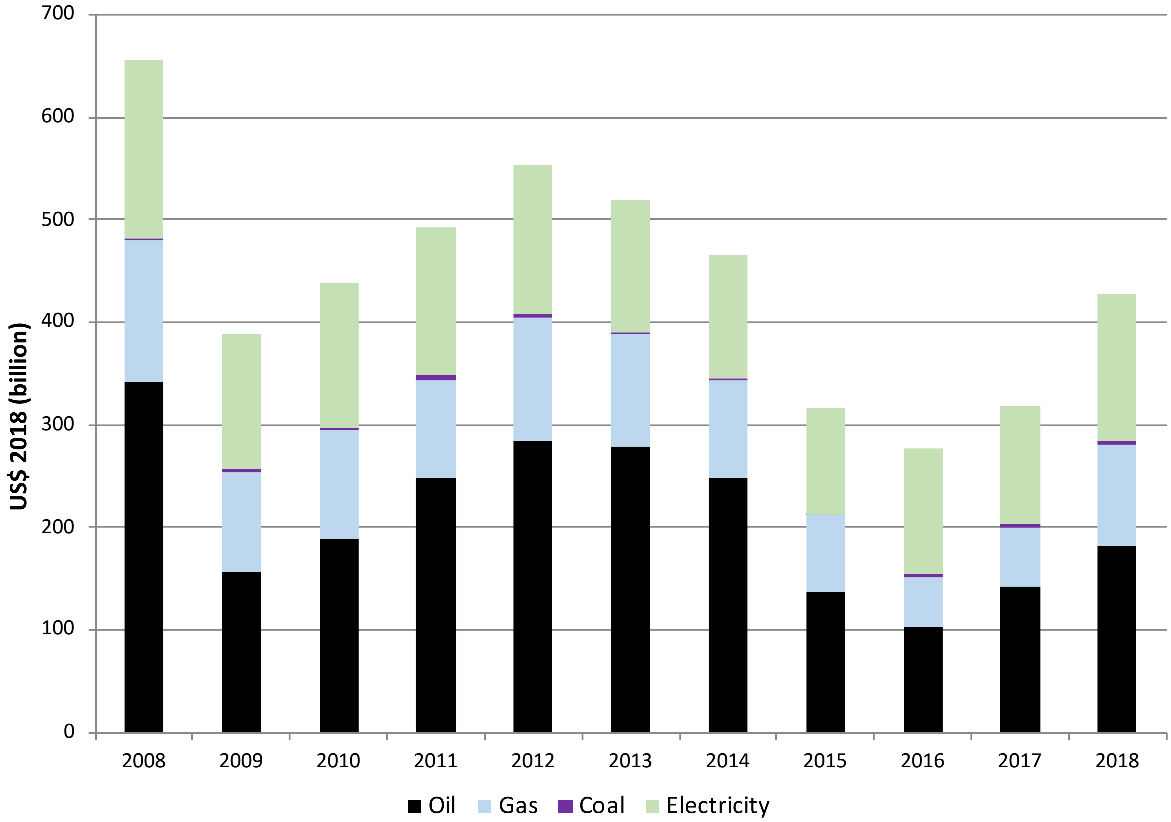


Figure 25: Global Fossil Fuel Consumption Subsidies 2008-2018.

Indicator 4.4.2: Coverage and strength of carbon pricing

***Headline Finding:** Carbon pricing instruments in early 2019 continue to cover 13.1% of global anthropogenic GHG emissions, but average prices were around 13% higher than in 2018.*

Adequately pricing carbon emissions is an essential component in shifting investment to develop a low-carbon economy. This indicator tracks the extent to which GHG emissions around the world are subject to a carbon price, and the weighted-average price these instruments provide (

Table 1), using data from the World Bank Carbon Pricing Dashboard.[167] The full methodology is presented in the appendix and remains unchanged from the 2017 Lancet Countdown report.

The coverage of carbon pricing instruments remained at around 13.1% of global anthropogenic GHG emissions between 2018 and 2019, implemented through 44 national and 27 sub-national instruments.

*Table 1: Carbon Pricing – Global Coverage and Weighted Average Prices per tCO2e. * Global emissions coverage is based on 2012 total anthropogenic GHG emissions.*

	2016	**2017**	**2018**	**2019**
Global Emissions Coverage*	12.1%	13.1%	13.1%	13.1%
Weighted Average Carbon Price of Instruments (*current prices, US$*)	$7.79	$9.28	$11.58	$13.08
Global Weighted Average Carbon Price (*current prices, US$*)	$0.94	$1.22	$1.51	$1.76

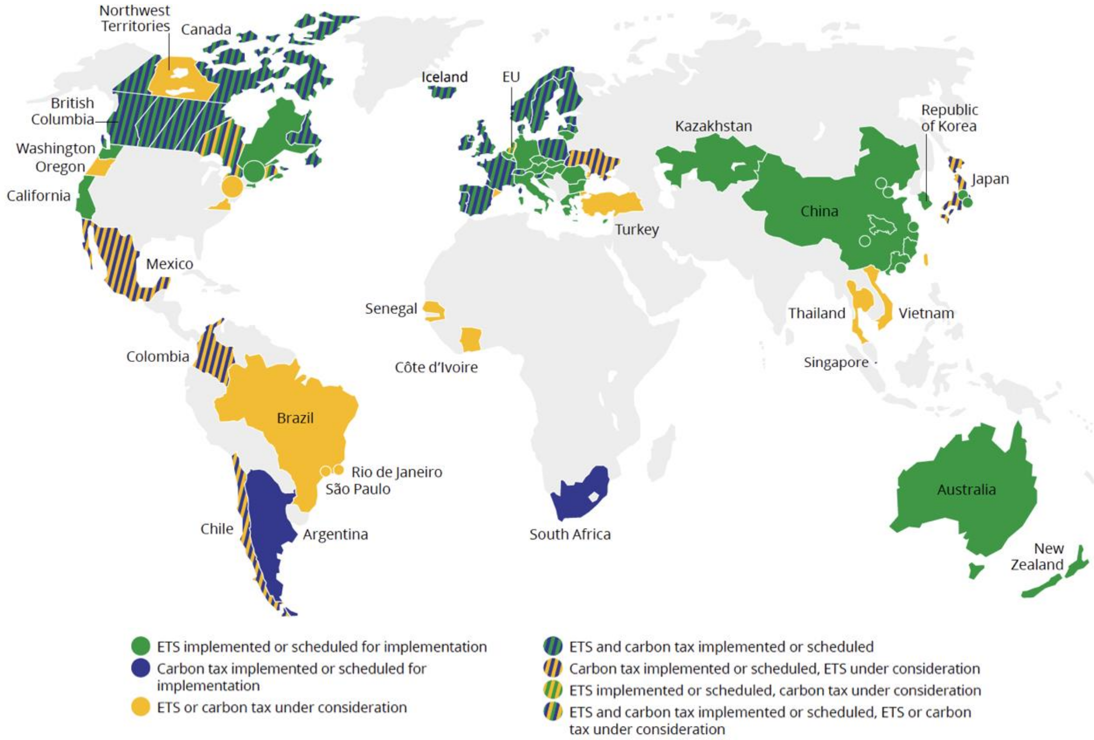


Figure 26: Carbon pricing instruments implemented, scheduled for implementation, and under consideration. Adapted from World Bank Group (2019).

The range of carbon prices across instruments continues to be vast (from <US$1 /t$CO_2$e in Poland, Ukraine and the Chongqing and Shenzhen pilot schemes in China , to US$127 /t$CO_2$e in Sweden), although weighted-average prices in early 2019 were 13% above 2018 levels, driven in large part by an increasing price under the EU Emissions Trading Scheme (EU ETS) (the largest carbon pricing instrument in the world, responsible for nearly half the economic value of all instruments combined). However, the weighted average of these carbon pricing instruments remains insufficient to remain "well below 2°", which would require a carbon price of US$40-80 /t$CO_2$e by 2020,[168] and the revenue generated through carbon pricing (which is described in Indicator 4.4.3) is far less than the potential annual impacts of unmitigated climate change on global GDP.[152]

As illustrated in Figure 26, further carbon pricing instruments are under consideration. With the addition of these instruments – and in particular the Chinese national ETS (replacing the existing sub-national 'pilots'), over 20% of global anthropogenic GHG emissions will be subject to a carbon price.[169]

Indicator 4.4.3: Use of carbon pricing revenues

***Headline Finding:** Revenues from carbon pricing instruments increased by US$10 billion between 2017 and 2018, reaching US$43 billion, with US$24.4 billion allocated to further climate change mitigation activities.*

As the previous indicator outlined, adequately pricing carbon is essential for mitigating GHG emissions. How the revenue generated by these pricing instruments is used will also have important consequences. Four ways the revenue may be used include: investment in further mitigation; investment in adaptation; recycling for other purposes (such as enabling the reduction of other taxes or levies); and contributing to other general government funds. This indicator tracks the total government revenue from carbon pricing instruments and where this is allocated.

Data on revenue generated is provided on the WBG Carbon Pricing Dashboard,[167] with revenue allocation information obtained from various sources. Only instruments with revenue estimates and with revenue received by the administering authority before redistribution are considered. Further information on the methodology and various sources used to obtain information on revenue allocation can be found in the appendix.

Table 2: Carbon pricing revenues and allocation in 2018.

	Mitigation	**Adaptation**	**Revenue Recycling**	**General Funds**	**Total Revenue (US$)**
Proportion of total funds (%)	56.6%	0.6%	12.8%	30%	-
Value (US$)	$24.36 billion	$258 million	$5.50 billion	$12.91 billion	$43.03 billion

Government revenue generated from carbon pricing instruments in 2018 totalled over US$43 billion; a US$10 billion increase from the $33 billion generated in 2017. This was driven by increasing prices of allowances sold at auction in the EU ETS, higher tax rates for instruments in Alberta, British Colombia and France, and allowance sales in California and Quebec.[170]

The revenue allocated to mitigation activities increased by around US$10 billion between 2017 and 2018, and revenue allocated to revenue recycling and general funds also increased slightly. Revenue allocated to adaptation however reduced significantly, from over US$1.5 billion to around US$250 million.

Conclusion

Section 4 has presented indicators on the economic impacts of climate change, the finance and economic underpinnings of climate change mitigation, and the economic value of the health-related benefits it brings. The results of these indicators suggest that the shift to a low carbon global economy is in some respects slowing, and in yet other cases, previously promising trends highlighted in the 2018 report are falling into reverse gear. Given the need to transition the global economy to net-zero GHG emissions by 2050 in order to limit warming to well below 2°C, governments at all levels, in collaboration with the private sector and the population at large, must take immediate steps towards implementing strong, ambitious policy and related action to steer and rapidly accelerate their economies towards a low-carbon state. The health sector and health professionals are able to contribute here through the removal of institutional investment in fossil fuels, assessments of the health economics of mitigation co-benefits, and by communicating the negative externalities associated with the continued use of fossil fuels.

Section 5: Public and Political Engagement

As earlier sections have made clear, climate change is human in both its origins and its impacts. Its origins lie in the burning of fossil fuels, particularly by early-industrialising and richer societies, and its impacts include an increasing toll on human health. Reductions in global GHG emissions at the speed required by the Paris Agreement depend upon engagement by all sectors of society.

In the 2019 Lancet Countdown report section 5 focuses on engagement in four domains: the media, government, corporate sector and, for the first time, individual engagement. It tracks trends in engagement across the last decade, complementing this evidence with analyses of the content and dynamics of engagement in 2018. The methods for an indicator relating to a fifth domain, scientific engagement, are currently being refined to ensure the long-term sustainability of this work, and will be reported again in 2020. In every case, indicators in this section build on methods used in earlier Lancet Countdown reports, which continue to be refined and extended.

The media is central to public understanding of climate change; it provides a key resource through which people make sense of climate change and assess the actions of governments to address it.[171-174] The media indicator (5.1) includes an analysis of global coverage of health and climate change in 62 newspapers from 2007 to 2018. For the 2019 Countdown report, this has expanded to include coverage of health and climate change in China's *People's Daily* (in its Chinese-language edition, *Renmin Ribao*). As the official outlet of the Chinese party-state, the *People's Daily* is China's most influential newspaper.[175] The indicator has been further enhanced by a content analysis of the elite press in two contrasting societies, India and the USA. Elite newspapers both reflect and shape engagement in climate change by governments and elite groups.[176-180]

The internet is an increasingly important medium of civic engagement and has transformed individual access to global knowledge and debates. The second indicator tracks engagement in health and climate change through individuals' information-seeking behaviour on the online encyclopaedia, Wikipedia.[181] Because of its accessibility, breadth and user trust, Wikipedia is one of the most widely-used online resources.[182-186]

Recognising that that climate change is harming people, the global public support government action to limit GHG emissions.[187-189] The third indicator relates to government engagement in health and climate change and focuses on high-level government engagement in health and climate change at the United Nations General Assembly. It tracks references at the UN General Debate, the major international forum where national leaders have the opportunity to address the global community on issues they consider important.[190,191]

The fourth indicator relates to the corporate sector, recognised to be central to achieving a rapid transition to a carbon-free economy, both through its business practices and via its wider political and public influence.[192-194] Focusing on the health sector, the indicator tracks engagement in health and climate change through analyses of the annual reports submitted by companies signed up to the UN Global Compact, the world's largest corporate sustainability initiative.[195]

Indicator 5.1 Media coverage of health and climate change

***Headline finding:** Media coverage of health and climate change continued to increase between 2007 and 2018 with the elite press paying attention to the health impacts of climate change and the co-benefits of climate change action.*

This indicator tracks coverage of health and climate change in the global media, including in the Chinese People's Daily. Additionally, it provides insight into what aspects of the health-climate change nexus are receiving attention in the elite media in India and the USA. For the 2019 Report of the Lancet Countdown, methods to track newspaper coverage have been improved; greater attention is also given to the content of coverage.

Global media coverage of health and climate change has increased since 2010. As with broader coverage of climate change, spikes in media engagement with health and climate change coincided with major events in climate governance.[196] These include the 2009 and 2015 UNFCCC Conferences of Parties (COPs) in Copenhagen and Paris and, in 2016, the Paris Agreement and the Sustainable Development Goals coming into force. Nonetheless, health continued to represent only a small proportion of wider coverage of climate change. Analysis details, together with data sources and methodological enhancements, are described in the appendix. The indicator is based on 62 newspapers (English, German, Portuguese, Spanish) selected to provide a global spread of higher-circulation papers.

Extending this analysis, Figure 27 tracks coverage of health and climate change in the *People's Daily*. While the Chinese media has changed and diversified in recent decades, the *People's Daily* retains its dominance.[175,197,198] Across the 2008-18 period, there was an average of 2519 articles per year relating to climate change. A small proportion of these related to human health, with a mean of 14 articles a year. Spikes in coverage are less closely tied to landmarks in global climate change governance (such as the signing of the Paris Agreement in 2015) than in the global media. The explanation may lie in the timing of *People's Daily* coverage of global events, including the COPs, which occurs after their conclusion; coverage of November/December COPs may therefore occur in the following calendar year.

This addition to Indicator 5.1 was based on the *People's Daily* online archive,[199] and combined electronic searching of the text corpus (key word searches and algorithm-based natural language processing) with manual screening of the filtered articles. Full details of methods are provided in the appendix.

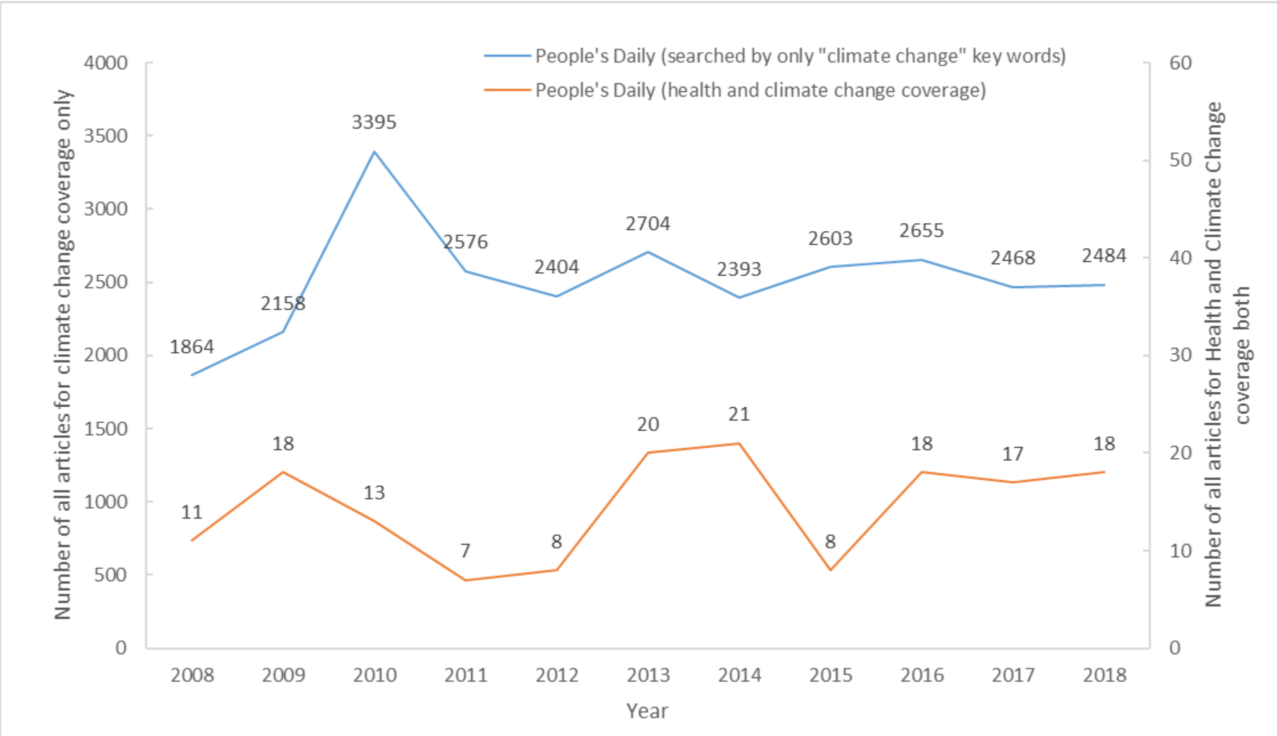


Figure 27: Number of articles reporting on climate change and on both health and climate change in the People's Daily 2008-2018.

The analysis of the content of coverage focused on the high-circulation elite press in India and the USA: *Times of India* (*ToI*), *Hindustan Times* (*HT*), *New York Times* (*NYT*) and *Washington Post* (*WP*). Two time-periods were selected to cover months (July-September) where both countries experienced extreme weather events (monsoon flooding and wildfires respectively) together with months (November-December) covering the 2018 COP in Katowice. Articles in international news databases Nexis and Factiva were keyword searched and manually screened for inclusion. Template analysis was used to identify themes; *a priori* coding (Lancet Countdown indicator-derived) and inductive coding (from recurrent topics in the data) were employed.[200] Full details of methods are provided in the appendix, together with additional analyses.

Coverage of health and climate change clustered around three broad connections between health and climate change (Panel 4). The first theme related to the health impacts of climate change. Discussed in 62% of the articles, these impacts related to climate change-related stressors (e.g. increased temperatures, wildfires, precipitation extremes, food security, population displacement) and health sequelae (e.g. vector-borne disease, heat stress, mental ill-health). Heat-related health impacts were the most commonly-mentioned impact. A second theme (44% of articles) focused on the common determinants of health and climate change, particularly air pollution, and the co-benefits to be derived from mitigation strategies to address them (e.g. investment in clean energy, active travel and plant-based diets). The third theme related to adaptation. Evident in 13% of the articles, it included both emergency response and longer-term planning. The three themes were represented in similar proportions in *HT, NYT* and *WP* while *ToI* gave greater emphasis to common causes and co-benefits (see appendix for further details).

Health impacts of climate change

'Climate change [is] making mosquitoes bolder and the germs they transmit stronger, leading to a spurt in mosquito-borne diseases, particularly chikungunya' (ToI, 9 August).

'As large wildfires become more common – spurred by dryness linked to climate change – health risks will almost surely rise … a person's short-term exposure to wildfire can spur a lifetime of asthma, allergy and constricted breathing.' (NYT, 17 November)

Benefits of addressing climate change and health together

'To protect our future, new infrastructure must be low-carbon, sustainable and resilient… In 2030, this kind of climate action could also prevent over 700,000 premature deaths from air pollution annually…If cities are built in more compact, connected and coordinated ways, they can improve residents' access to jobs, services and amenities while increasing carbon efficiency.' (HT, 5 December)

'For a short time on Thursday night, a small but fiercely determined group of marchers took over a busy D.C. street to demand better safety for pedestrians and bicyclists… The District has reported 31 traffic deaths so far this year, up from 29 in all 2017…. Yet lives could be spared … even if it means taking the space from curbside parking. Gove said. "This is a public health crisis. This is a climate change crisis."' (WP, 16 November)

Adaptation

'Ahmedabad Municipal Corporation (AMC) has adopted a heat action plan which necessitates measures such as building heat shelters, ensuring availability of water and removing neonatal ICU from the top floor of hospitals. It has helped bring down the impact of heatwave on vulnerable populations.' (ToI, 29 November)

'We rarely do much to protect our cities until disaster strikes.… (the) effects of climate change, including the ways it boosts droughts, floods and wildfires, would put more pressure on cities to adapt, mitigate the effects of climate change and become resilient… preparing for disasters and recovering from weather challenges require many different strategies, including holding that rainwater, keeping the flow from going into the drains faster, raising your homes above the flood line.' (NYT, 13 December)

Panel 4: Dominant themes in elite newspaper coverage of health and climate change in India and the USA

Indicator 5.2 Individual engagement in health and climate change

Headline finding: *Individuals typically seek information about either health or climate change; where individuals seek information across these areas, it is primarily driven by an initial interest in health-related content.*

The internet is an increasingly important domain of public engagement, particularly for information-seeking on issues that engage people's attention.[201] This indicator tracks individual-level engagement in health and climate change in 2018 through an analysis of usage of Wikipedia, the world's largest encyclopaedia. With reviews noting its accuracy,[182,202] Wikipedia is one of most-visited websites worldwide,[183] with a high correlation between user visits to Wikipedia and search activity on Google.[203] The analysis is based on the English Wikipedia, which represents around 50% of global traffic to all Wikipedia language editions.

This is a new indicator for the 2019 Report of the Lancet Countdown and its analysis uses the online footprint of Wikipedia users to map the dynamics of public information-seeking in health and climate change.[181,204] It analyses 'clickstream' activity, reported on a monthly basis, that captures visits to pairs of articles, for example an individual clicking from a page on human health to one on climate change .[205]

Articles were identified via key words and relevant hyperlinks within articles, refined using Wikipedia categories and then filtered by the initial key words. Data and methods are described in the appendix, together with further analysis.

Figure 28 indicates that articles on health and on climate change are internally networked, with extensive co-visiting within these clusters. However, it points to little connectivity between the clusters. Health and climate change are seldom topics that an individual connects when they visit Wikipedia; initial engagement in one topic rarely triggers engagement in the other. The proportion of co-clicks from a health article to a climate change article represented only 0.18% of total health article co-clicks to articles of any topic, and only 1.12% of climate change article co-clicks were to a health article This data also reflects the greater interest of the individual in health articles compared with climate change articles, with the majority (79%) of co-visits originated from a health-related page.

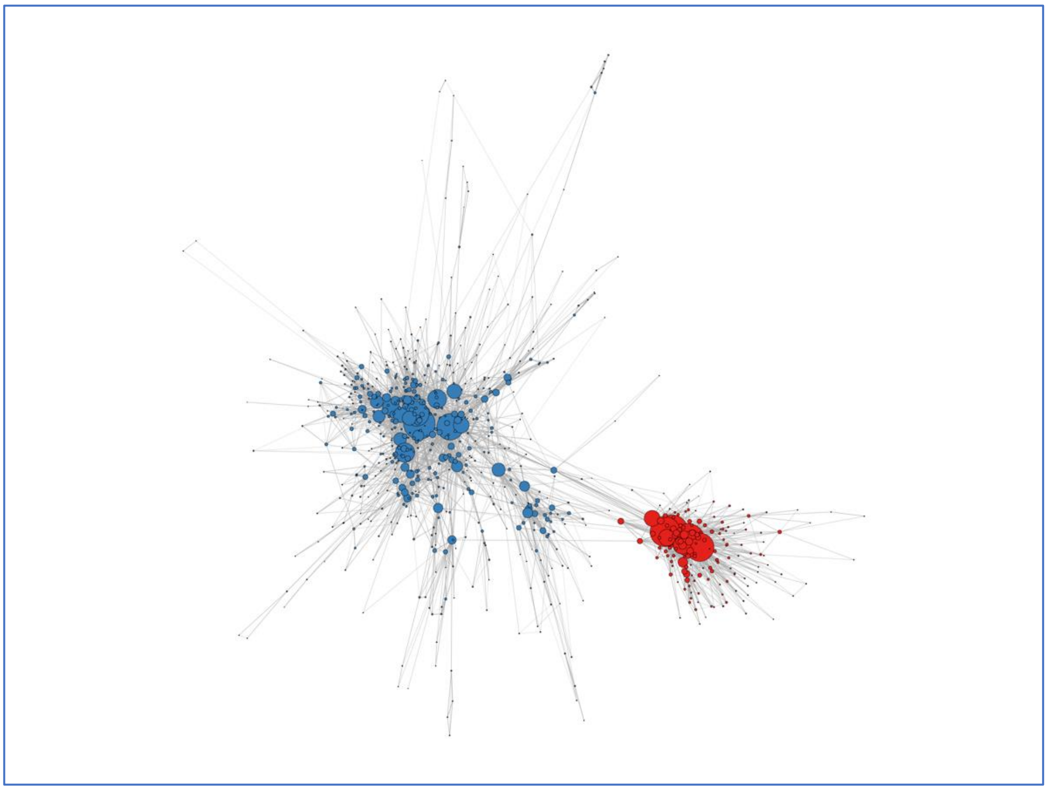


Figure 28: Connectivity graph of Wikipedia articles on health (blue) and climate change (red) visited in 2018. Popularity of articles is indicated by node size; lines represent co-visits in clickstream data.

Indicator 5.3 Government engagement in health and climate change

Headline finding: *National leaders are increasingly drawing attention to health and climate change at the UN General Debate (UNGD) in a trend led by small island developing states (SIDS), with SIDS making up 10 out of 28 countries referencing the climate change-health link at the UNGD in 2018.*

This indicator tracks high-level political engagement with climate change and health through references to this topic in annual statements made by national leaders in the UNGD. The UNGD takes place at the start of the annual UN General Assembly (UNGA) and provides a global platform for all UN member states to speak about their priorities and concerns.

An updated dataset, *the United Nations General Debate corpus*, was used for the analysis, based on 8,093 statements (1970-2018).[206,207] Key word searches used sets of health-related and of climate change-related terms; engagement in the health-climate change nexus was determined by the proximity of relevant key words within the statement. Methods and data, as well as further analyses are presented in full in the appendix.

Figure 29 shows the proportion of countries that make reference to the links between health and climate change in their UNGD statements, together with the proportion referring separately to climate change and/or to health. In 2018, 28 countries referenced the climate change and health link at the UNGD.

It points to an upward trend in government engagement in health and climate change since 1970, and one in-line with broader trends for engagement in climate change. This increase is particularly noticeable since 2004, peaking in 2014, when more than 20% of national leaders spoke of the links between climate change and health. This spike coincided with the transition from the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs) and preparations for the COP 21 in Paris. Since 2014, conjoint references to health and climate change have remained broadly stable; in 2018, 13% of countries made such references. However, Figure 29 points to much higher levels of engagement in health and climate change as separate issues. Around 75% of all countries referred to climate change and 50% to health issues in their 2018 UNGD statements.

The upward trend in engagement in health and climate change is led by the SIDS, for example, Fiji, Palau, Samoa, Dominica, and St Kitts and Nevis, with 10 SIDS making reference to the climate change-health link. In these speeches, connections between climate change and health are explicitly made and linked to wider inequalities between and within countries. For example, the 2018 address by St Kitts and Nevis notes that "NCDs and climate change are two sides of the same coin" while Dominica's statement makes clear that "climate change arises from activities that support and reflect inequalities… It is the poor whose lands are impacted by severe droughts and flooding and whose homes are destroyed and whose loved ones perish. It is the poor who have the least capacity to escape the heavy burdens of poverty, disease and death." The social justice theme is echoed in other speeches; for example, the Malawi address notes that "the hostile consequences of climate change, food insecurity and malnutrition are serious threats in a country that still relies on rain-fed subsistence agriculture."

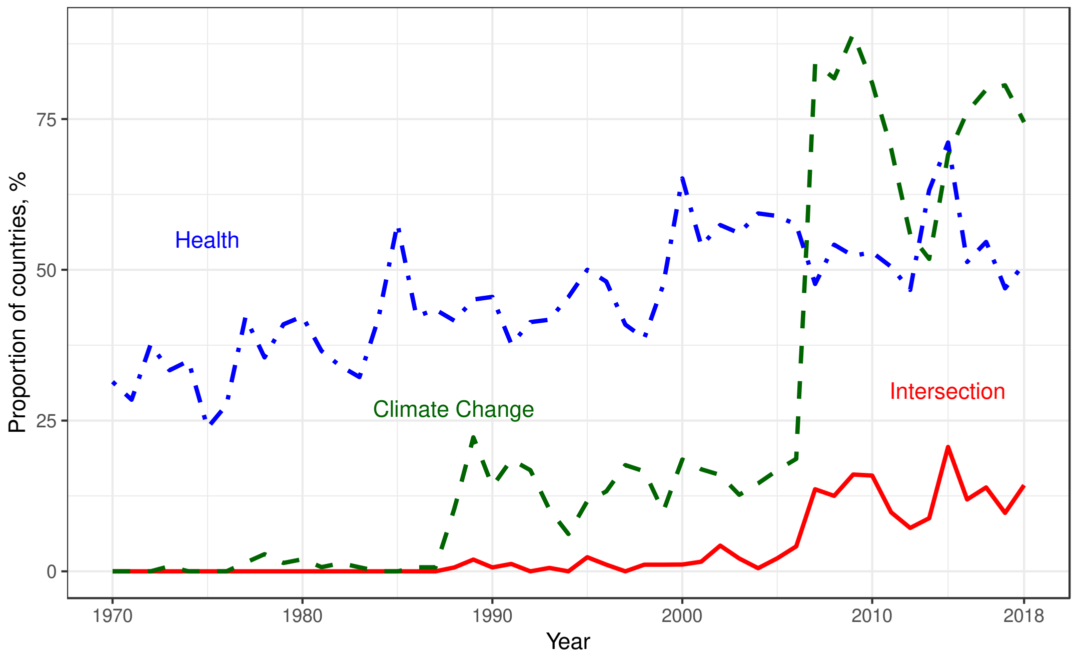


Figure 29: Proportion of countries referring to climate change, health, and the intersection between the two in their UNGD statements, 1970-2018.

Indicator 5.4 Corporate sector engagement in health and climate change

Headline finding: *Engagement in health and climate change remains low among companies within the UN Global Compact (UNGC), including companies in the healthcare sector.*

This indicator tracks corporate sector engagement through references to health and climate change in companies that are part of the UNGC, a UN-supported platform to encourage companies to put a set of principles, including environmental responsibility and human rights, at the heart of their corporate practices.[208] While the UNGC has been the subject of criticism, it remains the world's largest corporate citizenship initiative.[209-211]

Companies submit annual Communication of Progress (CPs) reports with respect to their progress in advancing UNGC principles. Over 12,000 companies have signed up to the UN Global Compact from more than 160 countries.[195]

Analysis was based on key word searches of sets of health-related and of climate change-related terms in CP reports in the UNGC database;[195] conjoint engagement in health and climate change was identified by the proximity of relevant key words within the CP report. Methods, data and additional analyses are presented in full in the appendix. With very few reports available prior to 2011, the analysis focuses on the period from 2011 to 2018.

Up to 2017, a small proportion of companies made reference to the links between health and climate change.[46] The pattern continues in the 2018 CP reports. While around 45% and

60% of the 2018 reports refer to climate change and to health respectively, only 15% refer to them together (see appendix). This pattern was even more pronounced in the corporate healthcare sector, which might be expected to be the global leader in addressing links between health and climate change. In 2018, while the majority of health sector companies referred to health (72%) and an increasing minority to climate change (47%), only 12% made conjoint reference to both.

Conclusion

Engagement by all sectors of society is essential if action on climate change is to be mobilised and sustained. Section 5 has focused on key domains of engagement, including the media, governments, the corporate sector and, in a new indicator, individual-level engagement. Each is recognised to be central to moving global emissions onto a pathway that holds global temperature increases to below 1.5°C. [212]

Two broad conclusions can be drawn from the analyses presented in section 5. First, engagement in health and climate change has increased over the last decade, with a more pronounced upward trend for engagement by the media and government than by the corporate sector. With respect to the elite media, there is evidence of informed and detailed engagement with the health impacts of climate change and with the co-benefits of climate change action. At the global forum of the UN General Assembly, an increasing number of countries are giving attention to the health-climate change nexus. Led by the SIDS, these countries are highlighting the north-south inequalities in responsibility for, and vulnerability to, climate change and its adverse health impacts.

Although media engagement is increasing, it is episodic rather than sustained, with 'issue attention' increasing at key moments in global climate governance, particularly the UNFCCC COPs. The role of the COPs in public and political engagement has been noted elsewhere, with the meetings providing a global stage for both national leaders and non-government organisations, including scientists, religious leaders and health professionals, to contribute to the public debate.[196,213] The pattern for the corporate sector, including the healthcare sector, is different; it does not display spikes in engagement linked to the global governance of the planet.

Second, while engagement has increased over the last decade, these indicators suggest that climate change is being more broadly represented in the media and by governments in ways that do not connect it to human health. As this suggests, the human face of climate change can be easily obscured. The analysis of individual engagement illustrates this pattern. The online footprint of Wikipedia users confirms that, while health is a major area of individual interest, it is rarely connected with climate change. In the public's mind, it appears that 'health' and 'climate change' represent different and separate realms of knowledge and concern and, where connections are made, this is driven by an interest in health rather than climate change.

Taken together, these two conclusions point to modest progress in making health central to public and political engagement in climate change but underline the challenge of mobilising action at the speed and magnitude required to protect the health of the planet and its populations.

Conclusion: The 2019 Report of the Lancet Countdown

The Lancet Countdown: Tracking Progress on Health and Climate Change was formed four years ago, building on the work of the 2015 Lancet Commission. It remains committed to an open and iterative process, always looking to strengthen its methods, source new and novel forms of data, and partner with global leaders in public health and in climate change. The 41 indicators presented in the 2019 report represent the consensus and work of the last 12 months, and are grouped into five categories: climate change impacts, exposures, and vulnerabilities; adaptation, planning, and resilience for health; mitigation actions and health co-benefits; economics and finance; and public and political engagement.

The data published here elucidate ongoing trends of a warming world threatening human wellbeing. As the fourth hottest year on record, 2018 saw a record-breaking 220 million additional exposures to extremes of heat, coupled with corresponding rising vulnerability across every continent. As a result of this and broader climatic changes, vectorial capacity for the transmission of dengue fever was the second highest ever seen, with 9 out of the last 10 most suitable years occurring since 2000. Progress in mitigation and adaptation remains insufficient, with the carbon intensity of the energy system remaining flat; 2.9 million ambient air pollution deaths; and a reversal of the previous downward trend of coal use.

And yet, as the material effects of climate change reveal themselves, so too does the world's response. Just under 50% of countries tracked have developed national health adaptation plans, 70 countries provide climate information services to the health sector, 109 countries have medium to high implementation of a national health emergency framework, and 69% of cities have mapped out risk and vulnerability assessments. Health adaptation funding continues to climb, with health-related funding now responsible for 11.8% of global adaptation spend. Finally, public and political engagement continues to grow, with flash-points around the school climate strikes, the UNFCCC's annual meetings, and divestment announcements from medical and health associations.

The last three decades have witnessed the release of increasingly concerning scientific data demonstrating the importance of a reduction in greenhouse gas emissions. Whilst there are a number of positive indicators published here, CO_2 continues to rise. The health implications of this are apparent today, and will most certainly worsen without immediate intervention.

Despite increasing public attention over the last 12 months, the world is yet to see a response from governments which matches the scale of the challenge. Here, the role of the health profession is essential – communicating the health risks of climate change, and driving the implementation of a robust response which maximises human health and wellbeing.

With the full force of the Paris Agreement being implemented in 2020, there is a crucial shift that must now occur – one which moves from discussion and commitment, to meaningful reductions in emissions.

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