THE LANCET

Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Watts N, Amann M, Arnell N, et al. The 2019 report of *The Lancet* Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. *Lancet* 2019; published online Nov 13. http://dx.doi.org/10.1016/S0140-6736(19)32596-6.

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

Appendix

Section 1: Climate Change Impacts, Exposures and Vulnerability

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.1: Health and heat
Sub-Indicator	1.1.1: Vulnerability to extremes of heat
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix.[1] This indicator displays an index derived by taking mean of proportion of the population over 65 years;[2] the prevalence of cardiovascular, diabetes and chronic respiratory diseases among population over 65 years using GBD study 2017 estimates;[3] and the proportion of the population living in urban areas as a measure of exposure to urban heat island.[4] The index ranges between 0 and 100 and is a measure of potential vulnerability to heat exposure of the population over 65 years by country. Aggregated trends are displayed by WHO regional classifications for the period 1990 to 2017.
Data	1. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2017 (GBD 2017) Population Estimates 1950-2017. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018. 2. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2017 (GBD 2017) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018. Available from http://ghdx.healthdata.org/gbd-results-tool. 3. Urban population (% of total) The United Nations Population Division's World Urbanization Prospects.
Caveats	There is no consistent and universally accepted standard for distinguishing urban from rural areas, in part because of the wide variety of situations across countries. Most countries use an urban classification related to the size or characteristics of settlements.[4] This indicator does not include the existence of heat early warning systems, or prevalence of cooling devices. Neither does it include the prevalence of green areas in cities.
Future Form of Indicator	GBD and urbanisation estimates now are revised annually; the indicator will be updated every year.

Additional Information

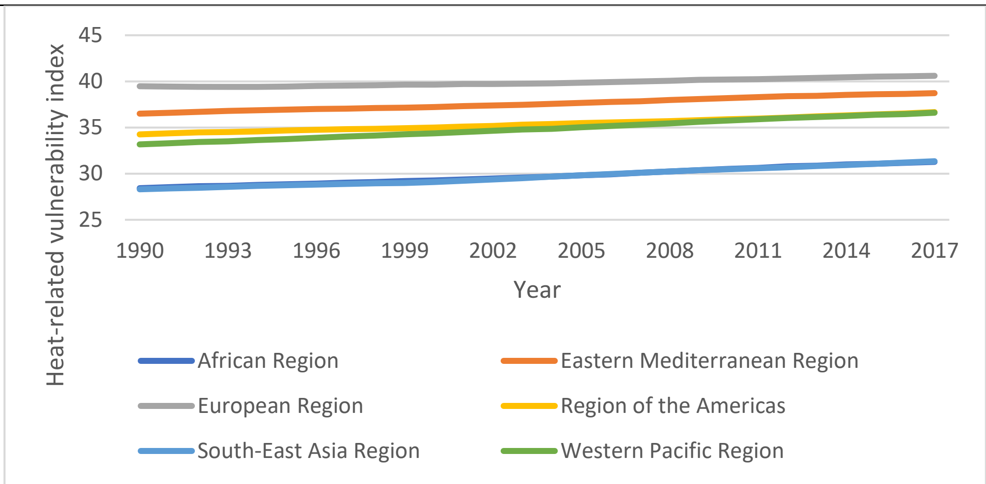


Figure 1: Trends in heat-related vulnerability for populations over 65 years by WHO region. This is based on an index ranging from 0 to 100.

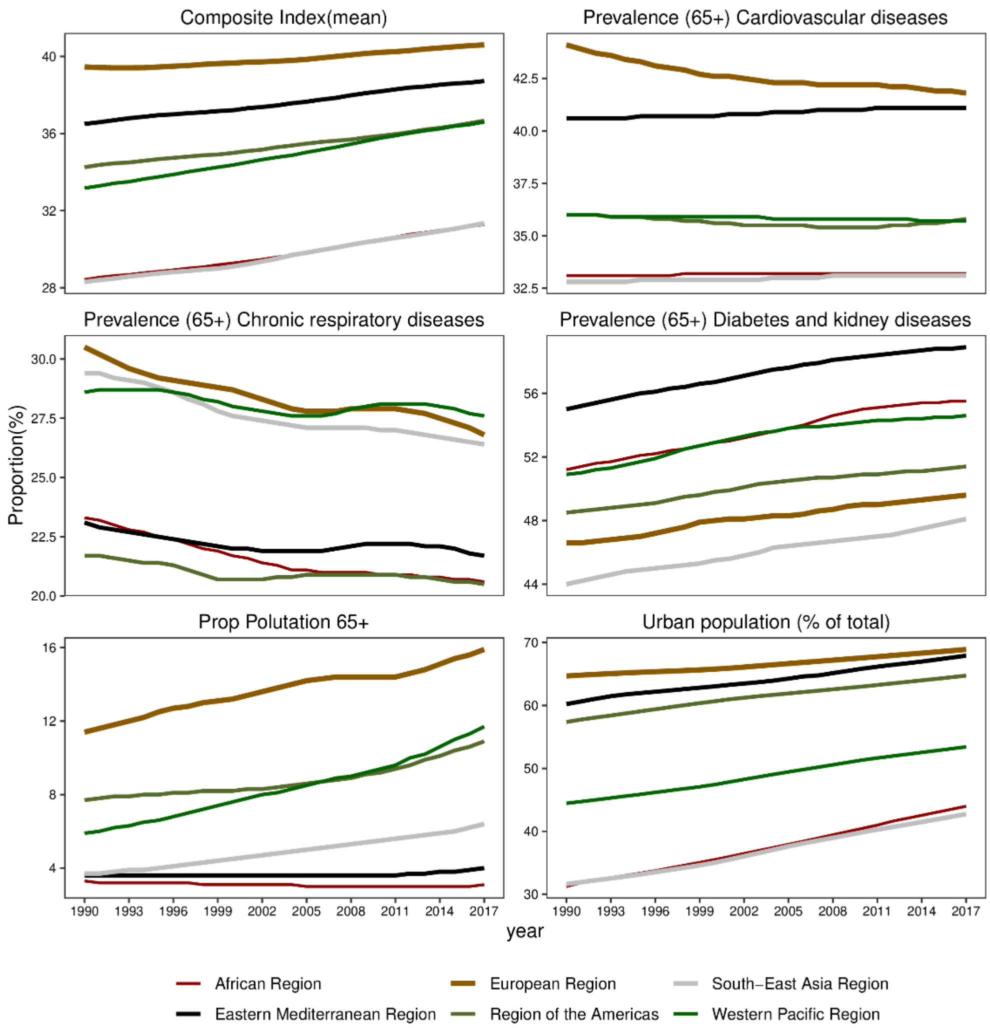
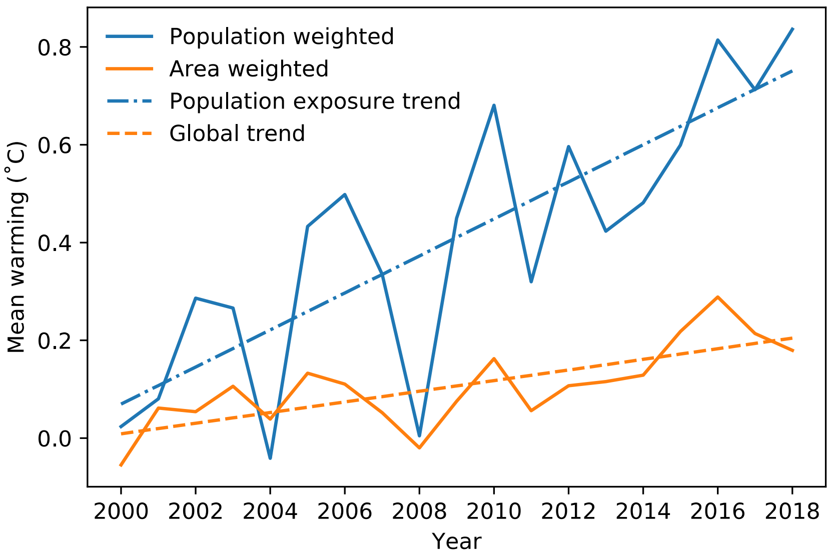


Figure 2: Prevalence of chronic diseases in the over 65 population, proportion of the population over 65 and proportion of total urban population, informing the heat vulnerability composite index 1990-2017.

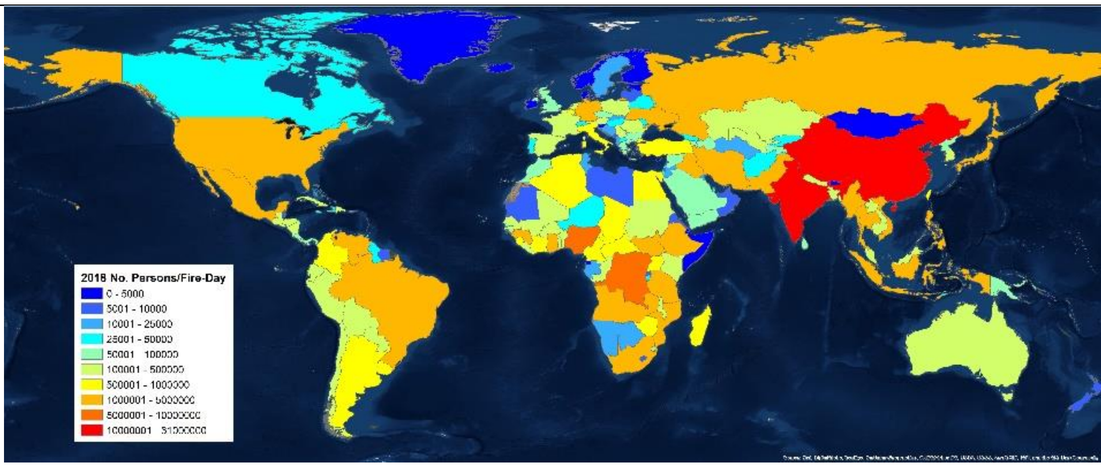
Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.1: Health and heat
Sub-Indicator	1.1.2: Health and exposure to warming
Methods	The methodology for this indicator remains similar to that described in the 2018 Lancet Countdown report appendix,[1] with improved resolution for the 2019 report. Change in summer temperature was calculated on a global grid (0.5° spacing). A baseline temperature grid was calculated as the average of summer temperatures (June, July, August for the northern hemisphere, December, January, February for the southern hemisphere) from 1986-2005 using a global grid of temperatures from the ERA-Interim numerical weather reanalysis dataset. Using this same dataset, temperature changes relative to the 1986-2005 average were calculated for every grid point for every year. The 'area weighted' average of the grid was calculated by weighting each grid cell by the relative area of that grid cell on the earth's surface, to take into account the mapping from the 2D rectangular grid to the spherical earth's surface. The 'population weighted' average was calculating by weighting each grid cell by the fraction of the total world population contained within that grid cell.
Data	Climate data from European Centre for Medium-Range Weather Forecasts (ECMWF), ERA-Interim project.[5] Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[6]
Future Form of Indicator	Future versions of this indicator are expected to migrate to ECMWF ERA5 climate data source.
Additional information	 *Figure 3: Mean summer warming relative to the 1986–2005 average.*

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.1: Health and heat
Sub-Indicator	1.1.3: Health and exposure of vulnerable populations to heatwaves
Methods	The methodology for this indicator remains similar to that described in the 2018 Lancet Countdown report appendix,[1] with improved resolution for the 2019 report. A heatwave was defined as a period more than 3 days at a given location where the minimum daily temperature was greater than the 99th percentile of the distribution of minimum daily temperature at that location over the 1986-2005 reference period for the summer months. Calculations were performed on a 0.5° global grid using ERA-Interim data. The gridded 99th percentile of daily minimum temperature was calculated for 1986-2005. For each year from 1986 to present, the number of heatwave events and total days of heatwaves per year was calculated according to the definition above. For each year from 2000 to present, the change in number of occurrences and number of days of heatwaves was calculated. The vulnerable population was defined as people over the age of 65. Gridded population and demographic data from GPWv4 was used. The change in exposures in person-events was calculated for each year by multiplying the change in number of heatwave events by the number of vulnerable people per grid cell. Additionally, the mean change in length of heatwaves weighted by vulnerable population was calculated.
Data	Climate data from European Centre for Medium-Range Weather Forecasts (ECMWF), ERA-Interim project.[5] Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[6]
Future Form of Indicator	Future versions of this indicator are expected to migrate to ECMWF ERA5 climate data source.

Working Group	1: Climate Change Impacts, Exposures and Vulnerability
Indicator	1.1: Health and heat
Sub-Indicator	1.1.4: Change in labour capacity
Methods	Global gridded (0.5°) three hourly temperature, dew point temperature and surface solar radiation downwards was used to calculate wet bulb globe temperature (WBGT) WBGT indoors (or outdoors in the shade) and WBGT outdoors in the sun. The WBGT calculator used was downloaded from www.climatechip.org. A productivity loss function derived from experimental data was used to quantify the productivity loss with increasing WBGT. The function relating the fraction of total work hours lost to Wet Bulb Globe Temperature (WBGT) is given by the cumulative normal distribution function: $$Loss\ fraction = \frac{1}{2}\left(1 + \mathrm{ERF}\left(\frac{\mathrm{WBGT} - \mathrm{Prod}_{\mathrm{mean}}}{\mathrm{Prod}_{\mathrm{SD}} * \sqrt{2}}\right)\right)$$ Where WBGT is WBGTmax, WBGTmean or WBGThalf and the parameters for a given activity level (defined as the amount of internal heat generated in performing the activity) are given in Table 1. Labour is divided into three sectors: service (activity level of 200W), industry (300W), and agriculture (400W). The loss curves for 200W, 300W, and 400W are shown in Figure 1. Table 1. Input values for labour loss fraction **Work level** | ***Productivity** mean* | ***Productivity** SD* **200** | 35.53 | 3.94 **300** | 33.49 | 3.94 **400** | 32.47 | 4.16 This fraction of work hours lost are clipped at both extremes. People take micro-breaks during normal work so when the function predicts 10% or less work hours lost it is assumed zero work hours are lost. It is further assumed that people always have some capacity for work, no matter what the conditions so it is assumed that a 90% of work hours lost is a maximum. The corresponding adjusted loss fraction is therefore given by: $$Adjusted\ loss\ fraction = \begin{cases} 0, if\ Loss\ fraction < 0.1 \\ Loss\ fraction, if\ 0.1 \leq Loss\ fraction \leq 0.9 \\ 0.9, if\ Loss\ fraction > 0.9 \end{cases}$$ The number of people in each grid cell working in each sector was then estimated from the working population of that grid cell and the approximate percentage of people working in each sector. This is then multiplied by the potential work hours lost per

	person to obtain the total population weighted hours lost in that grid cell. The total work hours lost (WHL) are then summed for global totals or country totals. To obtain the "equivalent full-time workers lost", potential WHL are divided by 4380 – the potential maximum daylight hours that can be worked per year.
Data	Climate data from European Centre for Medium-Range Weather Forecasts (ECMWF), ERA-Interim project.[5] Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[6] Sector employment from ILO.[7]
Caveats	The distribution of agricultural, manufacturing and service sector workers is only reported at country level, hence this proportion is distributed evenly to all grid cells. In the future this indicator will have finer detail on the sector employment. Potential full-time work lost assumes 12 hours a day, 365 days a year. Future versions of this indicator shall work to estimate potential full-time equivalent work lost, by linking potential WHL with average annual hours worked by country and sector.
Future Form of Indicator	This indicator will be updated in future to show the number of workers affected globally and in larger countries (eg China and India).
Additional information	*Table 1: The trend in potential work hours lost for the 3 sectors with the service sector assumed to work at a metabolic rate of 200W, the manufacturing sector at 300W and the agricultural sector at 400W.*

Year	Agriculture	Industry	Service	Total
2000	80.7	7.4	0.7	88.8
2001	84.2	7.9	0.8	92.9
2002	90.3	10.1	1.2	101.7
2003	96.5	11.5	1.4	109.5
2004	85	9.4	0.7	95.1
2005	94.2	12	1.5	107.6
2006	92.9	12.2	1.2	106.3
2007	93.1	13.3	1.4	107.8
2008	75.7	9.2	0.8	85.6
2009	95.6	14.4	1.5	111.5
2010	113.4	19.1	2.2	134.7
2011	81.9	13	1.2	96.1
2012	87.7	15.6	1.8	105.2
2013	97	17.8	1.8	116.6
2014	97	18.3	2.2	117.6
2015	102.1	19.4	2	123.5
2016	125.7	27.3	3.6	156.6
2017	118.7	26.1	3.4	148.2
2018	106.4	24	3.2	133.6

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.2: Health and extreme weather events
Sub-Indicator	1.2.1: Wildfires
Methods	Fire point locations were matched to a political border shapefile from the Global Burden of Disease (version 2017)[8] with 195 defined nations. Population count per squared-kilometre was matched to the GBD global shapefile using the NASA GPWv4 dataset. For each country, the daily number of fire points were multiplied by the total population count within the corresponding grid point to estimate the number of persons exposed to a fire event in a day. The number of persons exposed to a fire event in a day per country were averaged for years 2001-2004 and 2015-2018 to give a change in person days exposed to fire.
Data	Collection 6 active fire product from the Moderate Resolution Imaging Spectroradiometer (MODIS).[9] This contains both Terra (from November 2000) and Aqua (from July 2002) pixels in the same annual file Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[6]
Caveats	The satellite data does not account for cloud cover or smoke and data is not collected at night. While observing the same fire, Terra and Aqua may report slightly different coordinates of the fire centroid, therefore introducing a double counting issue. Fire characteristics change every year, and a year to year comparison is not appropriate. The average of the first four years of available MODIS data acts as an initial starting point to compare later years to reflect change. However, the GPW population count was not interpolated and may results in higher uncertainties in estimation of persons exposed.
Future Form of Indicator	This indicator will be extended to longer term averages. Subnational estimates will be reported to better represent the populations at risk.
Additional information	 *Figure 4: Person-days exposed to fire by country in 2018.*

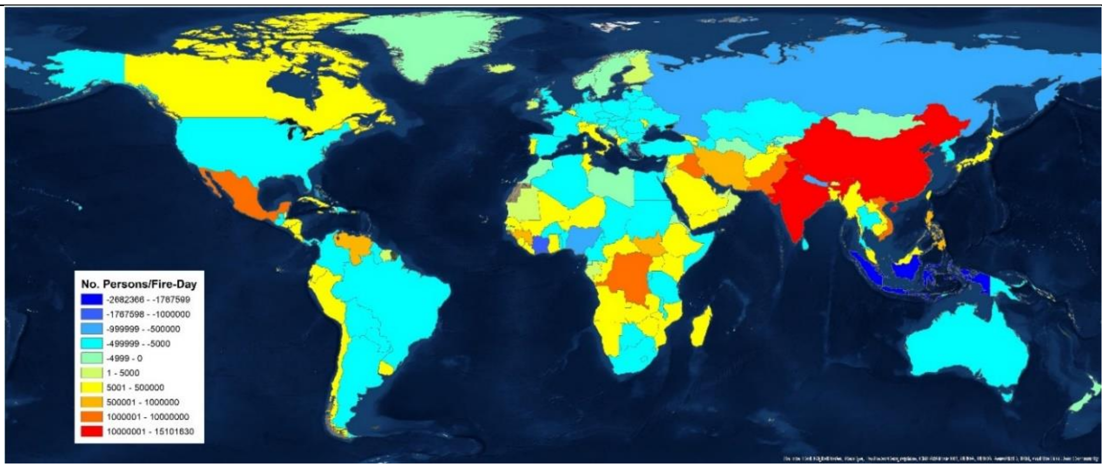


Figure 5: Average change in annual person days exposed to wildfires between 2001-2004 and 2015-2018.

Working Group	1: Climate Change Impacts, Exposures and Vulnerability
Indicator	1.2: Health and extreme weather events
Sub-Indicator	1.2.2: Flood and drought
Methods	The methodology for this indicator remains similar to that described in the 2018 Lancet Countdown report appendix,[1] with improved resolution for the 2019 report. **Drought** The drought indicator was based on the WMO-recommended Standard Precipitation Index (SPI),[10] based on the 6-month rolling sum of monthly precipitation. The index was calibrated using gridded monthly precipitation data covering the period from 1900-2005 from the CRU monthly precipitation dataset. A given month was defined as being in drought when the SPI for that month is less than -1.5. Yearly totals of months in drought were calculated on a 0.5° global grid. Exposure to drought was calculated using the GPWv4 gridded population dataset. The drought indicator is defined as gridded sum of months in drought times the gridded population and is given in units of person-months in drought. **Extreme rainfall** Extreme rainfall events are defined as starting when the 5-day rolling sum of daily precipitation exceeding the 10-year return level and ending when it dropped below this value. The rolling sum of precipitation was calculated for each day as the sum of the preceding 5 days total precipitation (in mm). The precipitation value corresponding to the 10-year return period was calculated using the method described the corresponding Lancet Climate Countdown 2018 appendix.[1] The baseline precipitation threshold was calculated by applying this method to daily total precipitation derived from ERA-Interim for the period 1986-2005. The number of extreme rainfall events per year in the period 2000 to present

	was calculated by counting the number of periods for each grid cell where the precipitation exceeded the baseline precipitation threshold, using the daily total precipitation derived from ERA-Interim. The number of exposure events was calculated by multiplying the number of extreme rainfall events by the number of people in each grid cell, given in units of person-events. Population data was derived from the NASA GWPv4.
Data	Climate data from European Centre for Medium-Range Weather Forecasts (ECMWF), ERA-Interim project;[5] and from the Climate Research Unit (CRU) climate dataset (University of East Anglia).[11] Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[6]
Caveats	Precipitation extremes are highly localised, as such significant impacts may not be evident from global mean trends alone. This section defines indicators of meteorological drought and flood risk, which must be understood to be a precursor and a necessary but not sufficient condition for the occurrence of agricultural and hydrological drought and flood.
Future Form of Indicator	Future versions of this indicator are expected to migrate to ECMWF ERA5 climate data source.

Working Group	1: Climate Change Impacts, Exposures and Vulnerability
Indicator	1.2: Health and extreme weather events
Sub-Indicator	1.2.3: Lethality of weather-related disasters
Methods	The methodology for this indicator remains the same as described in the 2018 report of the Lancet Countdown.[1] This indicator is based on the generic formulation from a climate change perspective of disasters as a function of hazard, exposure and vulnerability. Year to year variation was measured, showing the number of people killed as a proportion of those affected by different hazard type, normalised by the strength of the individual hazards as a measure of adaptive (or maladaptive) changes in national health care services and the associated disaster preparedness and response. Here, deaths are defined as the number of people who lost their life because the disaster happened, and people affected as those requiring immediate assistance during a period of emergency; hence requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance. The data has been presented as standardised anomalies, representing the difference between the variable that year and average of the variable from 1990-2009, normalised by the standard deviation of the variable over the same period. Only statistically significant (at 0.05 significance level) linear trends over time are shown.
Data	EM-DAT at the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain, Belgium[12]
Caveats	One underlying assumption is that the normalised number of people killed by climate related disasters is an accurate proxy for measuring health impacts of the climate. This measure ignores the longer causal chains involving the interaction of climate and health. Finally, a further limitation is that this measure ignores the longer causal chains involving the interactions of weather, climate, disasters, health and health services
Future Form of Indicator	Future efforts will include a comparison of estimates of those exposed with those affected. Additionally, the impact of replacing the number of people killed with the number requiring assistance also explored. A subsidiary indicator will come from the online Sendai Framework Monitor. Here countries will start reporting against the Sendai Framework indicators and the DRR related indicators of the SDGs. The first Sendai Framework and SDG progress report will be released in 2019. This indicator therefore aims to expand to include country specific progress in vulnerability levels of health service systems to climate risks in relation to this monitoring data.

Additional information	Significant increases in occurrences of flood and storm related disasters against the base period of 1990-1999 have occurred in Asia, Africa and the Americas.

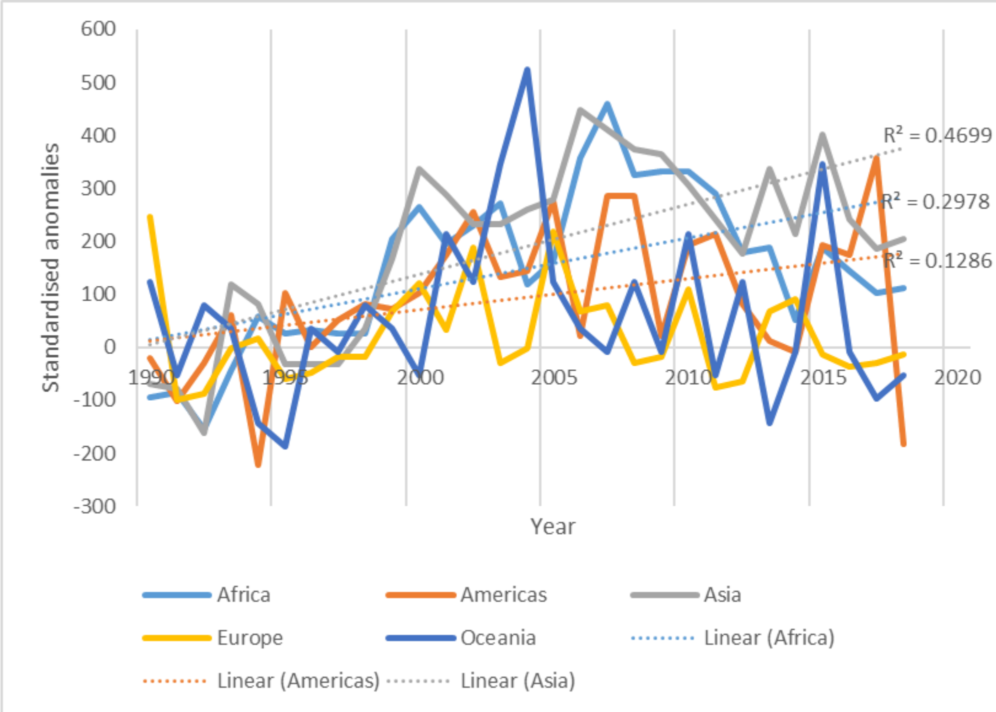


Figure 6: Time series of occurrences of flood and storm related disasters. Dashed lines and R^2 values present the linear relationship between time and the frequency of event occurrences in Africa, the Americas and Asia

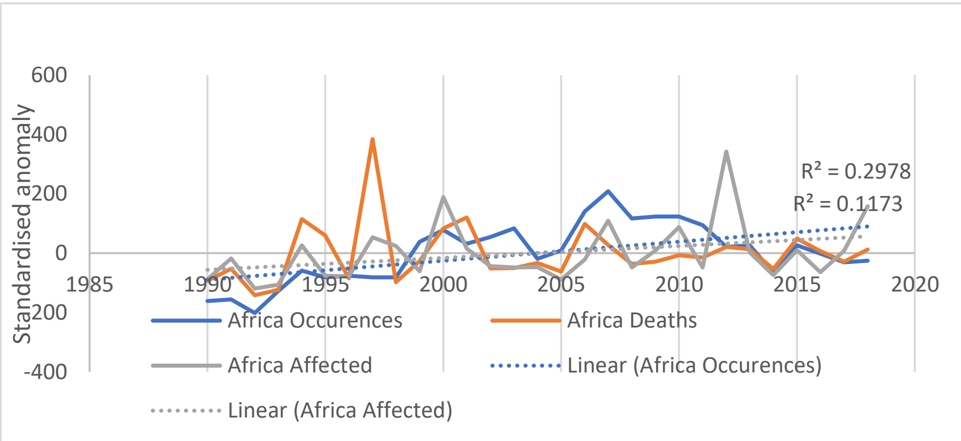


Figure 7: Time series of standardised anomalies of the deaths, occurrences and number of people affected by flood and storm hazard related disasters in Africa.

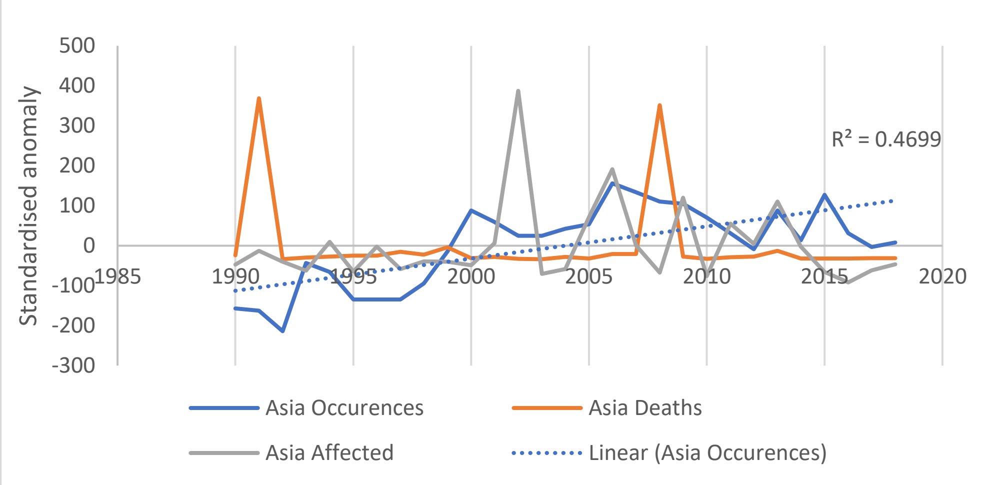


Figure 8: Time series of standardised anomalies of the deaths, occurrences and number of people affected by flood and storm hazard related disasters, in Asia

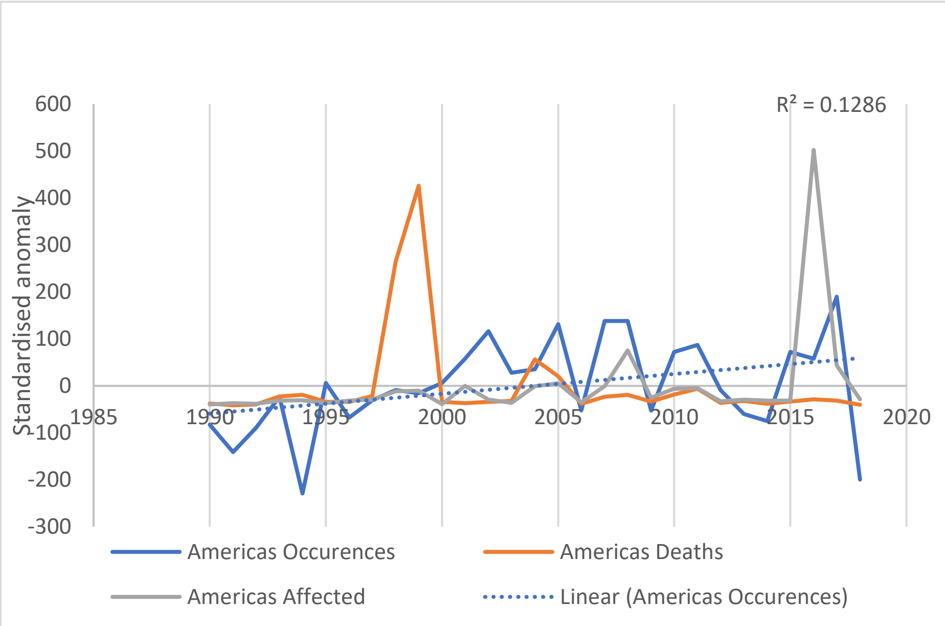


Figure 9: Time series of standardised anomalies of the deaths, occurrences and number of people affected by flood and storm hazard related disasters, in the Americas.

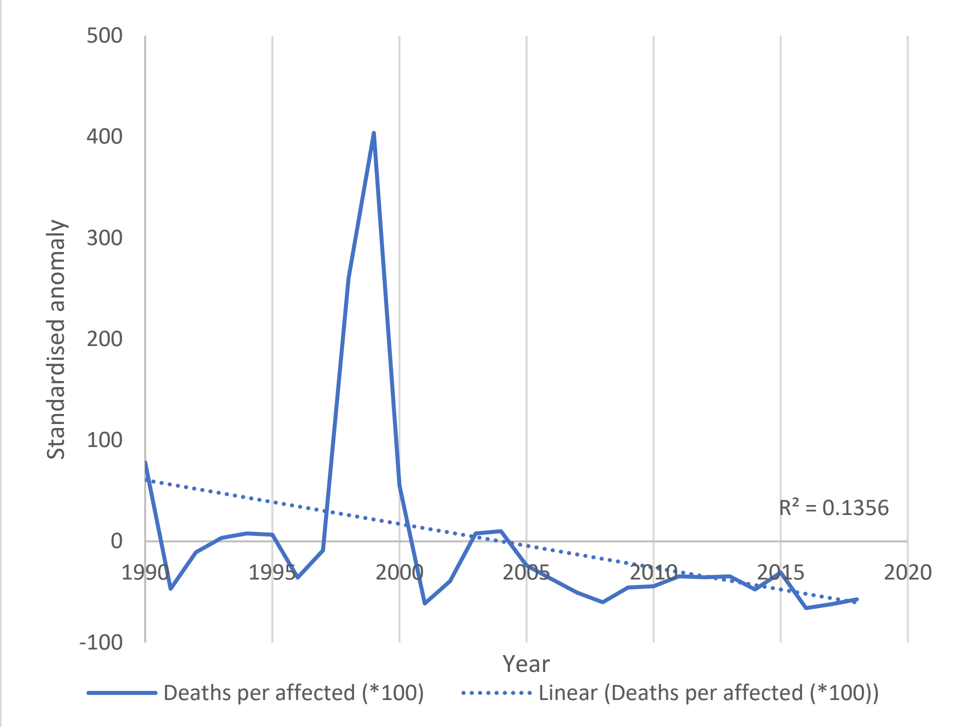


Figure 10: Time series of standardised anomalies of the ratio of deaths to number of people affected by flood and storm hazard related disasters, in the Americas.

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.3: Global health trends in climate-sensitive diseases
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix.[1] This indicator displays generally unprocessed descriptive trends for selected diseases retrieved from The Global Burden of Disease (GBD) project database over the period 1990-2017.[8] The derivation of estimates within the GBD study relies on modelling, rather than analysing direct observations, and the GBD methodology has already been described.[13] The trends are aggregated and presented by WHO region as mortality rates per 100,000 individuals per year over the period. As far as can be ascertained from the GBD documentation, climate change and weather are not part of the covariates included in the estimates, making it valid to examine GBD outputs in the light of climate and weather data to formulate coherent inter-country comparisons. Trends are described for: all causes of death, malaria, dengue, diarrhoeal diseases, protein-energy malnutrition, heat and cold exposure, and forces of nature. Deaths directly related to forces of nature have been adjusted for the effects of the most severe seismic events and related tsunamis. Years with events reported to have caused a substantial death toll from 1990 to 2016 where discounted by replacing with the same countries' force of nature mortality for the previous year.
Data	Global Burden of Disease Study 2017[8]

Caveats	This is not a direct measure of the impact of climate change on death and disease. Rather, it presents mortality figures for those diseases which are none to be influenced by climate. The trends presented therefore do not show detection and attribution of climate change to death. They do show the impact of climate relevant and climate sensitive diseases on mortality rates globally since 1990.
Future Form of Indicator	GBD estimates are now revised annually. Future versions of this indicator may include additional health conditions, may include morbidity as well as mortality, and may extend to national and subnational scales. Increased interest in geo-spatial disease analyses is likely to lead to additional information, such as fringe zone trends and outbreaks, and associate patterns of diseases to climate anomalies, such as those driven by the ENSO circulation. Future disease trends in the GBD estimates will be linked to direct measurements in resource poor areas in Africa and Asia, for example using longitudinal mortality registers from the INDEPTH network.[13]

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.4: Climate-sensitive infectious diseases
Sub-Indicator	1.4.1 Climate-sensitive infectious diseases - **dengue**
Methods	*Context:* Cases of dengue have doubled every decade since 1990, with 58·4 million (23·6 million–121·9 million) apparent cases in 2013, accounting for over 10,000 deaths and 1·14 million (0·73 million–1·98 million) disability-adjusted life-years.[14] Beside global mobility, climate change has been suggested as one potential contributor to this increase in burden.[15] *Aedes aegypti* and *A. albopictus,* the principal vectors of dengue, also carry other important emerging or re-emerging arboviruses, including Yellow Fever, Chikungunya, Mayaro, and Zika viruses, and are likely to be similarly responsive to climate change. *Methods:* Methods for calculating vectorial capacity (VC) follow Rocklöv et al. (2019).[16] VC refers to a vector's ability to transmit disease to humans. It incorporates interactions between host, virus, and vector, assuming that all three of these elements are present. Specifically, VC represents the average daily number of secondary cases generated by one primary case introduced into a fully susceptible population, and is expressed as: $$VC = ma^2 b_m p^n / -lnp$$ where *a* is the average vector biting rate, b_m is the probability of vector infection and transmission of virus to its saliva, *p* is the daily survival probability, *n* is the duration of the extrinsic incubation period – EIP, and *m* is the female vector-to-human population ratio. Here *m* is set to 1 assuming female vector and human population are constant. Detailed model description and explanation can be found in Rocklöv et al. (2019).[16] In this application, the time unit is 1 day and each of the vector parameters depends on temperature, with parameter values derived from the literature, typically from experimental data, as described in Liu-Helmersson et al., (2014).[17] Diurnal temperature range (DTR) was reconstructed using a representative daily temperature through a

piece-wise sinusoidal function based on the monthly average of daily minimum, maximum, and mean observations.

Historical trends were derived by backcasting the models on data from the Climate Research Unit (CRU) online database, time series (CRU-TS 3.22) of gridded (0.5°) monthly averages of daily temperature observations (minimums, maximum, and mean) for the time period 1950-2017.

Future projections were derived using climate data under two greenhouse gas emission pathways (RCP2.6 and RCP8.5),[18] representing the contrast between very strong mitigation action vs. business-as-usual given consequent radiative forcing of greenhouse gases in the year 2100 (+2.6 and +8.5 W m^{-2}, respectively), based on CMIP5 atmosphere-ocean general circulation models.[19,20] For each emission pathway, CMIP5 temperature datasets (min, max, mean resolution 0.5 × 0.5°) were used. Calculations from each of the five global models (NorESM1-M, MIROC-ESM-CHEM, IPSL-CM5A-LR, HadGEM2-ES, and GFDL-ESM2M) were averaged to derive a multi-model ensemble.

The annual average VC were extracted values per grid cell to *Aedes aegypti* and *Aedes albopictus* presence locations provided in Kraemer et al. (2015)[21] and averaged these values by country to get country-specific trends in VC at monthly (seasonality analysis) or yearly time steps from 1950-2017 for each species. 'Global vectorial capacity' indicates globally averaged values across all countries.

Historical percentage change figures reported in the main text were calculated relative to a 1950s baseline (5 year average, 1950-54), either an average for the 2010s (5 year average, 2013-2017) to illustrate the overall trend accounting for interannual variability or for the most recent year for which data were available (2017). Projected percentage changes in VC for each vector in 2030 (taken from 5yr average 2028-2032) was calculated relative to a present baseline (5 yr average 2013-2017).

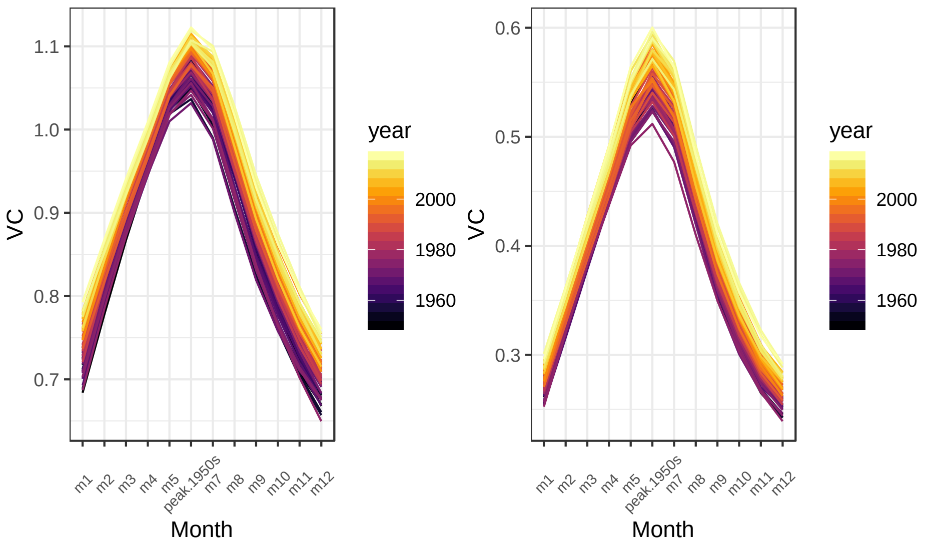


Figure 11: Change in seasonality of global vectorial capacity for the dengue vectors Aedes aegypti (left) and A. albopictus (right) in the period 1950-2017.

To produce this plot, all countries in the analysis have been centred around their 'peak month' as per a 1950 baseline. The plot illustrates that VC is increasing on average in all months of the year, reflecting higher maximum values and broader seasons.

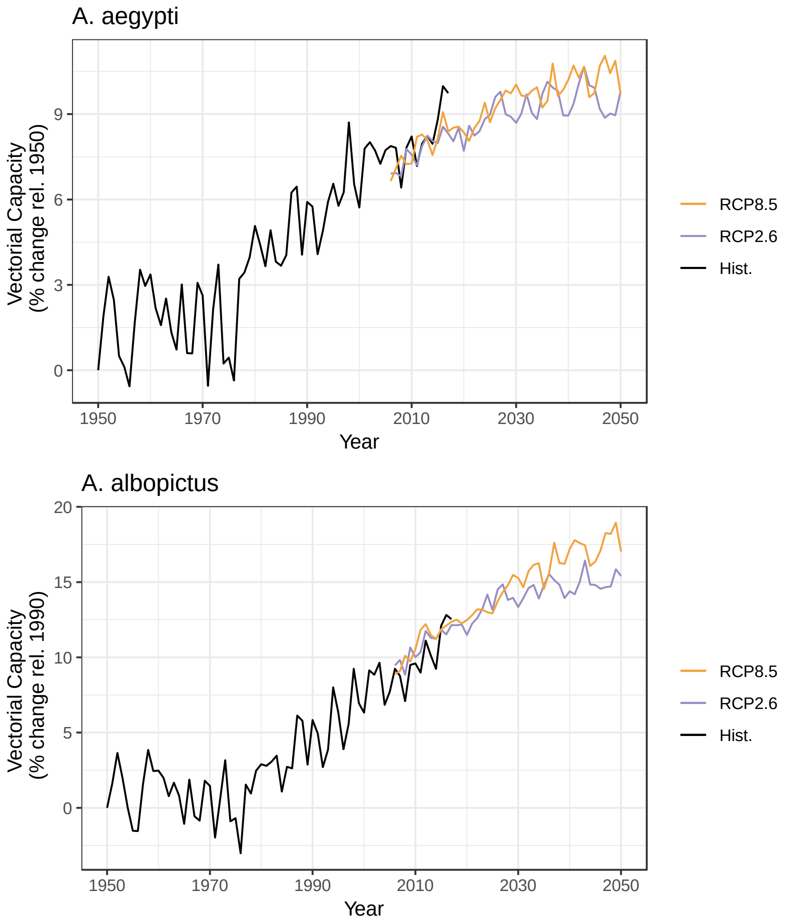


Figure 12: Changes in global vectorial capacity for the dengue virus vectors Aedes aegypti and A. albopictus since 1950. Projections to 2050 are also shown for two RCP scenarios (8.5 is equivalent to a 'business-as-usual' high emissions pathway while 2.6 is a strong mitigation pathway, such that the difference illustrates the effect of GHG emissions on disease risk).

Caveats	Key caveats and limitations of the VC model and its parameterisation are fully described in Liu-Helmersson et al. (2014, 2016)[17,22] and Rocklöv et al., (2019).[16] VC should not be confused with actual dengue cases, although it is an indicator of the risk of infection.
Future Form of Indicator	The disease indicators will be reported upon annually and assessed against the baseline data and trends presented here. Other climate-sensitive infectious diseases in addition to malaria, *Vibrio*, and dengue will be added through time and the current indicators refined. In future, it is intended to expand efforts to project trends (as for dengue) using available models (e.g., RCPs from AR5). In addition, efforts will expand to link environmental suitability information to disease outcomes e.g., via disease case or surveillance data. Numerous jurisdictions currently already undertake indicator (e.g., annual country- or regional-level reporting of confirmed human cases), event-based (e.g., outbreak investigation and 'epidemic intelligence'), and biosecurity (e.g.,

	sentinel site) surveillance for infectious diseases, vectors, or key zoonotic hosts. Many of these datasets and methods of analysis could be made available and leveraged in future for the Lancet Countdown. For example, EU member states already report cases of notifiable diseases, zoonotic diseases, and outbreaks of food-borne and zoonotic disease, while vector surveillance remains voluntary.[23]

Working Group	1: Climate Change Impacts, Exposures and Vulnerability
Indicator	1.4: Climate-sensitive infectious diseases
Sub-Indicator	1.4.1 Climate-sensitive infectious diseases - **malaria**
Methods	*Context* Temperature, precipitation and relative humidity are climatic factors that impact the abundance and feeding cycle rate of *Anopheles* mosquitoes, which transmit the *Plasmodium* parasites that cause malaria. Temperature also drives the development rate of *Plasmodium* parasites within the mosquito vectors[24]Temperatures within the range 18°C to 32°C are considered most suitable for *P. falciparum,* while a lower temperature limit of 15°C has been reported for *P. vivax*.[25] Below these lower limits the development of the parasite ceases while above 32°C the survival of the mosquito is compromised. Relative humidity greater than 60% is also considered as a requirement for the mosquito to survive long enough for the parasite to develop sufficiently to be transmitted to the human host stage. Rainfall and surface water are needed for the egg laying and larval stages of the mosquito life cycle, with monthly rainfall accumulation of at least 80mm considered more suitable for transmission.[24] A recent study found a significant increase in elevation of the lower temperature limits for the development of malaria parasites in Ethiopia.[26] Increasing temperatures in the region are eroding the perceived barrier to malaria transmission, allowing more favourable conditions to begin climbing into densely populated highland areas. Highland areas are the most densely populated agro-climatic zone in sub-Saharan Africa, occupying just 4.4% of the land area but 19.4% (44 million) of the population. The malaria indicator focuses on determining global changes in climate suitability over time between highland and lowland areas in regions that have not yet achieved elimination. *Methods* The number of months suitable for malaria transmission per year from 1950 – 2017 was calculated globally. Suitability is based on empirically-derived thresholds of precipitation, temperature and relative humidity for two primary parasites causing malaria (*Plasmodium falciparum*, *P. vivax*). Monthly observations of temperature, precipitation and vapour pressure data from the Climate Research Unit (CRU TS4.01)[11] were downloaded using the KNMI Climate Explorer.[27] The variables were extracted at a 0.5° spatial resolution over land. Elevation data at a 0.5° spatial resolution was obtained from JISAO, University of Washington.[28] Following New et al., (2002), relative humidity (RH) was estimated using the formula:

$$RH = \frac{e}{e_{sat}} \times 100,$$

where e is vapour pressure and e_{sat} is saturated vapour pressure (in hPa) at mean air temperature *T* in °C, given by:

$$e_{sat} = 6.108 \exp\left[17.27\, T / (237.3 + T)\right].$$

Climatic suitability was defined as the coincidence of precipitation accumulation greater than 80 mm, average temperature between 18°C and 32°C, and relative humidity greater than 60% for *P. falciparum*.[24] Suitability for *P. vivax* was calculated using the same thresholds with the exception of a lower average temperature limit of 15°C.[24,29] The combined values are an indication of the lower limit for potential malaria transmission for each species.

The mean number of months per year with suitable climate conditions for malaria transmission was then calculated across 3 continents (Africa, Asia, and the Americas) according to the dominant parasite present (Africa = *P falciparum*, other regions = *P. vivax*).[30]The analysis by malaria management status was further subdivided following country classifications from Newby et al. (2016)[31] who classified countries in the following categories: malaria controlling, malaria eliminating, or malaria free (Figure 13) A time series was included for the category malaria controlling countries in Latin America, Africa and Asia (see main text).

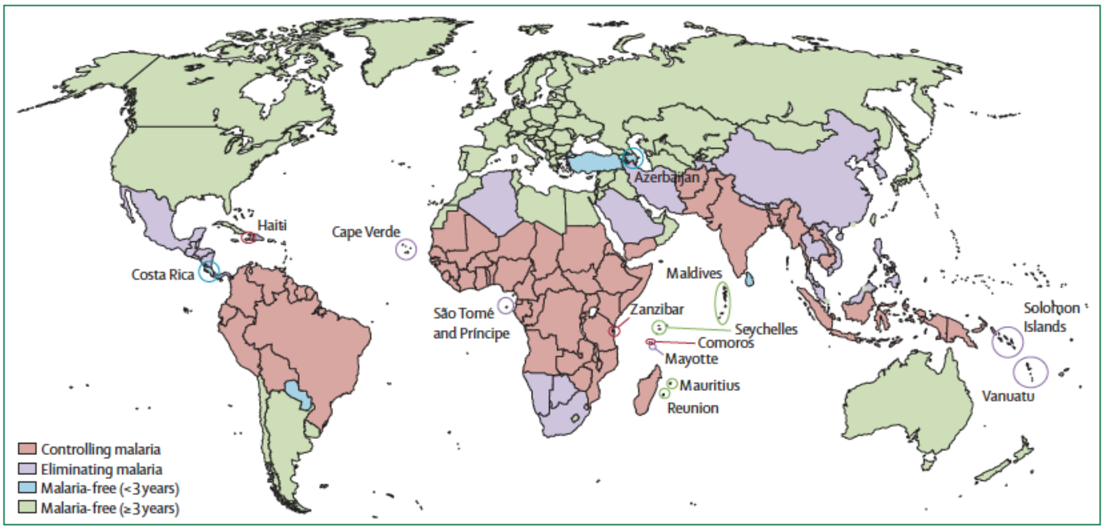


Figure 13: Categorisation of countries as malaria-free, eliminating malaria, or controlling malaria, 2015.[31]

In addition to management status, the analysis was stratified by elevation to contrast trends in highland areas (>=1500m) and lowland areas (<1500m). The percentage change figures reported in the main text were calculated relative to a 1950s baseline (5 year average, 1950-54 compared to 5 year average, 2013-2017) to illustrate the overall trend accounting for interannual variability.

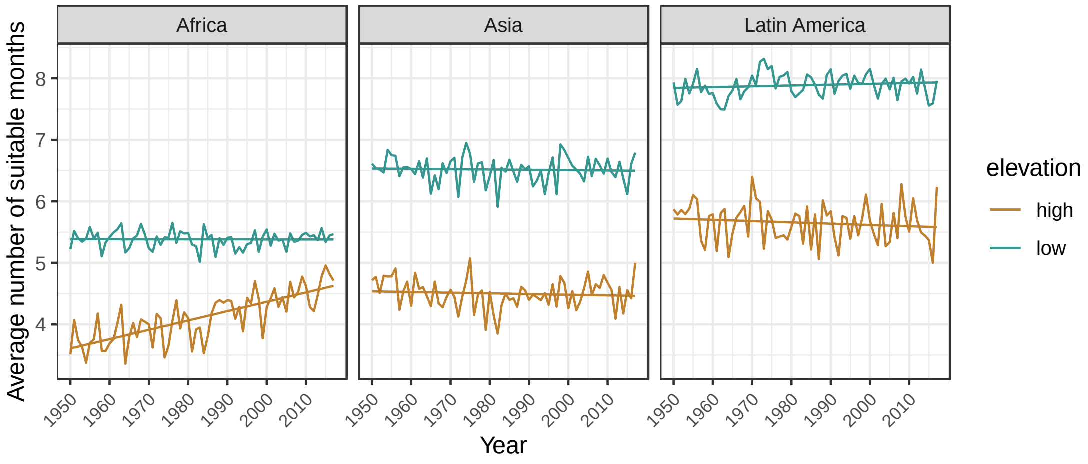


Figure 14: Environmental suitability for malaria 1950 to 2017, grouped by continent and elevation (high >=1500m, low <1500m). Results are for the dominant malarial parasite in each region (P. falciparum in Africa; P vivax in other regions).

Caveats	These results are based on climatic data, not malaria case data. The malaria suitability climate thresholds used are based on a consensus of the literature. In practice, the optimal and limiting conditions for transmission are dependent on the particular species of the parasite and vector.[24]Control efforts might limit the impact of these climate changes on malaria or conversely, the climate suitability may either enhance or hamper control efforts.[32]

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.4: Climate-sensitive infectious diseases
Indicator	1.4.1 Climate-sensitive infectious diseases - ***Vibrio***
Methods	*Context* *Vibrio* spp. are globally distributed aquatic bacteria that are ubiquitous in warm estuarine and coastal waters with low to moderate salinity. *V. parahaemolyticus, V. vulnificus*, and non-toxigenic *V. cholerae* (non-O1/non-O139) are pathogenic in humans. These *Vibrio* species are associated with sporadic cases of gastroenteritis, wound infections, ear infections, or septicaemia in circumscribed localities. *Vibrio* ecology, abundances, distributions, and patterns of infection are often strongly mediated by environmental conditions. Water temperature, salinity, and turbidity predict the distribution and abundance of *V. vulnificus* in Chesapeake Bay, with the number of infections increasing as a result of recent local warming and changes in rainfall.[33] Increased water temperatures also explain outbreaks of *Vibrio* infections in countries bordering the Baltic Sea,[34] and range expansions in Alaska.[35] This indicator focuses on mapping environmental suitability for pathogenic *Vibrio* spp. in coastal zones globally (<30km from coast). *Methods*: The indicator uses thresholds of >18°C for Sea Surface Temperature (SST) and <30 PSU for Sea Surface Salinity (SSS). These values were derived on the basis of a consensus in the literature.[36-38] Estimates for SST were obtained from NOAA Optimum Interpolation 1/4

Degree Daily Sea Surface Temperature (OISST) Analysis version 2 for the period 1982-2017. This dataset is provided by the NOAA/OAR/ESRL PSD.[39] The salinity fields were created from daily data obtained from Mercator Ocean Reanalysis.[40]

Here suitability is reported at two levels. First, it was calculated the percentage of coastline globally that experienced suitable conditions for *Vibrio* infections and summarised the results across three latitudinal bands (northern latitudes = 40-70°N; tropical latitudes = 25°S-40°N; and southern latitudes = 25-40°S). Second, suitability in two focal regions in which human *Vibrio* infection is frequently observed, the Baltic Sea and the northeastern coast of the United States (36-50°N) were calculated. For the Baltic (main text) and northeastern coast of the United States coast the percentage of coastline suitable for *Vibrio* infections are presented. In addition, the number of days per year suitable for outbreaks is presented for the Baltic (main text). The percentage change figures reported in the main text were calculated relative to a 1980s baseline (5 year average, 1982-86), either an average for the 2010s (5 year average, 2014-2018) to illustrate the overall trend accounting for interannual variability or for the most recent year for which data were available (2018).

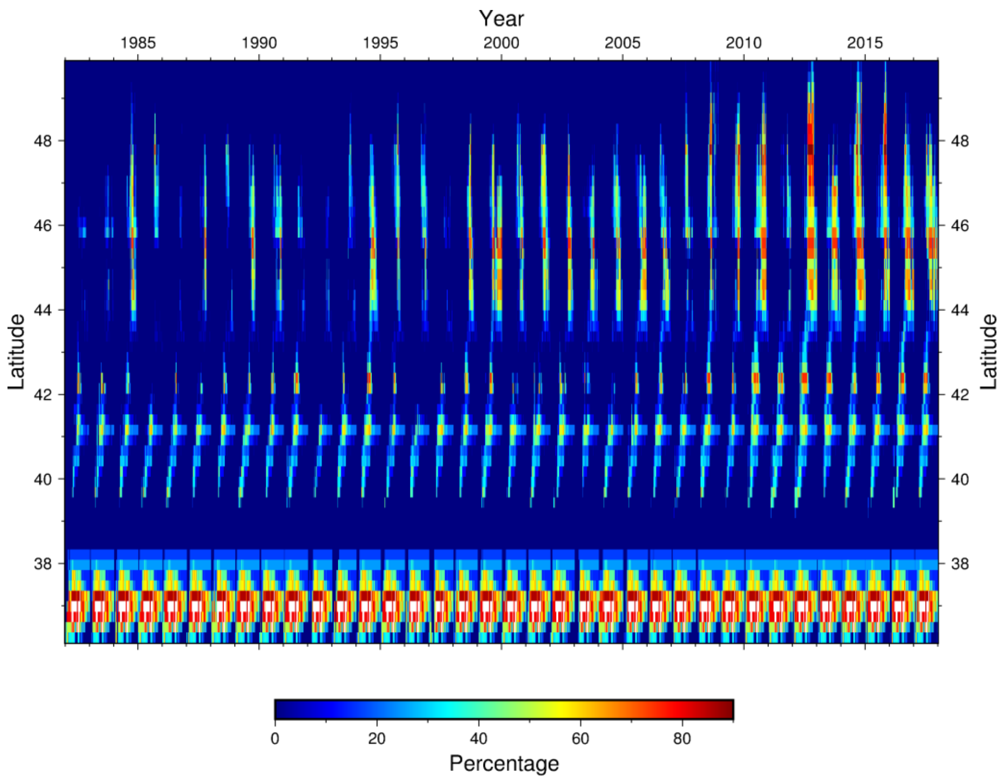


Figure 15: Percentage coastline suitable for Vibrio spp., V. parahaemolyticus, V. vulnificus, and non-toxigenic V. cholerae (non-O1/non-O139), by latitude along the United States northeast coastal region (36N-50N).

This Latitude-time plot (Hovmoller diagram, Figure 15) indicates poleward expansion of suitable environments for *Vibrio* spp. in this region. For latitudes >39 and similarly to the Baltic Sea, there is a general widening of the *Vibrio* spp. season as well as an increase in the amount of shoreline affected.

Caveats

The results are derived on the basis of suitable SST and SSS conditions only, and do not include other potentially important drivers (e.g. globalisation), environmental predictors of

	pathogenic *Vibrio* infections (e.g., cholorphyll-*a*, turbidity) nor disease case data. Nevertheless, these associations have been explored and are reported in the supporting references included above. In the global analysis, the slope of the trendlines over the time series is mostly flat for the tropical/subtropical region and the southern Hemisphere. However, the SST-only suitability shows a strong upward trend in the southern hemisphere, indicating that on average temperature conditions are also improving growth conditions for *Vibrio* in these areas, while SSS is generally limiting. However, locally suitable SSS conditions will also occur in these regions on the basis of, for example, variation in local rainfall and river runoff, which can make these regions sporadically suitable for *Vibrio* infections.

Working Group	1. Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.4: Climate-sensitive infectious diseases
Sub-Indicator	1.4.1 Climate-sensitive infectious diseases – ***Vibrio cholerae***
Methods	*Context:* Cholera is a water-borne disease caused by the bacterium *Vibrio cholerae*, which generally occurs in brackish riverine, estuarine, and coastal waters (Colwell and Huq 2001). Toxigenic *Vibrio cholerae* is responsible for epidemic cholera, while non-toxigenic *Vibrio cholerae* is responsible for sporadic cases of mild gastroenteritis, but not cholera. Improvements in water sanitation and health care services (e.g. oral cholera vaccine) have facilitated the control of cholera worldwide.[41] However, the ongoing, 7th cholera pandemic has an estimated burden of ~2.8 million cases annually that result in ~95,000 deaths per year, mainly in Africa.[42] Cholera control is achievable via safe drinking water, vaccines, and effective outbreak response. Hence, epidemics emerge under scenarios of pathogen introduction, political instability, war, and extreme water events in already fragile countries. Cholera prevention requires the understanding of the distribution and availability of its pathogen, toxigenic *Vibrio cholerae*, and the role of the environmental conditions that facilitate or limit *V. cholerae* emergence and persistence. The abundance of *V. cholerae* is associated with increases in SST and phytoplankton in coastal waters.[43] Thus, the distribution *V. cholerae sensu lato* was reconstructed using an ecological niche modelling approach linking *V. cholerae* reports and fine-scale sea surface temperature and phytoplankton in coastal waters during the last 15 years, assuming niche conservatism among toxigenic and non-toxigenic lineages. *Methods:* Analyses were performed following the protocols described by Escobar et al. (2015)[44] to estimate suitable sea waters for *V. cholerae* under climate variability. The environmental tolerances of *V. cholerae* were determined based on Escobar *et al.* (2015) reports of *V. cholerae* in coastal waters and an ecological niche model based on sea surface temperature and chlorophyll-*a*, which have been found to be main drivers of *V. cholerae* occurrence.[43-45] Annual mean, range, maximum, and minimum values of these oceanographic variables were estimated between 2003 and 2018 to compile 15 years of seawater conditions at 4 km^2 cell size in the exclusive economic zone of each country around the world (Figure 16).

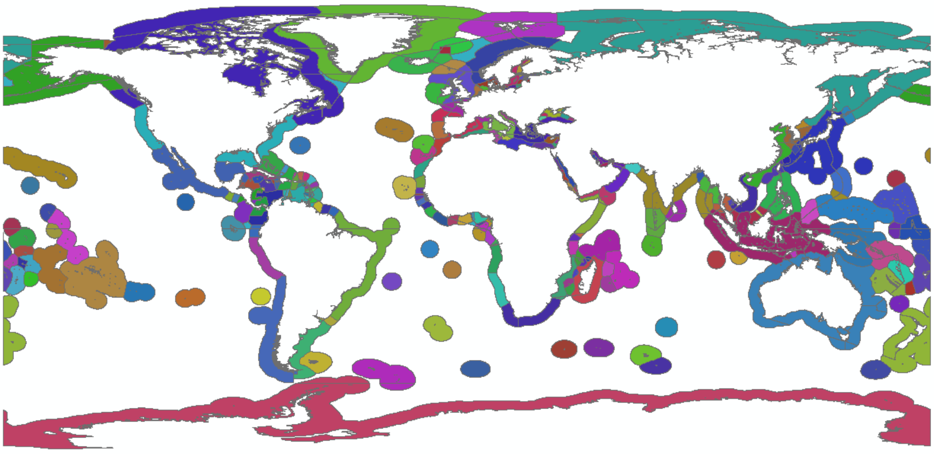


Figure 16: Exclusive economic zone of each country around the world.

A distance of ~200 miles was calculated off the coast of each country to resemble the exclusive economic zone defined by the United Nations with country borders defined elsewhere (Figure 16).[46]

Suitable seawater conditions for *V. cholerae* were determined by estimating the realised ecological niche of the bacterium. The realised ecological niche was reconstructed by linking *V. cholerae* reports with sea surface temperature and chlorophyll-*a* values from year 2003 as proxies of abiotic and biotic factors respectively.[47] Niche models were developed in a calibration of 100 km around each *V. cholerae* report as a proxy of the pathogen's potential dispersal.[44] Models were done using Maxent, a machine learning algorithm.[48] The Maxent version integrated in the *kuenm* package in R was used to develop a large population of candidate models from which to select the best model. Candidate Maxent models included different regularisation multipliers (i.e., 0.1, 0.5, 1, 1.5, 2) and diverse combinations of model features (i.e., linear, quadratic, threshold, product, hinge). The most parsimonious and significant model was selected as best model.[49] Specifically, the best model was selected based on Akaike information criterion, p-value, and omission rates.[49,50]

The final 2003 model was then projected to all the consecutive years to generate a time-series analysis of suitable coastal areas for *V. cholerae* between 2003 and 2018. Models were projected using model extrapolation and strict model transference in Maxent.[51] The original continuous values of the models (i.e., *V. cholerae* suitability index ranging from 0 to ~1) were converted to binary (i.e., suitable or unsuitable for *V. cholerae*). Binary models were generated using a threshold of 5% omission rate, which removes 5% of the lowest calibration values as a proxy of $\alpha = 0.05$, generally used in statistics.[52] The total area suitable for *V. cholerae* by country was used as a proxy of cholera transmission risk. Complementarily, for continuous models, the average *V. cholerae* suitability index was estimated by country as a proxy of coastal areas where the bacterium could successfully establish. Values of suitability were used to generate locally weighted scatterplot smoothing of risk vs. time.

Data	Data of sea surface temperature and chlorophyll-*a* across coastal areas were collected from the MODIS sensor in the Aqua satellite—launched in 2002 and part of the NASA Earth Observing System. Data were obtained at 4 km^2 spatial resolution and monthly temporal resolution during the period 2003-2018 and available at https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdMH1sstdmday.html for sea

	surface temperature and at https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdMH1chlamday.html for chlorophyll-*a*. Monthly averages from sea surface temperature and chlorophyll-*a* layers (i.e., Level 3 MODIS) were used to estimate annual mean, range, maximum, and minimum values for each variable for each year. These values were used during model calibration.
Caveats	*Vibrio cholerae* is not habitually surveyed in coastal waters or in environmental samples in general.[45] Instead, most *V. cholerae* reports originate from human cases in inland areas. The limited number of reports used in this modelling framework could result in an underestimation of the epidemiological potential of *V. cholerae* in coastal waters around the world. To mitigate this limitation, Maxent models were calibrated and projected allowing extrapolation to reduce overfit to the observed values. Beyond the presence of toxigenic *V. cholerae*, cholera epidemics require a number of non-climate related factors linked to population vulnerability (e.g., WASH failure, conflict, unsafe drinking water). Thus, this assessment focused in one component of cholera transmission risk, the plausible environmental suitability for *V. cholerae* in coastal waters. Finally, *V. cholerae* was modelled at the species level, assuming that toxigenic and non-toxigenic lineages would respond similarly to environmental conditions.
Future Form of Indicator	Sea surface temperature and chlorophyll-*a* conditions in future years will allow to determine percentages of change and their location in coastal waters around the world. New satellite-derived data will allow determining whether trends observed in this analysis are consistent in the coming years.
Additional Information	Results indicate that while some locations show stability or decrease in their suitability for *V. cholerae*, overall, a consistent trend to increase *V. cholerae*'s coastal suitability was detected at global scale, with a particularly strong signal for the past five years.

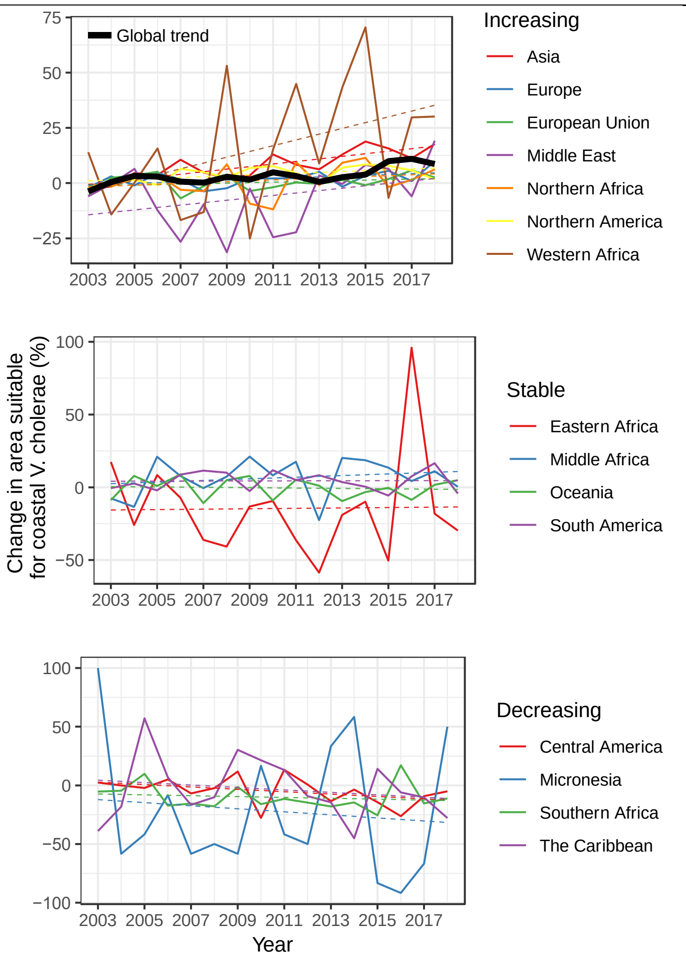
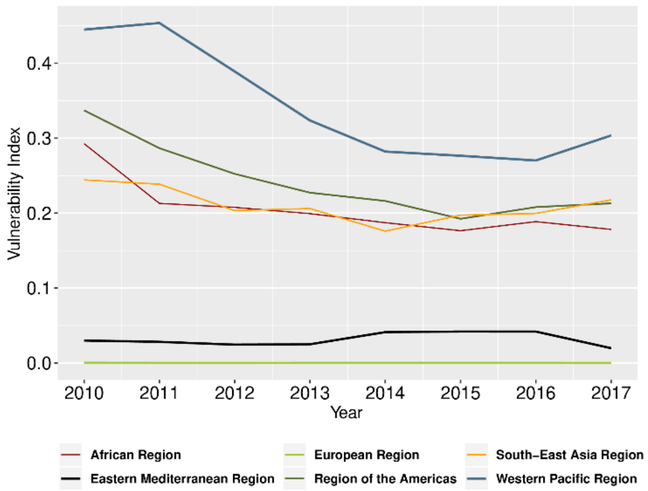


Figure 17: Change in suitability for Vibrio cholerae as a result of changing sea surface temperatures and chlorphyll-a concentrations. Top panel: Regions with an increasing trend (thick black line is the global trend); Middle panel: Regions with a stable trend; Lower panel: Regions with a decreasing trend. Regions are based on continental groupings of seawaters in countries' exclusive economic zones (EEZs).

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.4: Climate-sensitive infectious diseases
Sub-Indicator	1.4.2: Vulnerability to mosquito-borne diseases
Methods	This indicator computes adaptive capacity of a given country to manage threats posed by infectious diseases, taking into account core competency in key areas. The key areas are in surveillance, legislation, food safety, human resources, laboratory, point of entry, response, preparedness, risk communication and zoonosis which form part of International Health Regulations (IHR) Core Capacity Monitoring Framework.[53,54]A composite index was computed by taking average of the 11 core

	competencies. The average core capacities outlined in the monitoring framework has shown protective to outbreak risk.[55] Specifically, this indicator displays how the vulnerability to mosquito-borne outbreaks transmitted by the *Aedes aegypti* vectors relates to transmission potential by the vectorial capacity and systemic resilience to infectious outbreaks by the core capacities. Its estimated for each country and then aggregated by WHO regions. The IHR core capacities data covers the period 2010-2017, so trends for this period are presented. Vulnerability was computed by taking the vectorial capacity (VC) (including vector abundance which is normalised to range between 0 and 1) and dividing by the average core capacity of a country.. The formula below is used for the computation of adaptive capacity. Vulnerability = Vectorial capacity / average IHR core capacity The temperature dependent dynamic models developed by Liu-Helmersson et al. (2014)[56] and later updated by Rocklöv & Tozan (2019.[16] The VC included the estimated potential abundance of *Aedes aegypti* vectors. The abundance was estimated in response to local rainfall and temperature patterns at a daily time scale as outlined in Liu-Helmersson et al (2019).[57] Computation of *Aedes aegypti* VC and abundance estimates was done for each 0.5 × 0.5 grid cells using the Climatic Research Unit dataset (CRU TS 4.02)[11] and subsequently aggregated to country level using shapefiles. The CRU TS 4.02[11] climate data drives both the VC and the abundance models.  *Figure 18: Trends in the vulnerability index 2010-2017.*
Data	CRU Ts 4.02,1901-2017[11] IHR core capacities data, 2010-2017
Caveats	The abundance models generate predictions and not observed frequencies in relation to climate conditions, and so should be considered a potential abundance estimate. The IHR data is self-reported by countries and may therefore include reporting bias which would affect this indicator. A reduction of this indicator while keeping the

	vector hazard constant does not correspond to full protection but indicates rather that the situation has improved by important improvements in core capacities.
Future Form of Indicator	The future indicator will make use of the estimated protective effect (relative risk) of the IHR core capacities in modifying the climate induced hazard on vectors and virus interactions.

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.5: Food security and under-nutrition
Sub-Indicator	1.5.1: Terrestrial food security and under-nutrition
Methods	Actual crop yields vary from year to year not only with variations in weather, but also with changes in variety, farming practices and the occurrence of pest and disease. Crop yields as estimated by crop models are sensitive to the precise form of the crop model, and many models do not account for the short-term extremes that can significantly affect yields. The effect of year-to-year climatic variability on crop yields is therefore here represented by an agri-climatological proxy indicator, calculated from observed climate data and characterising potential variability in yield. Maize, wheat, rice and soybean were selected as important traded and subsistence crops. There are several potential proxies for variability from year to year in crop yield, including the number of hot days during critical periods in the growing season[58-61] and the accumulated temperature between lower and upper thresholds over the growing season.[58] The proxy used here is based on crop duration, defined as the time taken in a year to accumulate the reference period (1981-2010) average growing season accumulated temperature total (ATT).[58] If the ATT is reached early, then the crop matures too quickly and yields are lower than average. Here, the crop duration loss was defined as the difference in the time taken (in days) to accumulate the average growing season accumulated temperature. The index is calculated at a spatial resolution of 0.5°, across the area of land under cultivation for each crop.[62] The duration of the growing season and the low and high temperature thresholds for the calculation of ATT vary between crops. Climate data is taken from the Climate Research Unit TS4 gridded monthly observed climate data set,[11] and synthetic daily data is estimated for each grid cell by applying a regional average daily anomaly to the monthly value. The regional average daily anomaly is calculated from the WFDEI daily climatology.[63] The plots in the paper show the global average annual change in crop growth duration. The horizontal dashed line shows the average difference in crop growth duration over the reference period 1981-2010. Note that this is not zero because of the non-linear relationship between ATT and the time taken to accumulate a specific value of ATT.
Data	FAOSTAT Climate Research Unit TS4 gridded monthly observed climate data set WATCH Forcing Data ERA Interim daily climatology
Caveats	Different ways of calculating the agri-climate index using different data sets would produce slightly different time series, as would the use of different agri-climate proxies. However, the broad patterns of variability over space and time are likely to be consistent across proxies and data sources.

Working Group	1: Climate Change Impacts, Exposures, and Vulnerability
Indicator	1.5: Food security and under-nutrition
Sub-Indicator	1.5.2: Marine food security and under-nutrition
Methods	Sixteen FAO fishing areas (out of 19; the 3 areas excluded are those located in the Antarctica) which are important in terms of projected impacts and vulnerabilities associated with climate change were selected (Table 2 and Figure 21). Sixty-four countries located in these areas (for which Fish Capture Data is currently available) were selected in order to attribute the impacts of climate change (more specifically sea surface temperature; SST) to deterioration of major coral reef sites (Marine Protected Areas), decreased population of commercial fish species, and the consequent decreased consumption of capture-based fish.
Data	Data for SST was obtained from NOAA, and covers from 2003 to 2018. The location of coral reef sites and data on annual maximum bleaching alert area caused by thermal stress was obtained from NOAA Coral Reef Watch Zones , and is available in five-year intervals from 1985 to 2018. Data on fish consumption per capita from 1980 to 2016 was collected from FAO.
Caveats	There is a lack of information in the available databases such as FAO on fish species composition of the captured and farmed fish products. This could in turn lead to some concerns about the methodological approach used to calculate ω3 intake. More specifically, most of the approaches are based on fish intake, which usually ignore or underestimate variations in ω3 contents of different types of fishes, and especially capture-based compared with farmed-based fish.
Additional information	Figure 19 presents changes in sea surface temperature for the 64 countries investigated from different basins from 2003 to 2018. Figure 21 presents the global occurrence zone of coral reefs while Figure 22 reflects the increasing deterioration of annual maximum Bleaching Alert Area globally and threats to marine primary productivity being expected to follow. Figure 23 presents the trend of capture-based per capita fish consumption; a key source of ω3 fatty acids (Table 3). Figure 25 conceptualises the relationship between climate change and decreased consumption of capture-based fish to increased risk of ischemic heart diseases. Between 2003 and 2018, SST rose in 34 of the 64 territorial waters analysed (max. increase 3.5 ^{o}C), while even marginal SST decreases (≤1 ^{o}C) in 19 out of 30 territorial waters (Figure 19) could be linked to the weakening of a crucial ocean current, i.e., Atlantic Meridional Overturning Current (AMOC) by 15%, in response to melting ice from Greenland.[64,65] Summary exposure value (SEV) is the measure of a population's exposure to a risk factor that takes into account the extent of exposure by risk level and the severity of that risk's contribution to disease burden. SEV for "diet low in seafood omega-3 fatty acids" has increased in most of the investigated countries since 1990; however, there are countries with decreasing trends in exposure to this risk factor as well (Table 4). Nevertheless, the total overall number of deaths and disability adjusted life years (DALYs) attributable to diet low in seafood omega-3 fatty acids, has increased in our list of investigated countries; with the most populous countries including China, Indonesia, Pakistan, and Bangladesh having major impacts on this overall increase (Table 5 and Table 6) [66] Given the unfavourable variations in fish capture over the last three decades, it seems that countries in general have implemented strategies toward increased fish

	farming to compensate for decreased capture-based per capita fish consumption. However, owing to the substantially lower ω3 contents of farmed fish compared with captured fish, positive health impacts of this approach is in question. Therefore, adaptation strategies should be focused on shifting the existing fish farming activities from fresh water (in-land waters) to marine water (mariculture systems, e.g., cage culture). Moreover, ω3 enrichment in fish farming should also be pursued.

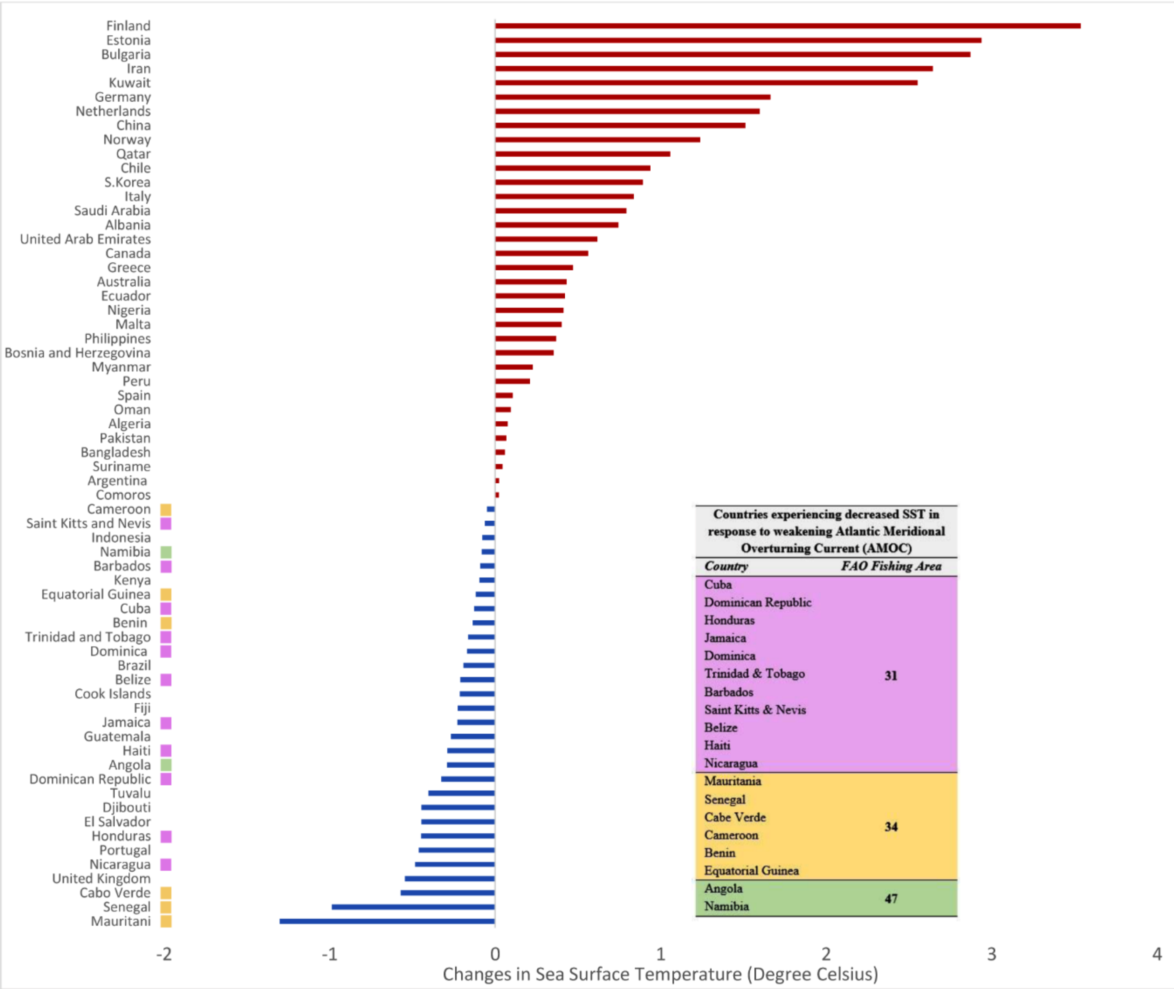


Figure 19: changes in SST for the 64 countries investigated from 16 FAO fishing areas from 2003 to 2018.

Table 2: Scope of investigation by country, basin, FAO fishing area, and coral reef site

No.	Country	Country Code ISO	Country Code UN	FAO Fishing Area	Large Marine Basin (Ocean)	Coral Reef Location	Marine Protected Areas with Coral Reefs
1	Canada	CA	124	18	Arctic Sea	-	-
				21	North-West Atlantic	-	-
				67	North-East Pacific	-	-
2	United Kingdom	GB	826	27	North-East Atlantic	-	-
3	Finland	FI	246			-	-
4	Norway	NO	578			-	-
5	Estonia	EE	233			-	-
6	Portugal	PT	620			-	-
7	Germany	DE	276			-	-
8	Netherlands	NL	528			-	-
9	Spain	ES	724	27	North-East Atlantic	-	-
				37	Mediterranean Sea	-	-
10	Cuba	CU	192	31	West-Central Atlantic	Caribbean Sea, Gulf of Mexico	Cayo Coco, Cayo Guillermo, Cayo Romano, Cayo Sabinal, Cayos de Ana Maria, Cienaga de Zapata, Punta Frances, Punta Pederales, Peninsula de Guanahacabibes, Cienaga de Zapata, Buenavista, Subarchipielago de Jardines de la Reina, Subarchipielago de los Canarreos, Sur Isla,de la Juventud, Subarchipielago de Sabana-Camaguey, Cuchillas del Toa, Desembarco del Granma,
11	Dominican Republic	DO	214				Del Este, Marine Mammal, Jaragua, Litoral Sur (Santo Domingol), Montecristi, Parque Submarino la Caleta
12	Honduras	HN	340				Bahia de Chismuyo, Cayos Cochinos, El Jicarito, El Quebrachal, Guameru, Guapinol, Las Iguanas, Islas del Cisne, Jeanette Kawas, la Alemania, Ragged Cay, Laguna de Guaymoreto, Montecristo, Punta Isopo, Teonostal, Parque Nacional Jeanette Kawas, Refugio de Vida Silvestre Punta Izopo
13	Jamaica	JM	388				Bogue, Middle Morant Cay, Montego Bay, Negril, Ocho Rios, Portland Bight

No.	Country	Country Code		FAO Fishing Area	Large Marine Basin (Ocean)	Coral Reef Location	Marine Protected Areas with Coral Reefs
		ISO	UN				
14	Dominica	DM	212				Cabrits, Soufriere / Scott's Head
15	Trinidad & Tobago	TT	780				Buccoo Reef, Little Tobago
16	Barbados	BB	052				Barbados
17	Saint Kitts & Nevis	KN	659				Southeast Peninsula
18	Belize	BZ	084				Bacalar Chico, Blue Hole, Gladden Spit, Half Moon Caye, Hol Chan, Sapodilla Cayes, Port Honduras, Glovers Reef, Man-o-War Cay, South Water Caay, Belize Barrier Reef Reserve System
19	Haiti	HT	332				-
20	Nicaragua	NI	558	31	West-Central Atlantic	Caribbean Sea,	Cayos Miskitos
				77	East-Central Pacific	-	-
21	Mauritania	MR	478	34	East-Central Atlantic	-	-
22	Senegal	SN	686			-	-
23	Cape Verde	CV	132			-	-
24	Nigeria	NG	566			-	-
25	Cameroon	CM	120			-	-
26	Benin	BJ	204			-	-
27	Equatorial Guinea	GQ	226			-	-
28	Bosnia & Herzegovina	BA	070	37	Mediterranean Sea &	-	-

No.	Country	Country Code		FAO Fishing Area	Large Marine Basin (Ocean)	Coral Reef Location	Marine Protected Areas with Coral Reefs
		ISO	UN				
29	Greece	GR	300		Black Sea	-	-
30	Italy	IT	380			-	-
31	Algeria	DZ	012			-	-
32	Malta	MT	470			-	-
33	Albania	AL	008			-	-
34	Bulgaria	BG	100			-	-
35	Suriname	SR	740				-
36	Argentina	AR	032	41	South-West Atlantic	Western Atlantic	-
37	Brazil	BR	076				Abrolhos Bank, Atol das Rocas, Fernabdo de Noronha, Parcel Manoel Luis, Recife de Fora, Parque Estadual Marinho do Parcel Manoel Luis,
38	Angola	AO	024	47	South-East Atlantic	-	-
39	Namibia	NA	516			-	-
40	Iran	IR	364			Persian Gulf, Hormoz Strait	Sheedvar & Lavan Islands, Kish & Hendourabi Islands, Kharg & Kharko Islands, Qeshm, Hormoz, Hengam, Islands, Farour & Bani Farour Islands, Nayband Bay, Dayyer & Nakhilo
41	Kuwait	KW	414			Persian Gulf	Kubbar, Qaro Island and Um Al-Maradem Islands
42	United Arab Emirates	AE	784	51	West Indian (South-East)		Rul Dibba, Dadna, Al Aqa, Al Bidiyah, Al Yasat, Marawaah
43	Qatar	QA	634				Khor Al Oudeid, Halul Island, Fasht al Dibal
44	Saudi Arabia	SA	682			Red Sea, Persian Gulf	Asir, Dawat Ad-Dafl , Dawat al- Musallamiyah, Coral, Farasan and Umm al-Qamari Islands

No.	Country	Country Code		FAO Fishing Area	Large Marine Basin (Ocean)	Coral Reef Location	Marine Protected Areas with Coral Reefs
		ISO	UN				
45	Oman	OM	512			Arabian Sea, Gulf of Oman	Daymaniyat Islands
46	Pakistan	PK	586				Astola (Haft Talar) Island
47	Comoros	KM	174			Mozambique Channel	Moheli
48	Djibouti	DJ	262			Gulf of Aden	Maskali Sud, Musha,
49	Kenya	KE	404			African East Coasts	Diani, Kisite, Kiunga, Malindi, Malindi-Watamu, Mombasa, Mpunguti, Watamu
50	Bangladesh	BD	050	57	East Indian	Bay of Bengal	Island of St. Martin's
51	Myanmar	MM	104				Lampi, Moscos Island
52	Australia	AU	036	57	East Indian	Shark Bay	Ashmore Reef, Cobourg, Coringa-Harold, Mermaid Reef, Ningaloo, Christmas & Solitary Islands, Elizabeth and Middleton Reefs, Emden, Great Barrier Reef, Lihou Reef, Lord Howe Island, Pulu Keeling, Rowley Shoals, Shark Bay Western Australia, Solitary Island, Yongala, South West Cobourg Peninsula, Lord Howe Island, Moreton Bay, Shoalwater & Corio Bays, Cocos Islands
				71	West-Central Pacific (Indo-Pacific)	Timor & Arafura Sea, Gulf of Carpentaria	
				81	South-West Pacific	Torres Strait, Coral Sea, Tasman Sea, Papua Gulf	
53	China	CN	156	61	North-West Pacific	South China Sea	Kat o Cau, Shan Hu Jiao
54	South Korea	KR	410			-	-
55	Indonesia	ID	360	57	East Indian	-	Over 17000 islands with 60 Coral Reef sites as MPAs (51020 km^2 of Reef area)
				71	West-Central Pacific (Indo-Pacific)	Banda,Timor,Seram Seas, Moluca, Flores,Java Seas, Celebes Sea, Triton Bay	
56	Philippines	PH	608	71	West-Central Pacific (Indo-Pacific)	China & Philippine Seas, Sulawesi,Sibuyan,Sulu Seas	Over 7000 islands with 60 Coral Reef sites as MPAs (25060 km^2 of Reef area)
57	Fiji	FJ	242			Koro Sea	Viti Levu, Vanua Levu, Beqa Barrier Reef, Kadavu, Yasawa,
58	Tuvalu	TV	798			-	-

No.	Country	Country Code		FAO Fishing Area	Large Marine Basin (Ocean)	Coral Reef Location	Marine Protected Areas with Coral Reefs
		ISO	UN				
59	El Salvador	SV	222	77	East-Central Pacific	-	-
60	Guatemala	GT	320			-	-
61	Cook Islands	CK	184	81	South-West Pacific	-	-
62	Chile	CL	152	87	South-East Pacific	-	-
63	Peru	PE	604			-	-
64	Ecuador	EC	218			-	-

** Sources:*

- Ramsar Site (International Wetland) https://www.ramsar.org/country-profiles
- UNESCO Biosphere Reserve (MAB) https://en.unesco.org/countries
- UNESCO World Heritage Site https://whc.unesco.org/en/list
- IUCN (Marine Protected Areas – MPAs) https://www.iucn.org/theme/marine-and-polar/our-work/marine-protected-areas
- Wells et al. (2008) [Wells S, Sheppard V, Van Lavieren H, Barnard N, Kershaw F, Corrigan C, Teleki K, Stock P, Adler E. National and regional networks of marine protected areas: a review of progress. Master Evaluation for the UN Effort. World Conservation Monitoring Centre, Cambridge, UK, 2008.]

Table 3: Comparison of the ω3 fatty acids content of farmed and captured fish.

No	Species (Common / Scientific name)	Omega 3 (g/kg)	
		Captured	Farmed
1	Sea bream (*Pagellus* sp.)	5.67-11.73	2.88-3.81
3	Sturgeon (*Huso huso*)	25.31	7.24
4	Sturgeon (*Acipenser baerii*)	19.98	5.23
5	Sturgeon (*Acipenser naccarii*)	16.66	3.51
6	Sturgeon (*Acipenser transmontanus*)	17.62	4.18
7	Sturgeon (*Acipenser nudiventri*)	18.08	6.35
8	Channel catfish (*Ictalurus punctatus*)	1.7	1
9	Catfishes (*Clarias* sp. ; *Heterobranchus* sp.)	2	1.25 - 1.7
10	African catfish (*Pangasius hypophthlmus*)	2.6	1.25
11	Catfishes (*Clarias* sp. ; *Heterobranchus* sp.)	2.4	1.25
12	Indian carp (*Cyprinus* sp.)	1.9	1.5
13	Chinese carp (*Cyprinus* sp.)	2.64	1.37
14	Red drum (*Sciaenops ocellatus*)	2.1	1.8
15	Salmon (*Oncorhynchus* sp.)	34.8 - 51.46	14.26
16	Atlantic salmon (*Salmo salar*)	19	12 – 15.55
17	Rainbow trout (*Oncorhynchus mykiss*)	11.82	6 - 10
18	Bluefin tuna (*Thunnus thynnus*)	15	12
19	Cod (Gadus sp.)	1.12	0.12
20	Asian sea bass (*Dicentrachus labrax*)	3.9	0.36
21	Blackspot bass (*Micropterus salmoides*)	1.6	0.36
21	Eel (*Anguilla japonica*)	15	10.2
22	Flatfish (*Paralichthys olivaceus*)	13.15	4 - 6
23	Mullet (*Mugil* sp.)	10	0.12

Table 4: Summary exposure value (SEV) to diet low in seafood omega 3 in the selected countries per 100 individuals, 1990 to 2017 (Global Burden of Disease 2017)

Country	Year						
	1990	1995	2000	2005	2010	2015	2017
Albania	41.8	43.5	44.6	44.5	44.6	46.2	46.8
Algeria	32.7	35.0	37.8	41.3	45.6	48.7	49.5
Angola	32.6	32.2	31.4	30.2	27.5	26.1	26.2
Argentina	29.9	28.8	28.0	29.2	26.7	24.8	25.1
Australia	35.7	35.3	35.7	34.8	33.7	33.3	33.1
Bangladesh	34.8	36.1	38.8	41.9	45.1	48.6	50.0
Barbados	34.3	35.1	36.0	38.1	38.9	40.6	41.2
Belize	29.1	29.5	30.8	31.3	32.3	34.1	35.1
Benin	30.8	31.0	30.9	30.5	30.2	30.5	30.9
Bosnia and Herzegovina	52.3	57.3	55.1	56.8	58.0	58.4	58.4
Brazil	31.9	30.8	29.4	29.8	29.4	28.9	29.7
Bulgaria	47.2	50.6	54.8	56.5	56.1	56.0	55.4
Cameroon	28.2	29.0	29.9	30.3	31.2	32.6	33.2
Canada	31.0	31.3	28.6	26.6	26.9	27.0	26.9
Cape Verde	33.6	34.1	33.3	33.3	34.9	38.5	40.1
Chile	40.5	39.2	38.7	38.7	37.5	36.5	36.5
China	47.0	51.5	54.6	55.9	56.3	57.7	57.4
Comoros	31.7	33.4	34.9	35.6	36.4	38.3	39.2
Cuba	45.6	52.0	55.4	54.7	53.4	53.7	54.0
Djibouti	31.3	33.6	34.7	37.1	39.6	42.4	43.1
Dominica	37.0	38.6	39.6	40.1	40.5	41.7	42.3
Dominican Republic	32.6	33.7	33.6	33.3	33.6	35.0	35.2
Ecuador	34.0	34.3	34.2	34.0	33.8	34.1	34.9
El Salvador	34.7	35.4	35.5	36.1	37.1	38.6	39.4
Equatorial Guinea	33.3	31.5	27.6	21.5	17.9	17.8	19.3
Estonia	47.0	49.2	50.8	50.8	50.2	50.1	49.6
Fiji	36.5	37.1	38.2	39.4	39.8	39.1	38.9
Finland	46.8	47.0	43.9	45.8	46.3	46.5	46.7
Germany	51.6	51.7	52.2	54.7	55.1	54.0	53.2
Greece	48.6	50.3	51.8	52.9	53.8	56.4	56.9
Guatemala	31.2	30.3	29.3	29.8	31.3	33.3	34.3
Haiti	36.7	36.7	36.8	37.7	39.3	41.2	42.0
Honduras	30.3	29.7	29.2	29.7	30.8	32.5	33.2
Indonesia	40.6	42.6	45.1	47.1	48.3	49.1	49.5
Iran	31.9	33.5	35.2	38.2	41.0	44.7	45.8
Italy	45.9	48.5	51.4	53.1	53.5	54.0	54.2
Jamaica	30.9	31.0	30.6	30.0	30.6	33.0	34.2
Kenya	27.8	29.1	30.1	30.5	30.9	32.0	32.6

Kuwait	34.0	33.7	28.0	24.6	23.8	28.1	30.0
Malta	46.0	45.4	45.2	45.4	46.1	47.0	46.7
Mauritania	33.3	33.9	34.1	33.9	33.7	33.9	34.2
Myanmar	41.0	42.8	43.8	43.2	41.4	40.4	40.5
Namibia	33.2	33.1	32.6	32.0	32.5	34.2	35.1
Netherlands	47.0	47.9	49.1	49.8	49.9	49.7	49.5
Nicaragua	29.6	31.2	32.6	34.0	35.7	37.8	38.6
Nigeria	35.6	35.4	35.4	35.1	34.3	33.6	33.5
Norway	46.4	46.6	46.0	44.8	43.3	42.4	42.3
Oman	32.4	31.3	29.8	29.9	32.9	40.4	41.9
Pakistan	32.5	31.7	31.5	32.6	34.3	36.2	36.9
Peru	35.7	37.5	39.7	42.2	43.4	43.6	43.9
Philippines	35.8	36.3	36.3	36.6	37.4	38.1	38.4
Portugal	49.0	47.8	48.0	49.5	50.2	50.9	51.0
Qatar	29.1	31.3	27.8	24.0	23.5	22.1	22.5
Saudi Arabia	26.4	26.7	27.6	29.0	30.1	31.0	31.9
Senegal	31.1	32.1	33.4	34.2	34.3	34.6	34.7
South Korea	46.6	48.2	50.2	52.5	53.8	53.9	54.1
Spain	43.0	44.9	46.2	47.1	48.0	49.4	49.2
Suriname	32.3	35.4	36.2	36.5	36.1	35.1	35.8
Trinidad and Tobago	37.4	39.9	39.8	38.1	36.0	35.0	35.4
United Arab Emirates	30.2	30.2	28.3	30.7	40.5	49.0	49.3
United Kingdom	46.3	46.2	45.3	43.9	43.5	43.8	43.8

Table 5: Deaths attributable to diet low in seafood omega 3 fatty acids, 1990-2017 (Global Burden of Disease 2017)

Country	Year						
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2017**
Albania	542	537	632	743	743	821	846
Algeria	5,497	6,038	6,644	7,034	7,509	8,438	8,810
Angola	1,129	1,319	1,462	1,505	1,483	1,533	1,626
Argentina	6,911	6,204	5,920	5,805	5,426	4,928	5,032
Australia	4,160	3,808	3,329	2,770	2,525	2,503	2,692
Bangladesh	6,802	6,911	8,918	16,543	24,646	26,869	28,602
Barbados	52	48	40	36	32	37	39
Belize	24	26	30	26	26	28	30
Benin	409	465	521	553	599	682	708
Bosnia and Herzegovina	1,505	1,807	1,514	1,400	1,360	1,406	1,391
Brazil	21,341	19,898	18,539	18,572	18,715	18,689	20,149
Bulgaria	5,014	6,098	6,294	5,814	5,199	4,869	4,830
Cameroon	669	884	1,237	1,497	1,629	1,747	1,790
Canada	5,384	5,277	4,537	3,871	3,569	3,840	3,970
Cape Verde	53	55	55	57	60	66	70
Chile	1,942	1,640	1,424	1,420	1,438	1,424	1,501
China	119,567	129,879	148,541	193,370	237,886	282,083	284,292
Comoros	59	66	71	73	79	89	94
Cuba	3,414	3,762	3,234	3,076	2,959	3,126	3,208
Djibouti	30	44	60	74	89	108	117
Dominica	16	15	12	10	10	11	11
Dominican Republic	857	910	1,026	1,269	1,488	1,956	2,005
Ecuador	946	986	1,111	1,250	1,190	1,214	1,311
El Salvador	747	779	750	857	887	972	984
Equatorial Guinea	81	78	56	36	30	32	36
Estonia	1,059	1,145	961	816	616	524	545
Fiji	177	197	230	228	254	264	267
Finland	2,284	2,001	1,708	1,594	1,526	1,402	1,505
Germany	39,907	34,567	30,912	26,505	24,100	24,287	24,720
Greece	3,222	3,351	3,467	3,459	3,379	3,342	3,576
Guatemala	854	873	878	924	1,029	1,233	1,371
Haiti	1,586	1,670	1,669	1,720	1,788	1,961	2,069
Honduras	601	795	901	997	1,107	1,320	1,400
Indonesia	22,660	25,559	31,199	37,337	42,449	46,970	48,178
Iran	10,696	11,379	12,335	12,740	12,739	14,211	14,955
Italy	14,145	13,878	13,501	12,600	12,015	12,341	12,067
Jamaica	247	259	230	181	207	257	274

Kenya	918	1,157	1,653	2,200	2,456	2,657	2,791
Kuwait	176	168	171	165	165	209	248
Malta	128	116	116	110	107	110	119
Mauritania	322	326	313	311	321	352	367
Myanmar	6,467	6,968	7,123	6,633	5,666	5,370	5,380
Namibia	178	220	280	255	195	196	206
Netherlands	4,405	4,028	3,684	2,937	2,406	2,278	2,377
Nicaragua	294	377	401	470	468	563	568
Nigeria	6,771	7,406	8,442	8,138	8,027	9,355	9,930
Norway	1,840	1,594	1,355	1,016	865	731	754
Oman	348	361	349	327	330	446	478
Pakistan	19,117	24,669	28,642	33,227	36,996	42,395	44,576
Peru	1,905	2,334	2,036	2,160	2,419	2,245	2,409
Philippines	8,648	11,400	13,133	14,043	16,907	19,515	19,792
Portugal	2,682	2,435	2,234	1,906	1,701	1,609	1,713
Qatar	36	48	45	39	42	51	58
Saudi Arabia	1,487	1,618	1,812	2,359	2,771	2,859	2,955
Senegal	773	915	1,048	1,110	1,207	1,379	1,422
South Korea	6,437	4,093	3,339	3,276	3,300	3,363	3,462
Spain	8,641	8,404	8,034	7,582	6,680	6,856	6,726
Suriname	74	65	68	73	72	81	85
Trinidad and Tobago	305	345	327	277	233	243	265
United Arab Emirates	106	146	176	193	338	630	775
United Kingdom	26,612	22,970	18,228	13,863	11,137	10,412	10,663
Total	383,261	395,373	416,958	469,434	525,591	589,486	603,192

Table 6: Disability-adjusted Life Years (DALYs) attributable to diet low in seafood omega 3 fatty acids, 1990-2017 (Global Burden of Disease 2017)

Country	Year						
	1990	1995	2000	2005	2010	2015	2017
Albania	11,541	11,161	13,154	15,308	14,492	15,235	15,410
Algeria	139,829	150,946	161,565	163,089	168,555	185,858	192,052
Angola	30,599	36,230	40,296	41,548	40,510	41,272	43,486
Argentina	141,250	124,897	115,838	109,912	99,350	87,146	89,483
Australia	75,593	63,849	53,459	42,297	36,764	35,250	37,286
Bangladesh	177,363	187,478	247,801	463,242	670,341	712,404	743,846
Barbados	912	830	711	661	600	669	698
Belize	503	589	689	600	605	661	726
Benin	9,155	10,836	12,503	13,352	14,394	16,428	16,998
Bosnia and Herzegovina	34,012	40,487	32,253	28,837	25,959	25,183	24,523
Brazil	551,840	505,105	465,799	455,187	450,223	431,814	461,409
Bulgaria	98,667	119,143	120,004	110,816	95,216	86,435	85,260
Cameroon	15,800	21,722	31,672	38,730	41,910	44,430	45,397
Canada	97,247	90,592	74,010	61,155	55,148	58,164	58,417
Cape Verde	974	1,043	1,082	1,119	1,174	1,287	1,345
Chile	37,817	31,923	27,711	28,194	28,891	27,935	28,681
China	3,053,285	3,375,982	3,659,304	4,144,350	4,819,810	5,723,980	5,617,600
Comoros	1,552	1,729	1,848	1,857	1,987	2,205	2,305
Cuba	67,904	71,872	62,890	57,842	54,408	56,468	57,661
Djibouti	895	1,296	1,780	2,201	2,619	3,082	3,287
Dominica	286	261	205	185	177	191	192
Dominican Republic	22,031	23,299	25,112	30,011	34,413	45,153	46,127
Ecuador	21,971	23,285	26,140	29,184	27,368	26,025	27,721
El Salvador	18,069	18,127	16,714	18,132	18,199	19,569	19,803
Equatorial Guinea	2,122	2,060	1,441	874	718	739	831
Estonia	20,086	22,795	17,664	14,143	9,724	7,657	7,663
Fiji	5,458	6,040	7,069	6,909	7,490	7,615	7,643
Finland	43,262	35,111	27,382	25,374	22,819	19,542	20,669
Germany	682,817	568,132	486,885	411,449	355,293	332,416	337,579
Greece	61,396	62,297	63,497	61,702	58,700	54,790	56,433
Guatemala	22,413	22,920	22,835	22,440	24,169	27,610	30,769
Haiti	42,230	44,068	43,623	44,507	46,311	50,349	52,830
Honduras	17,436	21,521	24,057	25,985	27,457	31,506	33,186
Indonesia	656,063	726,049	872,321	1,042,882	1,177,162	1,285,908	1,301,318
Iran	277,220	285,486	298,665	300,658	291,825	310,766	321,485
Italy	249,027	230,307	209,338	183,071	163,466	159,549	150,771
Jamaica	4,517	4,756	4,291	3,187	3,790	4,959	5,259

Kenya	21,170	27,711	42,183	58,601	65,604	69,438	72,347
Kuwait	5,664	5,340	5,383	5,152	5,259	6,663	7,850
Malta	2,428	2,126	2,040	1,873	1,737	1,713	1,827
Mauritania	7,576	7,655	7,333	7,192	7,348	7,963	8,249
Myanmar	172,931	184,164	185,858	170,553	142,763	130,920	129,488
Namibia	4,174	5,075	6,561	5,878	4,282	4,162	4,349
Netherlands	82,902	73,588	65,929	50,190	38,630	33,828	34,774
Nicaragua	6,729	8,372	8,600	9,966	9,714	11,595	11,528
Nigeria	144,626	159,737	186,849	181,494	178,489	208,897	222,680
Norway	32,246	26,215	20,669	14,775	12,112	9,855	10,150
Oman	9,755	9,980	9,576	8,925	8,822	12,591	13,622
Pakistan	493,052	661,240	788,322	928,222	1,033,683	1,179,641	1,234,636
Peru	43,310	51,843	43,916	46,424	51,786	44,825	47,004
Philippines	249,714	317,686	368,030	399,842	479,791	544,601	548,154
Portugal	49,909	43,985	38,909	31,224	25,702	22,873	23,890
Qatar	1,139	1,520	1,336	1,159	1,345	1,596	1,807
Saudi Arabia	36,292	41,002	46,643	63,398	76,597	82,971	87,138
Senegal	18,526	22,235	25,680	26,984	28,924	32,763	33,717
South Korea	164,697	95,390	73,451	66,409	62,941	58,276	57,100
Spain	154,307	144,292	131,412	120,075	102,795	99,177	94,949
Suriname	1,774	1,642	1,725	1,838	1,795	1,928	2,020
Trinidad and Tobago	7,261	8,045	7,600	6,412	5,349	5,460	5,853
United Arab Emirates	3,410	4,764	5,632	6,267	12,230	22,316	26,927
United Kingdom	488,039	401,595	307,467	227,825	180,867	165,346	169,413
Total	8,894,768	9,249,430	9,652,707	10,441,666	11,430,603	12,699,646	12,795,622

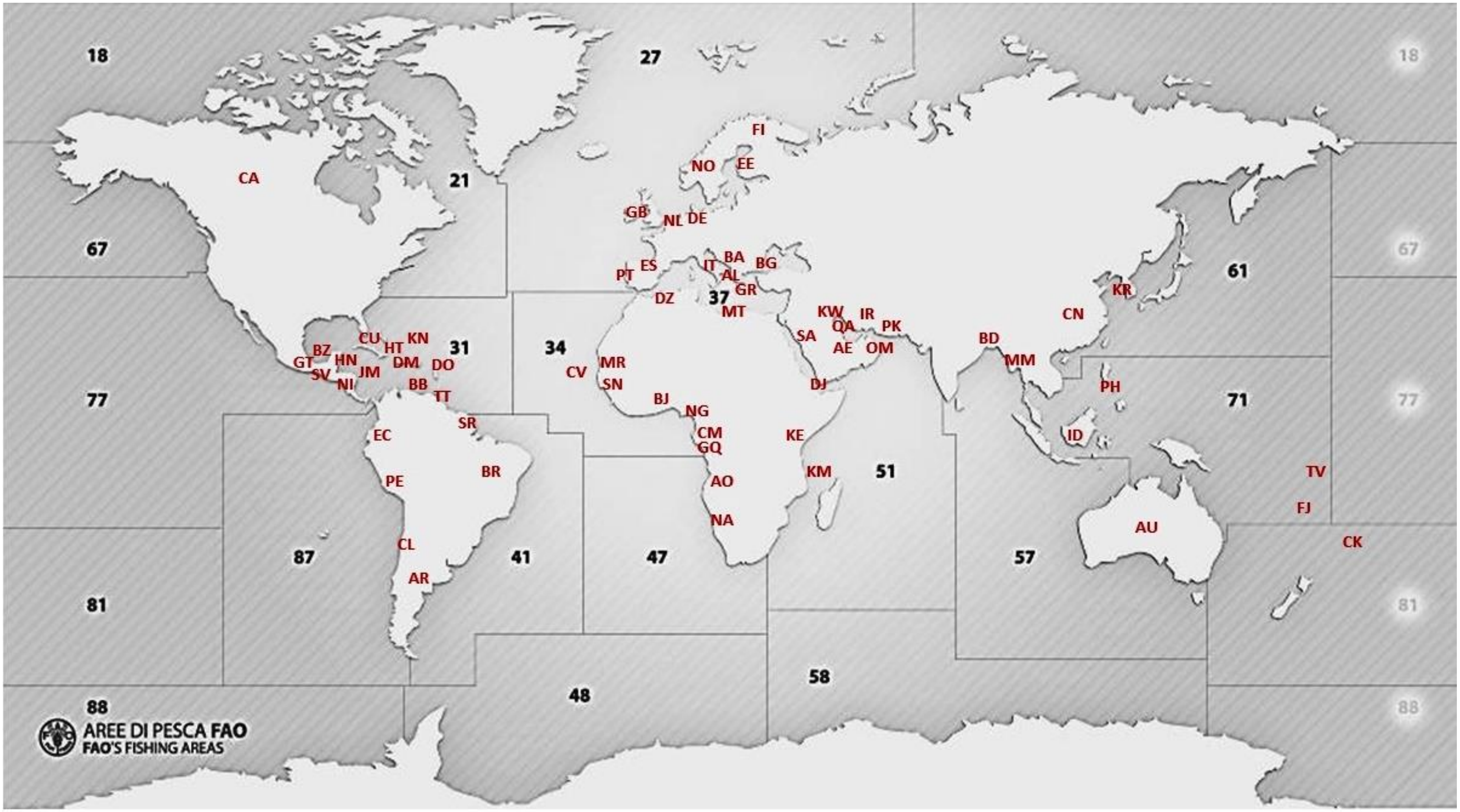


Figure 20: Geographical location of selected countries and their respective marine basins (FAO fishing areas)*

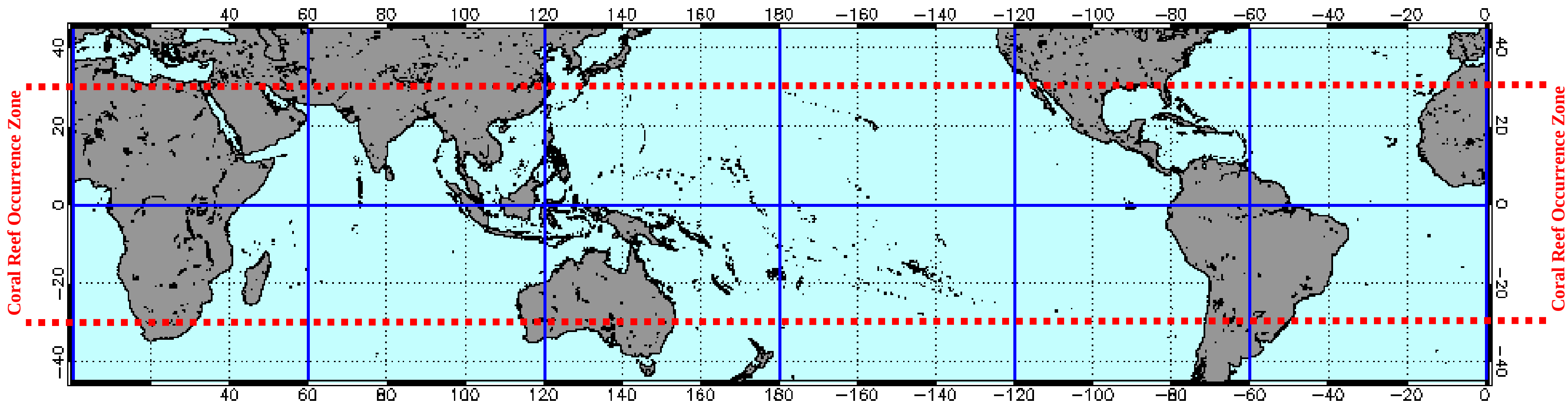


*Figure 21: Global occurrence zone of coral reefs**

* Source: NOAA Coral Reef Watch (*https://coralreefwatch.noaa.gov/product/5km/description_tile_60x40degree.php*)

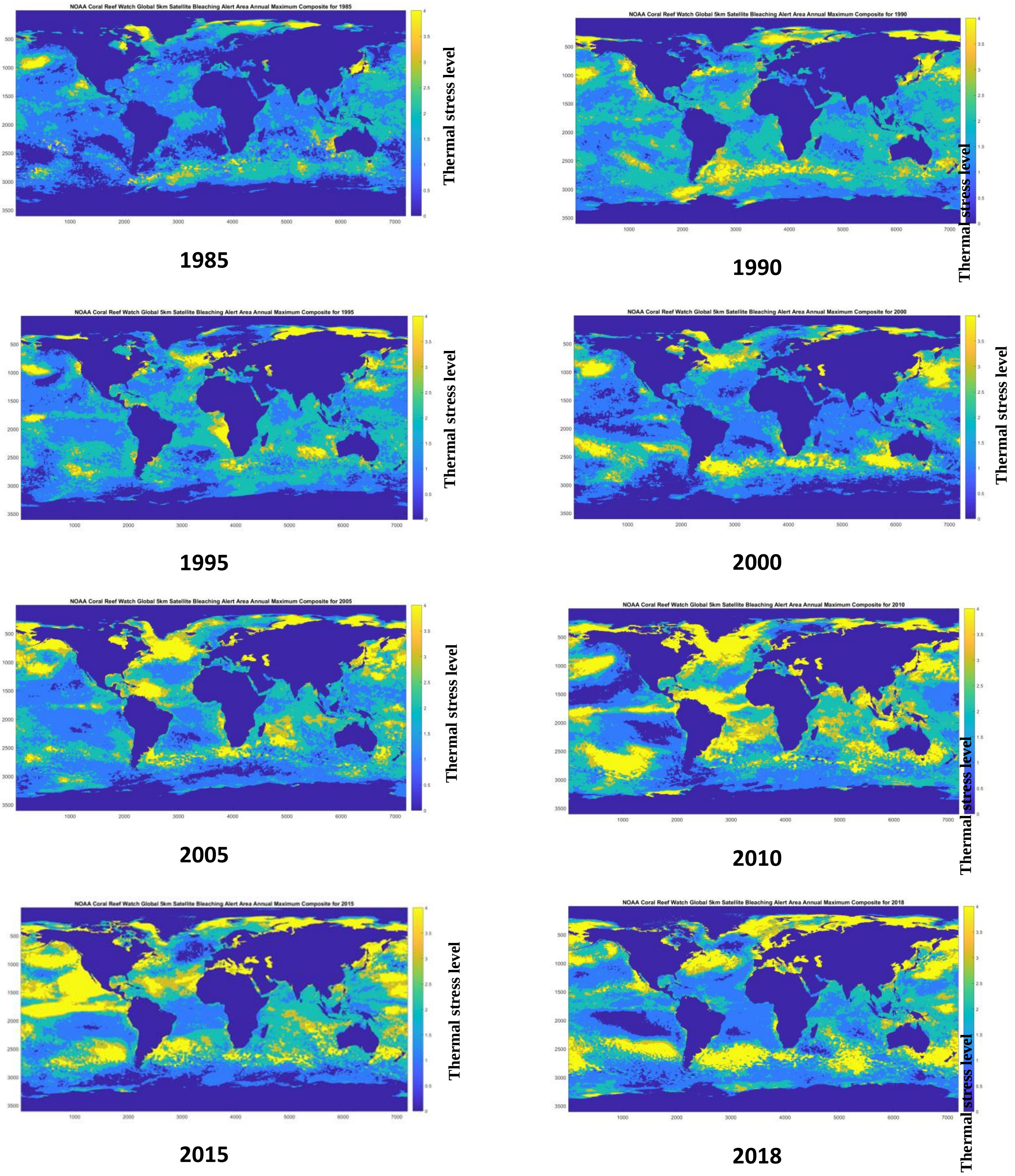
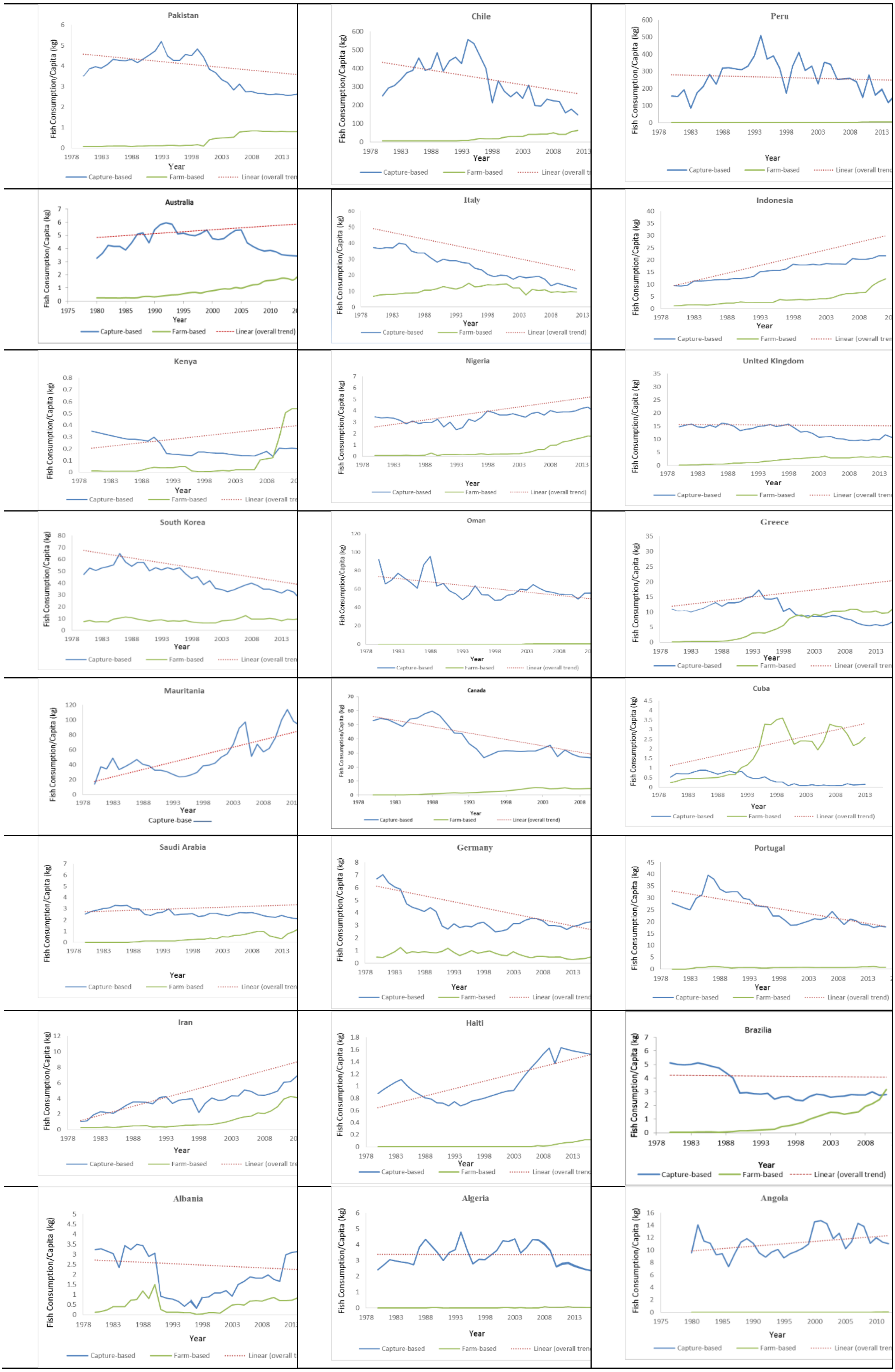


Figure 22: Comparing annual maximum Bleaching Alert Area caused by thermal stress in five-year intervals (1985-2018). (Map resolution: 3600×7200 pixels, each pixel equals approx. 5-km)*

* *Source:* NOAA Coral Reef Watch. 2018, updated daily. NOAA Coral Reef Watch Version 3.1 Daily Global 5-km Satellite Coral Bleaching Degree Heating Week Product, Jun. 3, 2013-Jun. 2, 2014. College Park, Maryland, USA: NOAA Coral Reef Watch. Data set accessed 2018-09-01 at https://coralreefwatch.noaa.gov/satellite/hdf/index.php.


Pakistan
Chile
Peru
Australia
Italy
Indonesia
Kenya
Nigeria
United Kingdom
South Korea
Oman
Greece
Mauritania
Canada
Cuba
Saudi Arabia
Germany
Portugal
Iran
Haiti
Brazilia
Albania
Algeria
Angola
Fish Consumption/Capita (kg)
Year
Capture-based
Farm-based
Linear (overall trend)


Djibouti
Barbados
Belize
Bulgaria
Cabo Verde
Cameroon
Myanmar
Namibia
China
Comoros
Cook Islands
Dominica
Dominican Republic
El Salvador
Equatorial Guinea
Estonia
Fiji
Finland
Guatemala
Kuwait
Malta
Fish Consumption/Capita (kg)
Year
Capture-based
Farm-based
Linear (overall trend)
capture -based
linear (overall trend)

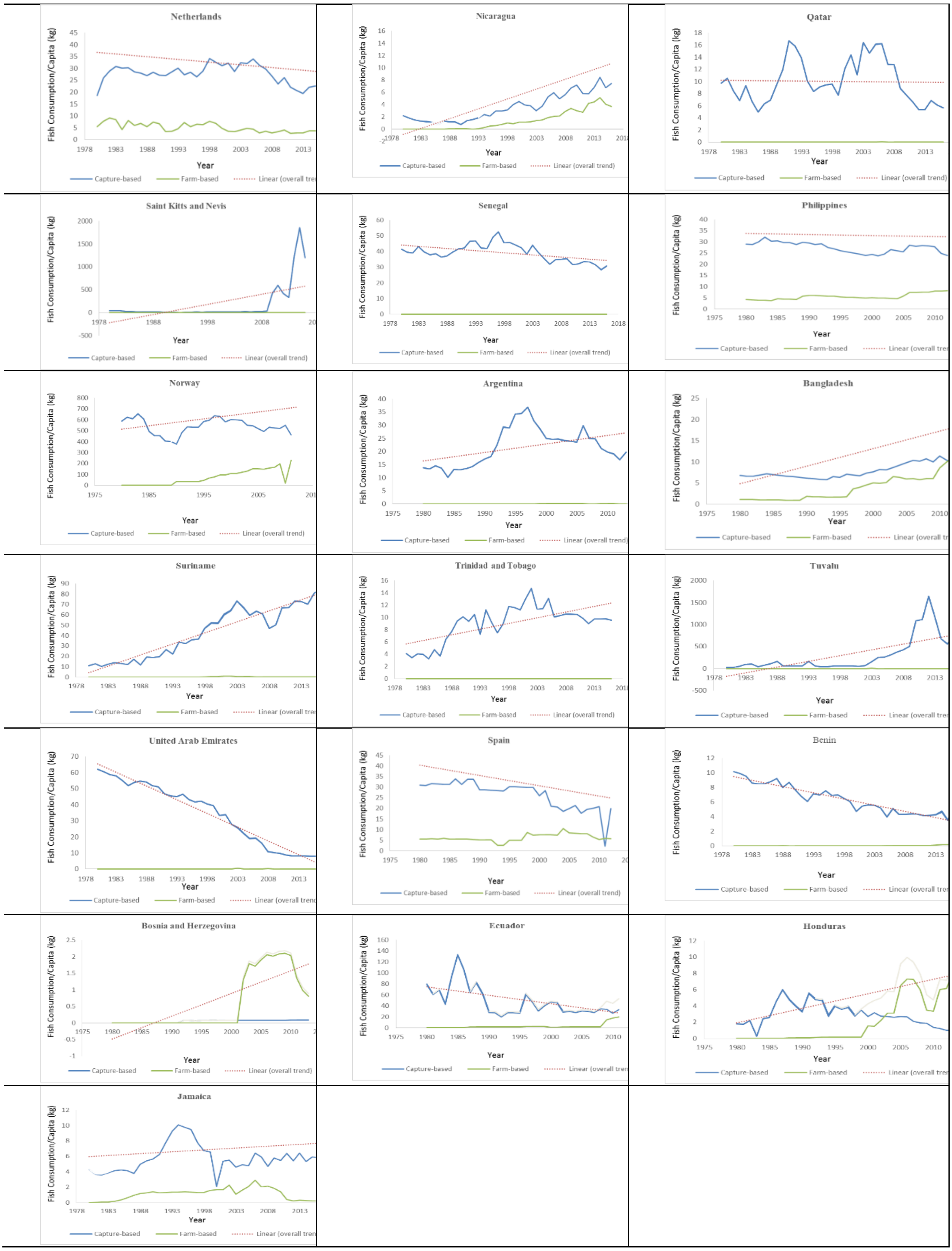


Figure 23: Trends of capture-based and farmed-based per capita fish consumption in the 64 countries investigated over the period of 1980-2016

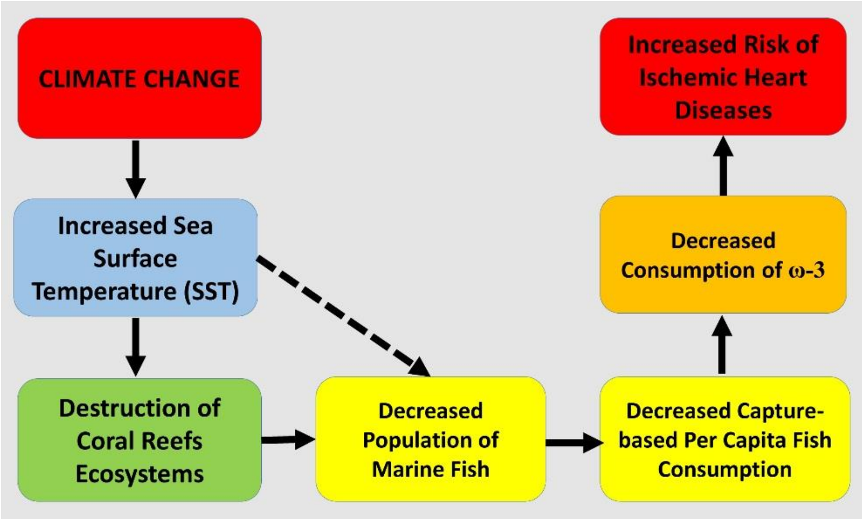
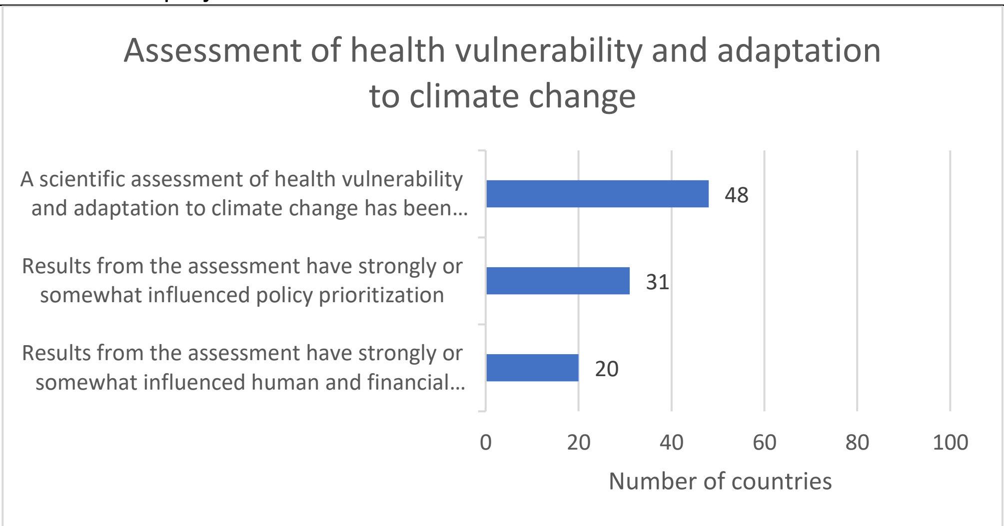


Figure 24: Pathway conceptualising the link between climate change and decreased consumption of capture-based fish to increased risk of ischemic heart diseases

Section 2: Adaptation, Planning, and Resilience for Health

Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.1: Adaptation planning and assessment
Sub-Indicator	2.1.1: National adaptation plans for health
Methods	The collection of data for this exercise included a voluntary national survey, the WHO Health and Climate Change Country Survey (2018) that was sent to all WHO member states and was completed by ministry of health focal points. Of the 194 WHO member states, 101 participated in the survey, providing representation from all 6 WHO regions, World Bank Group-defined income categories, and a diverse range of threats and vulnerabilities to the health effects of climate change. Survey participation has grown substantially from the 40 Member States that completed the 2015 WHO Health and Climate Change Country Survey. Validation of the 2018 country reported data was undertaken in multiple steps. First, survey responses were reviewed for missing information or inconsistencies with follow-up questions directed to survey respondents A summary of responses were shared with WHO regional focal points for review and comments. Source documents including national health strategies and plans, and scientific assessments of health vulnerabilities and assessments were collected. A desktop review was conducted to compare with survey results with follow-up to survey respondents to seek clarification or additional documentation. In the case of vulnerability and adaptation assessments, findings were also cross referenced with existing external publications.[67] Finally, partial results were reviewed by key national health and climate stakeholders and ministry of health officials as part of the development and review of the WHO UNFCCC health and climate change country profiles. Further information on the WHO Health and Climate Change Country Survey, its methodology and the WHO UNFCCC Health and Climate Change Country Profile Initiative can be found at https://www.who.int/globalchange/resources/countries/en/
Data	2018 WHO Health and Climate Country Survey
Caveats	The survey sample is not a representative sample of all countries as this survey was voluntary, however, the inclusion of 101 countries in this survey compared with 40 in the 2015 survey demonstrates a large increase in coverage. Additionally, the WHO is running a climate change and health special initiative in Small Island Developing States and there are 26 small island developing countries and territories represented within the total number of respondents.
Future Form of Indicator	The WHO Climate and Health Country Survey will be conducted biennially and will continue to be the primary source of data to track this indicator. The future evolution of this indicator will explore the monitoring and review of the existing strategies/plans and progress on level of implementation of strategies/plans. With more countries initiating the national adaptation plan (NAP) process, alignment of the health component with the overall NAP will also be more closely monitored. Interim information regarding the specific

	content of national strategies/plans, as explored in this qualitative analysis, may be re-assessed in the future.

Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.1: Adaptation planning and assessment
Sub-Indicator	2.1.2: National assessments of climate change impacts, vulnerability, and adaptation for health
Methods	Similar to the methods provided for indicator 2.1.1, national assessments of vulnerability, impacts and adaptation for health (health V&As) were monitored through the 2018 WHO Health and Climate Change Country Survey.
Data	2018 WHO Health and Climate Change Country Survey
Caveats	The survey sample is not a representative sample of all countries as this survey was voluntary, however, the inclusion of 101 countries in this survey compared with 40 in the 2015 survey demonstrates a large increase in coverage. Additionally, the WHO is running a climate change and health special initiative in Small Island Developing States and there are 26 small island developing countries and territories represented within the total number of respondents.
Future Form of Indicator	The WHO Climate and Health Country Survey will be conducted biennially and will continue to be the primary source of data to track this indicator. The future evolution of this indicator will explore the coverage and comprehensive of the assessments, such as the use of qualitative and/or quantitative data and the use of future projections of risks of climate-sensitive diseases.
Additional Information	 *Figure 25: Number of countries that have conducted a scientific assessment of health vulnerability and adaptation to climate change (n=101)*

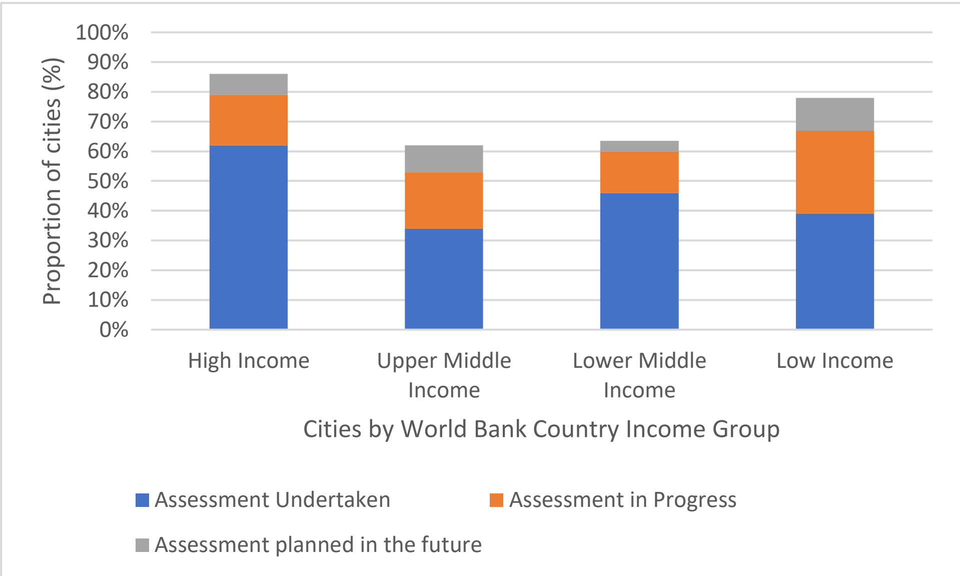
Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.1: Adaptation planning and assessment
Sub-Indicator	2.1.3: City-level climate change risk assessments
Methods	The CDP serves as an official reporting platform for the Compact of Mayors, and administrates, collects and analyses a global survey of city based environmental and climate change data on an annual basis. In 2018, 489 cities participated in the survey, with 469 reporting publicly, that included questions on emissions, adaptation assessments and plans. Respondents to the surveys to describe the magnitude of the impact of climate based hazards (extremely serious, serious, less serious) and identify three critical assets or services that may be most impacted. Based on this data two indicators can be developed. The first is a global cities-based indicator of government areas that have undertaken a climate change risk or vulnerability assessment. The second is global cities-based indicator of the perceived vulnerability of health infrastructure to climate change.
Data	CDP Cities Data
Caveats	This is a sample survey and cities are under no obligation to respond. As such the survey may suffer from selection bias. The majority of responding cities are also from High Income Countries (69%). As such, the results are not representative.
Future Form of Indicator	The CDP collect this data annually and it is foreseen that the data collection will continue to 2030.
Additional information	 *Figure 26: Proportion of cities that have conducted climate change risk assessments, by World Bank income group*

	Table 7: Cities that responded to the 2019 CDP survey by WBG Income Group

World Bank income Group	Freq.	Percentage
High Income	297	61%
Upper Middle Income	141	29%
Lower Middle Income	32	6%
Low Income	19	4%
Total Cities	489	

Table 8: Cities by CPD Region that have undertaken a climate change risk or vulnerability assessment at the local government area

	Africa	East Asia	Europe	Latin America	North America	Middle East	South Asia & Oceania	South & West Asia
Yes	16	11	75	43	83	0	14	2
No	11	2	13	45	28	1	0	3
In Progress	8	1	18	23	26	2	4	0
Intend future	3	0	5	12	16	0	0	0
Don't know	1	0	0	1	2	0	0	0
Total	39	14	111	124	155	3	18	5

Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.2: Climate information services for health
Methods	The number of World Meteorological Organization (WMO) national member states (NMS) whose Meteorological and Hydrological services are providing climate services to the health sector is calculated based on self-reported information provided by member states to the World Meteorological Organization (WMO) through the Country Profile Database Integrated questionnaire. The questionnaire is one of the main sources of information to the WMO Country Profile data base

	and is open all year round for WMO members to update their profile information. Reported data reflects answers to Question number 6.2 of this questionnaire: "Please indicate which user communities/sectors your NMS provides with climate products/information and estimate the extent to which these products are used to improve decisions". "Human Health" is one of multiple sectors which can be chosen.
Data	World Meteorological Organization Country Profile data base, which can be consulted online at https://www.wmo.int/cpdb/.
Caveats	The current data source from WMO only considers climate services provided by NMS. It is unclear the degree to which other providers, such as academic institutions and research projects, private sector products, products from other Ministries, or regional and global products and services are being used, in proportion to services made available by NMS. The open questionnaire can be updated at any time by WMO members, therefore the figures here reported may change over the year. As each country may update their profile information at different moments in time, snap shots do not reflect progress for any given year but rather information provided until a certain date. The current questionnaire does not record the number of WMO members that do not provide climate services to the health sector. The questionnaire captures information on the provision of climate services, the status of service provision to the health sector (divided in 5 categories) and the type of services provided (divided in 5 categories as well). However, only the provision and status of climate service has been reported here due to uncertainties over the quality of the data on the type of services provided. Questions do not capture the source or quality of the service and only one of the answer option covers the utility of the climate services. They do not capture whether data originates from national meteorological observations or is resulting from regional or global products. They do not capture the potential use of all-sector forecasts or outlooks which are accessed and used by the health sector. The WMO and WHO have some differences in their individual Member States. Responses collected from WMO Member States, were reclassified according to WHO Region. WMO members that are not individual WHO members were excluded from the analyses and include Macao and Hong Kong (reported as China), Curaçao and St. Maartens. The following WHO Members are not Members of WMO, therefore representative data is not available: Andorra, Equatorial Guinea, Marshall Islands, Nauru, Palau, San Marino.
Future Form of Indicator	WMO will implement new survey instruments in 2019 to provide greater insight on the status of climate service provision for the health sector, and the type of service provided. Other complementary WMO surveys capturing specific product types, user satisfaction, and application areas, may be publicly available in the future to inform future editions of this indicator. The World Health Organization (WHO) conducts a regular climate and health country survey with ministries of health or national health authorities in its 194 Member States. In 2017, this survey added indicators on the inclusion of

	meteorological information in integrated risk monitoring and early warning systems for climate-sensitive diseases. This information may be used to improve this indicator in future publications.
Additional information	Full list of countries providing climate services: Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Barbados, Belgium, Bosnia and Herzegovina, Brazil, Cameroon, Chad, Chile, China, Côte d'Ivoire, Croatia, Cyprus, Germany, Dominica, Ecuador, Egypt, El Salvador, Fiji, Finland, France, Georgia, Germany, Guinea-Bissau, Hungary, Iceland, Indonesia, Iraq, Ireland, Japan, Kazakhstan, Kenya, Latvia, Lesotho, Madagascar, Malawi, Malaysia, Maldives, Mali, Mexico, Mozambique, Morocco, Myanmar, Niger, Nigeria, Northern Macedonia, Peru, Philippines, Republic of Korea, Russian Federation, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Singapore, Slovenia, South Africa, Spain, Sudan, Thailand, Trinidad y Tobago, Ukraine, United Kingdom, United Republic of Tanzania, United States of America, Venezuela and Zimbabwe.

Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.3: Adaptation delivery and implementation
Sub-Indicator	2.3.1: Detection, preparedness and response to health emergencies
Methods	This indicator takes data from the International Health Regulations (IHR (2005)) State Party Self- Assessment Annual Reporting Tool (SPAR). Under the IHR (2005) all States Parties are required to have or to develop minimum core public health capacities to implement the IHR (2005) effectively. IHR (2005) also states that all States Parties should report to the World Health Assembly annually on the implementation of IHR (2005). In order to facilitate this process, WHO developed an IHR Monitoring questionnaire, interpreting the Core Capacity Requirements in Annex 1 of IHR (2005) into 20 indicators for 13 capacities. Since 2010, this self-reporting IHR monitoring questionnaire is sent annually to National IHR Focal Points (NFPs) for data collection. It contains a checklist of 20 indicators specifically developed for monitoring the development and implementation of 13 IHR capacities. The method of estimation calculates the proportion/percentage of attributes (a set of specific elements or functions which reflect the level of performance or achievement of a specific indicator) reported to be in place in a country. The core capacities to implement the International Health Regulations (2005) have been established by a technical group of experts, as those capacities required to detect, assess, notify and report events, and to respond to public health risks and emergencies of national and international concern. To assess the development and strengthening of core capacities, a set of components are measured for each of the core capacities, by considering a set of one to three indicators that measure the status and progress in developing and strengthening the IHR core capacities. Each indicator is assessed by using a group of specific elements referred to as 'attributes' that represents a complex set of activities or elements required to carry out this component. The annual questionnaire has been conducted since 2010 with a response rate of 72% in 2012, 66% in 2016 and 85% in 2017, and 100% of countries reporting at least once since 2010. Annual reporting results are complemented by after action reviews, exercises, and joint external evaluation (JEE).

	At the beginning of 2018, in compliance with the recommendations of the IHR Review Committee on Second Extensions for Establishing National Public Health Capacities and on IHR Implementation , and following formal global consultations with States Parties held in 2015, 2016, and 2017, and 2018, the WHO Secretariat replaced the IHR Monitoring questionnaire by the "IHR State Party Self-assessment Annual Reporting (SPAR) Tool". This has strong implication for the future of this indicator: preparedness and response capacities have now been merged into one capacity called "C8: National health emergency framework"; one capacity relevant to climate adaptation and resilience has been added ("C9: Health services provision"); and a in change capacity grading has been introduced, which requires countries to grade their capacity indicators in progressive levels from 1 to 5 as opposed to the previous "Yes/No/Not know" answers options.
Data	International Health Regulations (2005) Annual Reporting. Data is available through the Global Health Observatory Data Repository for 2010-2017 http://apps.who.int/gho/data/node.main.IHR?lang=en And through the SPAR interactive for 2018 http://gamapserver.who.int/gho/interactive_charts/ihrspar/atlas7.html?indicator=i7&geog=0&indicator=i7&date=2018&bbox=-312.53597590361454,-62.897000000000006,312.53597590361454,90.59700000000002&printmode=true
Caveats	There are some limitations to considering these capacities as proxies of health-system adaptive capacity and system resilience. Most importantly, IHR monitoring questionnaires responses are self-reported. Secondly, the countries that report IHR implementation annually differ from year to year within these regional aggregate scores. Thirdly, IHR Core Capacity Requirements are not specific to climate change, and hence whilst they provide a proxy baseline, they do not directly measure a country's adaptive capacity in relation to climate driven risk changes. Fourthly, these findings capture potential capacity – not action. Finally, the quality of surveillance for early detection and warning is not shown and neither is the impact of that surveillance on public health. Response systems have been inadequate in numerous public health emergencies and thus the presence of such plans is not a proxy for their effectiveness. Nonetheless, these four capacities provide a useful starting point to consider the potential adaptive capacity of health systems globally.

Additional information	*Table 9: Levels for the National Health Emergency Framework Capacity (C8) of the IHR (2005) SPAR Tool.*[68]

C8.1: Planning for emergency preparedness and response mechanism	
Level 1	A public health emergency risk profile and plans for emergency preparedness and response are under development
Level 2	Public health emergency risk profiles have been developed and emergency preparedness measures for priority public health risks is available at the national level
Level 3	Based on the all-hazard health emergency risk profile, plans for multisectoral all-hazard public health emergency preparedness and response are in place at the national levels
Level 4	Based on the all-hazard health emergency risk profile, plans for multisectoral all-hazard public health emergency preparedness and response are in place at national, intermediate and local levels
Level 5	Based on updated all-hazard health emergency risk profile and resource mapping, plans for multisectoral all-hazard public health emergency preparedness and response plan are regularly tested and updated
C8.2 Management of health emergency response operations	
Level 1	A health sector emergency response coordination mechanism60 or incident management system linked with a national emergency operation centre is under development
Level 2	A health sector emergency response coordination mechanism or incident management system linked with a national emergency operation centre are in place at the primary level of response
Level 3	Health sector emergency response coordination mechanisms and incident management system linked with a national emergency operation centre are in place at the primary level of response
Level 4	Health sector emergency response coordination mechanisms and incident management system linked with a national emergency operation centre are in place at national, intermediate and local levels
Level 5	A health sector emergency response coordination mechanism and incident management system linked with a national emergency operation centre have been tested and updated regularly
C8.3 Emergency resource mobilization	
Level 1	Inventories and maps of existing health sector resources for emergency response are under development
Level 2	Inventories and maps of existing health sector resources for emergency response are in place at the national level
Level 3	Inventories and maps of existing health sector resrources for emergency response are in place at the national, intermediate and local levels AND A mechanism to send and/or receive international assistance is in place
Level 4	Access to existing health sector resources for emergency response is in place at national, intermediate and local levels
Level 5	Resource mapping and mobilization mechanisms are regularly tested and updated

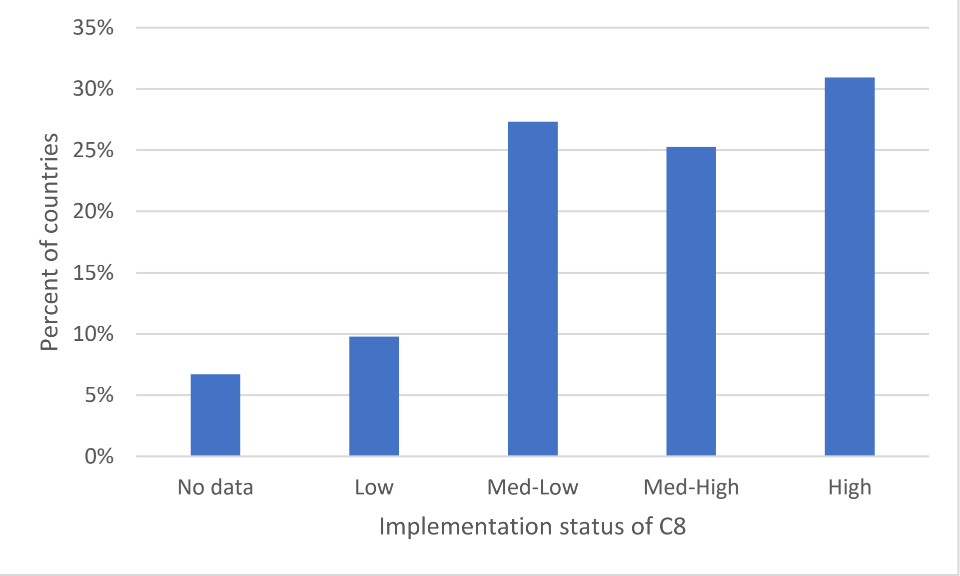


Figure 27: Implementation status of the IHR National Health Emergency Framework Core Capacity (C8) for all 194 WHO Member States for 2018

Table 10: National Health Emergency Framework by country for 2018. Numbers 1-5 correspond to the level of implementation of each of the components. 0=no implementation.[69]

Country	**C.8.1**	**C.8.2**	**C.8.3**
Afghanistan	1	1	2
Albania	Other	Other	Other
Algeria	3	1	4
Andorra	0	0	0
Angola	2	3	4
Antigua and Barbuda	1	4	4
Argentina	2	2	2
Armenia	3	4	4
Australia	5	5	5
Austria	2	2	1
Azerbaijan	3	4	4
Bahamas	3	4	4
Bahrain	5	4	4
Bangladesh	2	3	2
Barbados	No data	No data	No data
Belarus	No data	No data	No data
Belgium	5	4	4
Belize	2	4	4
Benin	2	2	0
Bhutan	2	3	2
Bolivia (Plurinational State of)	Other	Other	Other
Bosnia and Herzegovina	1	2	1

Botswana	1	1	0
Brazil	5	3	5
Brunei Darussalam	No data	No data	No data
Bulgaria	2	2	4
Burkina Faso	1	1	1
Burundi	1	1	0
Cabo Verde	1	1	1
Cambodia	1	3	1
Cameroon	2	2	1
Canada	5	5	5
Central African Republic	0	2	2
Chad	2	1	1
Chile	3	4	4
China	4	4	4
Colombia	2	5	4
Comoros	1	1	0
Congo	3	1	3
Cook Islands	2	4	4
Costa Rica	1	2	1
Côte d'Ivoire	1	3	1
Croatia	2	3	2
Cuba	5	5	5
Cyprus	4	5	4
Czechia	2	4	4
Democratic People's Republic of Korea	4	4	4
Democratic Republic of the Congo	2	1	2
Denmark	5	5	5
Djibouti	1	1	1
Dominica	4	4	4
Dominican Republic	1	2	5
Ecuador	3	5	4
Egypt	5	5	5
El Salvador	4	4	1
Equatorial Guinea	1	1	1
Eritrea	1	1	1
Estonia	3	4	4
Eswatini	1	3	1
Ethiopia	4	3	4
Fiji	3	3	2
Finland	4	5	5
France	5	5	1
Gabon	2	1	1
Gambia	2	1	2
Georgia	4	3	3

Germany	4	5	5
Ghana	2	1	1
Greece	No data	No data	No data
Grenada	No data	No data	No data
Guatemala	4	4	4
Guinea	2	4	5
Guinea-Bissau	2	3	3
Guyana	Other	Other	Other
Haiti	1	5	1
Honduras	0	2	1
Hungary	2	4	3
Iceland	5	5	5
India	3	3	4
Indonesia	3	3	2
Iran (Islamic Republic of)	5	5	5
Iraq	4	4	5
Ireland	4	5	3
Israel	5	5	5
Italy	5	5	5
Jamaica	4	4	4
Japan	Other	Other	Other
Jordan	4	4	4
Kazakhstan	1	1	4
Kenya	1	3	1
Kiribati	3	1	1
Kuwait	2	3	2
Kyrgyzstan	3	4	4
Lao People's Democratic Republic	2	2	2
Latvia	5	4	3
Lebanon	3	3	3
Lesotho	0	0	2
Liberia	1	5	1
Libya	0	0	4
Lithuania	5	5	4
Luxembourg	4	4	4
Madagascar	1	2	1
Malawi	2	1	2
Malaysia	5	5	5
Maldives	4	3	1
Mali	3	3	2
Malta	1	1	1
Marshall Islands	2	5	5
Mauritania	1	1	1
Mauritius	3	4	2
Mexico	5	5	3

Micronesia (Federated States of)	Other	Other	Other
Monaco	5	5	5
Mongolia	5	4	4
Montenegro	4	2	2
Morocco	4	4	4
Mozambique	3	2	2
Myanmar	2	3	4
Namibia	1	1	1
Nauru	0	0	0
Nepal	1	3	2
Netherlands	5	5	4
New Zealand	5	5	5
Nicaragua	3	4	4
Niger	4	1	2
Nigeria	2	3	1
Niue	2	4	4
Norway	5	5	4
Oman	5	5	5
Pakistan	2	2	3
Palau	4	5	4
Panama	4	4	4
Papua New Guinea	2	3	1
Paraguay	2	2	2
Peru	2	4	3
Philippines	No data	No data	No data
Poland	No data	No data	No data
Portugal	4	4	4
Qatar	5	5	5
Republic of Korea	5	5	5
Republic of Moldova	1	4	3
Romania	5	5	5
Russian Federation	5	5	5
Rwanda	1	2	3
Saint Kitts and Nevis	1	3	3
Saint Lucia	2	4	1
Saint Vincent and the Grenadines	1	1	1
Samoa	4	4	4
San Marino	1	1	2
Sao Tome and Principe	1	0	0
Saudi Arabia	4	4	4
Senegal	2	3	3
Serbia	4	4	4
Seychelles	1	1	1
Sierra Leone	2	4	2
Singapore	4	4	4

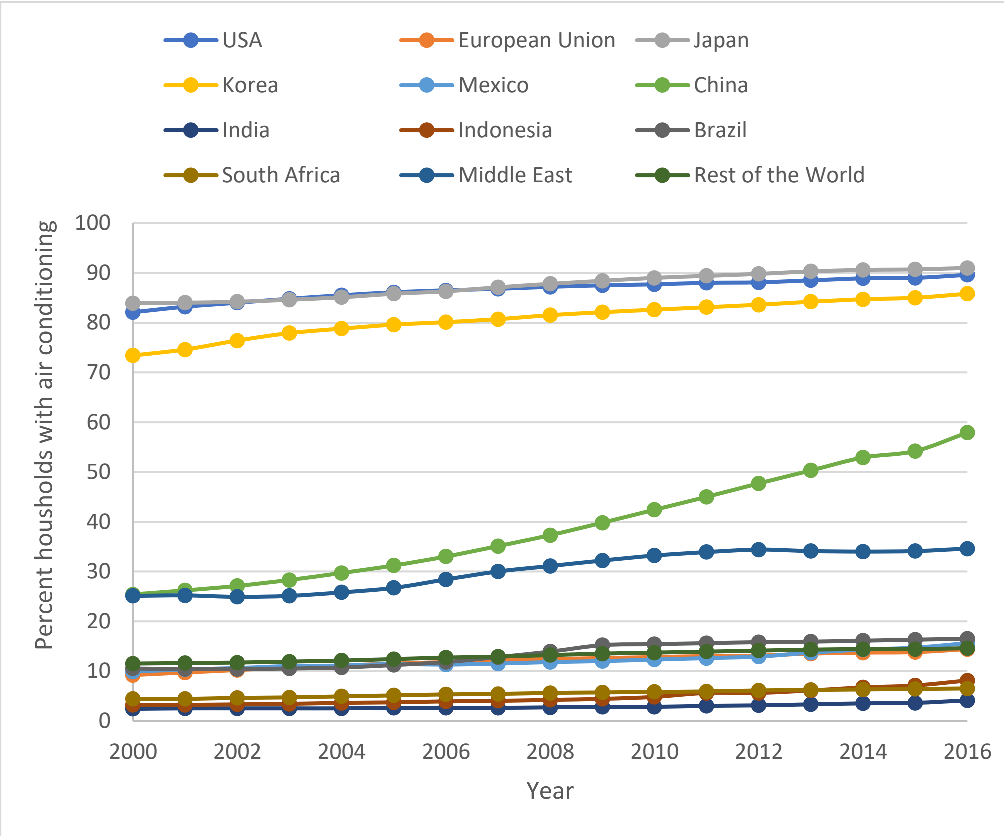
Slovakia	2	5	5
Slovenia	4	3	5
Solomon Islands	1	3	1
Somalia	1	1	1
South Africa	1	4	1
South Sudan	2	3	1
Spain	5	4	4
Sri Lanka	1	3	1
Sudan	4	5	5
Suriname	4	5	4
Sweden	4	4	4
Switzerland	Other	Other	Other
Syrian Arab Republic	2	3	3
Tajikistan	4	4	4
Thailand	3	3	3
Republic of North Macedonia	3	3	1
Timor-Leste	1	1	2
Togo	2	3	1
Tonga	2	3	4
Trinidad and Tobago	2	3	1
Tunisia	2	4	4
Turkey	1	4	4
Turkmenistan	4	4	3
Tuvalu	5	5	4
Uganda	3	4	3
Ukraine	1	4	4
United Arab Emirates	5	5	5
United Kingdom of Great Britain and Northern Ireland	5	5	5
United Republic of Tanzania	3	3	1
United States of America	5	5	5
Uruguay	5	5	4
Uzbekistan	3	3	2
Vanuatu	1	3	4
Venezuela (Bolivarian Republic of)	4	4	3
Viet Nam	2	3	2
Yemen	3	3	3
Zambia	1	3	1
Zimbabwe	2	2	1

Table 11: Implementation status by WHO region. Data taken from WHO.[68]

WHO Region	0-24%	25-49%	50-74%	75-100%	50-100%
Africa	25.53%	53.19%	21.28%	0%	21.28%
Americas	5.71%	20%	28.57%	34.29%	62.86%
East Mediterranean	9.52%	19.05%	19.05%	52.38%	71.43%
Europe	3.77%	11.32%	28.30%	47.17%	75.47%
South-East Asia	0%	45.45%	45.45%	9.09%	54.54%
Western Pacific	3.70%	22.22%	18.52%	40.74%	59.26%

Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.3: Adaptation delivery and implementation
Sub-Indicator	2.3.2: Air conditioning – benefits and harms
Methods	A meta-analysis found having home air conditioning to be the strongest protective factor against heatwave-related mortality (pooled relative risk [RR] = 0.23; 95% confidence interval = 0.1 – 0.6; based on 6 studies) and having visited other air conditioned environments as the second most protective factor (pooled RR = 0.34; 95% confidence interval = 0.2 – 0.5; based on 5 studies).[70] Thus, residential air conditioning is of special interest with regard to protection against heatwave-related mortality. The prevented fraction is the percent reduction in an adverse health outcome due to a preventive exposure, compared with the scenario of complete absence of the exposure.[71] The prevented fraction is determined by two factors: 1) the relative risk of the adverse health outcome in exposed persons compared with unexposed persons and 2) the prevalence of the exposure. The prevented fraction increases with decreasing relative risk and with increasing prevalence of exposure. The formula for prevented fraction is simply: $$P_e(1 – RR)$$ Where P_e is the prevalence of the exposure and RR is the relative risk of the adverse health outcome in exposed persons compared with unexposed persons. For the air conditioning indicator, the prevented fraction is the percent reduction in heatwave-related deaths due to a given proportion of the population (P_{ac}) having household air conditioning, compared with a scenario of complete absence of household air conditioning. Thus, the prevented fraction is simply: $$P_{ac}(1 – RR)$$ As intuitively expected, according to this formula, the higher the protection against heatwave-related mortality conferred by household air conditioning (i.e., the lower the relative risk of heatwave-related mortality in persons living in a household with air conditioning versus persons living in a household without air conditioning), the greater the prevented fraction; and the higher the proportion of the population with access to household air conditioning, the greater the prevented fraction. P_{ac} was assumed to be the same as the proportion of households with air conditioning. These data were kindly provided by the International Energy Agency. Based on the meta-analysis mentioned above, an RR of 0.23 was assumed. Thus, the formula for prevented fraction is:

	$$P_{ac}(1 - RR) = P_{ac}(1 - 0.23) = P_{ac}(0.77)$$ The prevented fraction could range from 0 for a region with no household air conditioning (i.e., $P_{ac} = 0$) to 0.77 for a region in which every household has air conditioning (i.e., $P_{ac} = 1.0$). A low prevented fraction does not necessarily translate into a high absolute number of heatwave-related deaths because in a given country/region the number of heatwave-related deaths that would occur in the complete absence of household air conditioning may be low. To estimate premature deaths from ambient $PM_{2.5}$ due to electricity use for air conditioning, country/region-specific premature deaths due to $PM_{2.5}$ emissions from power plants were estimated, as described in the appendix for Indicator 3.3.2. Then, country/region-specific data on final energy consumption from air conditioning, kindly provided by the International Energy Agency (IEA), was used to calculate the proportion of electricity generation used for air conditioning. This proportion was applied to the total premature deaths due to $PM_{2.5}$ emissions from power plants to estimate the number of premature deaths due to air conditioning.
Data	The IEA kindly provided data on the proportion of households with air conditioning (used for the prevented fraction calculation), CO_2 emissions due to air conditioning (megatons), and final energy consumption for air conditioning (terawatt hours; used for the calculation of premature deaths due to $PM_{2.5}$ from air conditioning) in the entire world and for major countries/regions.
Caveats	For the prevented fraction calculation, an RR of 0.23 was assumed for heatwave-related death for persons living in a household with air conditioning versus persons living in a household without air conditioning, based on a meta-analysis that included 6 studies, 4 from the United States and 2 from France. This RR may differ in other parts of the world. Furthermore, the proportion of households with air conditioning was used to estimate the proportion of the population having household air conditioning. The estimate did not take into account the size of households with versus without air conditioning or the vulnerability to heat stress of persons living in households with versus without air conditioning. Finally, data limitations prevented the estimation of the absolute number of heatwave-related deaths prevented by air conditioning. To estimate premature deaths due to $PM_{2.5}$ emissions from air conditioning, it was assumed that in a given country/region, the electricity market is completely connected, so that the share of electricity used for air conditioning can be equally applied to power plant emissions throughout the country/region. This assumption may not be accurate for larger countries/regions.
Future form of indicator	The meta-analysis of the relationship between living with air conditioning and heatwave-related (or, more generally, heat-related) mortality will be updated. If there are sufficient studies, morbidity will also be examined. The indicator may be updated each year as new data becomes available. City-level case studies to estimate absolute number of lives saved from air conditioning versus premature deaths from exposure to $PM_{2.5}$ due to air conditioning may also be performed. Additionally, national building codes, minimum energy performance standards and labeling rules for air conditioners, and progress on implementing the Kigali Amendment may be tracked in the future.

Additional information	 *Figure 28: Percent of households with air conditioning, by selected countries/regions (data kindly provided by International Energy Agency).*

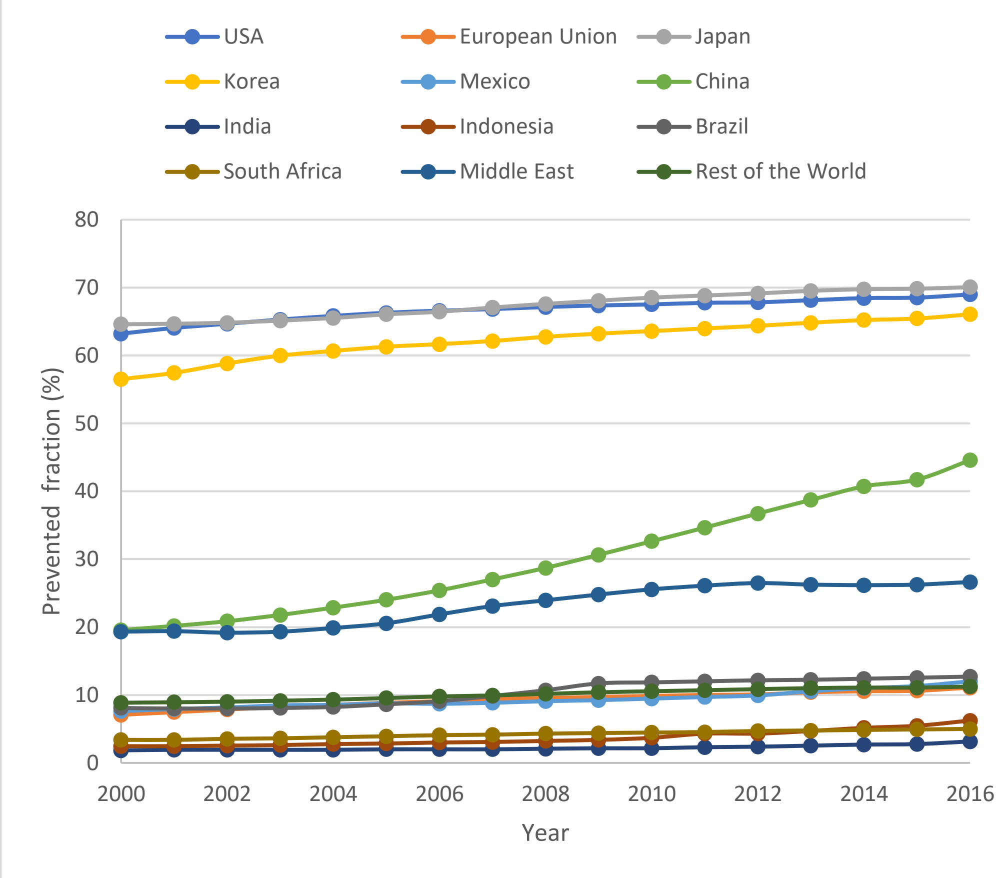


Figure 29: Prevented fraction of heatwave-related mortality due to air conditioning by selected countries/regions.

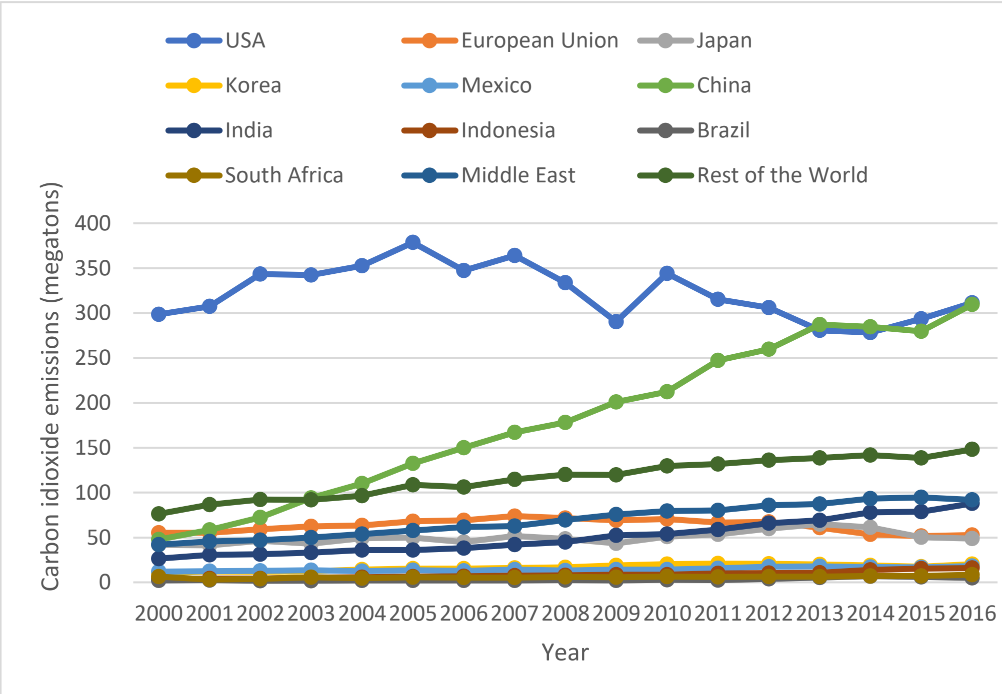


Figure 30: CO_2 emissions from air conditioning by selected countries/regions (data kindly provided by International Energy Agency).

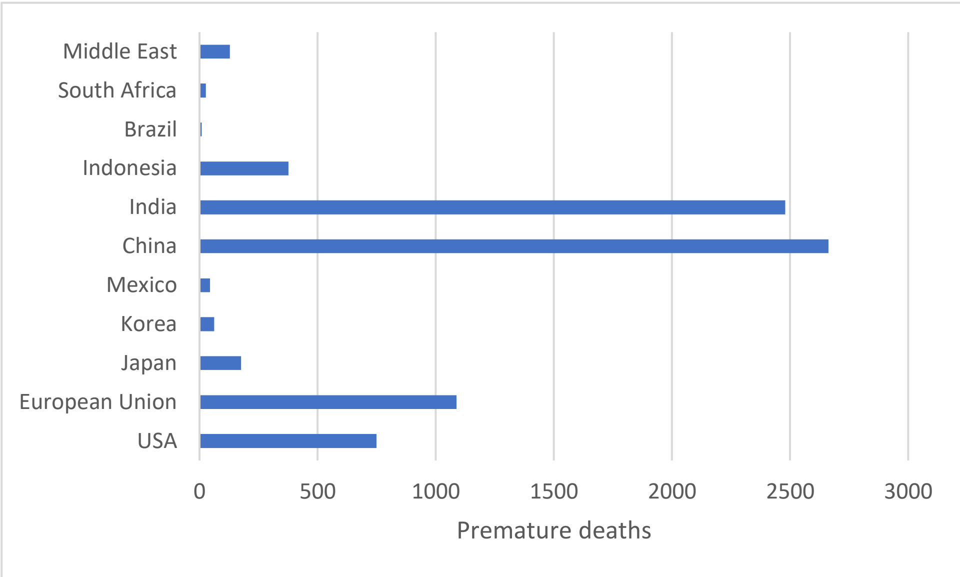


Figure 31: Premature deaths due to $PM_{2.5}$ emissions from air conditioning (data on final energy consumption for air conditioning used for this calculation kindly provided by the International Energy Agency).

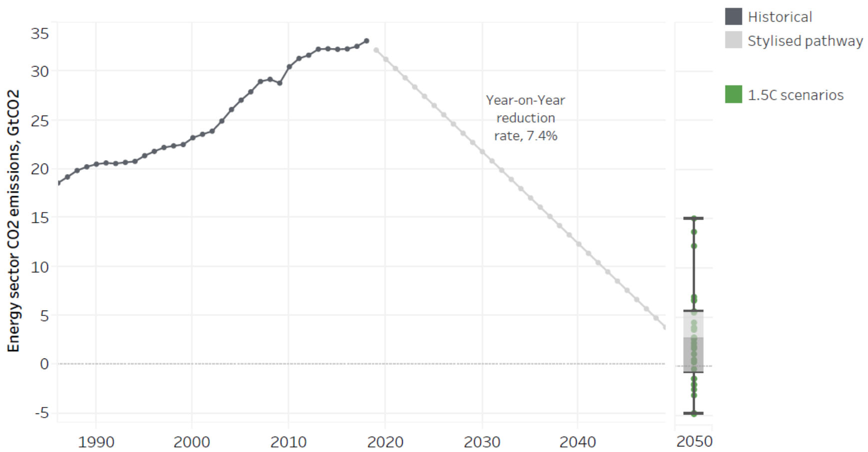
Working Group	2: Adaptation, Planning, and Resilience for Health
Indicator	2.4: Spending on adaptation for health and health-related activities
Methods	The 'Adaptation and Resilience to Climate Change' dataset is the same data source that used in the 2017 and 2018 Lancet Countdown reports.[1,72] It measures spending on economic activities related to adaptation and resilience to climate change. It was developed by data research firm kMatrix[73] in partnership with numerous stakeholders, and includes the key adaptation measures identified by the IPCC. This classification of adaptation activities was originally developed from attempts by the UK Department for Environment, Food and Rural Affairs to measure adaptation in 2009/2010[74]. The definition of adaptation activities was extended through collaboration with the Greater London Authority in 2014, and updated through a project with Climate-KIC in 2017. This added several new industrial sectors as well as significantly expanding the activities under health and healthcare. The methodology used for data acquisition and analysis is based on a system called as 'profiling', which was originally developed at Harvard Business School to track and analyse technical and industrial change.[75] This is the basis for building taxonomies of economic activities and value chains, which can then be populated with estimates of key economic metrics like sales value and employment by triangulating transactional and operational business data to estimate economic values. This methodology is particularly valuable in areas where government statistics and standard industry classifications are not available.[76] When measuring an industry or sector, the new taxonomy is

	populated from the bottom up, searching for evidence for the ideal definition and including only economic activities where sufficient evidence is available. For each transaction listed in the adaptation economy data, a minimum of seven separate sources must independently record the transaction for it to be confirmed and included in the database. Triangulating data from multiple sources permits large volumes of unsorted, fragmented data of different types from different sources to be processed to arrive at more accurate estimates of transactional value that would not be possible using a single source. For the adaptation economy, data is produced to a confidence level of around 80%. Accessing and analysing multiple types of data is also key to identifying the 'purpose' behind an economic activity, which is key for accurately assigning economic activities to the adaptation dataset. Developing the new definition of adaptation and resilience to climate change involved the top-down taxonomy of the entire 'make and mend' economy, and then adaptation and resilience in all forms. Then these categories were filtered to isolate economic activities that can be strictly identified as being relevant to adaptation and resilience to climate change. The taxonomy of A&RCC is drawn from 11 sectors of the economy at-large: Agriculture & Forestry, Built Environment, Disaster Preparedness, Energy, Health/Health Care, ICT, Natural Environment, Professional Services, Transport, Waste and Water.[74,77] There are a number of activities across different sectors that are 'health-related' in the adaptation and resilience to climate change dataset, outside of the strictly-defined healthcare sector. The indicator design therefore required the definition of those activities from the other 10 sectors of the A&RCC data that can be clearly related to health, and thus should be included in a definition of 'health-related' adaptation spending. The robust interim approach used for the 2017 and 2018 Lancet Countdown was again adopted for this year's Lancet Countdown. The 'health-related' activities consists of the activities of the Healthcare/Health Sector, Disaster Preparedness and Agriculture adaptation activities from the kMatrix dataset. A methodology is under development to define a full health-related adaptation definition across the entire A&RCC dataset, and an initial definition of an expanded health-related adaptation classification has been proposed. Geographical Coverage: The A&RCC dataset has global coverage for 226 countries and territories. Data has been reported for a subset of countries and territories for whom adaptation spending data, regional and income classifications, and population estimates are available. This year's indicator covers 191 countries and territories with data reported in the A&RCC dataset, and that are assigned a region in the WHO regional classification and an income group in the World Bank income group classification.[78] Per Capita values are based on 183 countries that also have population estimates from the IMF World Economic Outlook.[79]
Data	Adaptation and Resilience to Climate Change dataset: kMatrix Ltd, in partnership with University College London Comparison Data:

	The classification of WHO Regions was taken from the WHO Data Repository Metadata.[78] WHO metadata reports the World Bank Income Grouping values from 2018 (released 2018, based on 2017 calendar year data). 2015 to 2018 Population and GDP estimates from the April 2019 update of the IMF World Economic Outlook were used to calculate fiscal year values for 2015/16, 2016/17 and 2017/18.[79] For comparability, global total values present the global total for countries or territories that are included in the regional and world bank analysis. It does not include the 35 countries and territories which have neither a WHO Region nor a World Bank Income Group. Most of these are overseas territories or sub-national jurisdictions with relatively lower levels of adaptation spending. However, several larger states or jurisdictions that are not included in this global total are: Hong Kong, Taiwan and Puerto Rico.
Caveats	Economic activity or transactions are only measured where there is an economic 'footprint', i.e. where there is transactional/financial data available to be measured. Therefore, public sector spending without an economic 'footprint' (government spending on salaries, for example), cannot be measured. It also not possible to directly identify what percentage of measured spending is public versus private. Values are not currently adjusted for inflation. Values of sales generated are not directly comparable with values derived from national statistics. The reference period is the financial years 2015/16 to 2017/18. Further historical data could be available in the future.
Future Form of Indicator	There will be three major developments in the future form of the indicator. The first will be the development of the 'three-tier' definition of: 1) Adaptation activities with direct, important health impacts; 2) Those with less direct or more minor health impacts; 3) Those with no health impact or too tenuous a health impact. Secondly, in the future it is likely to possible to present historical data for the indicator, in order to provide trend data on change in spend over time. Finally, in the future the aim is to develop an indicator of adaptation spending as a percentage of the overall health sector spend and health-related spend as a percentage of the entire economy (represented by 24 industries), compiled using transactional data.

Section 3: Mitigation Actions and Health Co-Benefits

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.1: Energy system and Health
Sub-Indicator	3.1.1: Carbon intensity of the energy system
Methods	This indicator contains two components: 1. Carbon intensity of the energy system, both at global and regional scales, (1972-2016), in tCO_2/TJ; and 2. Global CO_2 emissions from energy combustion by fuel, in $GtCO_2$ (1972-2017). Global emissions without fuel breakdown are also provided for 2018. This sub-indicator is complimented by scenario values for 2050 of CO_2 emissions. The technical definition of carbon intensity is the tonnes of CO_2 emitted for each unit (TJ) of primary energy supplied. The rationale for the indicator choice is that carbon intensity of the energy system will provide information on the level of fossil fuel use, which has associated air pollution impacts. Higher intensity values indicate a more fossil dominated system, and one that is likely to have a higher coal share. As countries pursue climate mitigation goals, the carbon intensity is likely to reduce with benefits for air pollution. The indicator is calculated based on total CO_2 emissions from fossil fuel combustion divided by 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. The data is available for most countries of the world, for the period 1971-2016. Future CO_2 emissions for 2050 are taken from the IIASA hosted scenario database containing Integrated Assessment Model scenarios used in the IPCC SR1.5 report.[80]
Data	This indicator is based on based on the IEA dataset, CO_2 Emissions From Fuel Combustion: CO_2 Indicators, accessed via the UK data service.[81] Future emission values from Huppmann et al. 2018.[80]
Caveats	The indicator does not provide information on the share of different fossil fuels, their use in different sectors, and the absolute levels of usage. These are all important elements in understanding the air pollution emissions, and their impacts. Therefore, additional indicators (3.1.2 & 3.1.3) provide additional complimentary information.
Future Form of Indicator	This indicator will need to be updated to provide the data for the most recent years, which have seen important shifts in the use of fossil fuels, particularly coal.
Additional information	This year's report includes data to 2016, supplemented with additional statistics for 2017[82] and 2018,[83] and shows that global emissions of CO_2 from fuel combustion, having been flat between 2014-16, have increased since that period, reaching a new high of 33.1 $GtCO_2$ in 2018.[83] This 2.6% increase over the last two

	years is due to continued growth in energy demand, most of which is met by fossil fuels. As shown in Figure 32 below, these emissions need to fall (from 2019) at a rate of around 7.4% every year to get to levels in 2050 consistent with the 1.5°C target. The carbon intensity of the system also needs to reduce to near zero by 2050. In the last 15 years, carbon intensity has largely plateaued, as the growth of low carbon energy is insufficient to displace fossil fuels to start to bend the intensity curve downwards. In primary energy terms, low carbon energy accounted for 19% of total demand in 2018, down from 20% in 2000. Based on recent IEA data in the last couple of years, carbon intensity is reported to have reduced a small amount in the last couple of years due to displacement of coal by gas.[83] The challenge of reducing CO_2 emissions from the energy system, and achieve the resulting gains for global health, will require enormous political will and both supply and demand side policies. For example, even if all coal was removed from the power generation sector today and replaced with low carbon electricity, carbon intensity would reduce from approximately 57 to 41 tCO_2/TJ, and emissions by about one-third. While reducing coal is key, the other sources of gas and oil in the system are critical to address.  *Figure 32: Historical CO_2 emissions from the energy sector, and distribution of emission levels in 2050 based on scenarios used in the SR1.5 report.[80]*

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.1: Energy system and health
Sub-Indicator	3.1.2: Coal phase-out
Methods	Two indicators are used here: 1. Total primary coal supply by region / country (in EJ units); and 2. Share of electricity generation from coal (% of total generation from coal). The first indicator is complimented by scenario values of coal use for 2050. These indicators are important to enable tracking of changes in coal consumption at a regional and country level. Due to the level of coal used for power generation, a second indicator tracks the contribution to electricity generation from coal power plants in selected countries. As countries pursue climate mitigation goals, the use of coal is likely to reduce with resulting benefits for air pollution. The indicator on primary energy coal supply is an aggregation of all coal types used across all sectors (from the IEA energy balances). The data is available for most countries of the world, for the period 1978-2017, with global data provided for 2018. The indicator on the share of electricity generation from coal is estimated based on electricity generated from coal plant as a percentage of total electricity generated. Regional data is available from 1990-2016, with global share estimated for 2017; pre-1990 data is not used due to incomplete time series. Countries or regions with large levels of coal use (as a share of generation, or in absolute terms), have been selected to show in the figures. Future coal use and generation estimates for 2050 are taken from the IIASA hosted scenario database containing Integrated Assessment Model scenarios used in the IPCC SR1.5 report.
Data	This indicator is based on the extended energy balances from the International Energy Agency. The specific dataset is called World Extended Energy Balances, and is sourced via the UK data service.[84] Future coal use values are based on scenarios are sourced from Huppmann et al. 2018.[80]
Caveats	These indicators provide a proxy for air quality emissions associated with the combustion of coal. Further work is required to convert coal use by sector and type into emissions of different air quality pollutants.
Future Form of Indicator	As per 3.1.1, this indicator will need to be updated to provide the data for the most recent years, which have seen important shifts in the use of coal.
Additional information	While the share of coal in primary energy continues to fall, the overall growth in global energy demand means coal has returned to a growth trajectory since 2016,

	and continues to be the second largest contributor to global primary energy (after oil) and the largest source of electricity generation (at 38%, compared to gas, the next highest at 23%. Most of this growth is in the Asian region, notably in China, India and South-East Asia (Figure 33). Returning to the downward trend in coal demand and then accelerating will be critical to meeting the climate goals embodied in the Paris Agreement. As shown in Figure 34, to push towards the 1.5°C target, coal use levels need to be at 23 EJ (median level) by 2050, compared to 157 EJ in 2017, reducing at a year-on-year rate of 5.6%. If coal is to be phased out, a key sector to tackle will be power generation, which accounted for an estimated 64% in 2017 of total coal use.[82] Since 2016, coal generation has increased, while the share of generation remains at around 38%, as it has been since 2005 (Figure 33). Reductions in generation in other regions such as Europe and the USA have continued, but have been counterbalanced by increases in other regions. Using the scenarios that informed the IPCC SR1.5 report, rather than increasing, coal generation, a year-on-year reduction rate of 9% is required to achieve levels consistent with 1.5°C pathways (Figure 35). For a global fleet of just over 2000 GW, almost half of which is in China, this requires a net reduction per year of 60 GW. It is worth noting that the UK has seen 20% year on year reductions in coal generation since 2010, highlighting what can be achieved albeit for a specific country.[85] If coal phase-out can be sustained, it is likely to have significant air pollution co-benefits (Indicator 3.3), which in turn help offset the policy costs of mitigation. Some positive signs are emerging. First, a slowdown in capacity expansion, with a recent analysis by the Carbon Brief estimating only a net 20 GW increase in 2018.[86] Second, other generation options are becoming cheaper than coal, notably solar, particularly in countries such as India. Finally, the metrics monitoring plants in the planning pipeline are all in decline, while retirements continue at pace in specific regions e.g. USA, UK.[87] As outlined in the 2018 Lancet Countdown report,[1] some political momentum has gathered, in pledging coal phase out, such as the countries in the Powering Past Coal Alliance (PPCA).[88] Crucial to the success of phasing coal out will be the policies in China and India, and the extent to which they will draw down on new investment, and start replacing existing capacity.

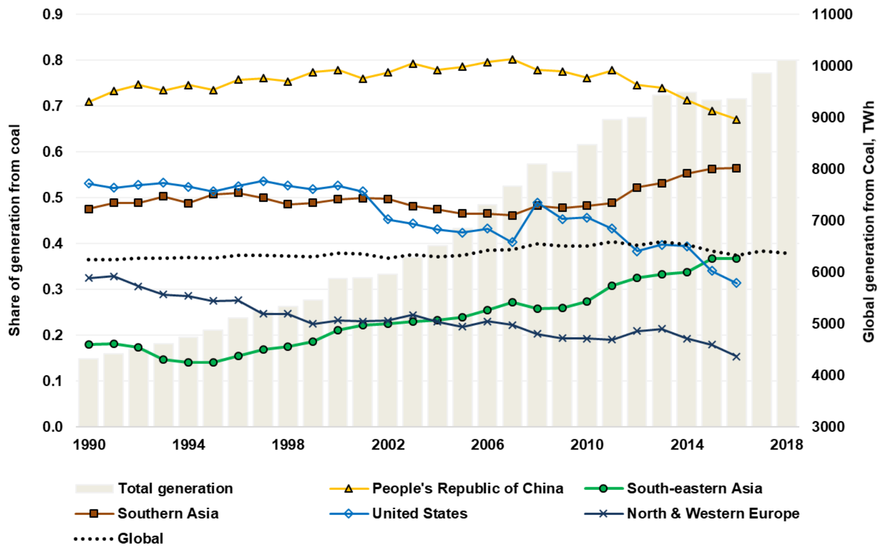


Figure 33: Share of electricity generation coal in selected countries and regions, and global coal generation. Regional shares of coal generation are shown by the trend lines (primary axis) and total coal generation by the bars (secondary axis). Data series are shown to at least 2016, and extended to 2018 for global coal generation.

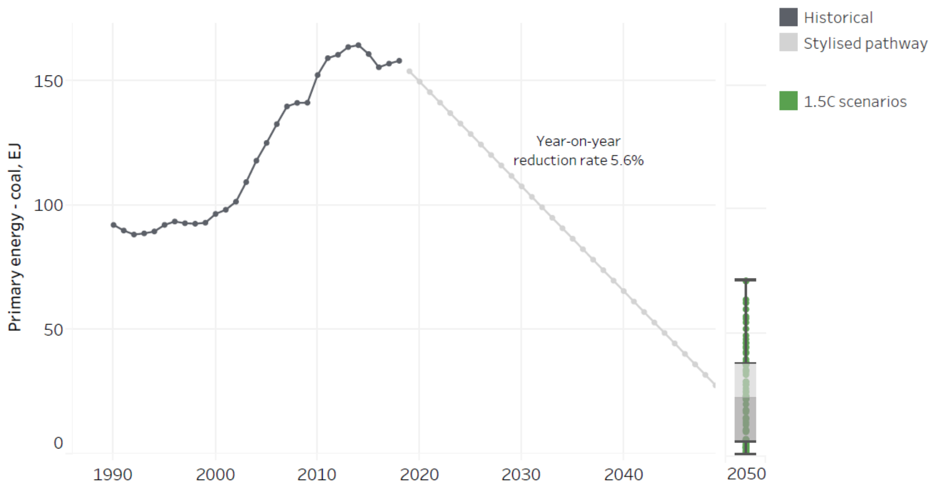


Figure 34: Historical primary energy supply of coal, and distribution of coal levels in 2050 based on scenarios used in the SR1.5 report.[80]

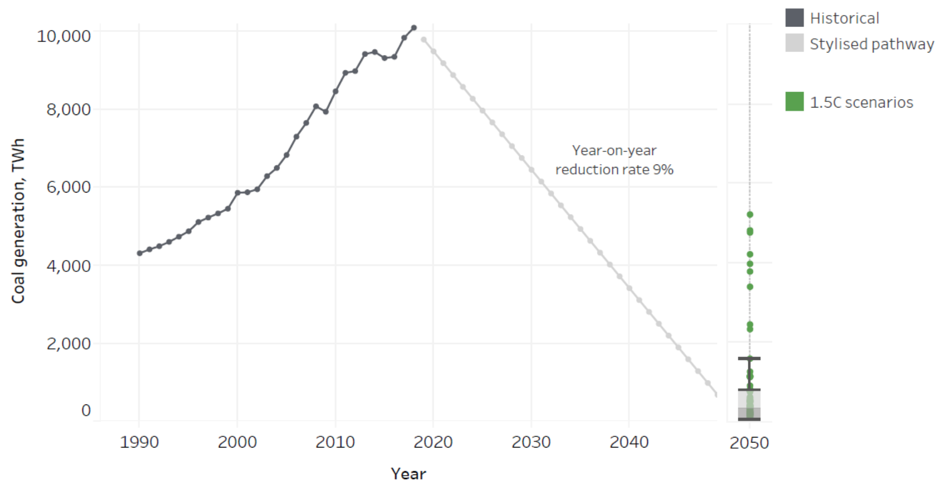


Figure 35: Historical generation by coal, and distribution of coal generation levels in 2050 based on scenarios used in the SR1.5 report.[80]

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.1: Energy system and health
Sub-Indicator	3.1.3: Zero-carbon emission electricity
Methods	Two indicators are used here, and presented in two ways: 1. Total low carbon electricity generation, in absolute terms (TWh) and as a % share of total electricity generated (to include nuclear, and all renewables); and 2. Total renewable generation (excluding hydro), in TWh, and as a % share of total electricity generated. The increase in the use of low carbon and renewable energy for electricity generation will push other fossil fuels, such as coal, out of the mix over time, resulting in an improvement in air quality, with benefits to health. The renewables (excluding hydro) indicator has been used to allow for the tracking of rapidly emergent renewable technologies. For both indicators, generation, rather than capacity, has been chosen as a metric as the electricity generated from these technologies is what actually displaces fossil-based generation. Countries with large levels of low carbon generation (as shares, or in absolute terms), or with higher fossil dependency, have been selected. The data is again taken from the IEA extended energy balances.[84] The absolute level indicators are total gross electricity generated aggregated from the relevant technology types. The share indicators are estimated as the low carbon or renewable generation as a % of total generation.

	The data is available for most countries of the world, for the period 1971-2016. Only the period from 1990 has been used, due to data gaps for selected countries prior to 1990. Future renewable generation estimates for 2050 are taken from the IIASA hosted scenario database containing Integrated Assessment Model scenarios used in the IPCC SR1.5 report.[80]
Data	This indicator is based on the extended energy balances from the International Energy Agency. The specific dataset is called World Extended Energy Balances, and is sourced via the UK data service (http://stats.ukdataservice.ac.uk/).[84] Future renewable energy use values are based on scenarios are sourced from Huppmann et al. 2018.[80]
Caveats	This indicator set does not provide information on the air pollutant emissions displaced due to the increasing share of RE generation.
Future Form of Indicator	This set should be developed to include an indicator to assess the direct impact on air quality emissions from additional low carbon generation, one approach being to compare the emission intensity of the current system with a counterfactual case, which does not have the additional share of RE generation.
Additional information	With the power sector accounting for 38% of total energy-related CO_2 emissions, the importance of renewables for displacing fossil fuels is crucial. In 2016, low carbon electricity globally accounted for 32% of total global electricity, with continued gains in China (see main report). As costs continue to fall, solar generation continues to grow at remarkable rates of around 30% but still only accounts for 2% of total generation. The types of generation levels from renewables across 1.5°C compliant scenarios are shown in Figure 36. It highlights that generation from new renewables (solar, wind, geothermal, ocean) need to increase by 9.7% per annum, to a level in 2050 that is larger than the total global generation today. Since 1990, the annual growth rate for these renewables was over 14%. To maintain the momentum in renewable generation growth, there is a need to ensure that all new generation growth is provided for by non-fossil fuel sources, with strong supply side policies to prevent investment in coal and gas.

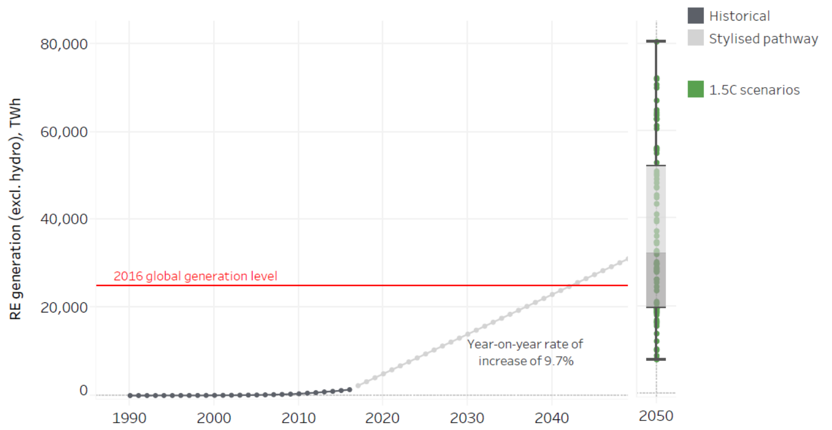
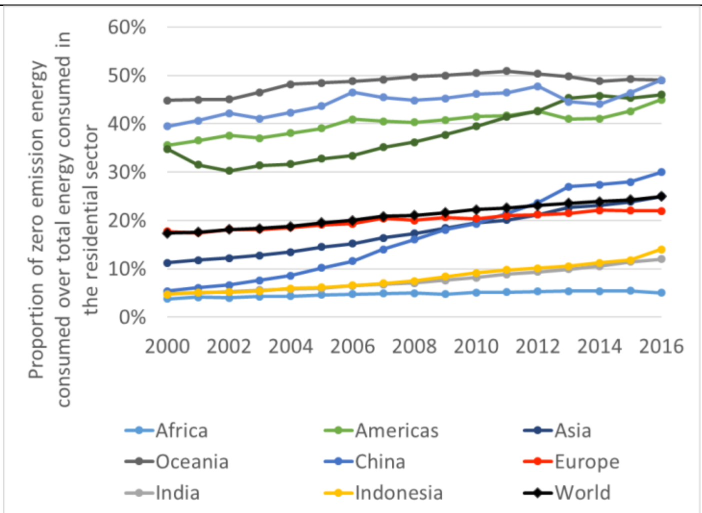
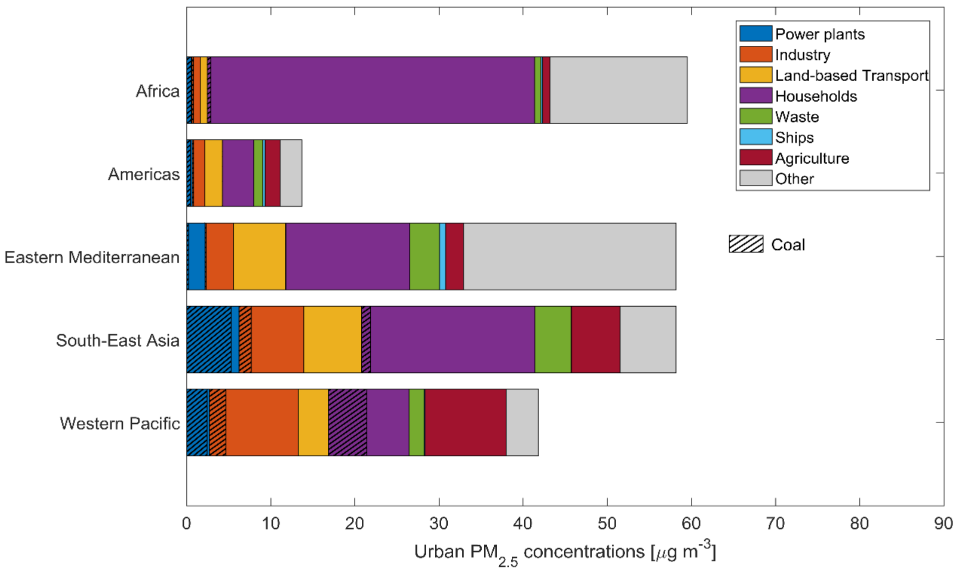


Figure 36: Historical generation by renewables (excl. hydro and bioenergy), and distribution of renewable generation levels in 2050 based on scenarios used in the SR1.5 report.[80]

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.2: Access and use of clean energy
Methods	The 2019 report presents a combination of data from both the Sustainable Development Goal 7, and fuel consumption in the residential sector produced by the International Energy Agency (IEA). Access to energy is defined by the IEA (2019) as: "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average".[89] Within SDG 7.1.2 (proportion of population with primary reliance on clean fuels and technology) "Clean" fuels are defined by emission rate targets and specific fuel recommendations included in the WHO guidelines for indoor air quality.[90] This indicator is modelled with household survey data compiled by WHO. Estimates of primary cooking energy for the total, urban and rural population for a given year are obtained separately using a multilevel model[91] done at the country level. The use of energy in the residential sector is drawn from the IEA extended global residential modelling produced in the World Energy Outlook from the 'World Extended Energy Balances' 2018 edition,[84] which covers all countries or major regions in the world. The values are measured in PJ and cover all fuels consumed within the residential sector final energy demand. Here, at point of final energy demand, clean energy includes electricity (independent of generation source), solar thermal and geothermal.

	The data provided in the 2019 report focus on energy use, as compared to access, as a measure of action to achieving the intent of SDG 7.1.2. The data is summarised for a selection of countries and the globe.
Data	The SDG indicator is based on data from the UN SDG database.[92] The additional energy usage and access is based on data from the IEA World Energy Balances 2018.[84] The energy access data is from the IEA energy access database.[93] The data on household fuel use for cooking was provided by the WHO.
Caveats	The data from the IEA on residential energy flows and energy access provide an indication of both the access to electricity and the proportion of the different types of energy used within the residential sector. These provide an important picture on how access and use might be interacting.
Future Form of Indicator	This indicator provides a better representation of the fuel mix used by households for different demands (heating, cooling, cooking, hot water, lighting and other plug loads) for the mix of income groupings at the country level. Future work will be done to disaggregate and look at access among vulnerable communities.
Additional Information	 *Figure 37: Proportion of zero emission energy consumption in the global residential sector.*

Working group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.3: Air pollution, energy and transport
Sub Indicator	3.3.1. Exposure to air pollution in cities
Methods	This indicator quantifies contributions of individual source sectors to ambient $PM_{2.5}$ exposure in cities worldwide. Coal has been highlighted as a fuel across all sectors. Estimates of sectoral source contributions to annual mean exposure to ambient $PM_{2.5}$ were calculated using the GAINS model,[94] which combines bottom-up emission calculations with atmospheric chemistry and dispersion coefficients. Energy statistics are taken from the IEA World Energy Outlook 2017,[95] merged with GAINS information on application of emission control technologies and their emission factors. Atmospheric transfer coefficients are based on full year simulations with the EMEP Chemistry Transport Model[96] at 0.5°×0.5° resolution using meteorology of 2015 and include a downscaling to capture sub-grid urban concentration gradients for approximately 5000 cities over 100,000 inhabitants globally. Calculated ambient $PM_{2.5}$ concentrations have been validated against in-situ observations from the latest version of the WHO's Urban Ambient Air Pollution Database (2016 update),[97] and other sources where available (e.g. Chinese statistical yearbook). Also, numbers compare well with the SHUE dataset presented in Lancet Countdown 2018.[1] For technical reasons, there are three deviations in the aggregation of countries versus the WHO regions: Sudan is included in the 'African Region' here, but belongs to WHO Eastern Mediterranean Region. Somalia is included in the 'African Region' here, but belongs to WHO Eastern Mediterranean Region. Algeria is included in the 'Eastern Mediterranean' here, but belongs to WHO African Region.
Caveats	The indicator relies on model calculations. Validation is only possible for a limited set of cities where observations are available. These are scarce particularly in low- and middle-income countries.
Future development of indicator	An ideal indicator would provide a marker of benefits for air quality and/or health that are directly attributable to climate change mitigation action, which requires scenario analysis. Going beyond coal, a more explicit quantification of effects of fossil-fuel versus non-fossil fuel based activities could be undertaken.

Additional Information	
	 *Figure 38: Source contributions to ambient $PM_{2.5}$ levels in urban areas, by WHO region, for the year 2016*

Working group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.3 Air pollution, energy, and transport
Sub Indicator	3.3.2. Premature mortality from ambient air pollution by sector
Methods	This indicator quantifies contributions of individual source sectors to ambient $PM_{2.5}$ exposure and its health impacts. Coal has been highlighted as a fuel across all sectors. Estimates of sectoral source contributions to annual mean exposure to ambient $PM_{2.5}$ were calculated using the GAINS model,[94] which combines bottom-up emission calculations with atmospheric chemistry and dispersion coefficients. Energy statistics are taken from the IEA World Energy Outlook 2017,[95] merged with GAINS information on application of emission control technologies and their emission factors. Atmospheric transfer coefficients are based on full year simulations with the EMEP Chemistry Transport Model[96] at 0.5°×0.5° resolution using meteorology of 2015 and include a downscaling to capture sub-grid urban concentration gradients for approximately 5000 cities globally. Calculations for Europe are described in detail by Kiesewetter et al. (2015).[98] Calculated ambient $PM_{2.5}$ concentrations have been validated against in-situ observations from the latest version of the WHO's Urban Ambient Air Pollution Database (2016 update),[97] and other sources where available (e.g. Chinese statistical yearbook).

	Premature deaths from total ambient $PM_{2.5}$ for regions other than Europe are calculated using the methodology of the WHO (2016) assessment on the burden of disease from ambient air pollution,[99] which relies on disease specific integrated exposure response relationships (IERs) developed within the Global Burden of Disease 2015 study.[100] Disease and age specific baseline mortality rates are taken from the GBD Results database.[101] For Europe, this indicator follows the WHO Europe methodology and apply dose-response relationships for all-cause mortality among population over 30 years of age as reported under the REVIHAAP assessment.[102] (WHO, 2013). Details are described in Kiesewetter et al. (2015).[98] Attribution of estimated premature deaths from AAP to polluting sectors was done proportional to the contributions of individual sectors to population-weighted mean $PM_{2.5}$ in each country. $PM_{2.5}$ concentrations for 2008 and 2016 were applied to a fixed 2015 population to estimate the differences in $PM_{2.5}$ attributable mortality due to emission changes only. For technical reasons, there are three deviations in the aggregation of countries compared with the WHO regions, as described for indicator 3.3.1.
Caveats	The indicator relies on model calculations which are currently available for a limited set of regions (Europe, South Asia, East Asia). Uncertainty in the shape of integrated exposure-response relationships (IERs) make the quantification of health burden inherently uncertain. Different dose-response relationships are used for Europe (REVIHAAP, recommended by WHO-Europe) and Asia (WHO-Global). The non-linearity of the IERs used for non-European countries complicates the translation between the mortality burden attributed to an individual source, which is calculated proportional to the source contribution to ambient $PM_{2.5}$, and the effect of mitigating this source. While a reduction of emissions would lead to a (roughly) proportional reduction of ambient $PM_{2.5}$, this would not necessarily result in a proportional reduction of the health burden. In highly polluted environments, the health benefits of a marginal reduction of emissions would be disproportionately smaller than the relative change in concentrations.
Future development of indicator	Other health indicators than premature deaths should be included for a more complete assessment of the health burden, particularly Years of Life Lost (YLLs) and Years Lived with Disability (YLDs). An ideal indicator would provide a marker of benefits for air quality and/or health that are directly attributable to climate change mitigation action, which requires scenario analysis. Going beyond coal, a more explicit quantification of effects of fossil-fuel versus non-fossil fuel based activities could be undertaken.

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.4: Sustainable and healthy transport
Methods	This indicator contains two components: 1. Clean fuel use for transport; and 2. Cycling as a modal share of transport. Fuel use data (by fuel type) from the IEA datasets are divided by corresponding population statistics from the World Bank. Data on travel mode shares from the TEMS tool was cross-referenced with cities that have signed up to the Charter of Brussels, an initiative to encourages cities to target a 15% bicycle modal share by 2020. The tool contains data on approximately 500 cities with more than 100,000 inhabitants, most of which are in Europe.
Data	Fuel use data is based on data from the IEA (2016), Global EB Outlook 2016: Beyond one million electric cars.[103] Data on cycling mode shares obtained from The EPOMM Modal Split (TEMS) tool, developed by the European Platform on Mobility Management.[104]
Caveats	The TEMS data provides estimates for broad mode types (car, public transport, bike, walk) for a limited number of cities only. The data record mode shares as trips rather than distances travelled. The data represent annual averages for a relatively limited number of years (the number of years of data varies between cities).
Future Form of Indicator	An ideal fuel use indicator would capture the direct health impacts of the use of transport fuels, with country- and urban-level specificity within the global coverage. In turn, the co-benefits of transitioning to less-polluting fuels would be quantified directly in terms of reduced exposures to air pollution and their corresponding health impact. To more fully capture sustainable uptake a future indicator could collate information on the proportion of total distance travelled by different modes of transport based on comprehensive local survey data. Other data on sustainable travel infrastructure, for instance the presence of cycle schemes, would also be useful.

Additional information

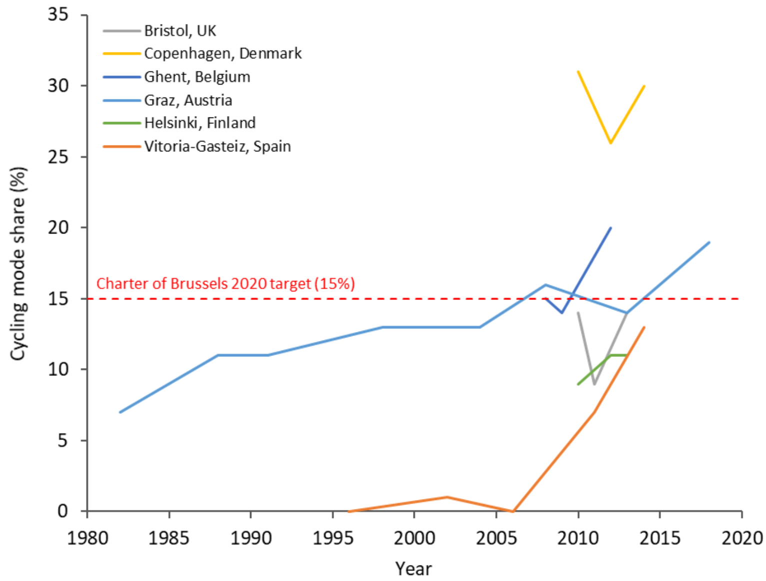


Figure 39: Cycling mode shares (%) over time for six European cities that have signed up to the Charter of Brussels. Data obtained from The EPOMM Modal Split (TEMS) tool.

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.5: Food, agriculture, and health
Methods	The following livestock are included:

Table 12: Livestock included for CO_2e emissions estimate

Ruminant	Non Ruminant
Cattle, dairy (FAO Item Code 960)	Chicken, broilers (FAO Item Code 1053)
Cattle, non-dairy (FAO Item Code 961)	Chicken, layers (FAO Item Code 1052)
Buffaloes (FAO Item Code 946)	Swine, market (FAO Item Code 1049)
Goats (FAO Item Code 1016)	Swine, breeding (FAO Item Code 1079)
Sheep (FAO Item Code 976)	

Emissions from enteric fermentation, manure management and manure left on pasture are obtained from Herrero et al (2013).[105] This information is presented in tonnes of carbon dioxide equivalent (CO_2e) per tropical livestock unit (tlu), which is converted to livestock head using the table below.

Table 13: Tonnes of CO2 per tlu. Data sourced from[106]

<table>
<tr><td></td><td>
<table>
<tr><td></td><td>Head per tlu</td></tr>
<tr><td>Bovine (Buffalo, Cattle (dairy), Cattle (non-dairy)</td><td>1.43</td></tr>
<tr><td>Small Ruminants (Goats, Sheep)</td><td>10</td></tr>
<tr><td>Poultry (Chicken)</td><td>100</td></tr>
<tr><td>Swine</td><td>5</td></tr>
</table>
The emissions per head are divided into world regions (as in the GLOBIOM model) and, for ruminants, livestock system. To convert to country values, a weighted average of the livestock numbers in all regions is taken.
To obtain the emissions from cut and grazed grasslands, the fertilizer applied to grassland and forage use efficiency from Chang et al (2016) is used.[107]
For Crops:
The emissions from fertilizer, rice cultivation and cultivation from organic soils (eg peatland) for maize, rice, wheat, soybean and other crops for the year 2000 are obtained from the study by Carlson et al. (2017),[108] which use IPCC methodology and a non-linear N_2O emission model.
Data from the FAO for emissions from fertilizer, rice cultivation and cultivation from organic land was obtained from 2000-2016.[106] The rate of increase/decrease for the years 2001-2016 in relation to 2000 are calculated. This rate is then applied to the data derived from Carlson et al. (2017)[108] to obtain values from 2000-2016.
</td></tr>
<tr><td>Caveats</td><td>
For livestock, data on stock numbers has been extracted from the FAO database, however, some data is missing for some years, most notably Somalia (missing data 2000-2011) for non-dairy cattle. Data on grazing emissions from small islands is also missing.
The emission factors differ from FAO numbers:

For livestock, this is due to calculation of emissions of enteric fermentation, manure management and manure left on pasture at Globiom region (n=29) and livestock system (n=8) level whereas the FAO use subcontinental (n=9) and climatic level (n=3).[106]
For crops, this is due to the FAO assuming slightly higher synthetic N application, greater manure N inputs, and a linear emissions factor of 1%, in contrast to a mean of 0.77% used by the non-linear model of Carlson et al. (2017).[108]

</td></tr>
<tr><td>Additional information</td><td>
The overall emissions from livestock has increased by 14% from 2000 to 2016. Enteric fermentation (67%) has the highest contribution to total livestock emissions, followed by manure management (17-18%), manure left on pasture (14%) and grassland fertilizer (1%) (Figure 40). The majority of the temporal increase in emissions is attributed to manure left on pasture, enteric fermentation and manure management which have increased by 17%, 15% and 12% respectively from 2000 to 2016, whereas the emissions from grassland fertilizer has only increased by 2%.
</td></tr>
</table>

As ruminants emit methane via enteric fermentation they have the highest emissions of all livestock (93% of total). This is split between non-dairy cattle (62-65%), followed by dairy cattle (10-12%), goats and sheep (10-11%) and buffalo (8%). Emissions from non-ruminants are divided between pigs (5%) and poultry (1-2%). The largest increase in emissions from 2000 to 2016 was poultry (58%), followed by non-dairy cattle (28%), small ruminant (23%), buffalo (22%), pigs (10%) and non-dairy (10%).

The overall emissions from crops have increased by 10% from 2000 to 2016. Fertilizer (21-25%) has the lowest contribution to total crop emissions, followed by cultivation of organic soils (27–29%) and rice cultivation (47-50%) (Figure 41). The majority of the temporal increase in emissions is attributed to emissions from fertilizer, which have increased by 30% from 2000 to 2016, whereas the emissions from rice and organic soil cultivation have only increased by 3% and 9%, respectively.

As rice produces methane in addition to fertilizer application, it has the highest emissions of all crops (52–55% of total), followed by wheat (6-7%), maize (5%) and soybean (1%). The largest increase in emissions from 2000 to 2016 is attributed to wheat (21%), followed by maize (19%) and soybean (12%) whereas emissions from rice have only increased by 5%. The majority of the increases are due to fertilizer emissions which have increased by between 25 and 40% while emissions from cultivation of organic soils have only increased by between 0 and 2% for the named crops.

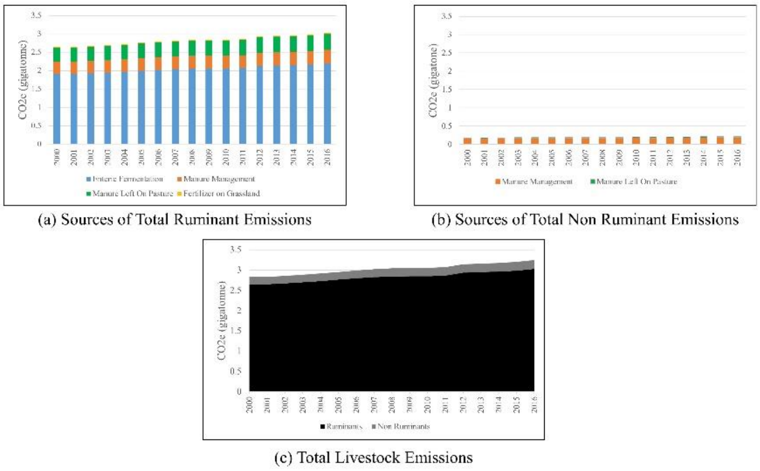
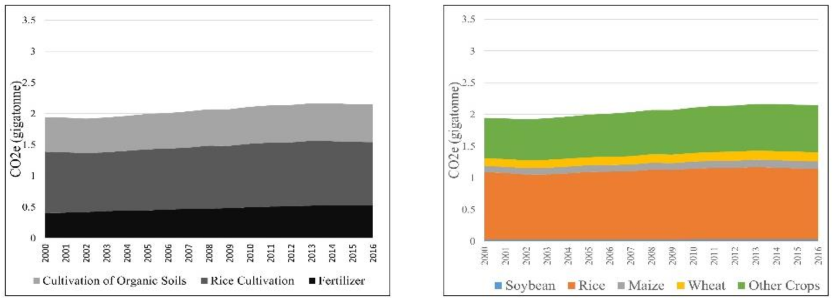


Figure 40: GHG emissions from livestock. a) Sources of total ruminant emissions; b) Sources of total non ruminant emissions; c) Total livestock emissions.



(a) Total Emissions of Crops Divided by Emissions Source

(b) Total Emissions of Crops Divided by Crop Type

Figure 41: GHG emissions from crops. a) Total emissions of crops by emissions source. b) Total emissions of crops by crop type.

Working Group	3: Mitigation Actions and Health Co-Benefits
Indicator	3.6: Healthcare sector emissions
Methods	This indicator is in the form of healthcare-associated GHG emissions per capita per year. Results are calculated by assigning aggregate national health expenditures from WHO to final demand for 'Health and Social Work' in the WIOD or EXIOBASE multi-region input-output (MRIO) models. Satellite environmental accounts are appended to each MRIO model, and GHG emissions are calculated using the standard Leontief inverse technique. This method provides an aggregate GHG emissions result for all types of healthcare expenditures. It is possible to produce a disaggregated estimate that differentiates among expenditure categories, such as hospitals, research, public health, and so on, as has been done for other national-level studies and a recent international comparison.[109-112] One method to do this would be to use expenditure accounts that are themselves already disaggregated. The OECD provides disaggregated health expenditures, but this data set is limited in its geographic coverage. In order to maintain a global scope, WHO expenditure data was preferred, with the trade-off of reduced sector resolution. A second method to create disaggregated results would be to use the supply-use data embedded in the MRIO models themselves to determine expenditures of each national 'Health and Social work' sector to all other sectors in the model, rather than relying on data that are independently reported to the WHO. This method has the advantage of high resolution but the disadvantage that Social Work expenditures would also be included, adding uncertainty to the results. A second disadvantage is that the WIOD and EXIOBASE only have full supply-use models for ~40 countries, which would again limit the geographic scope of the results. Other MRIO models such as EORA have higher granularity and covers 190 countries, but its environmental accounts only cover CO_2 and not the other GHGs. Results for years after the MRIO model year are achieved through deflation of expenditure data. WIOD tables are in US dollars. For model years after 2011,

	WHO expenditure data in current US dollars is deflated to $2011 using the US consumer price index from the World Bank. EXIOBASE tables are in euro. For model years after 2007, WHO expenditure data in current US dollars is converted to current national currencies using current market exchange rates, deflated in national currencies to 2007 using consumer price indices from the World Bank, and converted to 2007€ using 2007 market exchange rates.
Data	Environmentally extended multi-region input-output tables: • WIOD 2013 release with environmental accounts, latest model year 2011, latest emissions account year 2009, air emissions include CO_2, CH_4, N_2O, NO_x, SO_x, CO, NMVOC, and NH_3; • EXIOBASE version 2.2, latest model and emissions account year 2007, GHG emissions include CO_2, CH_4, N_2O. This is not the most recent version of EXIOBASE, but was chosen as EXIOBASE 3.4 produced health care sector GHG emissions intensity results for the US in 2011 that were less than half of those of the national USEEIO model developed by the USEPA, a discrepancy that could not be reconciled. Per capita health expenditure data and health expenditure as % of national GDP is from the World Health Organization's Global Health Expenditure Database.[113] Population data is also from the WHO.[114] Market exchange rates are from UN Statistics Division.[115] Consumer price indices are from the World Bank.[116]
Caveats	As only total health expenditure data is available from WHO, all expenditures are assigned to Final Demand, with no separation for investment. MRIO models are retrospective and do not intrinsically account for changes in economic structure or emissions intensities (e.g., for electricity) that have occurred in the intervening period. Results will not reflect individual healthcare systems' power purchase agreements for renewable energy; nor are emissions of waste anaesthetic gases, as these are not currently reported consistently to national governments and are not considered in environmental accounts.
Future Form of Indicator	This indicator could be updated with improved EE-MRIO models in future years. For example, the addition of non-CO_2 GHGs to the EORA full model would enable global coverage with additional resolution of expenditures within the healthcare sector.
Additional information	This is the first year that results are being presented for this indicator. Healthcare GHG emissions can be differentiated between those that occur domestically and those that occur in other countries. In the indictor results, countries also show wide variation in the location of healthcare GHG emissions, with the Russian Federation showing the highest proportion of emissions occurring domestically (88%) and Luxembourg showing the least (12%) (Figure 42).

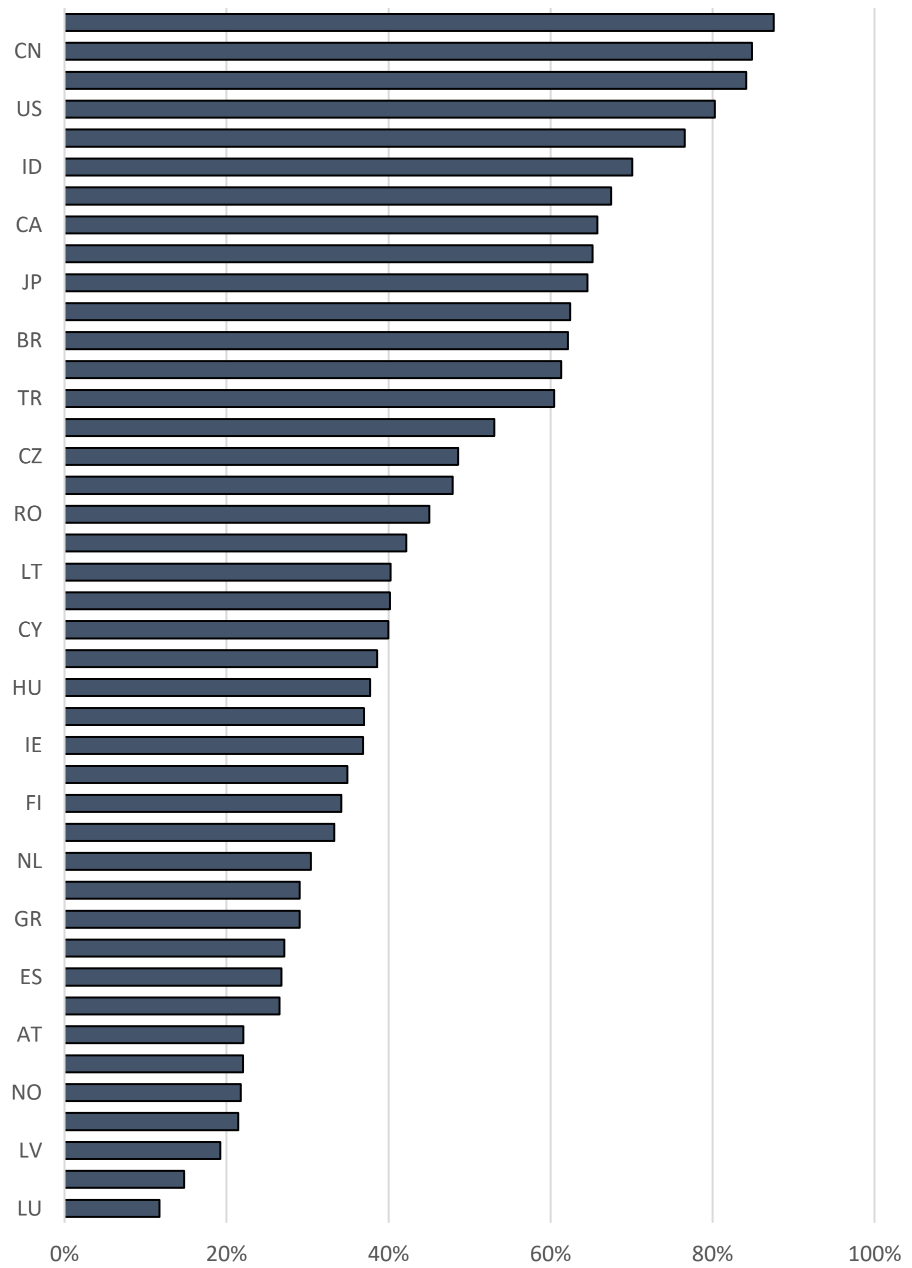


Figure 42: Proportion of healthcare sector emissions of domestic origin.

Section 4: Economics and Finance

<table>
<tr><td>Working Group</td><td>4: Economics and Finance</td></tr>
<tr><td>Indicator</td><td>4.1: Economic Losses due to Climate-Related Events</td></tr>
<tr><td>Methods</td><td>The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix.[1] Munch Re NatCatSERVICE provided the data for this indicator.[117] The NatCatSERVICE is a global database of natural catastrophe data. This has developed into one of the world's most comprehensive databases for information on natural catastrophe loss events. Data suitable for systematic and analytical evaluation on a worldwide scale are available from 1980 onwards. For this paper, data from 1990 are presented in order to align with the base year against which GHG emission reduction targets are commonly set.

NatCatSERVICE collect a range of information for around 1,200 events each year. For this paper only data on direct economic loss (physical/tangible losses), insured losses (all paid-out insured physical/tangible losses) are used. Further information can be found in the online NatCatSERVICE Methodology document.[118]

Table 14: Peril classification as classified by NatCatSERVICE.[118]below illustrates the 'peril classification' provided by NatCatSERVICE. Perils classified as Meteorological, Hydrological and Climatological have been included in the analysis. Geophysical perils are excluded, due to their general independence from climate change.

Table 14: Peril classification as classified by NatCatSERVICE.[118]

<table>
<tr><th>Family</th><th>Main Event</th><th>Sub-Peril</th></tr>
<tr><td>Geophysical</td><td>Earthquake
Volcanic Eruption
Mass Movement (Dry)</td><td>Earthquake (ground shaking)
Fire Following
Tsunami
Volcanic Eruption
Ash Cloud
Subsidence
Rockfall
Landslide (Dry)</td></tr>
<tr><td>Meteorological</td><td>Tropical Storm
Extra-Tropical Storm
Convective Storm
Local Windstorm</td><td>Winter Storm (extra-tropical cyclone)
Hail Storm
Lightning
Tornado
Local Windstorm
Sand/dust storm
Blizzard/Snowstorm
Storm Surge</td></tr>
<tr><td>Hydrological</td><td>Flood
Mass Movement (Wet)</td><td>General Flood
Flash Flood
Glacial Lake Outburst
Subsidence
Avalanche
Landslide (Wet)</td></tr>
<tr><td>Climatological</td><td>Extreme Temperature
Drought
Wildfire</td><td>Heat Wave
Cold Wave/Frost
Extreme Winter Conditions
Wildfire
Drought</td></tr>
</table>
</td></tr>
</table>

	Each natural catastrophe event recorded is assigned a direct economic loss, and where applicable, an insured loss. Where these are available, data is taken from official institutions, but where not, estimates are calculated. The process for estimation depends on what data is available. For example, if loss estimates from insurance market data is available, this data may be combined with data on insurance penetration and other event-specific information to estimate total economic losses. If only low-quality information is available, such as a description of the number of homes damaged or destroyed, assumptions on value and costs are made. Loss values are presented in US$, or if initially expressed in local currency, converted to US$ using the market exchange rates at the end of the month when the event occurred. Once data was received from the NatCatSERVICE economic losses (insured and uninsured) were divided by annual GDP values for each income grouping, sourced from the World Bank Database. Loss values for 1990-2016 were provided by MunichRe in US$2016 terms. GDP data taken from the World Bank Database were inflated to US$2016 terms to carry out the losses/$1000 GDP calculation. For 2017 onwards, data for both economic losses and GDP are sourced in current terms. For this paper, updated GDP values for 2016, 2017 and 2018 have been used.
Data	Munch Re NatCatSERVICE.[117]
Future Form of Indicator	An ideal form of this indicator would allow attribution of fatalities and economic losses to events induced by climate change. However, such attribution is unlikely to be feasible over the course of the Lancet Countdown. As such, it is not envisaged that this indicator will significantly alter.
Additional Information	*Table 15: Insured and uninsured losses from climate-related extreme events by WBG income group and year.*

		Number of Events	Insured Losses/$1000 GDP	Uninsured Losses/$1000 GDP
1990	Low Income	20	$0.00	$1.36
	Lower-Middle	90	$0.00	$2.51
	Upper-Middle	85	$0.03	$1.92
	High Income	217	$0.72	$0.96
1991	Low Income	12	$0.00	$0.26
	Lower-Middle	75	$0.26	$7.37
	Upper-Middle	89	$0.21	$4.14
	High Income	158	$0.65	$0.74
1992	Low Income	8	$0.00	$3.78
	Lower-Middle	86	$0.00	$4.63
	Upper-Middle	109	$0.01	$3.26
	High Income	187	$1.34	$1.28
1993	Low Income	24	$0.00	$5.11
	Lower-Middle	118	$0.00	$14.71
	Upper-Middle	151	$0.03	$4.30
	High Income	203	$0.52	$1.49
1994	Low Income	24	$0.00	$2.01
	Lower-Middle	106	$0.00	$2.96
	Upper-Middle	125	$0.04	$4.52
	High Income	203	$0.31	$0.81
1995	Low Income	17	$0.00	$190.71
	Lower-Middle	104	$0.06	$2.92

		Upper-Middle	136	$0.14	$3.42
		High Income	209	$0.53	$0.60
	1996	Low Income	27	$0.00	$27.29
		Lower-Middle	99	$0.04	$4.52
		Upper-Middle	141	$0.11	$4.16
		High Income	202	$0.47	$0.78
	1997	Low Income	29	$0.00	$2.69
		Lower-Middle	83	$0.01	$2.82
		Upper-Middle	121	$0.09	$2.51
		High Income	186	$0.21	$0.77
	1998	Low Income	38	$0.00	$3.73
		Lower-Middle	111	$0.66	$18.36
		Upper-Middle	125	$0.21	$7.28
		High Income	227	$0.69	$1.11
	1999	Low Income	37	$0.02	$3.68
		Lower-Middle	109	$0.13	$3.68
		Upper-Middle	133	$0.14	$4.56
		High Income	212	$0.99	$0.92
	2000	Low Income	57	$0.01	$6.59
		Lower-Middle	122	$0.03	$4.89
		Upper-Middle	136	$0.01	$1.21
		High Income	204	$0.37	$0.76
	2001	Low Income	40	$0.00	$2.51
		Lower-Middle	116	$0.00	$1.41
		Upper-Middle	126	$0.08	$1.16
		High Income	182	$0.42	$0.39
	2002	Low Income	30	$0.00	$2.58
		Lower-Middle	111	$0.29	$2.19
		Upper-Middle	130	$0.10	$2.90
		High Income	180	$0.61	$1.42
	2003	Low Income	42	$0.00	$2.09
		Lower-Middle	107	$0.00	$0.76
		Upper-Middle	118	$0.01	$3.43
		High Income	182	$0.56	$0.89
	2004	Low Income	21	$0.00	$6.28
		Lower-Middle	84	$0.00	$3.68
		Upper-Middle	122	$0.08	$3.59
		High Income	197	$1.20	$1.18
	2005	Low Income	38	$0.00	$5.11
		Lower-Middle	117	$0.47	$4.05
		Upper-Middle	155	$0.26	$2.93
		High Income	197	$2.51	$2.47
	2006	Low Income	53	$0.00	$2.45
		Lower-Middle	149	$0.20	$4.69
		Upper-Middle	139	$0.04	$1.48
		High Income	265	$0.39	$0.43
	2007	Low Income	72	$0.00	$4.06
		Lower-Middle	182	$0.19	$4.55
		Upper-Middle	199	$0.19	$2.02
		High Income	234	$0.50	$0.49
	2008	Low Income	52	$0.00	$2.27
		Lower-Middle	131	$0.00	$2.50
		Upper-Middle	146	$0.14	$2.91
		High Income	195	$0.88	$0.84
	2009	Low Income	55	$0.02	$2.64
		Lower-Middle	169	$0.13	$2.46
		Upper-Middle	146	$0.03	$0.87
		High Income	218	$0.48	$0.48
	2010	Low Income	65	$0.00	$1.57
		Lower-Middle	177	$0.04	$3.38

	Upper-Middle	149	$0.09	$2.42
	High Income	234	$0.59	$0.50
2011	Low Income	60	$0.00	$2.96
	Lower-Middle	147	$0.01	$1.59
	Upper-Middle	141	$0.75	$2.03
	High Income	220	$1.04	$0.77
2012	Low Income	85	$0.00	$3.10
	Lower-Middle	184	$0.11	$1.13
	Upper-Middle	198	$0.05	$1.11
	High Income	252	$1.23	$1.26
2013	Low Income	54	$0.00	$0.53
	Lower-Middle	159	$0.31	$3.03
	Upper-Middle	188	$0.13	$1.83
	High Income	234	$0.61	$0.62
2014	Low Income	70	$0.03	$0.76
	Lower-Middle	176	$0.13	$2.37
	Upper-Middle	205	$0.07	$1.33
	High Income	275	$0.56	$0.41
2015	Low Income	80	$0.02	$3.67
	Lower-Middle	244	$0.28	$2.29
	Upper-Middle	219	$0.05	$1.27
	High Income	288	$0.61	$0.47
2016	Low Income	84	$0.05	$4.33
	Lower-Middle	221	$0.06	$1.19
	Upper-Middle	227	$0.13	$2.34
	High Income	265	$0.75	$0.66
2017	Low Income	52	$0.03	$3.27
	Lower-Middle	197	$0.02	$1.21
	Upper-Middle	190	$0.12	$1.23
	High Income	273	$2.54	$3.03
2018	Low Income	74	$0.00	$1.10
	Lower-Middle	281	$0.07	$2.02
	Upper-Middle	221	$0.07	$0.79
	High Income	255	$1.39	$1.02

Working Group	4: Economics and Finance
Indicator	4.2: Economic costs of air pollution
Methods	This indicator is based on estimates of total Years of Life Lost (YLL) in each member state of the European Union, resulting from $PM_{2.5}$ exposure from emissions anthropogenic sources, assuming consistent levels of emissions and subsequent population exposure to 2115, integrated across the lifetime of the population present in 2015. The calculations are performed by the GAINS integrated assessment model (see Kiesewetter et al (2015) for a full description of the model and how YOLLs are estimated.[98] - YLLs are calculated based on the loss of life expectancy from all-cause mortality from ambient $PM_{2.5}$ exposure resulting from anthropogenic sources, using dose-response relationships following the WHO Europe methodology,[102] with population cohort exposure kept constant across lifetimes - Calculations are based on the population structure present in 2010, using data extracted from UN life tables. However, 2015 population numbers are used to calculate total YLLs from the calculated reduction in life expectancies.

	- Increased health risk from $PM_{2.5}$ exposure occurs once population cohorts reach 30 years old with younger cohorts only included once they reach this age, (maximum age = 100). Consequences for new additions to the population are not considered. - Energy production and consumption statistics are taken from the IEA Energy statistics are taken from the IEA World Energy Outlook 2017,[95] merged with GAINS information on application of emission control technologies and their emission factors. Total YLLs in each country and year are then multiplied by an estimated 'Value of a Life Year' (VLY), which is taken to be €50,000 for all countries, for all population cohorts, following the lower bound estimate suggested by Part III of the 2009 European Union Impact Assessment Guidelines.[119] Average annual values are then calculated by dividing the product of this calculation by 100.
Data	Energy statistics are taken from the IEA World Energy Outlook 2017[95] merged with GAINS information on application of emission control technologies and their emission factors. Calculations for Europe are described in detail by Kiesewetter et al. (2015).[98]
Caveats	See Indicator 3.3.2, for caveats related to the calculation of reduced life expectancy. There is relatively little literature attempting to estimate a VLY, and with such literature that does exist largely focussing on European countries. The value employed by this indicator (€50,000) is the lower bound estimate suggested for use by the 2009 European Union Impact Assessment Guidelines, with the upper value set at €100,000. As such, it is possible that the values presented by this indicator are conservative, however given the relative lack of evidence and complexity in producing estimates for VOLYs, it is difficult to make such a conclusion with confidence.
Future Form of Indicator	In future, this indicator will be developed to reflect the actual economic value of health consequences of annual changes in $PM_{2.5}$ exposure, rather than of reduced life expectancy from assumed constancy of exposure across lifetimes. The indicator may also be expanded to cover areas outside the European Union.

Additional Information

Table 16: Total economic losses due to years of life lost from $PM_{2.5}$ ambient air pollution

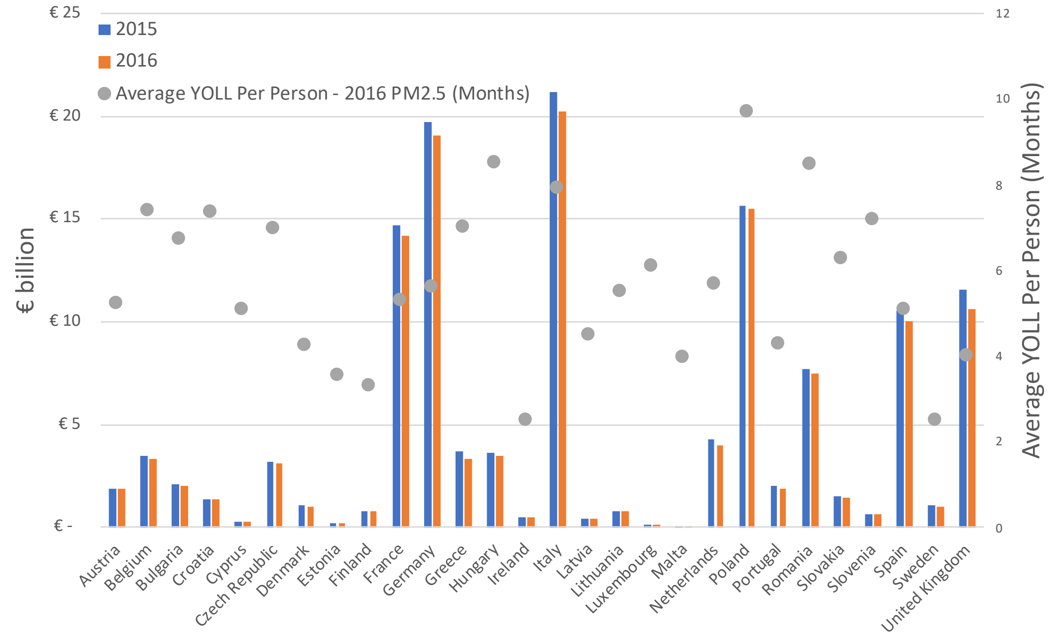


Figure 43: Total economic losses due to years of life lost from $PM_{2.5}$ ambient air pollution for 2015 and 2016 and average life lost per person for 2016 by EU country.

by European country for 2015 and 2016.

	2015	**2016**
Austria	€1.88 billion	€1.84 billion
Belgium	€3.49 billion	€3.35 billion
Bulgaria	€2.06 billion	€2.03 billion
Croatia	€1.38 billion	€1.33 billion
Cyprus	€0.25 billion	€0.25 billion
Czech Republic	€3.15 billion	€3.08 billion
Denmark	€1.07 billion	€1.00 billion
Estonia	€0.20 billion	€0.20 billion
Finland	€0.75 billion	€0.74 billion
France	€14.70 billion	€14.21 billion
Germany	€19.68 billion	€19.04 billion
Greece	€3.67 billion	€3.34 billion
Hungary	€3.59 billion	€3.51 billion
Ireland	€0.52 billion	€0.49 billion
Italy	€21.18 billion	€20.20 billion
Latvia	€0.42 billion	€0.41 billion
Lithuania	€0.76 billion	€0.75 billion
Luxembourg	€0.14 billion	€0.14 billion
Malta	€0.08 billion	€0.07 billion
Netherlands	€4.25 billion	€3.98 billion
Poland	€15.66 billion	€15.47 billion
Portugal	€2.01 billion	€1.91 billion
Romania	€7.68 billion	€7.50 billion
Slovakia	€1.48 billion	€1.44 billion
Slovenia	€0.62 billion	€0.61 billion
Spain	€10.55 billion	€10.05 billion

	Sweden	€1.05 billion	€1.00 billion
	United Kingdom	€11.52 billion	€10.63 billion
	Total	€133.76 billion	€128.55 billion

Working Group	4: Economics and Finance
Indicator	4.3: Investing in a low-carbon economy
Sub Indicator	4.3.1: Investment in new coal capacity
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix,[1] however the IEA definition of investment has changed, as described below. The data on investment in new coal-fired electricity generation capacity is sourced from the annual IEA *World Energy Investment* publication.[120] The revised approach from IEA 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 were presented as 'overnight' investment, in which all capital spending on a new plant is assigned to the year in which the plant became operational.
Data	IEA *World Energy Investment* publication.[120] Due to updated methodology, values presented here differ from those presented in the 2018 Lancet Countdown report.[1] A comparison of investment in new coal-fired electricity generation capacity using the new methodology compared with the old methodology is presented in the main report.
Additional Information	*Table 17: Annual investment in coal-fired capacity from 2006 to 2018 (an index score of 100 corresponds to 2006 levels).*

Year	Index (100 = 2006)
2006	100
2007	108
2008	114
2009	122
2010	128
2011	130
2012	123
2013	111
2014	103
2015	96
2016	87
2017	81
2018	79

Working Group	4: Economics and Finance
Indicator	4.3: Investing in a low-carbon economy
Sub indicator	4.3.2: Investments in zero-carbon energy and energy efficiency
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix,[1] however the IEA definition of investment has changed, as described below. The data for this indicator is sourced from the annual IEA *World Energy Investment* publication.[120] Four categories of investment are defined: • **Renewables & Nuclear** – investment in all renewable and nuclear electricity generation, and renewable transport and heating (including biofuels and solar thermal heating) • **Energy Efficiency** – See below • **Electricity Networks** – investment in electricity transmission and distribution infrastructure, and battery storage • **Fossil Fuels** – including oil, gas and coal, upstream mining, drilling and pipeline infrastructure, and coal, gas and oil power and other fossil fuel-based energy generation capacity. For most sectors, 'investment' is defined as ongoing capital spending on assets. For some sectors, such as power generation, this investment is spread out evenly from the year in which a new plant or upgrade of an existing one begins its construction to the year in which it becomes operational. For other sources, such as upstream oil and gas and liquefied natural gas (LNG) projects, investment reflects the capital spending incurred over time as production from a new source ramps up or to maintain output from an existing asset. This definition applies to (updated) 2017 and 2018 data, and differs from the definition previously employed by the IEA, in which investment was defined as overnight capital expenditure. For energy efficiency, 'investment' is defined as incremental spending by companies, governments and individuals to acquire equipment that consumes less energy than that which they would otherwise have bought. This definition remains unchanged. Other areas of expenditure, including operation and maintenance, research and development, financing costs, mergers and acquisitions or public markets transactions, are not included. Investment estimates are derived from IEA data for energy demand, supply and trade, and estimates of unit capacity costs, For more information, see IEA (2019).[120]
Data	IEA *World Energy Investment* publication.[120]
Additional Information	Values presented below are in US$2018, billion. 2017 values have been updated from those reported in the 2018 Lancet Countdown report,[1] due to improved data.

Table 18: Annual energy investments in US$2018 billions.

	2015	2016	2017	2018
Renewables & Nuclear	367	381	380	377

Energy Efficiency	232	233	239	240
Electricity Networks	276	306	298	297
Fossil Fuels	1,022	956	930	934
Total	**1,897**	**1,875**	**1,846**	**1,847**

Working Group	4: Economics and Finance
Indicator	4.3: Investing in a low-carbon economy
Sub Indicator	4.3.3. Employment in renewable and fossil fuel energy industries
Methods	The data for this indicator is sourced from IRENA[121] (renewables) and IBISWorld[122,123] (fossil fuel extraction). Renewable industries included are: • Large hydropower; • Solar heating/cooling; • Solar photovoltaic; • Wind energy; • Bioenergy; • Other technologies. Bioenergy includes liquid biofuels, soil biomass and biogas. 'Other technologies' includes geothermal energy, ground-based heat pumps, concentrated solar power, municipal and industrial waste, and ocean energy. Fossil fuel extraction values include direct employment, whereas renewable energy jobs include direct and indirect employment (e.g. equipment manufacturing), except for large hydropower (direct employment only). Due to an improvement in data collection and estimation methodology, employment values reported for fossil fuel extraction are in some years substantially higher than those reported in the 2018 Lancet Countdown report.[1] Similarly, an improvement to the methodology for estimating hydropower has altered historic values for Hydropower (previously called 'large' hydropower), and Other Technologies (which previously included small hydropower). For the 2018 data, 'Other Technologies' now also includes employment related to ground-based heat pumps.
Data	IRENA Renewable Energy and Jobs: Annual Review 2018[121] IBISWorld Industry Reports on Global Coal Mining and Global Oil & Gas Exploration & Production.[122,123]
Caveats	Fossil fuel extraction values include only direct employment, whereas renewable energy jobs include direct and indirect employment (e.g. equipment manufacturing).
Additional Information	*Table 19: Employment in Renewable Energy and Fossil Fuel Extraction.*

	Million Jobs						
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Hydropower	1.66	2.21	2.04	2.16	2.06	1.99	2.05
Other Technologies	0.22	.023	0.19	0.2	0.24	0.16	0.18
Solar Heating/Cooling	0.89	0.5	0.76	0.94	0.83	0.81	0.8

Wind Energy	0.75	0.83	1.03	1.08	1.16	1.15	1.16
Bioenergy	2.4	2.5	2.99	2.88	2.74	3.06	3.18
Solar Photovoltaic	1.36	2.27	2.49	2.77	3.09	3.37	3.61
Fossil Fuel Extraction	12.13	12.45	12.71	12.6	12.57	12.61	12.87

Working Group	4: Economics and finance
Indicator	4.3: Investing in a low-carbon economy
Sub Indicator	4.3.4: Funds divested from fossil fuels
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix.[1] The data for this indicator is collected and provided by 350.org.[124] It represents the total assets (or assets under management, AUM) for institutions that have publicly committed to divest in 2017 (for which data is available), with non-US$ values converted using the market exchange rate when the commitment was made, and thus do not directly represent the actual sums divested from fossil fuel companies. A company is committed to 'divestment' if it falls into any of the following five categories: • **'Fossil Free' -** An institution or corporation that does not have any investments (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) in fossil fuel companies (coal, oil, natural gas) and committed to avoid any fossil fuel investments in the future; • **'Full' -** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any fossil fuel company (coal, oil, natural gas); • **'Partial' -** An institution or corporation that made a binding commitment to divest across asset classes from some fossil fuel companies (coal, oil, natural gas), or to divest from all fossil fuel companies (coal, oil, natural gas), but only in specific asset classes (e.g. direct investments, domestic equity); • **'Coal and Tar Sands' -** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any coal and tar sands companies; • **'Coal only' -** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any coal companies. Seven organisations that were originally recorded as non-healthcare institutions have been considered as such for the purpose of this indicator

	(London School of Hygiene and Tropical Medicine, The Royal College of General Practitioners, New Zealand Nurses Organisation, HESTA, HCF, Berliner Ärzteversorgung and Doctors for the Environment Australia). In addition, the Health Alliance on Climate Change has been removed from the data (as no explicit divestment commitment has been made). Divestment commitments by the American Medical Association, which divested in 2018, was not included in the data provided by 350.org, and was added separately.
Data	Due to confidentiality issues, the full dataset is not available for publication. However, interested readers may visit the 350.org website for further information.

Working Group	4: Economics and finance
Indicator	4.4: Pricing greenhouse gas emissions from fossil fuels
Indicator	4.4.1: Fossil fuel subsidies
Methods	The data on fossil fuel consumption subsidies for this indicator is taken from the IEA,[125] and is calculated using the price-gap approach, for 42 mostly non-OECD countries (see data below). The 'price-gap' approach is the most commonly applied methodology for quantifying consumption subsidies. It compares average end-user prices paid by consumers with reference prices that correspond to the full cost of supply. The price gap is the amount by which an end-use price falls short of the reference price and its existence indicates the presence of a subsidy. Prices are presented in US$2018. Original data and a further description of the calculation methodology can be obtained from the IEA (2019).[125] Data for historic years have altered compared to the 2018 Lancet Countdown report[1] due to improved information (including availability of data for 2008 and 2017).

Data	IEA Energy Subsidies.[125]
Caveats	Fossil fuel production subsidies and consumption subsidies for most OECD countries are not included, due to the lack of consistent data.
Future Form of Indicator	An ideal future form of this indicator would have two key elements. The first element would be the consistent inclusion of production and consumption subsidies for all countries, available on an annual basis. The second element would be the use of this data, along with that of carbon pricing data (see Indicator 4.4.2), to create a 'net carbon price' indicator. The future practicality of this indicator will depend on the availability of data at the appropriate level of granularity.

Additional Information

Table 20: Global fossil fuel consumption subsidies 2008-2018.

Year	Oil	Gas	Coal	Electricity	Total
2008	342,193	137,311	2,124	173,892	655,521
2009	156,187	98,364	2,491	130,521	387,563
2010	189,297	104,919	2,726	140,919	437,862
2011	248,485	95,964	3,689	144,301	492,439
2012	283,478	121,938	3,347	144,512	553,274
2013	279,148	109,455	1,808	128,354	518,764
2014	248,175	95,739	1,200	120,316	465,430
2015	136,807	74,998	1,577	104,074	317,456
2016	102,455	49,576	2,263	122,061	276,356
2017	142,849	56,983	2,944	115,974	318,751
2018	181,654	98,543	3,382	145,102	428,681

Table 21: Fossil fuel consumption subsidies by country 2014-2015.

Country	Product	2014	2015	2016
Algeria	Oil	4,129.9	5,310.7	9,564.2
	Electricity	1,875.3	2,566.1	3,560.4
	Gas	1,588.5	2,132.0	3,956.0
	Coal	-	-	-
	Total	**7,593.7**	**10,008.8**	**17,080.5**
Angola	Oil	2.6	6.3	1,382.4
	Electricity	527.5	216.3	517.1
	Gas	-	-	-
	Coal	-	-	-
	Total	**530.1**	**222.6**	**1,899.6**
Argentina	Oil	2,104.7	2,462.4	3,864.0
	Electricity	1,773.5	2,510.8	517.1
	Gas	502.3	491.1	1,716.4
	Coal	0.9	0.9	1.0
	Total	**4,381.4**	**5,465.1**	**6,436.4**
Azerbaijan	Oil	269.2	731.9	786.1
	Electricity	688.5	748.3	913.8
	Gas	542.5	574.2	915.8
	Coal	-	-	-
	Total	**1,500.1**	**2,054.4**	**2,615.7**

	Bahrain	Oil	172.6	273.6	324.3
		Electricity	1,070.0	1,149.4	107.0
		Gas	-	-	-
		Coal	-	-	-
		Total	**1,242.6**	**1,423.1**	**431.3**
	Bangladesh	Oil	4.5	7.4	21.5
		Electricity	403.2	594.2	1,119.9
		Gas	683.0	802.1	1,685.0
		Coal	-	-	-
		Total	**1,090.7**	**1,403.7**	**2,826.4**
	Bolivia	Oil	628.7	816.4	1,263.3
		Electricity	-	-	-
		Gas	49.6	64.7	155.4
		Coal	-	-	-
		Total	**678.3**	**881.1**	**1,418.8**
	Brunei	Oil	104.3	181.0	217.0
		Electricity	-	-	23.5
		Gas	-	-	-
		Coal	-	-	-
		Total	**104.3**	**181.0**	**240.4**
	China	Oil	15,538.3	17,423.9	17,971.1
		Electricity	28,195.9	22,623.6	24,857.3
		Gas	-	-	1,611.6
		Coal	-	-	-
		Total	**43,734.3**	**40,047.5**	**44,440.0**
	Chinese Taipei	Oil	116.6	139.3	9.5
		Electricity	-	-	328.2
		Gas	-	-	-
		Coal	-	238.8	38.7
		Total	**116.6**	**378.1**	**376.4**
	Colombia	Oil	802.1	671.0	832.5
		Electricity	-	-	-
		Gas	-	-	-
		Coal	-	-	-
		Total	**802.1**	**671.0**	**832.5**
	Ecuador	Oil	1,464.5	2,371.6	3,434.7
		Electricity	-	-	-
		Gas	-	-	0.5
		Coal	-	-	-
		Total	**1,464.5**	**2,371.6**	**3,435.2**
	Egypt	Oil	4,349.7	10,732.8	12,222.4
		Electricity	3,443.0	8,131.4	12,137.4
		Gas	129.4	560.7	2,310.6
		Coal	-	-	-
		Total	**7,922.1**	**19,424.8**	**26,670.4**
	El Salvador	Oil	12.9	21.5	25.7
		Electricity	245.0	345.3	412.5
		Gas	-	-	-
		Coal	-	-	-
		Total	**257.9**	**366.8**	**438.3**
	Gabon	Oil	141.2	129.9	121.3
		Electricity	-	-	0.9
		Gas	0.6	0.7	0.8
		Coal	-	-	-

		Total	**141.9**	**130.5**	**123.0**
	Ghana	Oil	28.6	109.8	164.4
		Electricity	-	-	-
		Gas	0.8	5.1	6.7
		Coal	-	-	-
		Total	**29.4**	**114.9**	**171.1**
	India	Oil	11,118.0	13,002.7	17,339.2
		Electricity	2,613.7	-	4,351.2
		Gas	1,307.6	1,489.8	3,679.3
		Coal	-	-	-
		Total	**15,039.4**	**14,492.5**	**25,369.6**
	Indonesia	Oil	6,728.6	13,449.5	24,014.5
		Electricity	11,549.4	5,386.9	7,329.9
		Gas	-	-	-
		Coal	-	-	-
		Total	**18,278.0**	**18,836.4**	**31,344.4**
	Iraq	Oil	3,246.6	5,144.2	6,432.6
		Electricity	2,114.2	1,988.3	2,060.1
		Gas	326.0	548.0	702.5
		Coal	-	-	-
		Total	**5,686.9**	**7,680.5**	**9,195.3**
	Iran	Oil	10,735.6	16,347.6	26,575.6
		Electricity	4,963.0	14,418.9	16,587.0
		Gas	15,480.6	17,895.0	26,044.4
		Coal	-	-	-
		Total	**31,179.2**	**48,661.6**	**69,207.1**
	Kazakhstan	Oil	1,843.6	1,921.3	3,187.6
		Electricity	722.3	791.8	1,429.5
		Gas	302.6	331.2	597.7
		Coal	1,994.6	2,389.7	2,891.1
		Total	**4,863.1**	**5,434.0**	**8,106.0**
	Korea	Oil	-	-	-
		Electricity	-	-	-
		Gas	-	-	-
		Coal	163.1	127.6	82.8
		Total	**163.1**	**127.6**	**82.8**
	Kuwait	Oil	1,286.1	1,398.2	1,743.4
		Electricity	4,325.0	4,113.2	3,739.8
		Gas	1,280.8	1,382.6	1,976.7
		Coal	-	-	-
		Total	**6,891.9**	**6,894.0**	**7,459.9**
	Libya	Oil	3,340.8	3,959.3	4,079.8
		Electricity	421.6	484.8	601.3
		Gas	6.8	10.9	16.8
		Coal	-	-	-
		Total	**3,769.3**	**4,454.9**	**4,697.9**
	Malaysia	Oil	1,553.3	2,085.0	1,911.4
		Electricity	-	-	384.9
		Gas	-	-	-
		Coal	-	-	-
		Total	**1,553.3**	**2,085.0**	**2,296.3**
	Mexico	Oil	738.9	63.4	60.2
		Electricity	10,093.4	11,685.2	13,502.1
		Gas	-	-	42.8

	Coal	-	-	51.6
	Total	**10,832.3**	**11,748.7**	**13,656.7**
Nigeria	Oil	54.5	885.1	2,467.5
	Electricity	-	76.7	411.5
	Gas	-	-	20.0
	Coal	-	-	-
	Total	**54.5**	**961.9**	**2,899.0**
Oman	Oil	118.2	128.1	122.3
	Electricity	-	-	-
	Gas	-	-	-
	Coal	-	-	-
	Total	**118.2**	**128.1**	**122.3**
Pakistan	Oil	94.9	109.4	128.5
	Electricity	288.2	1,824.3	-
	Gas	1,324.1	1,537.2	3,263.2
	Coal	-	-	-
	Total	**1,707.3**	**3,470.9**	**3,391.7**
Qatar	Oil	308.3	439.5	325.8
	Electricity	677.4	670.7	973.0
	Gas	340.7	540.0	881.8
	Coal	-	-	-
	Total	**1,326.4**	**1,650.2**	**2,180.6**
Russia	Oil	-	-	-
	Electricity	21,641.1	9,441.8	14,333.7
	Gas	11,727.4	11,807.9	22,897.1
	Coal	-	-	-
	Total	**33,368.5**	**21,249.7**	**37,230.8**
Saudi Arabia	Oil	24,164.6	29,052.0	25,755.8
	Electricity	10,700.9	10,975.0	12,793.0
	Gas	4,081.1	4,577.6	6,175.3
	Coal	-	-	-
	Total	**38,946.6**	**44,604.6**	**44,724.1**
South Africa	Oil	-	-	-
	Electricity	6,014.2	5,324.3	4,157.9
	Gas	-	-	-
	Coal	-	-	-
	Total	**6,014.2**	**5,324.3**	**4,157.9**
Sri Lanka	Oil	74.6	189.7	205.6
	Electricity	-	5.2	166.4
	Gas	-	-	-
	Coal	-	-	-
	Total	**74.6**	**194.9**	**372.1**
Thailand	Oil	550.8	863.9	977.5
	Electricity	-	-	-
	Gas	-	-	294.3
	Coal	-	-	-
	Total	**550.8**	**863.9**	**1,271.8**
Trinidad and Tobago	Oil	406.2	453.0	516.0
	Electricity	203.6	210.0	334.4
	Gas	-	-	-
	Coal	-	-	-
	Total	**609.8**	**663.0**	**850.4**
Turkmenistan	Oil	1,038.9	1,519.4	1,320.2
	Electricity	898.5	306.6	351.0

	Gas	1,924.6	2,272.2	3,058.6
	Coal	-	-	-
	Total	**3,862.0**	**4,098.2**	**4,729.8**
Ukraine	Oil	-	-	-
	Electricity	2,460.4	2,130.9	3,201.7
	Gas	-	-	1,020.7
	Coal	-	-	-
	Total	**2,460.4**	**2,130.9**	**4,222.4**
UAE	Oil	414.2	500.6	196.1
	Electricity	1,791.0	1,582.4	2,788.7
	Gas	5,962.9	6,338.6	8,688.4
	Coal	-	-	-
	Total	**8,168.1**	**8,421.6**	**11,673.3**
Uzbekistan	Oil	19.8	109.8	443.8
	Electricity	274.3	1,005.2	1,942.9
	Gas	1,374.1	2,383.3	4,529.5
	Coal	-	-	-
	Total	**1,668.2**	**3,498.4**	**6,916.3**
Venezuela	Oil	4,744.8	9,554.0	11,682.2
	Electricity	2,086.7	4,666.8	6,512.3
	Gas	640.5	1,238.3	2,258.7
	Coal	-	-	-
	Total	**7,472.1**	**15,459.1**	**20,453.1**
Vietnam	Oil	2.7	283.4	0.4
	Electricity	-	-	259.2
	Gas	-	-	36.2
	Coal	104.8	187.3	316.5
	Total	**107.5**	**470.7**	**612.3**

Working Group	4: Economics and finance
Indicator	4.4: Pricing greenhouse gas emissions from fossil fuels
Sub Indicator	4.4.2: Coverage and strength of carbon pricing
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix.[1] The World Bank provides the data for this indicator, through the interactive Carbon Pricing Dashboard.[126] Prices are those as of 1st August 2016, 1st December 2017, and 1st April 2018, and 1st April 2019, respectively. For 2019, the indicator includes only instruments that had been introduced by 1st April 2019. Baseline-and-credit systems are excluded from the analysis. GHG coverage data is presented as a proportion of 2012 global anthropogenic GHG emissions (53, 937 $MTCO_2e$) as calculated by EDGAR (Emissions Database for Global Atmospheric Research).[127] Monetary values are presented in US$, in current prices. Here data is presented for 2018 and 2019. See the 2018 Lancet Countdown report for 2017 data.[1]

Data

World Bank Carbon Pricing Dashboard.[126]

Caveats

Instrument coverage of GHG emissions, in both absolute and proportional term, are based on total anthropogenic GHG emissions in 2012 – the last year in which consistent data was available. 'Baseline and Credit' instruments are not included due to a lack of price data. Some instruments experience an overlap in coverage. For example, the UK Carbon Price Floor applies to the power sector in the UK, which is also subject to carbon pricing under the EU ETS. Other instruments experience partial overlap. As such, total emissions coverage is likely to be overestimated (*ceteris paribus*), although this effect is likely to be minor (<2.5% total coverage). The price used to calculate the weighted average prices are the prevailing prices on a single day. The prices for many instruments (particularly ETS instruments) are likely to alter over the course of a year, however the effect on the final summary values is likely to be minor. Prices are presented in current values.

Future Form of Indicator

As with Indicator 4.4.1, an ideal future form of this indicator would have two key elements. The first element would be the consistent inclusion of production and consumption subsidies for all countries, available on an annual basis. The second element would be the use of this data, along with that of carbon pricing data (see Indicator 4.4.2), to create a 'net carbon price' indicator. The future practicality of this indicator will depend on the availability of data at the appropriate level of granularity.

Additional Information

Table 22: Emissions covered and percentage of global emissions covered by carbon pricing mechanisms in 2018 and 2019.

	2018			2019		
Instrument	**Emissions Covered ($MtCO_2e$)**	**% Global Emissions Covered**	**US$ Price (1st April 2018)**	**Emissions Covered ($MtCO_2e$)**	**% Global Emissions Covered**	**US$ Price (1st April 2019)**
Alberta SGER	119.66	0.22%	23.25	124.80	0.22%	22.49
Alberta carbon tax	109.20	0.20%	23.25	109.20	0.20%	22.49
Argentina carbon tax	-	-	-	79.25	0.15%	6.24
BC carbon tax	42.07	0.08%	27.13	42.70	0.08%	26.24
Beijing pilot ETS	84.65	0.16%	9.44	84.65	0.16%	11.19
California CaT	377.69	0.69%	15.1	377.69	0.69%	15.77
Canada federal fuel charge	-	-	-	179.73		15.00
Chile carbon tax	46.67	0.09%	5	46.67	0.09%	5.00
Chongqing pilot ETS	97.24	0.18%	3.82	97.24	0.18%	0.55
Colombia carbon tax	41.62	0.08%	5.67	41.62	0.08%	5.17
Denmark carbon tax	21.59	0.04%	28.82	21.59	0.04%	26.39
EU ETS	2131.84	3.92%	16.37	2131.84	3.92%	24.54
Estonia carbon tax	0.76	0.00%	2.48	0.76	0.00%	2.25
Finland carbon tax	25.09	0.05%	76.87	25.09	0.05%	69.66
France carbon tax	175.63	0.32%	55.3	175.63	0.32%	50.11
Fujian pilot ETS	200.00	0.37%	3.18	200.00	0.37%	1.52
Guangdong pilot ETS	366.30	0.67%	2.32	366.30	0.67%	2.92

	Hubei pilot ETS	162.09	0.30%	2.32	162.09	0.30%	4.13
	Iceland carbon tax	1.59	0.00%	35.71	1.59	0.00%	31.34
	Ireland carbon tax	30.79	0.06%	24.8	30.79	0.06%	22.47
	Japan carbon tax	999.43	1.84%	2.74	999.43	1.84%	2.60
	Korea ETS	452.91	0.83%	20.52	468.29	0.86%	22.45
	Latvia carbon tax	2.06	0.00%	5.58	2.06	0.00%	5.06
	Liechtenstein carbon tax	0.06	0.00%	100.9	0.06	0.00%	96.46
	Mexico carbon tax	307.33	0.56%	3.01	307.33	0.56%	2.99
	New Zealand ETS	39.85	0.07%	15.22	39.85	0.07%	17.06
	Norway carbon tax	39.56	0.07%	64.29	39.56	0.07%	59.22
	Ontario CaT	136.86	0.25%	15.1	-	-	-
	Poland carbon tax	15.54	0.03%	0.09	15.54	0.03%	0.08
	Portugal carbon tax	20.80	0.04%	8.49	20.80	0.04%	14.31
	Quebec CaT	66.56	0.12%	15.1	68.85	0.12%	15.77
	RGGI	83.96	0.15%	4.3	80.28	0.15%	4.89
	Saitama ETS	7.03	0.01%	5.69	7.91	0.01%	5.85
	Shanghai pilot ETS	169.69	0.31%	6.21	169.69	0.31%	4.48
	Shenzhen pilot ETS	61.20	0.11%	6.73	61.20	0.11%	0.55
	Singapore carbon tax	-	-	-	42.02	0.08%	3.69
	Slovenia carbon tax	4.96	0.01%	21.45	4.96	0.01%	19.44
	Spain carbon tax	9.02	0.02%	24.8	9.02	0.02%	16.85
	Sweden carbon tax	26.14	0.05%	139.11	26.14	0.05%	126.78
	Switzerland ETS	5.95	0.01%	7.88	17.98	0.03%	96.46
	Switzerland carbon tax	17.98	0.03%	100.9	5.95	0.01%	5.17
	Tianjin pilot ETS	118.25	0.22%	1.35	118.25	0.22%	2.08
	Tokyo CaT	13.92	0.03%	5.69	13.92	0.03%	5.85
	UK carbon price floor	136.45	0.25%	25.46	136.45	0.25%	23.59
	Ukraine carbon tax	287.01	0.53%	0.02	287.01	0.53%	0.37

Working Group	4: Economics and finance
Indicator	4.4: Pricing greenhouse gas emissions from fossil fuels
Sub Indicator	4.4.3: Use of carbon pricing revenues
Methods	The methodology for this indicator remains the same as described in the 2018 Lancet Countdown report appendix.[1] Data on revenue generated is provided by the World Bank's interactive 'Carbon Pricing Dashboard'.[126]

The method of revenue expenditure classification is adapted from Carl and Fedor (2016).[128] Definitions and assumptions regarding the categories as applied in this paper are as follows:

- **Climate Change Mitigation** – revenues are explicitly allocated to activities or infrastructure that seeks to reduce, or enable the reduction, of greenhouse gas emissions, from any source, within or outside of the sectors or jurisdiction in which the carbon price is applied;
- **Climate Change Adaptation** – as above, but for adaptation activities or infrastructure;
- **Revenue Recycling** – revenues are explicitly returned to some broad portion of the population through individual or business tax rate cuts, tax eliminations, or rebates in order to achieve broad revenue neutrality. Revenue returned to directly compensate for the cost of GHG emissions (through free permit allocation or targeted assistance for energy-intensive, trade-exposed firms) are not included);
- **General Funds** – revenues are explicitly used for purposes other than those described above, or the use of revenues is unspecified or information is unavailable.

Only revenue that may be considered government income is included. For example, revenue generated by sale of permits issued to utilities under the Californian cap and trade instrument, which much then be used to finance discounts on household energy bills through 'carbon credits', are not considered, as this revenue does not pass through the State government. Instruments for which price data is not available, either due to the type of instrument or simply lack of data, are not included.

Other assumptions as applied to individual instruments are noted in the table below.

Data

World Bank Carbon Pricing Dashboard.[126]

Additional Information

			Revenue Allocation (US$2018 million)				
	Revenue (US$2018 million)		Mitigation	Adaptation	Revenue Recycling	General Funds	Note
Alberta SGER	340	%	41.3%	0.0%	57.3%	1.5%	(3)
		$	$140.6	$0.0	$195.0	$5.0	
Alberta Carbon Tax	1,013	%	49.1%	0.0%	43.0%	7.9%	(13)
		$	$497.4	$0.0	$435.6	$80.0	
Argentina Carbon Tax	200	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$200.2	
BC Carbon Tax	1,056	%	0%	0%	100%	0%	(4)
		$	$0.0	$0.0	$1,056.3	$0.0	
California ETS	3,020	%	96.4%	3.6%	0.0%	0.0%	(5)
		$	$2,910.0	$110.0	$0.0	$0.0	
Chile Carbon Tax	165	%	0%	0%	0%	100%	(1)
		$	$0.0	$0.0	$0.0	$165.5	
Colombia Carbon Tax	93	%	0.0%	100.0%	0.0%	0.0%	(6)
		$	$0.0	$92.6	$0.0	$0.0	
Denmark Carbon Tax	543	%	0%	0%	50%	50%	(2)
		$	$0.0	$0.0	$271.7	$271.7	
Estonia Carbon Tax	3	%	0%	0%	0%	100%	(1)
		$	$0.0	$0.0	$0.0	$2.8	
EU ETS	15,948	%	85.4%	0.3%	0.0%	14.2%	(7)
		$	$13,625.2	$55.8	$0.0	$2,267.2	
Finland Carbon Tax	1,459	%	0%	0%	50%	50%	(2)
		$	$0.0	$0.0	$729.3	$729.3	
	8,142	%	38.0%	0.0%	0.0%	62.0%	(2)

France Carbon Tax		$	$3,094	$0.0	$0.0	$5,048.1	
Iceland Carbon Tax	44	%	0%	0%	0%	100%	(2)
		$	$0.0	$0.0	$0.0	$44.0	
Ireland Carbon Tax	489	%	13.7%	0.0%	0.0%	86.3%	(2)
		$	$66.7	$0.0	$0.0	$422.0	
Japan Carbon Tax	2,361	%	100%	0%	0%	0%	(2)
		$	$2,361.4	$0.0	$0.0	$0.0	
Korea ETS	92	%	0.0%	0.0%	0.0%	100.0%	(14)
		$	$0.0	$0.0	$0.0	$92.3	
Latvia Carbon Tax	9	%	0%	0%	0%	100%	(1)
		$	$0.0	$0.0	$0.0	$9.1	
Lichtenstein Carbon Tax	4	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$4.0	
Mexico Carbon Tax	306	%	0.0%	0.0%	0.0%	100.0%	(12)
		$	$0.0	$0.0	$0.0	$306.0	
New Zealand	0	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$0.4	
Norway Carbon Tax	1,644	%	30.0%	0.0%	30.0%	40.0%	(2)
		$	$493.1	$0.0	$493.1	$657.5	
		$	$1,491.0	$0.0	$0.0	$0.0	
Poland Carbon Tax	1	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$1.2	
Portugal Carbon Tax	155	%	0.0%	0.0%	100.0%	0.0%	(8)
		$	$0.0	$0.0	$154.9	$0.0	
Quebec ETS	642	%	96.5%	0.0%	0.0%	3.5%	(9)
		$	$619.5	$0.0	$0.0	$22.5	
RGGI	239	%	83.6%	0.0%	11.0%	5.4%	(10)
		$	$200.1	$0.0	$26.3	$12.9	
Shanghai Pilot ETS	2	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$1.9	
Slovenia Carbon Tax	83	%	33.3%	0.0%	0.0%	66.7%	(2)
		$	$27.7	$0.0	$0.0	$55.4	
Spain Carbon Tax	124	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$123.6	
Sweden Carbon Tax	2,572	%	0.0%	0.0%	50.0%	50.0%	(2)
		$	$0.0	$0.0	$1,286.2	$1,286.2	
Switzerland Carbon Tax	1,178	%	27.6%	0.0%	72.4%	0.0%	(2)
		$	$325.0	$0.0	$852.7	$0.0	
Switzerland ETS	**4**	%	0.0%	0.0%	0.0%	100.0%	(15)
		$	$0.0	$0.0	$0.0	$4.4	
UK Carbon Price Floor	1,091	%	0.0%	0.0%	0.0%	100.0%	(11)
		$	$0.0	$0.0	$0.0	$1,091.0	
Ukraine Carbon Tax	4	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$4.0	

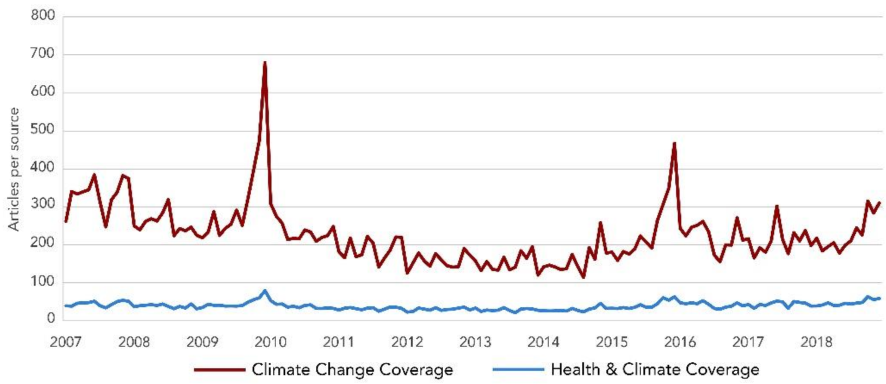
(1) No data available.
(2) Carl and Fedor (2016).[128] Assumed no change.
(3) From Jan 2017, a small business tax cut was introduced to help business adjust to the levy, estimated at $195 million in 2018/19 (and assumed the same for 2017). All other revenue allocated in 2016/17 went to mitigation, except for CAN$6 million operating costs (US$5 million).[129,130]
(4) See 2017 Lancet Countdown Report.[131] Assumed no change.
(5) Data soured from Table ES-1 in CCI (2019).[132]
(6) 'Revenue raised is earmarked for the Colombia in Peace Fund to support ecosystem protection and coastal erosion management'.[133]
(7) Based on Figure 5 in Velten et al (2016)[134] (assume proportions of spending remain the same). Assume 'cross-cutting action', 'Other' and 'non-specified' are 50% mitigation, 50% adaptation. All 'non-climate' spending is assumed to go to general funds.
(8) Pereira *et al* (2015).[135]
(9) All programs funded thus far are mitigation-related.[136] CAN$29 million (US$22.5 million) operating costs. No new values for 2018, so assumed these values remained constant
(10) Assumed same as distribution in 2016.[137]
(11) Hirst, D. (2018).[138]
(12) Narassimham *et al* (2017).[139]
(13) Graney & French (2019).[140]
(14) Specific rules on use of revenues are yet to be decided.[141]

Revenues from auctioning allowances are fed into the federal government budget.[142]

Section 5: Public and Political Engagement

Working Group	5: Public and Political Engagement
Indicator	5.1: Media engagement in health and climate change
Sub-Indicator	5.1.1: Trends in global media coverage of health and climate change
Methods	Intersecting trends in coverage of climate change and health were identified in 62 selected newspaper sources from January 2007 through December 2018. The 62 sources are located 36 countries spanning six World Health Organization (WHO) regions around the world: African Region, Region of the Americas, South-East Asia Region, European Region, Eastern Mediterranean Region, and Western Pacific Region. These sources were monitored through Nexis Uni, Proquest and Factiva databases accessed via the University of Colorado libraries. The searches were conducted with the following key words in English, Spanish, Portuguese and German respectively: • ENGLISH: malaria or diarrhoea or infection or disease or sars or measles or pneumonia or epidemic or pandemic or public health or healthcare or epidemiology or health care or health or mortality or morbidity or nutrition or illness or infectious or NCD or non-communicable disease or communicable disease or air pollution or nutrition or malnutrition or mental disorder or stunting AND climate change or global warming or green house or extreme weather or global environmental change or climate variability or greenhouse or low carbon or ghge or renewable energy or carbon emissions or co2 emissions or climate pollutants • SPANISH: malaria or diarrea or infección or enfermedad or sars or sarampión or neumonía or epidemia or pandemia or salud pública or epidemiología or salud or mortalidad or morbilidad or nutrición or enfermedad or enfermedad infecciosa or NCD or no transmisible or enfermedad contagiosa or transmisible or contaminación del aire or nutrición or desnutrición or trastorno mental or retraso del crecimiento AND cambio climático or calentamiento global or clima extremo or cambio ambiental global or variabilidad climática or invernadero or bajo carbono or ghge or energía renovable or emisiones de carbono or emisiones de CO2 or contaminantes climáticos • PORTUGUESE: malária or diarréia or infecção or doença or sars or sarampo or pneumonia or epidemia or pandemia or saúde pública or saúde or epidemiologia or mortalidade or morbidade or nutrição or doença or doença infecciosa or NCD or doença não transmissível or doença contagiosa ou transmissível or poluição do ar or nutrição or desnutrição or transtorno mental or retardo de crescimento AND mudanças climáticas or aquecimento global or clima extremo or mudança ambiental global or variabilidade climática or estufa or baixo carbono or GEE or energia renovável or emissões de carbono or emissões de CO2 or poluentes climáticos • GERMAN: malaria or durchfallerkrankung or infektion or erkrankung or SARS or masern or lungenentzündung or epidemisch or pandemisch or gesundheitswesen or gesundheitsvorsorge or epidemiologie or gesundheit or

	sterblichkeit or krankhaftigkeit or ernährung or krankheit or infektiös or nicht-übertragbare krankheit or übertragbare krankheit or luftverschmutzung or ernährung or mangelernährung or mentale störung or kleinwuchs AND klimawandel or globale erwärmung or treibhaus or extremwetter or globale umweltveränderungen or klimavariabilität or wenig kohlenstoff or erneuerbare energie or kohlenstoffemissionen or CO2 emissionen or klimaschadstoffe Updated verification checks were performed to improve the search signal, by analysing whether the search string should be modified (without significantly jeopardising internal validity) in order to reduce 'false positives' (it was noted that in the 2017 and 2018 Lancet Countdown reports,[1,131] returns were found to not centrally address climate change and health together). After considerable deliberation and discussion, for the 2019 report the full search set was recoded for 2017-2018, removing the search term 'temperature'. This improvement was made because it was through comparative analyses that this term often generated an additional hit, but articles were addressing a fever related to some illness, rather than climate change or global warming. Additional false positives were also identified through verification checks, comparing search functions across the databases. It was found that different databases ran the same search string differently. Therefore, search string grammar was revised such that all databases would use the same criteria with which to perform the search and return articles. This eliminated a significant portion of articles which did not address or mention health and climate change together. Additional verification checks were also performed to generate adjustment factors and to attempt to gain some insight into the rates and types of false positives remaining in the data. Due to the size and scope of the dataset, a full manual search is not possible. Therefore, these checks were performed by taking a systematic random sample of articles from each year, from a selection of newspapers within each region. The adjustment factors were generated to take into account the rates of complete mis-identification of articles based on the sample analysed; for example, a common mis-hit is where an article discusses growing plants in a 'greenhouse' and also discusses plant 'diseases.' The adjustments factors were then applied at the WHO regional level. Analysis found different rates of these types of mis-hits for each region as follows: Africa 19%, Americas 31%, Southeast Asia 28%, Europe 39%, Eastern Mediterranean 14%, Western Pacific 43%. These rates are preliminary and future work will include continuing to revise and refine these adjustment factors. Due to the use of these adjustment factors and the revised search methods, the 2019 Lancet Countdown report provides a more robust assessment of climate change/global warming and public health indicators.
Data	This indicator uses data from 62 sources in 36 countries around the world over 12 years, from January 2007 through December 2018, collected and cured by the Media and Climate Chane Observatory (MeCCO) of the University of Colorado.
Caveats	As noted above, the MeCCO team improved the search and generated adjustment factors in order to reduce noise in search returns. This has reduced the chances of incorrectly identifying conjoint references to health and climate change in newspaper articles. This has confronted caveats articulated in previous reports[1,131]

	and has strengthened this monitoring validity in the 2019 Lancet Countdown report. Nonetheless, by continuing to monitor newspapers around the world (rather than, for example, television or radio) the explanatory power across all 'media coverage' remains limited. There also remain concerns with the degree to which the databases return hits of duplicate articles which are not warranted (i.e. are not actually the same article reproduced elsewhere but rather are simply two entries in the database for a single article) and with the degree to which the articles are engaging with health and climate change as integrated issues of concern. The analysis examining false positives revealed high variability in the occurrence of duplicate articles across time and newspapers and as such was not included in the adjustment factors. The analysis also indicated that a significant portion of articles, anywhere between 40-60% across regions, may mention both climate change and health but do not deeply engage with them as integrated issues. However, tracking this coverage remains informative because it gives an idea of how comparable the issues are on the public agenda and in public awareness; as such, and due to the very high variability across newspapers, it is not included in the adjustment factors.
Future Form of Indicator	Possible further expansion into television and radio, pending data availability. The precision of this indicator will continue to be improved.
Additional information	Coverage of climate change and public health tracks relatively consistently with several trends in media coverage of climate change or global warming more generally, where political, scientific, cultural, ecological and meteorological themes provide news hooks for stories over time (Figure 44). Coverage of total articles has gone up 39% overall across all regions from 2015-2018 compared to 2011-2014. With some monthly upticks associated with the particularly high-profile United Nations Framework Convention on Climate Change (UNFCCC) Conferences of Parties (COPs), climate change negotiations in 2009 and 2015, this data indicate a gradual trend toward more sustained attention to climate change and public health in the public arena over time.  *Figure 44: Newspaper reporting on health and climate change (applying adjustment factors that account for rates at which the search terms mis-identify articles), and climate change more generally (for 62 newspapers) in 2007-18.*

Working Group	5: Public and Political Engagement
Indicator	5.1: Media engagement in health and climate change
Sub-Indicator	5.1.2: Media coverage of health and climate change for *People's Daily* in China
Methods	Six steps to filter the articles, as shown below:

1. Key words for the topics of (a) Health, and (b) Climate Change were identified as shown in Table 23.

Table 23: Key words list of the topic of Health and Climate Change.

中文 Chinese		英文 English	
健康相关词汇 Key words for "Health"	气候相关词汇 Key words for "Climate Change"	Key words for "Health"	Key words for "Climate Change"
发育迟缓	气候变化	stunting	climate change
疟疾	全球变暖	malaria	global warming
腹泻	温室	diarrhea	green house
感染	极端天气	infection	extreme weather
疾病	全球环境变化	disease, illness	global environmental change
肺炎	低碳	pneumonia	low carbon
流行病	可再生能源	epidemic, pandemic	renewable energy
公共卫生	碳排放	public health	carbon emission, CO2 emission
流行病学	气候污染	epidemiology	climate pollutant
卫生保健	气候	health care	climate （climate variability included）
卫生	全球升温	health	global temperature rise
死亡率	再生能源	mortality	renewable energy
发病率	CO2排放	morbidity	CO2 emission
营养	污染	nutrition	pollution (including climate pollutant)
非传染性疾病		ncd, non-communicable disease	
传染性疾病		communicable disease	
传染病		infectious	
空气污染		air pollution	
精神障碍		mental disorder	
传染		infectious	

疾患		illness	
瘟疫		plague	
流感		flu	
流行感冒		flu	
治疗		cure	
保健		health care	
健康		healthy	
死亡		death	

2. The articles in the Database of *People's Daily* (http://data.people.com.cn/) were searched from January, 2008 to December, 2018, which contained any of the key words in the column of "Climate Change" in Table 23. The distribution of articles with the key words in different years is shown in Figure 45.

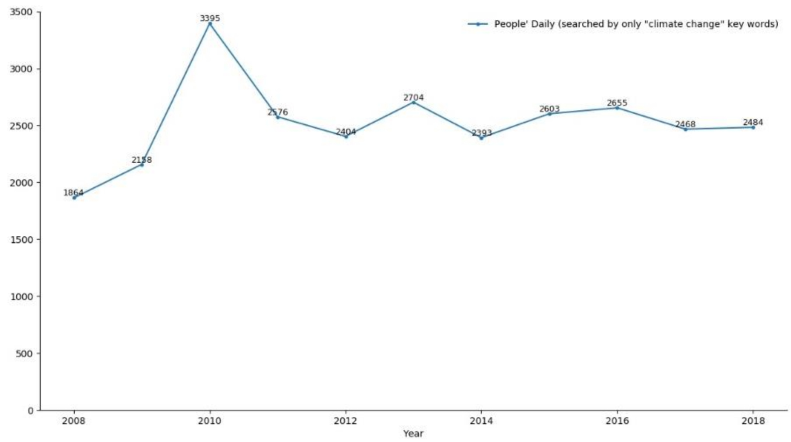


Figure 45: Number of articles identified from People's Daily database by inputting key words from topic Climate Change.

People's Daily

3. The selected articles were processed from step 2 for the filtration in step 4. This step is based on a natural language processing (NLP) method to transform the articles into the format that is ready to input into the model. The two main NLP methods used in this step is Word Segmentation and Removing stop words. In this step, it regulated the format of Chinese words to reduce recognition ambiguity resulting from this format.
4. Filtration was performed to identify the real topic of each article preprocessed in step 3. The real topic was represented by the proportion of each topic in the individual article. Technically, a classic algorithm in NLP, called Latent Dirichlet Allocation (LDA) was used in this process. LDA is an algorithm to extract the topic of articles. In the LDA algorithm, the number of topics that extracted can be set by the operator.[143] Each topic is composed by the key words, such as, the key words in Table 23 for the topic of "Climate Change". The number of topics was set as 15, including

		"Climate Change", "Health", and "other" (13). The other 13 were extracted from the articles from the model as the result of the highest frequency topics. The number of articles identified as containing the real topic "Climate Change" is shown as blue line in Figure 45. Since the composition of each article is represented by the probability of the corresponding topics, a probability threshold was set. If the topic, which is Climate Change or Health, in an article is larger than the threshold, the article was classified as containing the topic. After the filtration, the articles classified as containing both topics became the articles that contain both "Health" and "Climate Change," individually at a probability greater than 0.5% .Therefore, this step filtered out the non-relevant or low-relevance articles with respect to "Climate Change" and both "Health" and "Climate Change". The number of articles focusing on climate change after step 4 between 2008 and 2018 is shown as the dotted blue line in Figure 46. 5. The articles were further filtered based on their relevance of both "Climate change" and "Health", since containing "Climate Change" and "Health" separately is different to covering the topic "Health and Climate Change". To start the filtration, the key words in the articles were labelled with number "1"to represent the "Climate Change" key words and number "2" to represent the "Health" key words. For every word labelled "1", the nearest key word labelled "2" was found. Then, the distance between labelled words was counted. If the distance between the word labelled "1" and the nearest word labelled "2" was less than or equal to threshold 50, it was marked as focusing on Health and Climate Change in this step. In Chinese sentences, the distance of 50 is about 3 to 4 sentences. So, if the gap between two topic words is more that 3-4 sentences, the two topic words were considered as non-related. The number of articles focusing on both Health and Climate Change between 2008 and 2018 is shown as the black line in Figure 46: Number of articles reporting of climate change (dotted blue line) and number of articles reporting of both health and climate change after the relevance check in People's Daily (black line)..

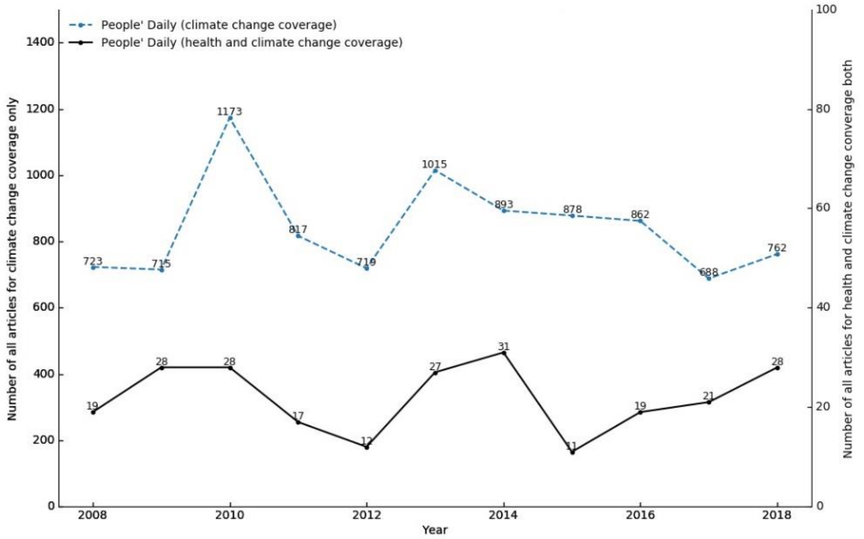


Figure 46: Number of articles reporting of climate change (dotted blue line) and number of articles reporting of both health and climate change after the relevance check in People's Daily (black line).

6. ***People's Daily***The filtered articles were manually screened. If the manual screening confirmed that the topic was "Health and Climate Change", it was retained. The red line in Figure 47 shows the selected articles after the manual screening.

People's Daily

The criteria used in the manual screen are described below.

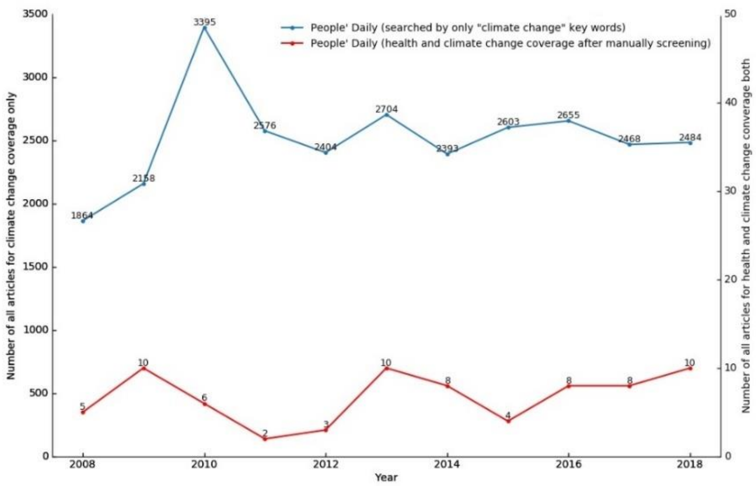


Figure 47: Number of articles reporting of climate change (blue line) and health and climate change (red line) in the People's Daily in 2008-18. Number of articles reporting of only climate change coverage are represented by blue lines. Also shown is the number for the combined topic "Health and Climate Change" coverage after manual screen.

<table>
<tr><td>Data</td><td>All the articles from 2008 to the present published on People's Daily (from the official website of People's Daily).[144]</td></tr>
<tr><td>Additional information</td><td>Across the period 2008-18, 74 articles in total were identified as "Health and Climate Change" related, which was one-third of the articles filtered. This manual screening stage removed mainly four types of articles identified through the first five steps:

The key word from the topic of "Health" might refer to the health of animals and the health of the environment; for example, the topic of the article is climate change and ecosystem health rather than climate change and human health. 23 articles were excluded for this reason.
The article lists some facts, such as a recent increase in the prevalence of a certain disease. But the reason why is uncertain, climate change/environmental change is one of the conjectures. 16 articles were excluded for this reason.
The key word "Climate Change" refers to short-term weather or temperature variation, but not the long-term trends of global climate change. 23 articles were excluded for this reason.
The article has mentioned human health change and climate change in one or two sentences, but the topic of the article is of low relevance to the combined topic of "Health and Climate Change". 46 articles were excluded for this reason
The article includes the key words and meets the other selection criteria, but the combined topic of health and climate is not addressed. 12 articles were excluded for this reason

Note: the figure in the 2019 Lancet Countdown report includes categories 2-4. This is for reasons of comparability with other analyses where there was a less extensive process of manual screening.

It was also noted in Figure 47 that the number of articles on Climate Change was highest in 2010 and also comparatively higher in 2016, both having a time lag behind the important COPs in 2009 and 2015. This time lag is attributed to the tendency in the People's Daily to report climate change and to discuss the conference outcomes after the important COPs were held (which are usually held in December).

Table 24: The titles of 74 selected articles after the above-mentioned six steps.
<table>
<tr><th>年份 Year</th><th>文章名字 Chinese Title</th><th>English Title</th></tr>
<tr><td rowspan="5">2008</td><td>全球变暖也会有寒冬</td><td>Global warm also has cold winter</td></tr>
<tr><td>极端天气的警示</td><td>The warning of extreme weather</td></tr>
<tr><td>温暖融化冰雪</td><td>Snow melts in the warm</td></tr>
<tr><td>适应气候变化是现实的选择</td><td>Adapt to climate change is the choice of reality</td></tr>
<tr><td>煤火自燃每年"烧"掉1亿美元</td><td>Coal spontaneous combustion "burns" one hundred billion US dollars</td></tr>
<tr><td rowspan="2">2009</td><td>流行病蔓延与全球变暖</td><td>Epidemic disease spread and global warming</td></tr>
<tr><td>以人为本 保护大气</td><td>Take human as the core, protect our atmosphere</td></tr>
</table>
</td></tr>
</table>

			研究报告预示减排政策转变？	Research predict that emission reducing policy will change?	
			人畜共患病缘何频发	Zoonosis why spreading?	
			我国内地确诊165例甲型H1N1流感病例	165 Influenza A (H1N1) inflection patients has confirmed	
			全球约有13.5万人感染甲感	135 thousand people has confirmed to have H1N1 inflection	
			非洲多国遭遇粮荒	Lack of food threatening many African countries	
			秋冬季节性流感可能被甲感取代	August seasonal influenza is potentially replaced by H1N1	
			北极熊颅骨缩小的警示	The warning of the shrinking of polar bear skull	
			“流泪”的冰川	“Crying” glacier	
		2010	生态平衡也需动态控制	Ecological balance also need dynamic control	
			遥望赤道雪峰	Look at the equator snowy peak	
			先中碳　再低碳（热点研究）	First mid-carbon, then low carbon	
			北方高温将持续到月末	The high temperature in the North will keep until the end of month	
			蒙古国开征空气污染费	Mongolia start to impose air pollution fee	
			并非危言耸听	Not alarmism	
		2011	“减氮”也重要	“reduce nitrogen” also important	
			身陷洪水不离家	Staying in the flood not leaving home	
		2012	分清雾与霾，防范别大意	Be aware to the haze, distinguish frog and the haze	
			极端气候事件导致的经济损失将增加	Financial lost caused by extreme climate event will increase	
			“火炉”城市越来越多	“hot” cities keep growing	
		2013	雾霾天，口罩怎么选？	How to choose mask in haze day	
			新型城镇化 重点在质量	The key point of new urbanization is the quality	
			近年降水为何“北多南少”	Why recent precipitation is “more in north less in south”	
			澳大利亚 优先发展自行车道路网	Australia first develop the web of bicycles	
			陕西“杀人蜂”为何肆虐	Why Shanxi killer bees prosperous	
			让“骑行”成为“流行”	Make bicycling become fashion	
			澳大利亚热议环境治理困境	Australia heated debate the difficulties of environmental governance	
			东三省遭遇“霾汰”天	The three provinces in the northeast of China has dirty haze day	

			雾霾对生殖能力影响不大	Haze day will not influence fertility	
			雾霾来袭，咱们一起突围	Haze surrounding, we rush out together	
		2014	中国代表团出席第六十七届世界卫生大会	Chinese delegation attends the 67th Word Health Assembly	
			美国要求电厂减排30%	US government requires power plant to reduce emission 30%	
			知识窗	Wisdom window	
			气候变暖将严重挤压南亚经济	Climate change will seriously squeeze the Southeast Asia	
			冰川在哭泣	Glacier is crying	
			遏制全球变暖 行动刻不容缓	Limit global warming, action needed	
			气候灾变问题很遥远吗	Is climate disaster far away from us?	
			减霾需要"拆风机"？	Reduce haze need "wind reduction machine"?	
		2015	中国正成为全球发展领域的领导者	China is becoming the global development leader	
			"厄尔尼诺"所致干旱重创非洲多国	"el nino" causes dry land, and damage many countries in Africa	
			气候变化可能威胁社会发展和全球健康成果	Climate change can endanger the social development and global health	
			减贫也要应对气候变化	Poverty reduction also need to face climate change	
		2016	广西长寿之乡为何多	The reason why there are many longevity villages in Guangxi	
			城市绿化不能只顾"好看"	City Afforestation of city cannot only concentrate on "good looking"	
			绿水青山就是金山银山	The greens and clear water is the wealth	
			携手迈向清洁和可持续的未来	Step to clean and sustainable future together	
			非洲空气污染呈加重态势	Air pollution in Africa shows a rising trend	
			大数据的"孤岛困境"	Big data's "island difficulty"	
			"气质"达标 任重道远	air quality improvement still need effort	
			用绿色建筑还城市蓝天	Return to city blue sky by green buildings	
		2017	管住贪婪的嘴巴	Keep greedy mouth close	
			中国环境治理经验值得借鉴	The experience of environmental governance of China is a good example	
			将绿色转型进行到底	Carry out the Green Transition to the end	

	“没有海洋健康，就没有人类繁荣”	“No healthy ocean, no human prosperity”
	英国寻求向电动汽车时代转型	England is looking for the transition to electricity car
	今夏为啥这么热	Why this summer is so hot?
	让清洁美丽世界为文明添彩	Make the beauty of clean world a pearl on the civilization
	山火肆虐，加州进入紧急状态	California is in emergency as wildfires rage
2018	气候变化影响人类健康	Climate change affect human health
	极端天气持续肆虐欧洲	Extreme weather overwhelm Europe
	地球南北，何以冰火两重天	Why the north and south of Earth are cold and warm?
	非洲萨赫勒地区粮食危机加剧	The food crisis in the Sahel region of Africa exacerbate
	世界气象组织：近期全球持续极端天气与气候变化相关	World Meteorological Organization: Recent persistent global extreme weather is associated with climate change
	干旱和高温加剧北半球野火灾情	Drought and high temperatures exacerbate wildfires in the Northern Hemisphere
	极端高温“烤”验北半球	Extreme high temperature is burning the Northern Hemisphere
	欧洲多国遭西尼罗河病毒侵袭	West Nile virus infects many countries in Europe
	警惕地球“发热多汗”	Keep alert on Earth’s fever and sweating
	全球粮食安全形势不容乐观	Global food security situation is sobering

Working Group	5: Public and Political Engagement
Indicator	5.1: Media engagement in health and climate change
Sub-Indicator	5.1.3: Content of coverage in US and Indian newspapers
Methods	This new indicator extends the capacity to track media engagement by focusing on the *content* of media coverage of health and climate change, enabling further understanding about what is being reported, as well as the levels of coverage. **Media sources and timeframe** This indicator focuses on the elite media in two countries, representing very different contexts. Two newspapers from India and two from the US were

selected; *Hindustan Times* (HT), *Times of India* (TOI), *Washington Post* (WP), and *New York Times* (NYT).

The focus of analysis was narrowed for articles to two time periods during 2018. First, the time period July to September (inclusive) for both the Indian and US sources was considered. This time period was used as it covers a period of extreme weather events in both regions; wildfires in the US and monsoon flooding in India. This enabled consideration of media reporting in light of these events, and the ways in which links may be made through them to climate change and health. Second, reporting during November to December 2018 was considered. This time period covers the lead up to and hosting of the COPs. In addition, this covers the time period during which findings from the Lancet Countdown report itself have been reported in the media.

Search terms

Media articles were obtained in conjunction with Indicator 5.1.1 (trends in media coverage). Search terms developed by this team of researchers, designed to return articles at the intersection of health and climate change were used. For identification of articles in the Indian media (HT and TOI), the Factiva database was used. For identification of articles in the US media (WP and NYT), the Nexis database was used.

Articles in which appeared a minimum of one key search term from both (a) health, and (b) climate change were identified **Error! Reference source not found.**.

Table 25: Search terms for Health and Climate Change

Health terms	Climate change terms
• **malaria** • **diarrhoea** • **infection** • **disease** • **sars** • **measles** • **pneumonia** • **epidemic** • **pandemic** • **public health** • **health care** • **epidemiology** • **healthcare** • **health** • **mortality** • **morbidity** • **nutrition** • **illness** • **infectious**	• climate change • global warming • green house • extreme weather • global environmental change • climate variability • greenhouse • low carbon • ghge • renewable energy • carbon emission • co2 emission • climate pollutant

- **ncd**
- **non-communicable disease**
- **noncommunicable disease**
- **communicable disease**
- **air pollution**
- **nutrition**
- **malnutrition**
- **mental disorder**
- **stunting**

Pre-screening of articles

The articles across the five months and four media sources were pre-screened in order to ensure that only those making meaningful connections between health and climate change were retained for further analysis.

The procedure used to select articles was as follows:

a. An article must make a meaningful connection between health and climate change. This can be made explicitly, or implied through the narrative used, but health topics and climate change aspects must be clearly linked to be included.
b. Articles were retained when any reference is made to health and climate change that meets criterion (a). This may include long articles where only passing reference is made to the link, as well as articles where the focus is more substantial.
c. Where reference to air pollution is made, it was not deemed to meet the criterion (a) unless an explicit or implicit link was made to health. For example, an article that covers the need for coal-fired plants to close in order to meet climate change targets and reduce air pollution, was not retained unless a link was also made to the health impacts of either air pollution or climate change. It was not enough simply to reference air pollution in the context of climate change for this to be deemed reference to 'health'. Some articles coded (c) have been included as borderline cases.

In order to carry out pre-screening in a systematic manner, the following approach was adopted:

- Coder 1 (Paul Haggar) read all articles within the target months, that were returned by the search string. Where an article was deemed to be a definite false positive (no meaningful link between health and climate change), this was noted. Where an article was questionable/borderline, this was separately noted, with brief comment provided as to why this was the case.
- Coder 2 (Stuart Capstick) subsequently reviewed the article content of all false positive articles coded as such by Coder 1, to ensure no articles had been incorrectly coded. Coder 2 also read through all

questionable/borderline articles coded by Coder 1, to give a second opinion as to whether these should be included.
- Duplicate articles were identified and excluded by both coders, in order to avoid double-counting of media reporting.

Having pre-screened the articles, a dataset of 248 articles was retained across the four media sources.

Development of coding framework
In order to identify recurrent and discrete themes within media reporting, a version of 'template analysis'[145] was used,which allows for both deductive coding (*a priori* themes of interest to be specified in advance) and inductive coding (themes are incorporated based on prevalent or recurrent topics detected in the data).

So as to align the thematic coding to the wider Lancet Countdown report, *a priori* codes were derived from pre-existing indicators. Themes from Working Group 1 and Working Group 2 were particularly drawn upon. An iterative process was used to refine the coding framework, whereby samples of articles were test-coded, with the suitability of thematic categories repeatedly revisited until both coders were satisfied that these provided a fair representation of the themes evident across the media articles.

Both coders independently coded all articles, allowing for multiple codes to be assigned where appropriate (for example, where an article referred both to health impacts and co-benefits). Instances where discrepancies arose were reconciled through agreement between the two coders.

The final framework incorporated the following codes/themes:

- Health impacts of climate change; specifically:
  - Generic/ non-specific health impacts
  - Heatwaves and temperature increase
  - Precipitation extremes
  - Wildfires
  - Disease
  - Food security/ malnutrition
  - Population displacement
  - Mental health
  - Other impacts
- Co-benefits and co-hazards; specifically:
  - Generic/ non-specific co-benefits
  - Air pollution (transport)
  - Air pollution (energy)
  - Air pollution (non-specific or generic)
  - Food/ diet
  - Other co-benefits and co-hazards
- Adaptation; specifically:
  - Generic adaptation

	- Longer-term planning - Emergency responses - Other adaptation - Miscellaneous
Data	Newspaper articles in *Hindustan Times*, *Times of India*, *New York Times*, *Washington Post*. Articles analysed during time period July to September, and November to December. The data used is the full text of media articles. This cannot be made publicly available due to copyright restrictions, however the full search strings applied and databases used are detailed above.
Caveats	The content analysis is able to provide a broad picture of how health and climate change are being reported in the target news sources and time points. The selected newspapers cannot be taken to be representative of reporting across the two countries (US and India) or the WHO regions in which they are located, given that different media sources are known to have widely diverging positions on climate change. The coding framework used is intended to identify themes in reporting at the intersection of health and climate change; it is not intended to provide insights into the more general ways in which climate change and/or health is reported in news media. Because the content analysis used search terms provided by the global media tracker developed by the MeCCO team for its analysis of trends in newspaper coverage, the articles returned are necessarily those in which there was found to be a conjunction of a pre-selected health term and climate change term. The exact search terms used are likely to have influenced the types of articles obtained. For example, the bank of returned articles available to the content analysis was already set up in such a way that an air pollution and climate change co-occurrence was present in many places.
Future Form of Indicator	Analyses of the content of coverage will form part of the Working Group's future programme of work. The analysis for the 2019 Lancet Countdown report will therefore enable the indicator to be refined (e.g. its thematic structure) and extended (e.g. to other countries and newspapers) for future Lancet Countdown reports.
Additional Information	**Illustrative Extracts from the Data** The following extracts from articles give an impression of the themes identified through analysis; they are sub-headed by theme. **Health impacts of climate change** *"A major scientific report … presents the starkest warnings to date of the consequences of climate change for the United States… More people will die as heat waves become more common, … and a hotter climate will also lead to more outbreaks of disease… Other parts of the country… will endure worsening droughts… Those droughts can lead to fires… as the most destructive wildfire in state history killed dozens of people… Climate change*

	is taking the United States into uncharted territory, the report concludes. [The New York Times, 24 November 2018; “US Climate Study Has Grim Warning of Economic Risks”, Coral Davenport and Kendra Pierre-Louis] *“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”* [The New York Times, 17 November 2018; “New Casualty As Fires Rage: California's Air”, Julie Turkewitz and Matt Richtel] Title: *“[F]or decades, global hunger was on the decline. Now it's getting worse again - and climate change is to blame”.* [The Washington Post, 11 September 2018, title of article, Rick Noack] *“A new invasive tick species capable of transmitting several severe diseases is spreading in the United States, posing an emerging threat to human health… Warming temperatures and climate change make the environment more hospitable to ticks or mosquitoes that spread pathogens…”* [The Washington Post, 29 November 2018, “New tick species capable of transmitting deadly disease is spreading in the US”, Lena H. Sun] *“[C]limate change [is] making mosquitoes bolder and the germs they transmit stronger, leading to a spurt in mosquito-borne diseases, particularly Chikungunya”* [The Times of India, 9 August 2018; “Global warming, climate change adding sting to mosquito bites, spurt in vector-borne diseases”, Syed Akbar] *“… It’s become commonplace to hear about the steady exodus from India’s big cities due to unhealthy levels of pollution… British environmentalist Norman Myers said millions of people had already begun being displaced by “shoreline erosion, coastal flooding and severe drought” and calculated as many as 250 million people would be forced to move by the middle of the 21st century…”* [The Times of India, 24 August 2018; “The Climate Change Exodus”, Vivek Menezes] *“With temperature soaring over 42 degrees Celsius, the 2014 Australian Open offered one of the most sweltering experiences ever …Global warming is real as is the ordeal professional sportspersons go through day in and day out… In extreme cases, heatstroke occurs when the body can no longer cool itself and starts to overheat. If left untreated, organ failure and brain damage can also take place.”* [Hindustan Times, 18 September 2018; “Hot, hotter and hottest: An uncomfortable truth”, Abhishek Paul] “*A less recognised, but inextricably linked, challenge [to health] is climate change. The physiological impacts of rising temperatures causing heat stress, heat exhaustion and stroke are particularly harmful… dehydration can also occur during heatwaves… climatic conditions affect disease trends for dengue and malaria, …increasing the burden on the health sector. Drought*

	situations … can have deleterious consequences on the nutritional status of affected populations... The mental health impacts of climate change including stress in post-climatic events and increased suicides by farmers in post-drought situations have also been documented in several regions." [Hindustan Times, 28 December 2018; "Urgent solutions needed to mitigate the impact of climate change on health", Poornima Prabhakaran] **Co-benefits and co-hazards** *"[C]lean power, clean cars, clean manufacturing and efficient buildings… can lower our health care costs, cut heating bills for the poor, drive 21st-century innovation, foster decent jobs, [and] mitigate climate change".* [The New York Times, 15 August 2018; "If Mother Nature Gets a Vote in 2020", Thomas L. Friedman] "*Air pollution is shaving months -- and in some cases more than a year -- off your life expectancy, depending on where you live… Worldwide, outdoor air pollution reduces the average life expectancy at birth by one year. …The sources of PM 2.5 pollution and greenhouse gas emissions are often ''tightly linked,''… meaning that moving to cleaner sources of energy can also deliver quick dividends for public health."* [The New York Times, 23 August 2018; "In the Air Everywhere You Go, And Taking Weeks Off Your Life", Somini Sengupta] *"The Environmental Protection Agency revealed… a sorry new climate-change plan, seemingly designed to weaken as much as legally possible the federal government's response to the greatest long-term threat the world faces…the administration's plan would result in up to 1,400 American deaths every year by 2030... In addition to planet-warming greenhouse gases, coal plants spew fine particulate matter that enters people's lungs and bloodstreams, contributing to heart and breathing problems, from asthma and bronchitis to premature death. … The country, and the world, are losing precious time, even as extreme weather, wildfires and other major disasters offer Americans a taste of what is in store."* [The Washington Post, 25 August 2018, "A dirty plan that would kill Americans", Editorial Board] *"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. [An activist] said, "This is a public health crisis. This is a climate change crisis.""* [The Washington Post, 16 November 2018, "Marchers commemorate pedestrians killed in D.C. and demand stricter safety measures", Fredrick Kunkle] *"[P]ractising breastfeeding protects the environment by reducing carbon footprint caused due to milk formula sales and additionally provides short and long-term health benefits to children".*

	[The Times of India, 15 December 2018; "Rising use of infant formula harming environment: Study", Rupali Mukherjee] *"… plant-based meat and dairy products are on the rise in the west… some researchers and startups claimed it tastes similar to meat, is healthier as it avoids use of antibiotics and would reduce carbon footprint…"* [The Times of India, 26 August 2018; "Experts debate pros and cons of plant meat", U Sudhakar Reddy] "*…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."* [Hindustan Times, 5 December 2018; "To protect our future, new infrastructure must be low-carbon, sustainable", Nanina Lal Kidwai] "*It is estimated that household air pollution (HAP) related to cooking causes 1.3 million premature deaths in India … Owing to these problems and to realise India's voluntary commitment as part of the 2015 Paris climate agreement, the government introduced… aims at provisioning cleaner liquefied petroleum gas cylinders to poor households. So far, over 50 million households have benefitted from the scheme*." [Hindustan Times, 7 December 2018; "We need better reporting of household air pollution", Martand Shardul] **Adaptation** *"…Extreme heat, already the deadliest natural disaster in an average year, will become even deadlier… A growing body of research finds … the broad benefits of cooling down cities. … Fortunately, some South Asian cities… are recognising the importance of cool and green roofs to combat high urban temperatures and are implementing programmes to encourage their use…* [Hindustan Times, 18 September 2018; "India can, and must, tackle the problem of hot cities", Kurt Shickman] *"Climate change is hitting home. India saw an increase of 40 million in the number of people exposed to heatwaves from 2012 to 2016 … 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 of vulnerable population."* [The Times of India, 29 November 2018; "40 million more Indians hit by heatwaves in 5 years: Report", no by-line] *"[A]daptation… may offer value for a community whether or not the climate changes. For instance, a city might invest in green spaces to reduce flooding - resulting in more parks, lower urban temperatures, and other human health benefits".*

[The Washington Post, 16 November 2018, “How did climate change initiatives do in the midterms? Some lost - but some won”, Megan Mullin]

Graphical Information

Basic quantitative information about instances of codes/themes is presented graphically in the following figures. Figure 48 provides a breakdown of the proportions of newspaper articles in which principal themes were identified.

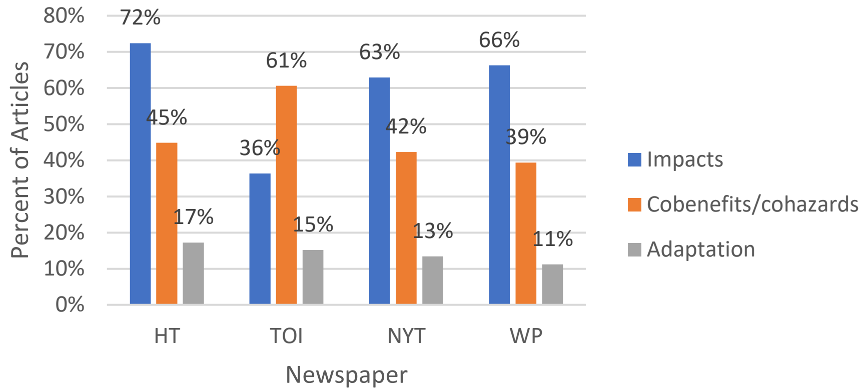


Figure 48: Proportion of newspaper articles where themes were identified. HT = Hindustan Times, TOI = Times of India, NYT = New York Times, WP = Washington Post.

Figure 49 provides a similar breakdown of the proportions of articles in newspapers from each country in which principal themes were identified.

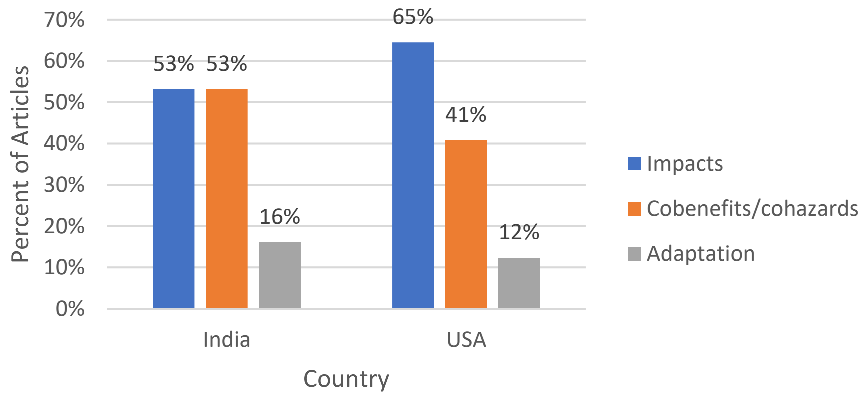


Figure 49: Proportion of newspaper articles where themes were identified, by country. HT = Hindustan Times, TOI = Times of India, NYT = New York Times, WP = Washington Post.

Figure 50 shows the proportion of codes identified within the first theme according to the sub-theme identified.

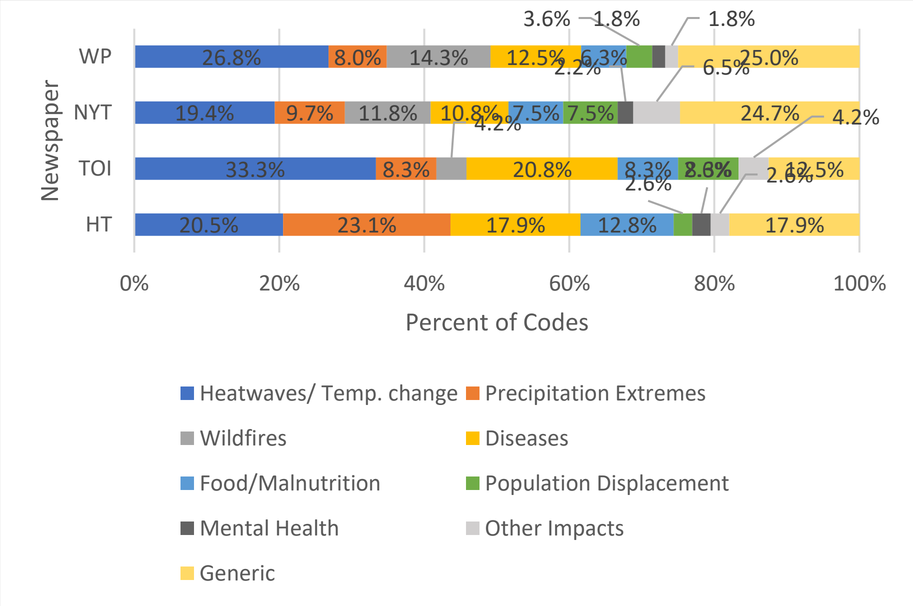


Figure 50: Proportion of sub-themes of 'Impacts' in newspaper articles. HT = Hindustan Times, TOI = Times of India, NYT = New York Times, WP = Washington Post.

Figure 51 shows the proportion of codes identified within the second theme according to the sub-theme identified.

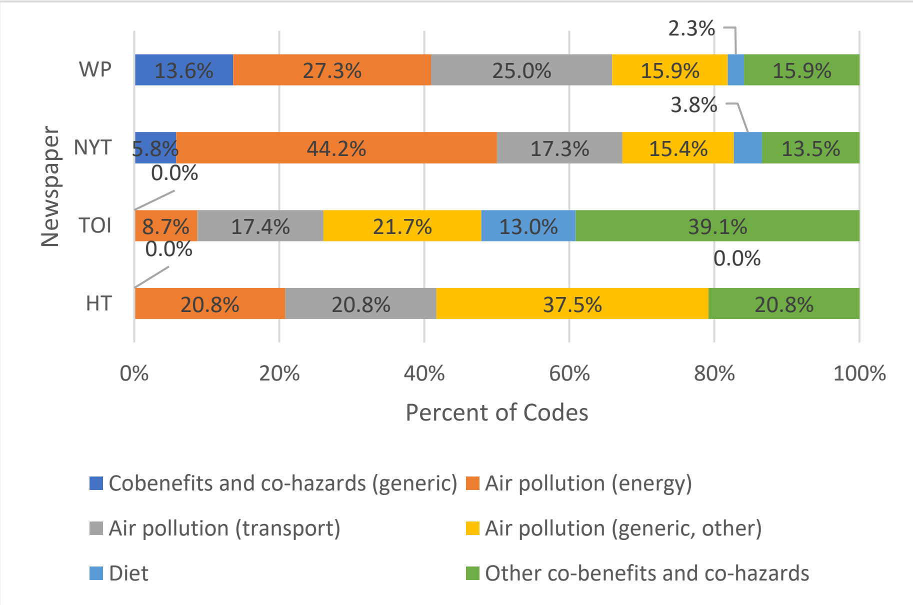


Figure 51: Proportion of sub-themes of 'Cobenefits/cohazards' in newspaper articles.HT = Hindustan Times, TOI = Times of India, NYT = New York Times, WP = Washington Post.

Figure 52 shows the proportion of codes identified within the third theme according to the sub-theme identified.

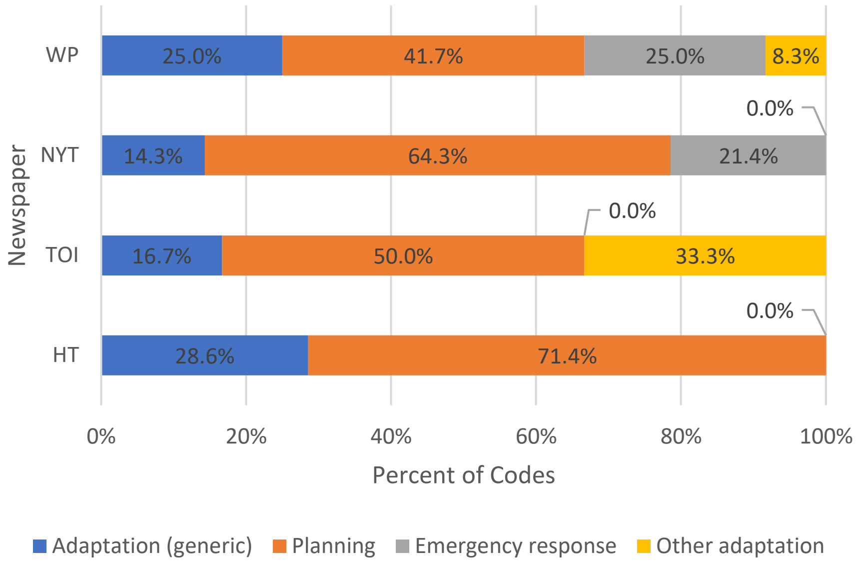


Figure 52: Proportion of sub-themes of 'Adaptation' in newspaper articles.HT = Hindustan Times, TOI = Times of India, NYT = New York Times, WP = Washington Post.

Working Group	5: Public and Political Engagement
Indicator	5.2: Individual engagement in health and climate change
Methods	This new indicator provides an individual-level indicator of public engagement. It tracks engagement with climate change and health through people's usage of the online encyclopaedia, Wikipedia. Over the years, Wikipedia has grown to be a major and trusted source of information that has outpaced traditional encyclopaedias in terms of reach, coverage, and comprehensiveness.[146] It is regularly listed among the ten most-visited websites worldwide.[147] The English edition covers more than five million articles and over 130,000 active editors. People around the world use it to engage in topics they are interested in. Fortunately, the traffic that goes to Wikipedia – and even that which goes to individual articles of the encyclopaedia – can be analysed over time because the Wikimedia foundation makes these statistics available to everyone for free. This makes it a global indicator of what people pay attention to on a daily basis. **The indicator** To investigate to what extent people do not only pay attention to climate change and human health in isolation, but also to the connection between both, this indicator draws on *clickstream statistics* from the English Wikipedia. *Clickstream* refers to a dataset provided by the Wikimedia foundation.[148] It reports "streams of clicks", or in other words, how people get to a Wikipedia article, and

what links they click on. This is reported on a monthly basis and in pairs of resources, the first being where the visit came from, the second which page was visited. For instance, in the data for 2018, people who visited the page on *Global warming* followed the link to the article on *Climate change* 17,791 times. This gives an indicator of monthly-level global attention towards one issue (if both articles are representative of the same issue) or two issues (if articles come from different domains, such as climate change and health). By looking at climate change – health articles pairs, an indicator of attention towards climate change consequences for human health over time is generated.

Measurement strategy
The approach to using clickstream data as an indicator of public engagement in climate change and health is based on the following premises: (1) The Wikipedia platform is a globally used source for information on a multitude of topics;[149] (2) Citizens use the platform to inform themselves about topics they are interested in; (3) By tracking engagement with Wikipedia, articles that are related to climate change as wells as with articles on health, it is possible to identify public engagement with the relationship between both topics.

The following behavioural patterns are relevant for the validity of the measure as a proxy for public engagement with climate change and health:

(a) A person is generally interested in the nexus between climate change and public health and informs her/himself about the topic online by, e.g., reading the Wikipedia article on *Effects of global warming on human health*.[150]

(b) A person is interested in climate change and the consumption of information about the topic then sparks interest in its consequences for human health. For instance, the person reads the article on *Global warming*[151] and then turns to the article on *Malnutrition*.[152])

(c) A person is interested in a certain aspect of human health or consequences of climate change with an immediate impact on human health, and then turns its attention to climate change issues. For instance, the person reads the article on *Malaria*[153] () and then turns to the article on *Global warming*.[151]

Indicator construction
In order to use the Wikipedia viewership statistics as a proxy for public engagement with climate change and health, it is key to select articles that are representative of these topics. To generate the populations of articles related to climate change on the one hand and health on the other, a semi-automated approach was implemented. Based on an initial set of keywords,[1] related articles were searched for, using the internal Wikipedia search.

[1] For climate change articles, the keywords were *climate change, warming, ipcc*, and green house, and *greenhouse*. For health articles, the seed keywords were *epidemy, disease, malaria, diarrhoea, infection, sars, measles, pneumonia, epidemic, pandemic, public health, health care, healthcare, epidemiology, mortality, morbidity, nutrition, illness, infectious, ncd, non-communicable disease, noncommunicable disease, communicable disease, air pollution, nutrition, malnutrition, mental disorder,* and *stunting*.

	For each search using one of the keywords, the first 100 results that led to an article with a minimum word count of 300 were then extracted and identified, ensuring that the articles that were chosen as seed articles had been given a certain degree of attention by Wikipedia editors, therefore being more likely to link to other relevant articles. Next, the articles collected were screened via the Wikipedia search for categories, which were used on the Wikipedia to categorise pages in a meaningful way (e.g., using categories such as *Climate change* or *Effects of global warming*). Those categories were then themselves screened for relevant articles. All additional articles were once more filtered such that those with a title matching one of the initial keywords were chosen. For the health-related articles, several articles that turned out to be irrelevant for purposes of the indicator were excluded manually. Health topics are covered extensively on the Wikipedia, articles and topics that, in principle, could be related to climate change were prioritised. In addition, the variety of links to further health-related articles on the effects of global warming Wikipedia page[150] were exploited. This list can be viewed as a curated list of relevant health articles. All in all, 237 articles related to climate change and 825 articles related to health were identified as being representative for either of the issues. The complete list of articles is listed below. For the clickstream analysis, the set of articles was extended by also taking "second-level pages" into account, that is pages that are linked to in the set of 237 climate change or 825 health articles and that are also somewhat related to climate change or health. Sometimes, people might not directly jump from one of the major articles on climate change to another one on health, but travel through an intermediary page (e.g., a possible individual stream of clicks could be: *Climate change → Human impact on the environment → Respiratory disease*). The clickstream data only allowed identification of click volume for pairs of articles, but by extending the network, clickstreams involving relevant pages that are linked in the original set of articles could also be captured. After taking these additional articles into account, 1040 articles related to climate change and 2865 articles related to health were identified.
Data	This indicator draws on publicly available data from the Wikimedia foundation. Data from all platforms, i.e. accesses to the Wikipedia via desktop machines, mobile browsers, and mobile apps was considered. The clickstream data were downloaded from the Wikimedia Dumps.[154] Spider traffic (i.e. traffic generated by automated bots crawling the platform) was excluded. Referer-resource pairs (i.e. the pairs of the article of origin and the target article) that had less than 10 clicks were removed in the original dataset, the actual clickstream traffic is likely to be underreported. However, this is not expected to add any systematic bias, in particular since the focus of the indicator is mainly in changes of engagement over time. Clickstream data is available from November 2017 onwards. This indicator exclusively focuses on data from 2018 in the 2019 Lancet Countdown report. The analyses are limited to the English Wikipedia. The benefits of the Wikipedia usage metadata for the purpose of tracking public engagement in climate change and health are that this data: (a) is globally

	available, (b) covers the time period of interest, (c) is collectible at virtually no cost, and, most importantly, (d) has high face validity to measure engagement in this very specific topic. Reading articles on Wikipedia is motivated by attention towards a particular issue. Individuals invest time to inform themselves about a topic, which is one manifestation of engagement. Aggregate reading behaviour can therefore be seen as an *a priori* valid approximation of public issue engagement.
Caveats	All clickstream information is only available at the aggregate level. It is not possible to link the data to information about individuals who visited the platform. Also, the data is not geo-referenced, so it is not possible to infer where page visits came from. Although the English Wikipedia is predominantly used in English-speaking countries (according to the Wikimedia Traffic Analysis Report,[155] about 40% of the traffic on the English Wikipedia comes from the US), it is a globally popular resource. It makes up for 50% of the global traffic to all Wikipedia language editions. Therefore, it can be seen as a global indicator of public attention that is somewhat biased towards attention from countries such as the United States, United Kingdom, India, Canada, and Australia. Extending the analyses to other language editions will help to remedy this bias and uncover potential geographic engagement heterogeneity in the future. More generally, the measure represents an online proxy for an offline phenomenon. In addition, it is sensitive towards the selection of articles used to capture engagement. The global popularity of the platform, which consistently ranks among the ten most visited websites worldwide, speaks in favour of its usefulness for this application. However, more direct indicators of public engagement, such as survey-based measures, might provide a useful supplement and source for validation in the future. While the data is available for free, access to future data depends on the Wikimedia API. There is no indication of Wikimedia restricting access in the future. Instead, Wikimedia has invested in data quality and making access more robust and convenient.
Future Form of Indicator	In future reports, this indicator will have increased precision, scope, and value. First, the number of articles used will be increased. With an ever-growing Wikipedia, more relevant articles might become available This requires a joint automated and human classification effort to ensure that the coverage of relevant articles (true positives) is as large as possible and the number of irrelevant articles (false positives) in the sample minimal. Second, the data collection and analysis efforts will be extended to other language editions (both for the pageviews and the clickstream data). This would make it possible to track more fine-grained trends at the regional level. It is likely that there is heterogeneity in public engagement in climate change and health, as different regions of the world are currently affected by health consequences of climate change to varying degrees. Studying engagement in different language versions of the Wikipedia could at least partly pick up this heterogeneity. Third, the analyses with related event data will be enriched. It is plausible to assume and could already be partly shown that public engagement is sensitive towards events, such as extreme weather events or epidemics, but also political

	and scientific activity such as the COPs or the publication of IPCC reports and protests such as the School Strikes for Climate. Fourth, complementary data to track and validate public attention, such as survey, experimental, and other online data will be explored. Beyond the 2019 Lancet Countdown report, analyses of individual-level engagement will be undertaken, using pageview data from Wikimedia. In time, this indicator may draw on both clickstream and pageview data.
Additional information	*List of English Wikipedia articles used to track public engagement in climate change* 1998 United Nations Climate Change Conference, 2001 United Nations Climate Change Conference, 2002 United Nations Climate Change Conference, 2003 United Nations Climate Change Conference, 2004 United Nations Climate Change Conference, 2005 United Nations Climate Change Conference, 2006 United Nations Climate Change Conference, 2007 United Nations Climate Change Conference, 2008 United Nations Climate Change Conference, 2009 United Nations Climate Change Conference, 2010 United Nations Climate Change Conference, 2011 United Nations Climate Change Conference, 2012 United Nations Climate Change Conference, 2013 United Nations Climate Change Conference, 2014 United Nations Climate Change Conference, 2015 United Nations Climate Change Conference, 2016 United Nations Climate Change Conference, 2017 United Nations Climate Change Conference, 2018 United Nations Climate Change Conference, Abrupt climate change, Academy of Climate Change Education and Research, Adaptation to climate change in Jordan, Adaptation to global warming in Australia, Advisory Group on Greenhouse Gases, Alice, the Zeta Cat and Climate Change, Amundsen-Nobile Climate Change Tower, Attribution of recent climate change, Australian Greenhouse Office, Aviation and climate change, Avoiding Dangerous Climate Change (2005 conference), Bølling-Allerød warming, Book:Global warming, Book:Global warming denial, Business action on climate change, Campaign against Climate Change, CCS and climate change mitigation, Centre for Climate Change Economics and Policy, Civil Society Coalition on Climate Change, Climate change, Climate Change (Scotland) Act 2009, Climate Change Accountability Act (Bill C-224), Climate change acronyms, Climate Change Act 2008, Climate change adaptation, Climate change adaptation in Bangladesh, Climate change adaptation in Greenland, Climate change adaptation strategies on the German coast, Climate change and agriculture, Climate change and ecosystems, Climate Change and Emissions Management Amendment Act, Climate change and gender, Climate change and indigenous persons, Climate change and invasive species, Climate change and potatoes, Climate change and poverty, Climate Change and Sustainable Energy Act 2006, Climate Change Authority, Climate change denial, Climate Change Denial Disorder, Climate Change Denial: Heads in the Sand, Climate change education (CCE), Climate change feedback, Climate change in Africa, Climate change in Argentina, Climate change in Australia, Climate change in Bangladesh, Climate change in Europe, Climate change in France, Climate change in Germany, Climate change in Grenada, Climate change in Guatemala, Climate change in Honduras, Climate change in India, Climate change in Indonesia, Climate change in Pakistan, Climate change in the Arctic, Climate change in the Caribbean, Climate change in the United Kingdom, Climate change in Turkey, Climate change in Tuvalu, Climate change in Vietnam, Climate change mitigation, Climate change mitigation scenarios, Climate change opinion by country, Climate Change Performance Index, Climate change policy of California, Climate change policy of the George W. Bush administration, Climate change policy of the United States, Climate Change Response Act 2002, Climate change scenario, Climate Change TV, Climate change, industry and society, Climate Change: Global Risks, Challenges and Decisions, Cloud formation and climate change, Co-benefits of climate change mitigation, Committee on Climate Change, Committee on Climate Change Science and Technology Integration, Conservatory (greenhouse), Cool It: The Skeptical Environmentalist's Guide to Global Warming, Criticism of the IPCC Fourth Assessment Report, Debate over China's economic responsibilities for climate change mitigation, Deforestation and climate change, Delta 3 greenhouse, Description of the Medieval Warm Period and Little Ice Age in IPCC reports, Durban Industry Climate Change Partnership Project, Economic impacts of climate change, Economics of climate change mitigation, Economics of global warming, Economists' Statement on Climate Change, Effects of climate change on island nations, Effects of climate change on plant biodiversity, Effects of climate change on terrestrial animals, Effects of climate change on wine production, Effects of global warming, Effects of global warming on Australia, Effects of global warming on human health, Effects of global warming on humans, Effects of global warming on marine mammals, Effects of global warming on oceans, Effects of global warming on South Asia, Effects of global warming on Sri Lanka, Euro-Mediterranean Center on Climate Change, European Climate Change Programme, Extinction risk from global warming, ExxonMobil climate change controversy, Fisheries and climate change, G8 Climate Change Roundtable, Garnaut Climate Change Review, Global Roundtable on Climate Change, Global warming, Global warming conspiracy theory, Global warming controversy, Global warming game, Global warming hiatus, Global warming in Antarctica, Global warming in popular culture, Global Warming Policy Foundation, Global Warming Pollution Reduction Act of 2007, Global warming potential, Global Warming Solutions Act of 2006, Global Warming: The Signs and The Science, Glossary of climate change, Grantham Institute – Climate Change and Environment, Greenhouse, Greenhouse and icehouse Earth, Greenhouse debt, Greenhouse Development Rights, Greenhouse effect, Greenhouse gas, Greenhouse gas accounting, Greenhouse gas emissions accounting, Greenhouse gas emissions by Australia, Greenhouse gas emissions by the United Kingdom, Greenhouse gas emissions by the United States, Greenhouse gas emissions by Turkey, Greenhouse gas footprint, Greenhouse gas inventory, Greenhouse gas monitoring, Greenhouse gas removal, Greenhouse Gases Observing Satellite, Greenhouse Mafia,

	Historical impacts of climate change, History of climate change science, How Global Warming Works, Human Rights and Climate Change, Index of climate change articles, Indian Network on Climate Change Assessment, Indigenous Peoples Climate Change Assessment Initiative, Individual action on climate change, Individual and political action on climate change, Intergovernmental Panel on Climate Change, International Climate Change Partnership, International Conference on Climate Change, International Journal of Greenhouse Gas Control, IPCC Fifth Assessment Report, IPCC First Assessment Report, IPCC Fourth Assessment Report, IPCC list of greenhouse gases, IPCC Second Assessment Report, IPCC Summary for Policymakers, IPCC supplementary report, 1992, IPCC Third Assessment Report, Life-cycle greenhouse-gas emissions of energy sources, List of authors of Climate Change 2007: The Physical Science Basis, List of climate change books, List of climate change initiatives, List of countries by greenhouse gas emissions, List of countries by greenhouse gas emissions per capita, List of ministers of climate change, List of scientists who disagree with the scientific consensus on global warming, Long-term effects of global warming, Major Economies Forum on Energy and Climate Change, Media coverage of global warming, Midwestern Greenhouse Gas Reduction Accord, Mitigation of global warming in Australia, Muslim Seven Year Action Plan on Climate Change, New South Wales Greenhouse Gas Abatement Scheme, Oeschger Centre for Climate Change Research, Ozone depletion and climate change, Physical impacts of climate change, Physical properties of greenhouse gases, Political economy of climate change, Politics of global warming, Portal:Global warming, Post–Kyoto Protocol negotiations on greenhouse gas emissions, Premier's Climate Change Council, Program on Energy Efficiency in Artisanal Brick Kilns in Latin America to Mitigate Climate Change, Public opinion on global warming, Rapid Climate Change-Meridional Overturning Circulation and Heatflux Array, Regional climate change initiatives in the United States, Regional effects of global warming, Regional Greenhouse Gas Initiative, Regulation of greenhouse gases under the Clean Air Act, Renewable Energy Sources and Climate Change Mitigation, Ringed seals and climate change, Royal Greenhouses of Laeken, Runaway greenhouse effect, Scientific opinion on climate change, Scorcher: The Dirty Politics of Climate Change, Seawater greenhouse, Special Report on Global Warming of 1.5 °C, Surveys of scientists' views on climate change, Template:United Nations climate change conferences, The Great Global Warming Swindle, The Greenhouse Conspiracy, Total equivalent warming impact, Tropical cyclones and climate change, United Kingdom Climate Change Programme, United Nations Climate Change conference, United Nations Special Envoy on Climate Change, United States federal register of greenhouse gas emissions, United States House Select Committee on Energy Independence and Global Warming, Valleyfield greenhouse, White House Office of Energy and Climate Change Policy, World Climate Change Conference, Moscow, World People's Conference on Climate Change, World Wide Views on Global Warming *List of English Wikipedia articles used to track public engagement in health* 1793 Philadelphia yellow fever epidemic, 1863–1875 cholera pandemic, 1889–90 flu pandemic, 1974 smallpox epidemic in India, 2009 Bolivian dengue fever epidemic, 2013 Swansea measles epidemic, 2015–16 Zika virus epidemic, Academy of Nutrition and Dietetics, Acute eosinophilic pneumonia, Adult-onset Still's disease, Advances in Nutrition, Affordable Medicines Facility-malaria, Africa Fighting Malaria, Africa/Harvard School of Public Health Partnership for Cohort Research and Training, African Malaria Network Trust, African Nutrition Leadership Programme, Against Malaria Foundation, Aging-associated diseases, Air pollution, Air pollution and traffic congestion in Tehran, Air pollution forecasting, Air pollution in Hong Kong, Air pollution in Macau, Air pollution on vegetation, Air pollution sensor, Airborne disease, Airport malaria, Alan Howard (nutritionist), Alexander disease, Alveolar hydatid disease, Alzheimer Disease and Associated Disorders, Alzheimer's disease, Alzheimer's disease biomarkers, Alzheimer's Disease Cooperative Study, Alzheimer's disease in the media, Alzheimer's Disease Neuroimaging Initiative, Amazon Malaria Initiative, America's Health Care Crisis Solved, American Association of Public Health Dentistry, American Association of Public Health Physicians, American College of Epidemiology, American Journal of Epidemiology, American Public Health Association, American Society for Nutrition, American Society for Parenteral and Enteral Nutrition, Anaerobic infection, Andersen healthcare utilization model, Animal nutrition, Animal nutritionist, Annals of Epidemiology, Annual Review of Nutrition, Anthroponotic disease, Anti-IgLON5 disease, Antidiarrhoeal, Antimalarial medication, Apparent infection rate, Applied Physiology, Nutrition, and Metabolism, Asia Pacific Leaders Malaria Alliance, Asia Pacific Malaria Elimination Network, Aspiration pneumonia, Aspirin exacerbated respiratory disease, Association for Nutrition, Association of Medical Microbiology and Infectious Disease Canada, Association of Public Health Laboratories, Atypical pneumonia, Australian Measles Control Campaign, Autoimmune disease, Autoimmune disease in women, Autoimmune inner ear disease, Autosomal dominant polycystic kidney disease, Autosomal recessive polycystic kidney disease, Bachelor of Science in Public Health, Bacterial pneumonia, Balwadi Nutrition Programme, Bangladesh National Nutrition Council, Batten disease, Baumol's cost disease, Behavior change (public health), Behçet's disease, Belgian Health Care Knowledge Centre, BENTA disease, Bills of mortality, Binswanger's disease, Biochemistry of Alzheimer's disease, Biologically based mental illness, Biomarker epidemiology, Biphasic disease, Blackheart (plant disease), Blood-borne disease, Blount's disease, Bluetongue disease, British Journal of Nutrition, Caerphilly Heart Disease Study, Calcium pyrophosphate dihydrate crystal deposition disease, California Center for Public Health Advocacy, Camurati–Engelmann disease, Canadian Public Health Association, Canadian Society for Epidemiology and Biostatistics, Canavan disease, Cancer Epidemiology (journal), Cancer Epidemiology, Biomarkers & Prevention, Canine vector-borne disease, Capitation (healthcare), Cardiovascular disease, Caribbean Public Health Agency, Caroli disease, Carrion's disease, Castleman's disease, Cat-scratch disease, Catheter-associated urinary tract infection, Causes of mental disorders, Cavitary pneumonia, Center for Infectious Disease Research, Center for Infectious Disease Research and Policy, Centre for History in Public Health, London School of Hygiene and Tropical Medicine, Chagas disease, Chelates in animal nutrition, Child Health and Nutrition Research Initiative, Child mortality, Childhood chronic illness, Children's right to adequate nutrition in New Zealand, Chinese Classification of Mental Disorders, Chlamydia infection, Chlamydophila pneumoniae, Cholera outbreaks and pandemics, Chronic diseases, Chronic illness, Chronic Lyme

	disease, Chronic obstructive pulmonary disease, Cinematography in healthcare, Classification of mental disorders, Classification of pneumonia, Clinical epidemiology, Clinical Epidemiology (journal), Clinical nutrition, Clinton health care plan of 1993, Clostridioides difficile infection, CNS demyelinating autoimmune diseases, Coalition for Epidemic Preparedness Innovations, Coeliac disease, Cognitive epidemiology, Coinfection, Cold agglutinin disease, Collider (epidemiology), Colorado Department of Health Care Policy and Financing, Commission on the Accreditation of Healthcare Management Education, Common disease-common variant, Communicable diseases, Community Dentistry and Oral Epidemiology, Community-acquired pneumonia, Comorbidity, Comparison of the healthcare systems in Canada and the United States, Compartmental models in epidemiology, Compression of morbidity, Computational epidemiology, Conflict epidemiology, Congenital cytomegalovirus infection, Congenital malaria, Contagious bovine pleuropneumonia, Contagious disease, Convention on Long-Range Transboundary Air Pollution, Corn stunt disease, Coronary artery disease, Council on Education for Public Health, Creutzfeldt–Jakob disease, Critical illness insurance, Critical Reviews in Food Science and Nutrition, Crohn's disease, Cryptic infection, Cryptogenic organizing pneumonia, Degenerative disc disease, Degenerative disease, Dental public health, Department of Epidemiology, Columbia University, Depression of Alzheimer disease, Desquamative interstitial pneumonia, Developmental disorder, Diagnosis of malaria, Diagnostic and Statistical Manual of Mental Disorders, Diarrheal diseases, Disease, Disease burden, Disease cluster, Disease Control Priorities Project, Disease diffusion mapping, Disease in fiction, Disease Isolation, Disease management (health), Disease resistance, Disease surveillance, Disease X, Diseases, Diseases and epidemics of the 19th century, Diseases of abnormal polymerization, Diseases of affluence, Diseases of poverty, Doctor of Public Health, Dole Nutrition Institute, Drugs for Neglected Diseases Initiative, Dukes' disease, Dust pneumonia, E-epidemiology, Ear infection, Early-onset Alzheimer's disease, Ebola virus disease, Economic epidemiology, Ehrlichiosis ewingii infection, EMBRACE Healthcare Reform Plan, Emerging infectious disease, Emerging Themes in Epidemiology, Endemic (epidemiology), Endogenous infection, Environmental disease, Environmental epidemiology, Eosinophilic pneumonia, Ephialtes (illness), Epidemic, Epidemic Intelligence Service, Epidemic models on lattices, Epidemic polyarthritis, Epidemic typhus, Epidemiology, Epidemiology (journal), Epidemiology and Infection, Epidemiology and Psychiatric Sciences, Epidemiology data for low-linear energy transfer radiation, Epidemiology in Country Practice, Epidemiology of asthma, Epidemiology of attention deficit hyperactive disorder, Epidemiology of autism, Epidemiology of bed bugs, Epidemiology of binge drinking, Epidemiology of breast cancer, Epidemiology of cancer, Epidemiology of chikungunya, Epidemiology of child psychiatric disorders, Epidemiology of childhood obesity, Epidemiology of depression, Epidemiology of diabetes mellitus, Epidemiology of domestic violence, Epidemiology of HIV/AIDS, Epidemiology of malnutrition, Epidemiology of measles, Epidemiology of metabolic syndrome, Epidemiology of plague, Epidemiology of pneumonia, Epidemiology of schizophrenia, Epidemiology of suicide, Epidemiology of syphilis, Epstein-Barr virus-associated lymphoproliferative diseases, Eradication of infectious diseases, Escape Fire: The Fight to Rescue American Healthcare, Essence (Electronic Surveillance System for the Early Notification of Community-based Epidemics), European Centre for Disease Prevention and Control, European Journal of Clinical Nutrition, European Journal of Epidemiology, European Journal of Nutrition, European Parliament Committee on the Environment, Public Health and Food Safety, European Programme for Intervention Epidemiology Training, European Prospective Investigation into Cancer and Nutrition, European Public Health Alliance, European Public Health Association, European Society for Clinical Nutrition and Metabolism, European Society for Paediatric Infectious Diseases, European Society of Clinical Microbiology and Infectious Diseases, European Working Group for Legionella Infections, Evolution of Infectious Disease, Evolutionary epidemiology, Experimental epidemiology, Fair Share Health Care Act, Familial renal disease in animals, Fazio–Londe disease, Febrile infection-related epilepsy syndrome, Federation of European Nutrition Societies, Feline infectious anemia, Feline infectious peritonitis, Feline lower urinary tract disease, Field Epidemiology Training Program, Fifth disease, Fire breather's pneumonia, First Nations nutrition experiments, Focal infection theory, Focus of infection, Food & Nutrition Research, Food and Nutrition Bulletin, Food pyramid (nutrition), Foodborne illness, Foot-and-mouth disease, Free-market healthcare, Fungal pneumonia, Gastrointestinal disease, Genetic epidemiology, Genetic Epidemiology (journal), Geospatial Measurements of Air Pollution, Germ theory of disease, GIS and public health, Global Acute Malnutrition, Global Alliance for Improved Nutrition, Global Burden of Disease Study, Global Coalition Against Pneumonia, Global Infectious Disease Epidemiology Network, Global Malaria Action Plan, Global Network for Neglected Tropical Diseases, Global Public Health Intelligence Network, Global Research Collaboration for Infectious Disease Preparedness, Globalization and disease, Gram-negative bacterial infection, Graves' disease, Groningen epidemic, Group B streptococcal infection, Health care access among Dalits in India, Health Care Card, Health Care Compact, Health care efficiency measures, Health care finance in the United States, Health Care for Women International, Health care fraud, Health care in Argentina, Health care in Australia, Health Care in Canada Survey, Health care in Colombia, Health care in Cyprus, Health care in France, Health care in Karachi, Health care in Mozambique, Health care in New Zealand, Health care in Poland, Health care in Saudi Arabia, Health care in Spain, Health care in Sweden, Health care in the Philippines, Health care in the United Kingdom, Health care in the United States, Health care in Turkey, Health care in Venezuela, Health care prices in the United States, Health care ratings, Health care rationing, Health care reforms proposed during the Obama administration, Health care sharing ministry, Health care system in Japan, Health care system of the elderly in Germany, Health care time and motion study, Healthcare availability for undocumented immigrants in the United States, Healthcare in Albania, Healthcare in Austria, Healthcare in Azerbaijan, Healthcare in Bahrain, Healthcare in Belgium, Healthcare in Brazil, Healthcare in Canada, Healthcare in China, Healthcare in Croatia, Healthcare in Cuba, Healthcare in Denmark, Healthcare in Egypt, Healthcare in England, Healthcare in Estonia, Healthcare in Ethiopia, Healthcare in Finland, Healthcare in Georgia (country), Healthcare in Germany, Healthcare in Greece, Healthcare in Hungary, Healthcare in Iceland, Healthcare in India, Healthcare in Indonesia, Healthcare in Iran, Healthcare in Iraq, Healthcare in Israel, Healthcare in Italy, Healthcare in Kenya, Healthcare in Kuwait, Healthcare in Luxembourg, Healthcare in Madagascar, Healthcare in Malawi, Healthcare in Malaysia, Healthcare in Malta, Healthcare in Mexico, Healthcare in Moldova, Healthcare in Nicaragua, Healthcare in Nigeria, Healthcare in Norway, Healthcare in Pakistan, Healthcare in Panama, Healthcare

	in Peru, Healthcare in Portugal, Healthcare in Qatar, Healthcare in Romania, Healthcare in Russia, Healthcare in Rwanda, Healthcare in Saint Helena, Healthcare in San Marino, Healthcare in Scotland, Healthcare in Senegal, Healthcare in Serbia, Healthcare in Sierra Leone, Healthcare in Singapore, Healthcare in Slovakia, Healthcare in Slovenia, Healthcare in South Africa, Healthcare in South Korea, Healthcare in Switzerland, Healthcare in Taiwan, Healthcare in Tanzania, Healthcare in Thailand, Healthcare in the Czech Republic, Healthcare in the Isle of Man, Healthcare in the Netherlands, Healthcare in the Palestinian territories, Healthcare in the Republic of Ireland, Healthcare in the United Arab Emirates, Healthcare in Tristan da Cunha, Healthcare in Uganda, Healthcare in Ukraine, Healthcare in Wales, Healthcare in Zambia, Healthcare rationing in the United States, Healthcare real estate, Healthcare reform debate in the United States, Healthcare reform in China, Healthcare reform in the United States, Healthcare shortage area, Healthcare Spending Account, Healthcare transport, Healthcare UK, HealthCare Volunteer, HealthCare.gov, History of emerging infectious diseases, History of health care reform in the United States, History of malaria, History of mental disorders, History of Tay–Sachs disease, History of USDA nutrition guides, Holozoic nutrition, Home health care software, Homosexuality as a disease, Hookworm infection, Hospital-acquired infection, Hospital-acquired pneumonia, How to Have Sex in an Epidemic, Human genetic resistance to malaria, Human papillomavirus infection, Hypertensive disease of pregnancy, ICAN: Infant, Child, & Adolescent Nutrition, Idiopathic disease, Idiopathic interstitial pneumonia, Idiopathic multicentric Castleman disease, Idiopathic orbital inflammatory disease, Idiopathic pneumonia syndrome, IgG4-related disease, IgG4-related ophthalmic disease, IgG4-related skin disease, Illness, Imagine No Malaria, Immigrant health care in the United States, Indiana University School of Public Health-Bloomington, Indoor air pollution in developing nations, Inequality in disease, Infant mortality, Infant nutrition, Infection, Infection control, Infection Control Society of Pakistan, Infection rate, Infections associated with diseases, Infectious causes of cancer, Infectious coryza in chickens, Infectious disease (athletes), Infectious disease (medical specialty), Infectious Disease (Notification) Act 1889, Infectious Disease Pharmacokinetics Laboratory, Infectious Disease Research Institute, Infectious diseases, Infectious Diseases Institute, Infectious Diseases Society of America, Inflammatory bowel disease, Inflammatory demyelinating diseases of the central nervous system, Integrated disease surveillance program, Integrated Management of Childhood Illness, International Association of National Public Health Institutes, International Journal of Behavioral Nutrition and Physical Activity, International Journal of Epidemiology, International Journal of Sport Nutrition and Exercise Metabolism, International Lyme and Associated Diseases Society, International Society for Environmental Epidemiology, International Society for Infectious Diseases in Obstetrics and Gynaecology, International Society for Pharmacoepidemiology, International Statistical Classification of Diseases and Related Health Problems, International Union of Air Pollution Prevention and Environmental Protection Associations, Intestinal infectious diseases, Iron Triangle of Health Care, Jembrana disease, Jennifer McMahon (nutritionist), Journal of Alzheimer's Disease, Journal of Clinical Epidemiology, Journal of Epidemiology, Journal of Epidemiology and Biostatistics, Journal of Epidemiology and Community Health, Journal of Exposure Science and Environmental Epidemiology, Journal of Human Nutrition and Dietetics, Journal of Nutrition, Journal of Nutritional Biochemistry, Journal of Parenteral and Enteral Nutrition, Journal of the Academy of Nutrition and Dietetics, Jurosomatic illness, Kashin–Beck disease, Kawasaki disease, Krabbe disease, Kuru (disease), Kyasanur Forest disease, Landscape epidemiology, Leveraging Agriculture for Improving Nutrition and Health, Lipid pneumonia, List of autoimmune diseases, List of diseases eliminated from the United States, List of epidemics, List of feline diseases, List of foodborne illness outbreaks, List of foodborne illness outbreaks by death toll, List of ICD-9 codes 290–319: mental disorders, List of infections of the central nervous system, List of infectious diseases, List of infectious diseases causing flu-like syndrome, List of Legionnaires' disease outbreaks, List of mental disorders, List of national public health agencies, List of pneumonia deaths, List of types of malnutrition, Liverpool Neurological Infectious Diseases Course, Lobar pneumonia, Localized disease, London Declaration on Neglected Tropical Diseases, Lower respiratory tract infection, Lung disease, Lyme disease, Lyme disease microbiology, Lymphocytic interstitial pneumonia, Lysosomal storage disease, Madras motor neuron disease, Malaria, Malaria and the Caribbean, Malaria antigen detection tests, Malaria Atlas Project, Malaria Consortium, Malaria Control Project, Malaria culture, Malaria Day in the Americas, Malaria Eradication Scientific Alliance, Malaria Journal, Malaria No More, Malaria No More UK, Malaria Policy Advisory Committee, Malaria prophylaxis, Malaria vaccine, Malarial nephropathy, MalariaWorld, Malaysian Journal of Nutrition, Malnutrition, Malnutrition in children, Malnutrition in India, Malnutrition in Kerala, Malnutrition in Peru, Malnutrition in South Africa, Malnutrition in Zimbabwe, Management of Crohn's disease, Managerial epidemiology, Marburg virus disease, Mass psychogenic illness, Massachusetts smallpox epidemic, Maternal healthcare in Texas, Maternal mortality, Maternal mortality ratio, Mayaro virus disease, Measles, Measles & Rubella Initiative, Measles hemagglutinin, Measles morbillivirus, Measles resurgence in the United States, Measles vaccine, Medical students' disease, Medicines for Malaria Venture, Mekong Basin Disease Surveillance, Melanie's Marvelous Measles, Meningococcal disease, Mental disorder, Mental disorders and gender, Mental illness, Michael Colgan (nutritionist), Micronutrient malnutrition, Mitochondrial disease, Mixed connective tissue disease, Mobile source air pollution, Modern Healthcare, Molecular epidemiology, Molecular Nutrition & Food Research, Morbidity and Mortality Weekly Report, Mosquito-borne disease, Mosquito-malaria theory, Motor neuron disease, Motor Neurone Disease Association, Muesli belt malnutrition, Multiple complex developmental disorder, Multisystem developmental disorder, Music therapy for Alzheimer's disease, Mycobacterium avium-intracellulare infection, Mycoplasma hominis infection, Mycoplasma pneumonia, National Air Pollution Symposium, National Association for Public Health Policy, National Center for Disease Control and Public Health (Georgia), National Comorbidity Survey, National Emerging Infectious Diseases Laboratories, National Foundation for Infectious Diseases, National Health and Nutrition Examination Survey, National Institute for Communicable Diseases, National Institute of Malaria Research, National Malaria Eradication Program, National Perinatal Epidemiology Unit, National School of Public Health (Spain), Neglected tropical disease research and development, Neglected tropical diseases, Neonatal infection, Nephropathia epidemica, Neuro-Behçet's disease, Neurodevelopmental disorder, Neuroepidemiology (journal), NINCDS-ADRDA Alzheimer's Criteria, Noma (disease), Non-alcoholic fatty liver disease, Non-communicable disease, Non-communicable diseases, Non-specific interstitial pneumonia, Norwegian Institute of Public Health,

<table>
<tr>
<td></td>
<td>
Notifiable disease, Notifiable diseases in Sweden, Nutrition, Nutrition (journal), Nutrition and Cancer, Nutrition and Education International, Nutrition and Health, Nutrition Foundation of the Philippines, Nutrition in Clinical Practice, Nutrition Journal, Nutrition Reviews, Nutrition transition, Nutritional Neuroscience (journal), NutritionDay, Nutritionist, Occult pneumonia, Occupational exposure to Lyme disease, Opportunistic infection, Organic mental disorder, Outline of air pollution dispersion, Overnutrition, Overwhelming post-splenectomy infection, Oxford Brookes Centre for Nutrition and Health, Paediatric and Perinatal Epidemiology, Paget's disease of bone, Pandemic, Pandemic severity index, Papaya Bunchy Top Disease, Parasitic disease, Parasitic pneumonia, Parkinson's disease, Pay for performance (healthcare), Pelvic inflammatory disease, Pervasive developmental disorder, Pervasive developmental disorder not otherwise specified, Peyronie's disease, Pick's disease, Pinta (disease), Plague (disease), Plant nutrition, Plum Island Animal Disease Center, Pneumococcal infection, Pneumococcal pneumonia, Pneumocystis pneumonia, Pneumonia, Pneumonia (non-human), Pneumonia jacket, Pneumonia severity index, Pogosta disease, Portal:Malaria, Portal:Pervasive developmental disorders, Postorgasmic illness syndrome, Pott disease, Prebiotic (nutrition), Pregnancy-associated malaria, President's Malaria Initiative, Prevalence of mental disorders, Prevention of Tay–Sachs disease, Private healthcare, Progressive disease, Protein–energy malnutrition, Psychiatric epidemiology, Psychogenic disease, Public health, Public Health Agency of Canada, Public Health Agency of Sweden, Public Health Emergency of International Concern, Public health genomics, Public health informatics, Public health insurance option, Public health intervention, Public health laboratory, Public health law, Public health nursing, Public Health Nutrition, Public health observatory, Public health problems in the Aral Sea region, Public Health Research Institute, Public health surveillance, Public health system in India, Public Health Wales, Publicly funded health care, Quantum suicide and immortality, Rare disease, RBM Partnership To End Malaria, Reactive airway disease, Real-time outbreak and disease surveillance, Refugee health care in Canada, Reproductive health care for incarcerated women in the United States, Reproductive system disease, Respiratory disease, Respiratory diseases, Respiratory tract infection, Rheumatoid disease of the spine, Ron Rivera (public health), Royal Commission on the Future of Health Care in Canada, Rural health care in Australia, School health and nutrition services, Serratia infection, Services for mental disorders, Shona Holmes health care incident, Sickle cell disease, Single-payer healthcare, Skin and skin structure infection, Skin infection, Social Psychiatry and Psychiatric Epidemiology, Sociality and disease transmission, Societal and cultural aspects of Tay–Sachs disease, South African Malaria Initiative, South Texas Center for Emerging Infectious Diseases, Southern tick-associated rash illness, Spatial and Spatio-temporal Epidemiology, Specific replant disease, Stateville Penitentiary Malaria Study, Strengthening the reporting of observational studies in epidemiology, Streptococcus pneumoniae, Subclinical infection, Suicide epidemic, Superinfection, Surgical Infections, Susceptibility and severity of infections in pregnancy, Sweating sickness epidemics, Swedish Healthcare, Systemic disease, Target Malaria, Tay–Sachs disease, Template:Acari-borne diseases, Template:Eradication of infectious disease, Template:Gram-positive actinobacteria diseases, Template:Infectious disease, Template:Infectious-disease-stub, Template:Pervasive developmental disorders, Template:Plant nutrition, Template:Vertically transmitted infection, The Global Fund to Fight AIDS, Tuberculosis and Malaria, The Journal of Nutrition, Health and Aging, Theiler's disease, Tick-borne disease, Tick-Borne Disease Alliance, Timeline of Alzheimer's disease, Timeline of healthcare in China, Timeline of healthcare in Cuba, Timeline of healthcare in Egypt, Timeline of healthcare in Ethiopia, Timeline of healthcare in France, Timeline of healthcare in Germany, Timeline of healthcare in India, Timeline of healthcare in Italy, Timeline of healthcare in Japan, Timeline of healthcare in Kenya, Timeline of healthcare in Nigeria, Timeline of healthcare in Russia, Timeline of healthcare in South Africa, Timeline of healthcare in the Democratic Republic of the Congo, Timeline of healthcare in the United Kingdom, Timeline of malaria, Timeline of measles, Timeline of peptic ulcer disease and Helicobacter pylori, Top dying disease, Traditional Healthcare, Tropical disease, Two-tier healthcare, Tyzzer's disease, UCSC Malaria Genome Browser, Undernutrition, Universal Declaration on the Eradication of Hunger and Malnutrition, Ureaplasma urealyticum infection, Usual interstitial pneumonia, Vaccine-preventable diseases, Vapours (disease), Vector (epidemiology), Venereal Disease Research Laboratory test, Ventilator-associated pneumonia, Vermont health care reform, Vertically transmitted infection, Very early onset inflammatory bowel disease, Veterinary public health, Viral pneumonia, Virgin soil epidemic, Vogt–Koyanagi–Harada disease, Waterborne diseases, Weather and climate effects on Lyme disease exposure, Whipple's disease, WHO disease staging system for HIV infection and disease, WHO Disease Staging System for HIV Infection and Disease in Adults and Adolescents, WHO Disease Staging System for HIV Infection and Disease in Children, Wildlife trafficking and emerging zoonotic diseases, Wilson's disease, Wilt disease, World Malaria Day, World Pneumonia Day

Additional analyses

Complementing the analysis presented in the 2019 Lancet Countdown report, the Figures below provide the standalone network plots for the climate change and the health-related articles, respectively.
</td>
</tr>
</table>

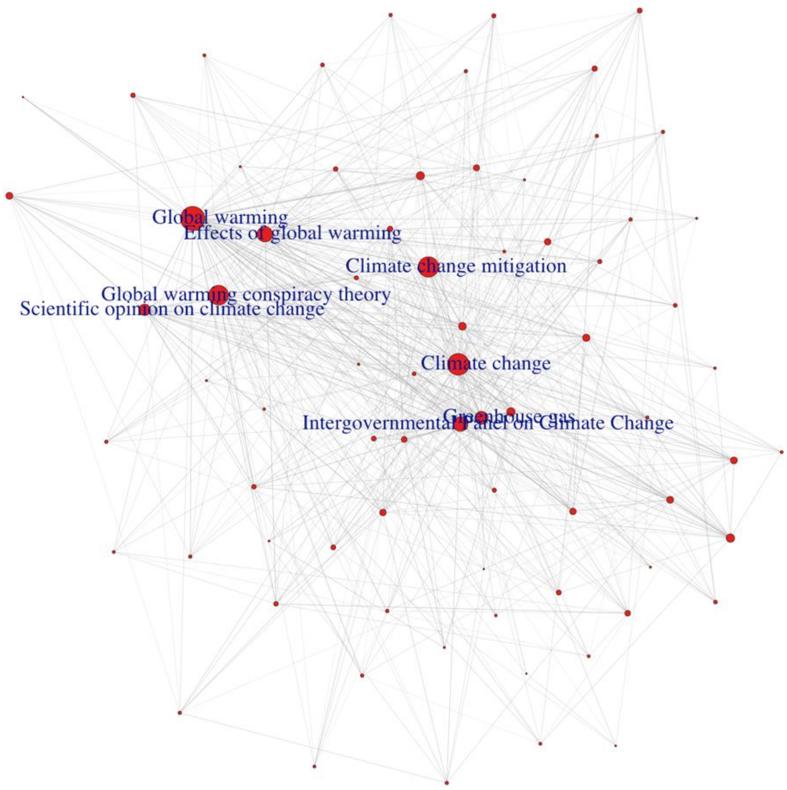


Figure 53: Connectivity graph of Wikipedia articles on climate change. Popularity of articles displayed by node size. Edges represent co-visits in the 2018 clickstream data.

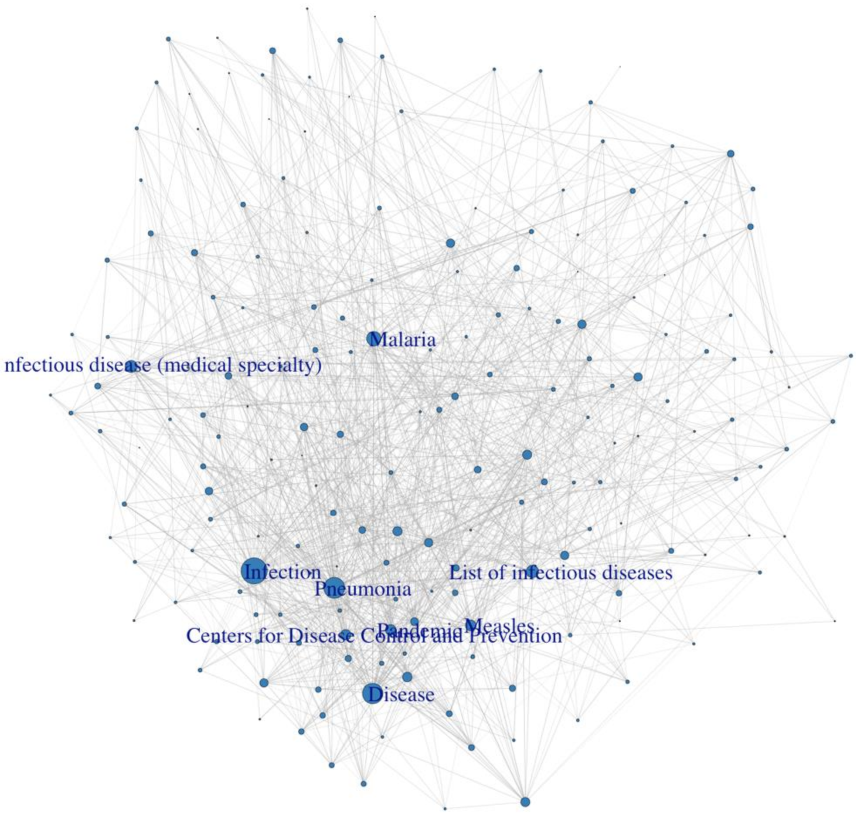


Figure 54: Connectivity graph of Wikipedia articles on health. Popularity of articles displayed by node size. Edges represent co-visits in the 2018 clickstream data.

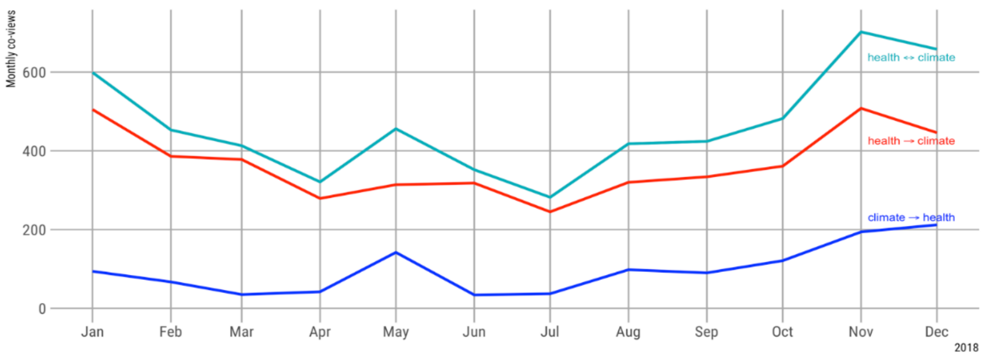


Figure 55: Aggregate monthly co-clicks on articles in Wikipedia related to human health and climate change in 2018

<table>
<tr><td>Working Group</td><td>5. Public and Political Engagement</td></tr>
<tr><td>Indicator</td><td>5.3 Engagement in health and climate change in the United Nations General Assembly</td></tr>
<tr><td>Methods</td><td>In order to produce the measure of high level political engagement with climate change and health in the UN General Assembly, a new dataset of UN General Debate (UNGD) statements is used, which is discussed below. The approach to using UNGD statements to produce the indicators is based on the application of natural language processing to the corpus of UNGD statements. References to key search terms linked to (a) health, and (b) climate change are identified.

Table 26: Search terms for Health and Climate Change.

<table>
<tr><th>Health terms</th><th>Climate change terms</th></tr>
<tr><td>
malaria
diarrhoea
infection
disease
sars
measles
pneumonia
epidemic
pandemic
public health
health care
epidemiology
healthcare
health
mortality
morbidity
nutrition
illness
infectious
ncd
non-communicable disease
noncommunicable disease
communicable disease
air pollution
nutrition
malnutrition
mental disorder
stunting
</td><td>
climate change
global warming
green house
temperature
extreme weather
global environmental change
climate variability
greenhouse
low carbon
ghge
renewable energy
carbon emission
co2 emission
climate pollutant
</td></tr>
</table>

In order to produce an indicator of engagement with the intersection of climate change and health, this indicator focused on whether any of the climate change</td></tr>
</table>

related terms appeared immediately before or after any health terms in the GD statements. This was based on a search of the 25 words before and after a reference to a climate change related term. The choice of 25-word window context corresponds to approximately half a paragraph of text. Given that UNGD statements are highly structured and methodically developed by governments over prolonged periods of time, it was assumed that half a paragraph of text around public health terms captures a sufficiently narrow context. The number of climate change term references in these contexts were then searched and counted to produce the measure of engagement with the link between health and climate change. A robustness analysis was then conducted by varying the size of the context (5, 10, and 50 words). This substantively produced the same trends over time. A sample of the references produced by the search were then also further examined to ensure that the references identified reflect engagement with the health impacts of climate change.

Data

This indicator draws on a new and updated dataset of GD statements: *the United Nations General Debate corpus*, in which the annual GD statements have been pre-processed and prepared for the application of natural language processing to the official English versions of the statements.[156] The dataset contains all of the country speeches made in the UN General Debate between 1970 and 2018. Table 27 presents summary of the data by year.

Table 27: Summary information for UN General Debate Corpus.

Year	Total speeches	Total sentences	Total words
1970	70	11841	304290
1971	116	19892	508823
1972	125	21208	541279
1973	120	21452	536685
1974	129	22051	569216
1975	126	21379	534621
1976	134	23827	600415
1977	140	24822	606142
1978	141	25267	625725
1979	144	26501	652551
1980	149	27223	657862
1981	145	26097	633723
1982	147	23438	638526
1983	149	26780	641172
1984	150	27982	660963
1985	137	19265	592782
1986	149	19041	577652

		1987	152	18346	563107	
		1988	154	18604	569545	
		1989	153	19444	574455	
		1990	156	17893	522230	
		1991	162	18553	538391	
		1992	167	18594	543162	
		1993	175	20165	587786	
		1994	178	19946	580989	
		1995	172	17872	537258	
		1996	181	18058	523208	
		1997	176	17709	515090	
		1998	181	18888	515338	
		1999	181	18541	531704	
		2000	178	16262	464742	
		2001	189	14753	415053	
		2002	188	13985	380817	
		2003	189	14737	399773	
		2004	192	14904	405687	
		2005	185	13016	353420	
		2006	193	14647	390874	
		2007	191	14585	388214	
		2008	192	14298	385176	
		2009	193	16038	423681	
		2010	189	14438	392266	
		2011	194	16295	430321	
		2012	195	16842	444763	
		2013	193	16398	441245	
		2014	194	15865	422284	
		2015	193	16134	436593	
		2016	194	16001	420489	
		2017	196	16814	439993	
		2018	196	16987	455558	

Total	**8,093**	**923,678**	**24,875,639**

	The data was pre-processed for analysis by removing punctuation, symbols, numbers, and URLs. Any tokens smaller than three characters were also removed to reduce typos and mistakes from the document digitisation process. In addition, all tokens were normalised (lowercased). All pre-processing and analysis was carried out in R using “quanteda” package.[157]
Caveats	The search for climate change terms in the context of public health references is a proxy for the semantic linkage between the two sets of terms in GD statements. This approach produces a scalable and reproducible measure with a high degree of reliability that does not involve human judgement or subjective biases. However, there may be examples of governments referring to climate change and health but not the direct linkages between the two, which are included in the count; and there may be examples of governments discussing the health impacts of climate change in their UNGD statements, which are not included in our measure because the distance between the mention of the climate change term and the health term exceeds 25 words. Based on an analysing a sample of the speeches and references, such cases are relatively rare and do not have a significant bearing on the indicator or the trends uncovered. It is also worth noting that the analysis here is based on a narrow range of search terms, which excludes reference to many of indirect links between climate change and health. A number of GD statements in this time period refer to such indirect connections, such as the effects of climate change on water and agriculture – however, these are not included here. Therefore, the results present a somewhat conservative estimate of high level political engagement with the intersection of climate change and health. Future work in this area will consider engagement with these indirect links.
Future Form of Indicator	In the future, this indicator will look more closely at the references to indirect links between climate change and health. For example, what are the main ways in which governments view climate change impacting on health? This indicator will consider whether this changes over time, based on awareness of the multiple ways in which climate change and health are connected. Some of the references to the indirect links between climate change and health made in UNGD statements have been highlighted in the main 2019 Lancet Countdown report.
Additional Information	Some additional findings and breakdowns are presented here. Figure 56 below presents the proportion of countries that engage with the intersection of climate change and health by WHO region. It is worth noting that the relatively higher level of political engagement by countries in the Western Pacific is especially driven by the small island development states (SIDS) in this region. It also worth noting that North America WHO region contains only two countries, USA and Canada. As neither of these countries refer to the health impacts of climate change (the US statement made no reference to climate change), the North America region has zero proportion of countries engaged with the climate change-health links.

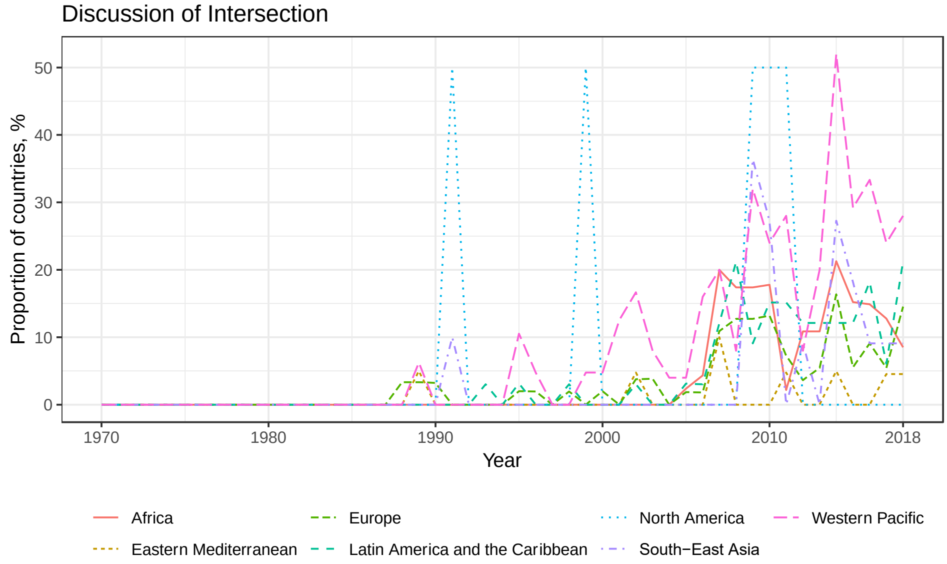


Figure 56: Proportion of countries referring to intersection of health and climate change by region, 1970-2018.

Figure 57 below presents the total number of references to the health impacts of climate change in GD statements between 1970 and 2018. The figure demonstrates a very similar trend to when the proportion of countries is considered; with spikes seen in 2009-10 and 2014 in both approaches.

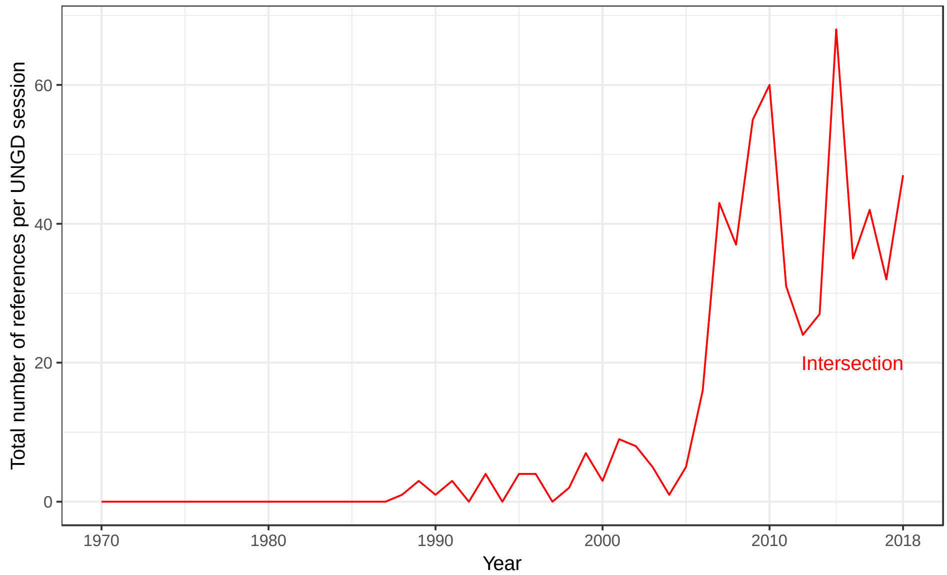


Figure 57: Total number of references to intersection, 1970-2018.

Figure 58, below, presents the total number of references to the climate change-health link between 1970 and 2018 by WHO region. The figure shows that the most references tend to be made by countries in the Western Pacific. Countries in Africa, Latin America and the Caribbean, and Europe are the most engaged after the

Western Pacific countries. In general, the figure suggests that there is lower engagement among countries in the Eastern Mediterranean, North America, and South-East Asia.

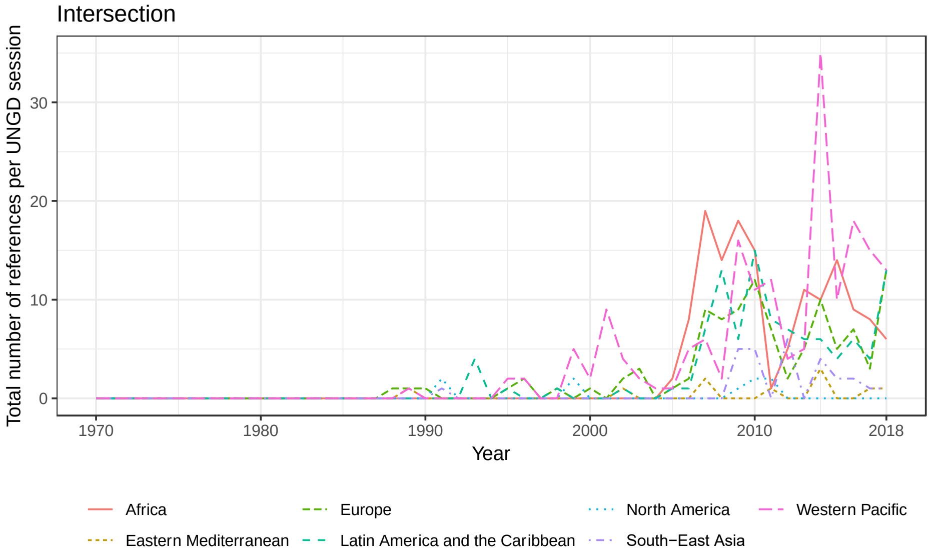


Figure 58: Total number of references to intersection by region, 1970-2018

In addition to grouping countries by WHO region, different types of countries are also considered in terms of their potential importance and role in addressing issues related to climate change. This is provided in Figure 59. As noted in previous Lancet Countdown reports,[1,131] the SIDS have driven much of the engagement with the health impacts of climate change, as well as climate change more generally, in the UN General Assembly. As such, a SIDS grouping is included. Arguably the three most important countries/unions in addressing climate change are USA, China, and the EU. This is both in terms of their carbon dioxide emissions and their power within the international system. This group is referred to as Tier 1 countries in Figure 59. Finally, an additional grouping of countries that are also important in terms of their CO_2 emissions, their influence in international politics, and their potential impact on addressing climate change are considered. This grouping, which, in this indicator, is referred to as Tier 2 countries includes: Poland, Australia, South Africa, Brazil, India, France, Germany, and Indonesia.

Figure 59 shows the proportion of countries that engage with the intersection of climate change and health based on these country groupings. Figure 60 shows the total number of references to the climate change-health intersection according to these groupings. Both figures demonstrate the higher level of engagement with the climate change-health linkages by SIDS than by Tier 1 or Tier 2 countries.

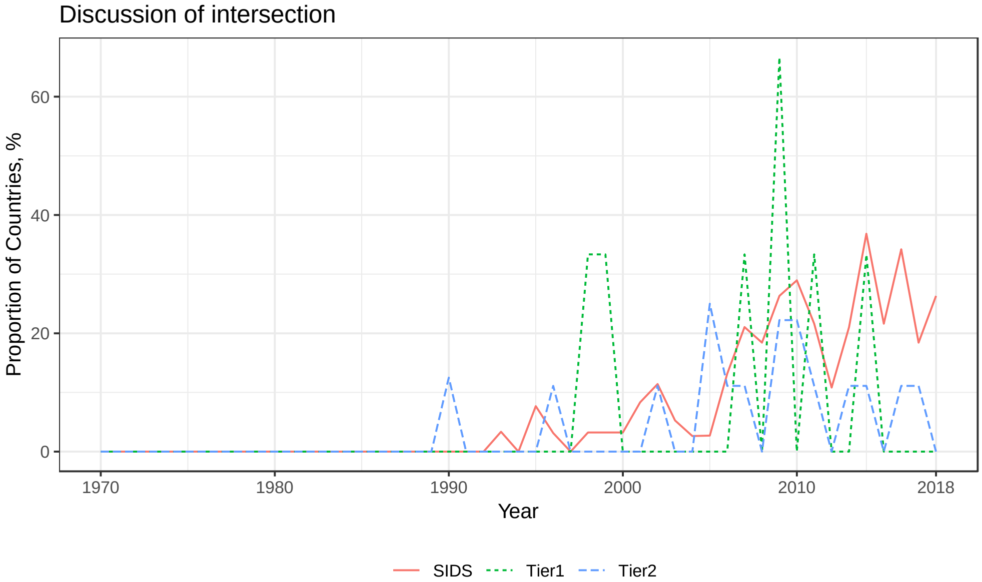


Figure 59: Proportion of countries referring to intersection of health and climate change by country grouping, 1970-2018.

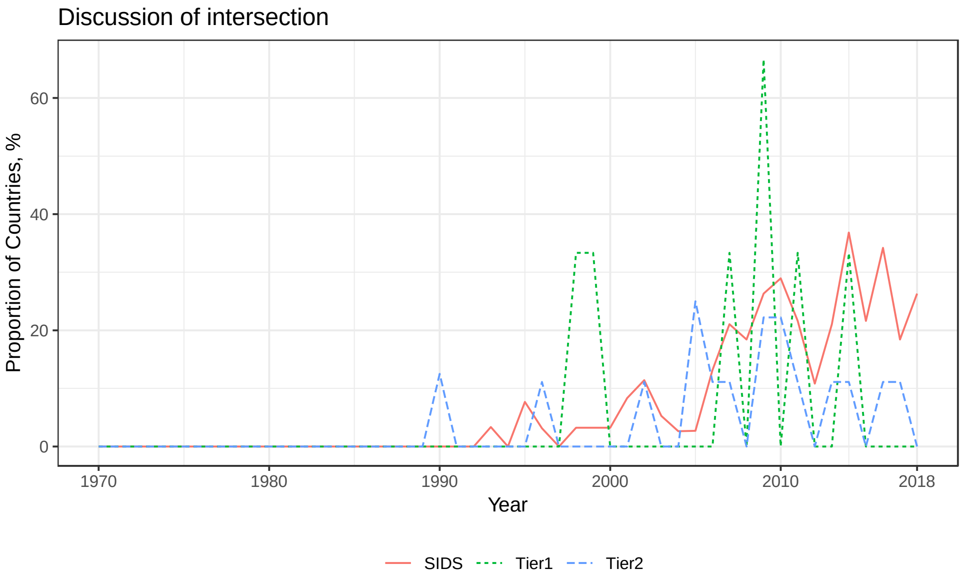


Figure 60: Total number of references to intersection by country grouping, 1970-2018.

Figure 61 below shows the level of political engagement with climate change and health separately, rather than engagement with the intersection of climate change and health. This is measured by the references to the key search terms associated with climate change and health in General Debate speeches. Figure 62 shows the proportion of countries that refer to public health in their GD statements between

1970 and 2017, while Figure 63 shows the proportion of countries that make a reference to climate change during this period. The figures show that in general there is higher levels of engagement with climate change than health. Figures 64 and 66 also show a sharp increase in engagement with climate change in the General Debate around 2006, followed by a decline in 2009 after the COP15 in Copenhagen that year. However, there has been an increase in engagement with climate change in recent years around the Paris Agreement. Engagement with health has in comparison been lower. However, there has broadly been increasing engagement with public health during this time period, and a sharp increase in 2000 with the launch of the Millennium Development Goals (MDGs). There is also an increase in the salience of global health from 2012 onwards, which coincides with the transition from the MDGs to the Sustainable Development Goals (SDGs).

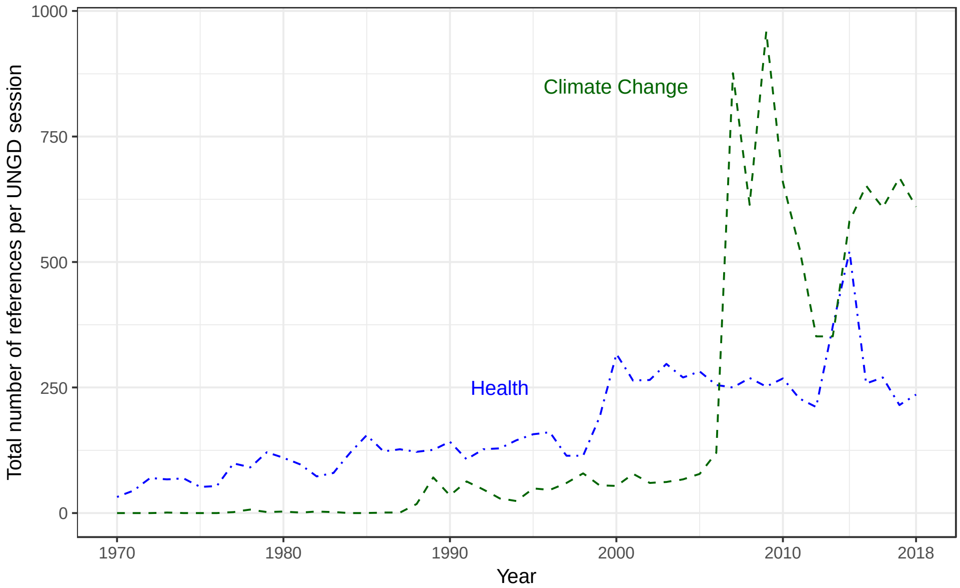


Figure 61: Total number of references to public health and climate change, 1970-2018.

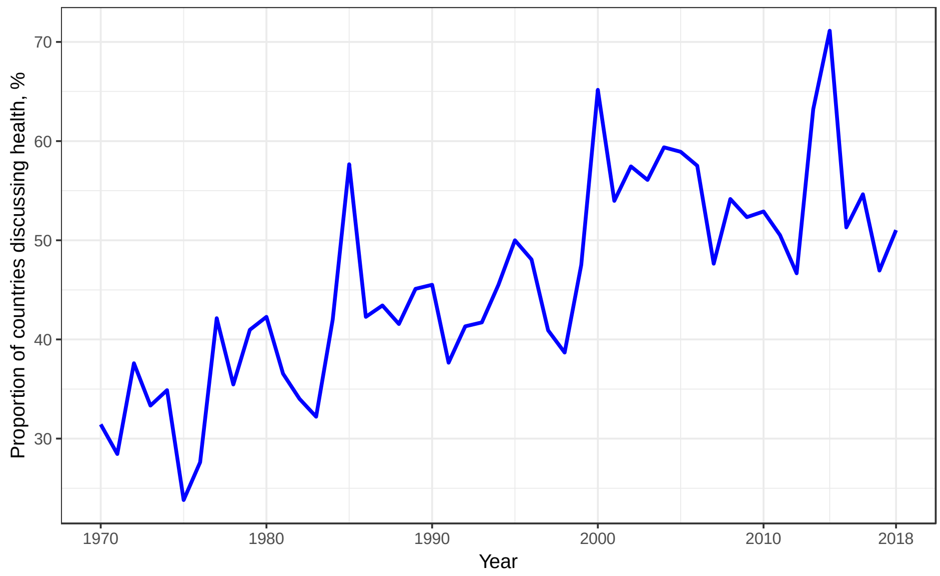


Figure 62: Proportion of countries referring to public health, 1970-2018.

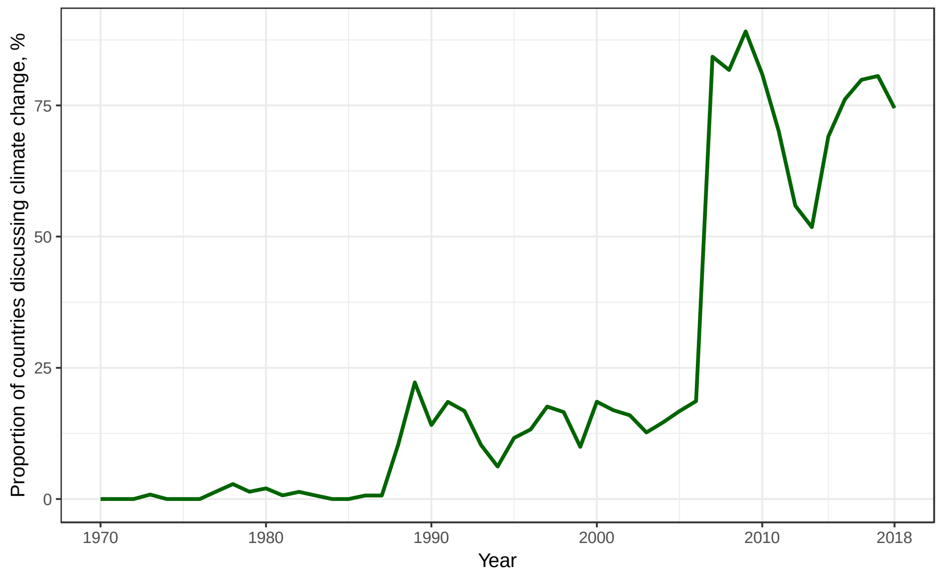


Figure 63: Proportion of countries referring to climate change, 1970-2017.

Figure 64 below presents a world map, which shows the countries that refer to the intersection of climate change and health in their 2018 GD statements, and the number of individual references they make. The map shows the relatively low level of engagement with the health impacts of climate change around the world in 2018. However, due to their size the SIDS do not show up on the map. As noted, the SIDS tend to be highly represented among nations engaging with the health-climate change links.

Figure 65 and Figure 66 present world maps, which show the countries that refer to public health and climate change respectively in their 2018 GD statements, as well as indicating the number of references made by each country. The figures demonstrate that while there is relatively low engagement with the intersection of health and climate change, there is considerable engagement with the issues of climate change and health separately.

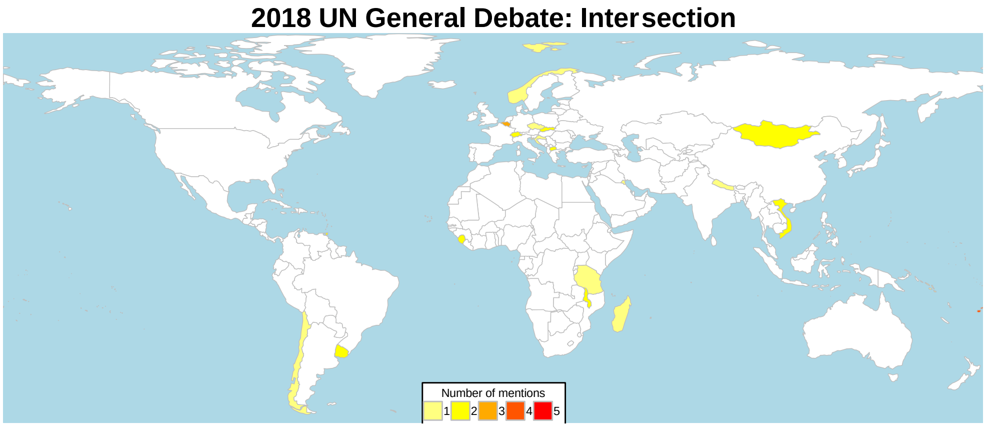


Figure 64: World map showing references to intersection of climate change and health, 2018.

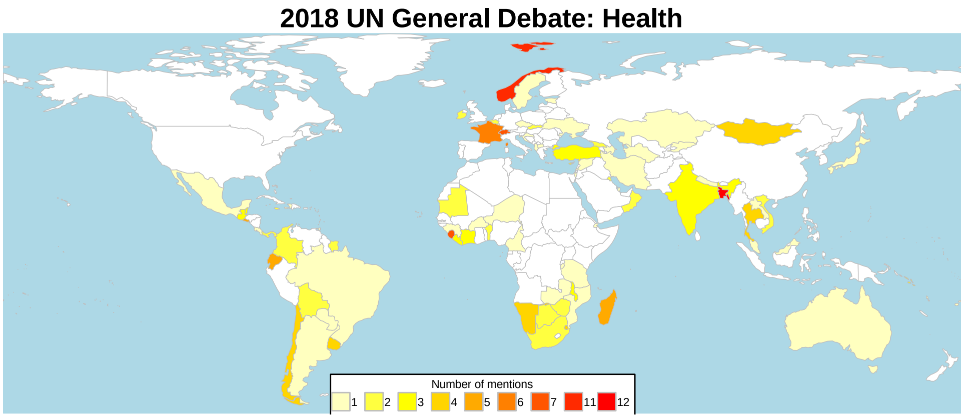


Figure 65: World map showing references to public health, 2018.

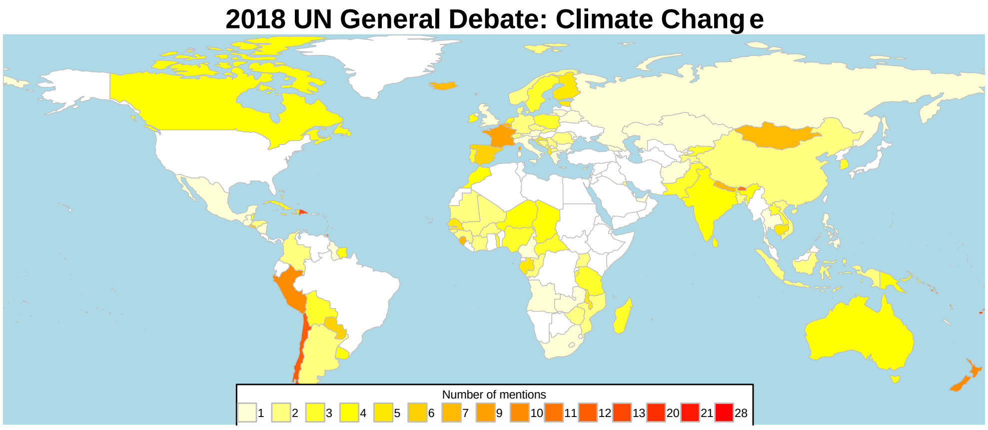


Figure 66: World map showing references to climate change, 2018.

The figures below show engagement with climate change, health, and the intersection of climate change and health over 1970-2018 for selected countries.

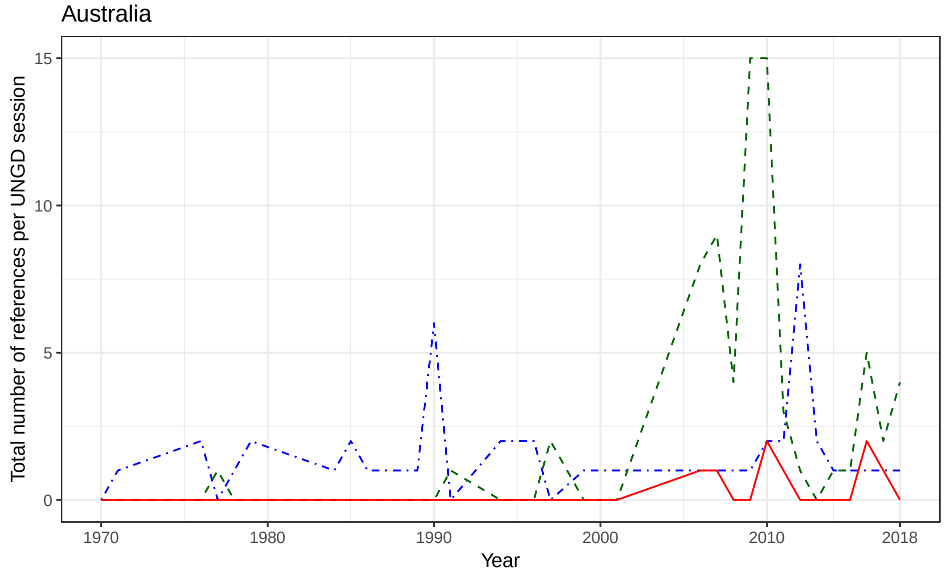


Figure 67: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in Australia.

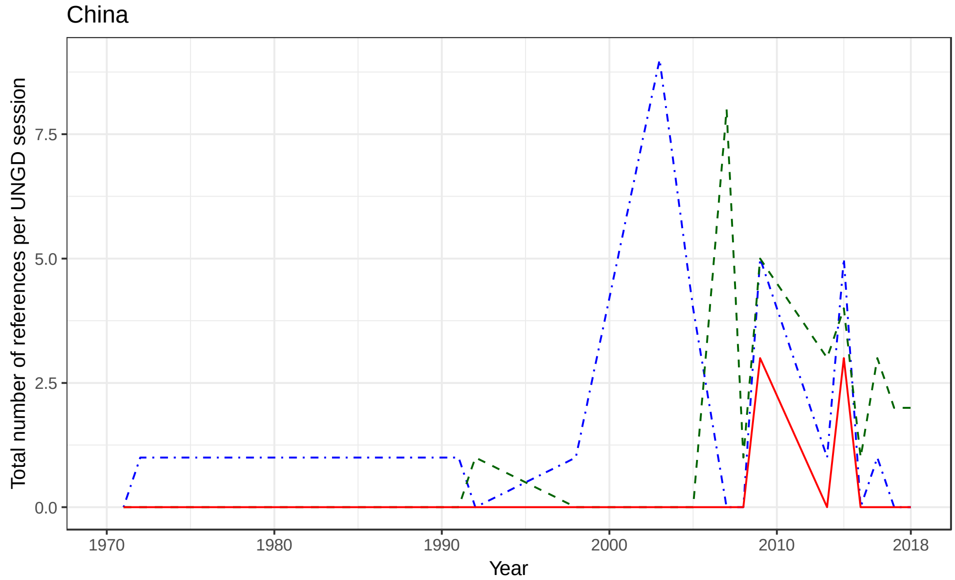


Figure 68: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in China.

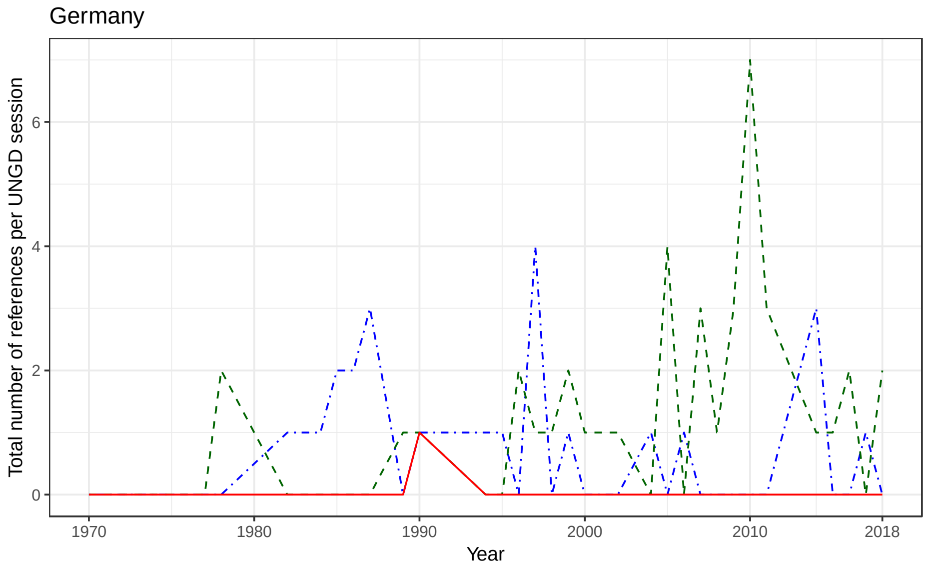


Figure 69: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in Germany.

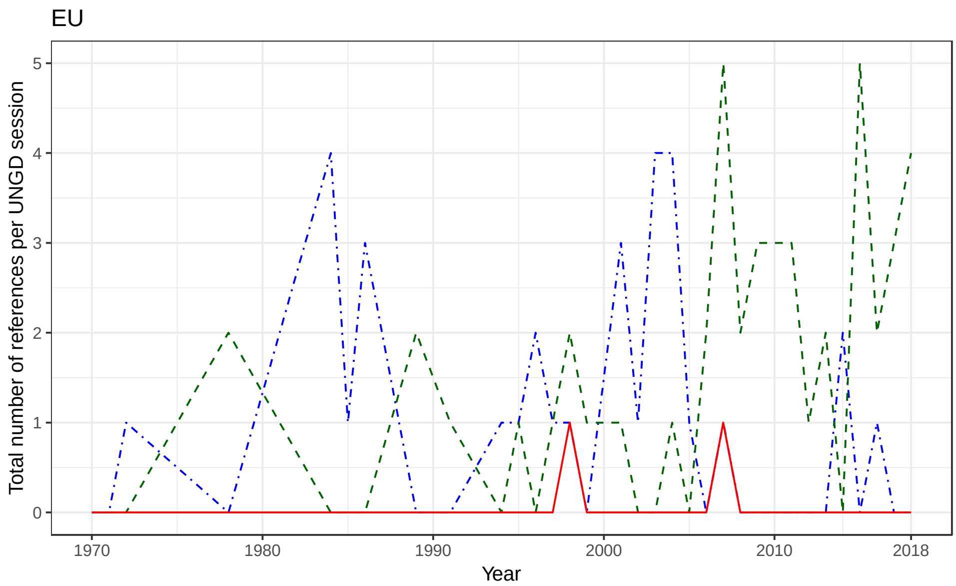


Figure 70: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in the European Union.

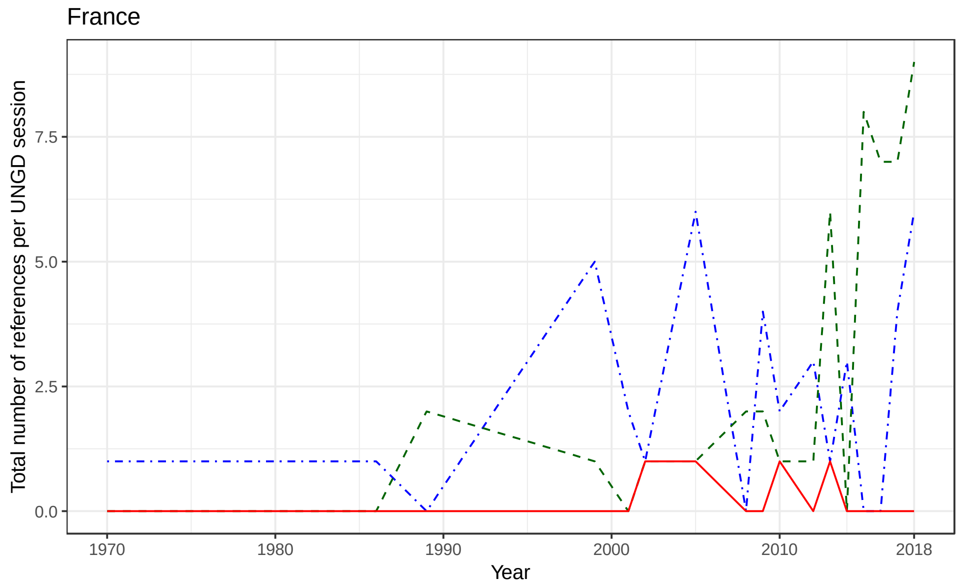


Figure 71: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in France.

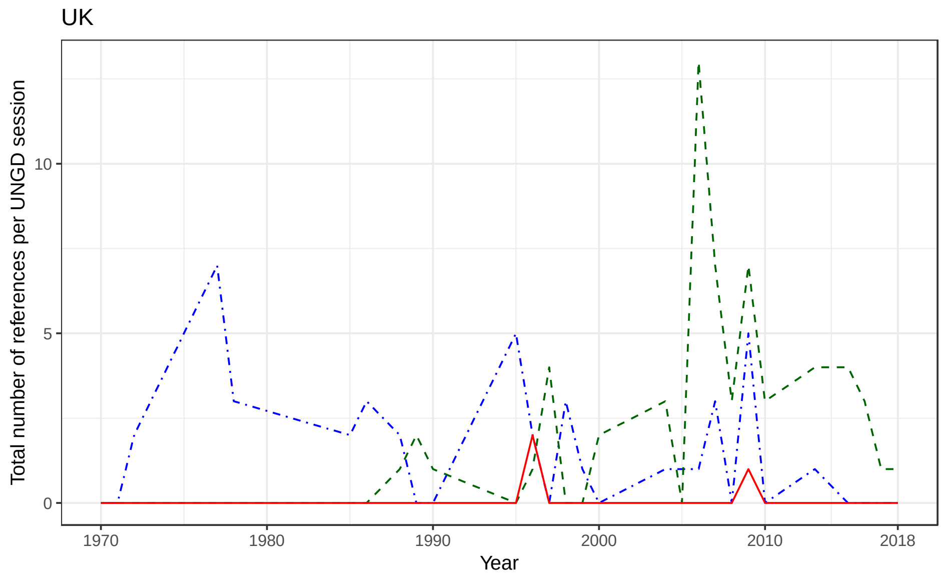


Figure 72: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in the United Kingdom.

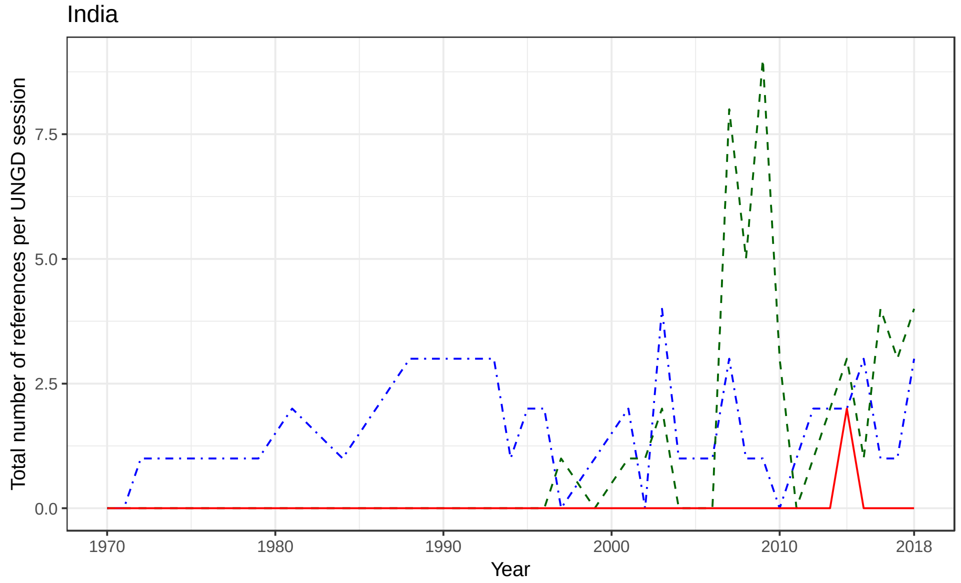


Figure 73: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in India.

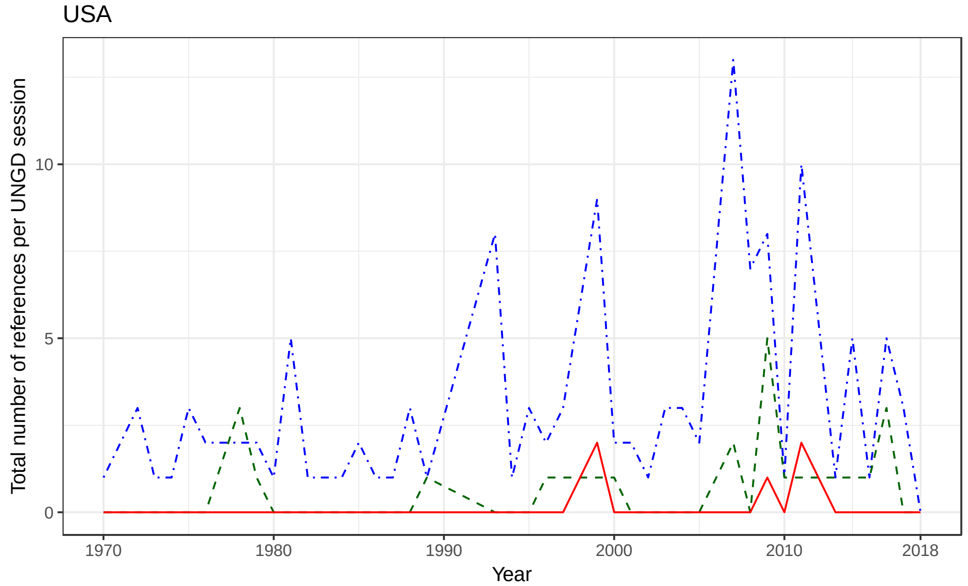


Figure 74: Engagement with climate change, health, and the intersection of climate change and health over 1970-2018 in the United States of America.

Working Group	5. Public and Political Engagement
Indicator	5.4 Corporate engagement with health and climate change in the healthcare sector
Methods	In order to produce the measure of engagement with climate change and health in healthcare companies' UN Global Compact Communication of Progress (COP) reports, publicly available COP reports were used. The approach to using the COP

reports to produce the indicators is based on identifying references to key search terms linked to (a) health, and (b) climate change.

Table 28: Search terms for Health and Climate Change.

Health terms	Climate change terms
• **malaria** • **diarrhoea** • **infection** • **disease** • **sars** • **measles** • **pneumonia** • **epidemic** • **pandemic** • **public health** • **health care** • **epidemiology** • **healthcare** • **health** • **mortality** • **morbidity** • **nutrition** • **illness** • **infectious** • **ncd** • **non-communicable disease** • **noncommunicable disease** • **communicable disease** • **air pollution** • **nutrition** • **malnutrition** • **mental disorder** • **stunting**	• climate change • global warming • green house • temperature • extreme weather • global environmental change • climate variability • greenhouse • low carbon • ghge • renewable energy • carbon emission • co2 emission • climate pollutant

In order to produce an indicator of engagement with the intersection of climate change and health, this indicator focused on whether any of the climate change related terms appeared immediately before or after any public health terms in the COP reports. This was based on a search of the 25 words before and after a reference to a public health related term. Table 29 presents total number of references identified in COP reports per year, where the column “Intersection” is the count of climate change terms appearing in the context (25 words before and after) of health terms.

Table 29: total number of references identified in COP reports per year.

	Health	Climate	Intersection
2011	15362	9338	473
2012	20097	11171	475
2013	25542	12041	643

2014	29963	13231	712
2015	28277	13399	735
2016	30326	15048	918
2017	32493	16378	1068
2018	34223	17447	1098

Data

This indicator draws on the publicly available UN Global Compact COP reports. A total of 37,102 reports were downloaded from COP from 138 countries across 43 industries. The total number of reports per year for 2011-2018 in are presented in Table 30 (prior to 2011 there were total of 11 reports).

Table 30: Total COP reports by year, 2011-2018.

Year	Number of reports
2018	5490
2017	5602
2016	5299
2015	5182
2014	4582
2013	4561
2012	3811
2011	2564

COP reports are submitted in 31 different languages. For the development of this indicator only reports available in English (17,896 or 48.23%), were included. A number of the English language files were corrupt or could not be converted into plain text format for analysis. The distribution of available English-language reports over time is presented in Table 31.

Table 31: English -language COP reports by year.

Year	Number of reports
2018	2670
2017	2662
2016	2653
2015	2452
2014	2261
2013	2141
2012	1774
2011	1276

These English language reports come from companies representing 132 countries, with the top 10 being Denmark (1,360 reports), USA (1,226), France (1,057), UK (1,031), Sweden (890), Germany (815), Japan (746), India (615), Australia (460), Netherlands (452), and Switzerland (427).

There are only single COP report submissions before 2011, the sample of COP reports was limited to the period 2011-2018. These documents were pre-processed and

<table>
<tr><td></td><td>prepared for the application of natural language processing by converting the reports to plain text format; removing punctuation and numbers; removing stopwords; regularising (lowercasing); and stemming. All of the pre-processing was conducted using the Python NLTK toolkit.</td></tr>
<tr><td>Caveats</td><td>As noted above, only COP reports that were submitted in English were considered. This includes just under half of all available UN General Compact COP reports.

This analysis here is based on a narrow range of search terms, which excludes reference to many of indirect links between climate change and health. Reports may also discuss indirect connections, such as the effect of climate change on agriculture, however, these are not included here. Therefore, the results present a somewhat conservative estimate of high corporate engagement with the intersection of climate change and health. Future work in this area will consider engagement with these indirect links, as well as providing additional forms of analysis.</td></tr>
<tr><td>Future Form of Indicator</td><td>In the future, this indicator will increase the number of reports analysed by translating our key search terms into several other key languages, and incorporating reports submitted in languages other than English into this sample. Translation of key terms into Spanish, Portuguese, and German has already been implemented in WG5. These translations will be used in next year's report.</td></tr>
<tr><td>Additional Informatio n</td><td>Figure 75 presents the proportion of healthcare equipment and services companies referring to climate change, health, and the intersection in CP reports from 2011 to 2018, with only 12% of companies making reference to both in 2018.

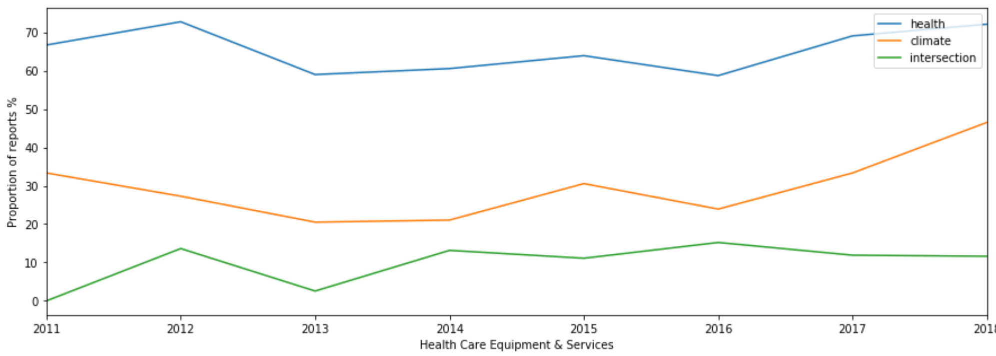


Figure 75: Proportion of healthcare sector companies referring to climate change, health, and the intersection of health and climate change in CP reports, 2011-2018

Some additional findings and breakdowns are presented in this section. Figure 76 presents the total number of references to climate change, health, and the intersection of climate change and health across all of the COP reports (and all sectors). As noted in the main report, there are low and fairly constant levels of engagement with the climate change-health linkages.</td></tr>
</table>

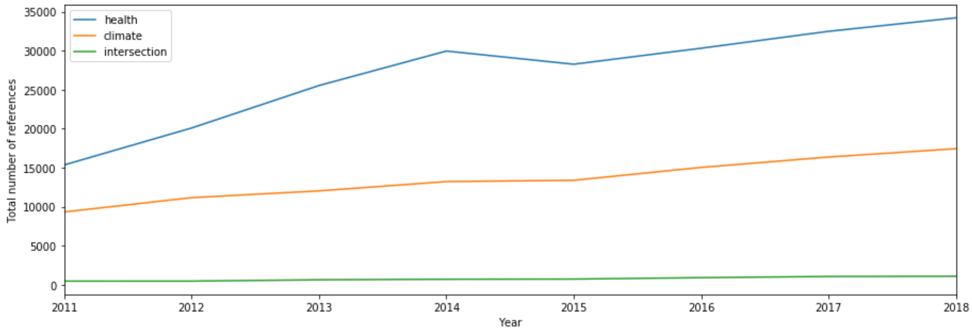


Figure 76: Total references to climate change, health, and the intersection of climate change and health across all COP reports, 2011-2018.

Figure 77 presents the total references with the intersection of climate change and health to better show any trends occurring in engagement. The figure shows that there while total references may still be quite low, there has been an increase in engagement with the climate change-health linkages, particularly since 2015.

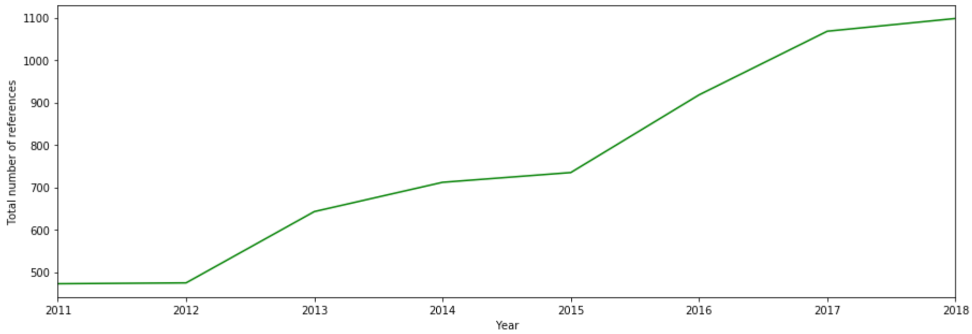


Figure 77: Total references to the intersection of climate change and health across all COP reports, 2011-2018.

Figure 78 shows that the total proportion of COP reports that refer to climate change, health, and the intersection of climate change and health. The report shows that engagement with climate change and health are generally much higher than with the intersection. Around 60% of all COP reports refer to climate change in 2018, while approximately 45% of all reports refer to health in 2018. In contrast only 15% of reports refer to the intersection of climate change and health in 2018. The figure shows that there has been a very slight increase in the level of engagement across all three issues, however, the increase in engagement with the climate change-health intersection is far less pronounced than when total references are considered.

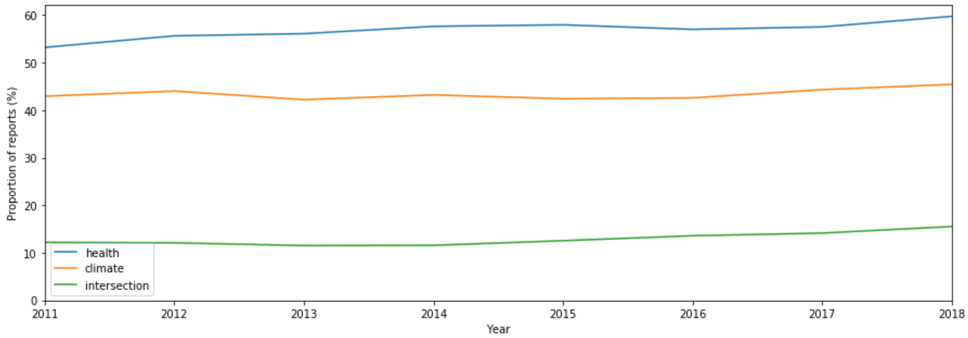


Figure 78: Proportion of COP reports referring to climate change, health, and the intersection of climate change and health, 2011-2018.

Engagement with climate change and health in the UN Global Compact COP reports by WHO region was also considered. Figure 79 shows the total number of references to the climate change-health intersection based on which of the WHO regions a company is based on, and Figure 80 shows the proportion of companies based in the different WHO regions that refer to the health impacts of climate change in their annual COP report.

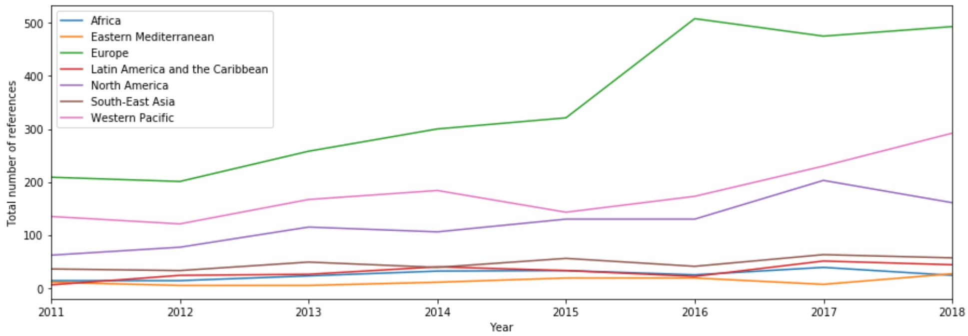


Figure 79: Total references with the intersection of climate change and health by WHO region, 2011-2018.

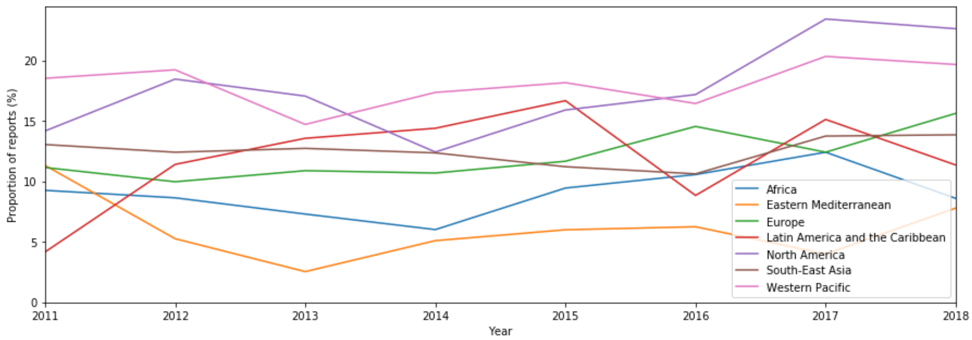


Figure 80: Proportion of companies referring to intersection of health and climate change by WHO region, 2011-2018.

Figure 80 shows that the highest proportion of COP reports engaging with the climate change-health intersection in recent years has come from corporations based in North America, followed by the Western Pacific region. The lowest engagement comes from corporations based in the Eastern Mediterranean region.

Engagement across different sectors was also considered. Table 32 shows the total number of references to climate change, health, and the intersection across the different sectors, while Table 33 shows the proportion of corporations in each sector that engage with climate change, health, and the climate change-health intersection. Figure 81 and Figure 82 present this information in the form of bar graphs.

Table 32: Total number of references to the intersection of climate change and health by sector.

	health	climate	intersection
Aerospace & Defense	2127	1014	63
Alternative Energy	1260	1607	89
Automobiles & Parts	6223	2970	209
Banks	3683	2869	72
Beverages	5210	2671	199
Chemicals	14438	5967	619
Construction & Materials	12564	6398	364
Diversified	1648	751	33
Electricity	4095	4393	179
Electronic & Electrical Equ...	4923	2452	98
Equity Investment Instruments	811	121	8
Financial Services	10971	10995	350
Fixed Line Telecommunications	3062	1307	68
Food & Drug Retailers	777	390	14
Food Producers	12953	4447	372
Forestry & Paper	2448	1951	60
Gas, Water & Multiutilities	2665	2893	101
General Industrials	14241	6847	471
General Retailers	5608	3208	111
Health Care Equipment & Ser...	6843	677	108

	Household Goods & Home Cons...	2361	1295	61
	Industrial Engineering	4903	2140	165
	Industrial Goods & Services	0	0	0
	Industrial Metals & Mining	7461	2493	150
	Industrial Transportation	4370	2279	108
	Leisure Goods	428	295	8
	Life Insurance	1048	239	4
	Media	3135	1531	38
	Mining	5057	1496	100
	Mobile Telecommunications	5202	2628	170
	Nonequity Investment Instru...	153	49	3
	Nonlife Insurance	1145	229	4
	Not Applicable	1475	711	60
	Oil & Gas Producers	10073	7035	392
	Oil Equipment, Services & D...	1926	761	54
	Personal Goods	3697	1481	89
	Pharmaceuticals & Biotechno...	14516	1512	274
	Real Estate Investment & Se...	3364	1690	58
	Real Estate Investment Trusts	1584	775	96
	Software & Computer Services	4219	2307	110
	Support Services	9759	4775	223
	Technology Hardware & Equip...	9786	5883	279
	Tobacco	41	19	0
	Travel & Leisure	4414	2813	98

Table 33: Total proportion of corporations in each sector engaging with the intersection of climate change and health.

	health	climate	intersection
Aerospace & Defense	60.773481	45.856354	9.392265
Alternative Energy	62.711864	61.864407	26.271186
Automobiles & Parts	60.135135	36.261261	15.090090
Banks	60.154242	52.185090	10.282776
Beverages	61.994609	52.021563	17.250674
Chemicals	66.140351	55.964912	29.473684
Construction & Materials	55.576560	44.801512	14.933837
Diversified	62.666667	52.000000	18.666667
Electricity	68.000000	64.727273	25.818182
Electronic & Electrical Equ...	44.395280	29.793510	7.079646
Equity Investment Instruments	40.476190	23.809524	5.952381
Financial Services	55.065739	52.822892	11.446249
Fixed Line Telecommunications	64.210526	52.105263	15.263158
Food & Drug Retailers	50.000000	52.500000	17.500000
Food Producers	65.507246	47.826087	17.246377
Forestry & Paper	60.165975	52.282158	15.352697
Gas, Water & Multiutilities	52.061856	49.484536	14.948454
General Industrials	50.107373	38.081603	11.238368
General Retailers	51.052632	37.543860	10.701754
Health Care Equipment & Ser...	64.768683	29.537367	10.676157
Household Goods & Home Cons...	57.203390	36.864407	11.016949
Industrial Engineering	52.848723	40.275049	12.966601
Industrial Goods & Services	0.000000	0.000000	0.000000
Industrial Metals & Mining	64.453961	47.751606	16.059957
Industrial Transportation	54.311927	40.550459	8.623853
Leisure Goods	55.223881	37.313433	8.955224
Life Insurance	47.619048	49.206349	4.761905
Media	54.158607	38.491296	4.255319
Mining	60.264901	45.033113	23.841060

Mobile Telecommunications	73.898305	60.677966	25.762712
Nonequity Investment Instru...	93.333333	80.000000	20.000000
Nonlife Insurance	52.000000	38.000000	2.000000
Not Applicable	56.250000	31.944444	11.805556
Oil & Gas Producers	70.852018	61.434978	31.614350
Oil Equipment, Services & D...	63.687151	40.223464	16.759777
Personal Goods	59.533898	37.500000	7.627119
Pharmaceuticals & Biotechno...	70.224719	43.258427	20.786517
Real Estate Investment & Se...	51.219512	46.341463	10.670732
Real Estate Investment Trusts	72.000000	64.000000	44.000000
Software & Computer Services	55.873926	33.237822	6.733524
Support Services	51.705115	34.904714	6.569709
Technology Hardware & Equip...	58.620690	46.551724	16.379310
Tobacco	50.000000	25.000000	0.000000
Travel & Leisure	60.925926	47.407407	10.185185

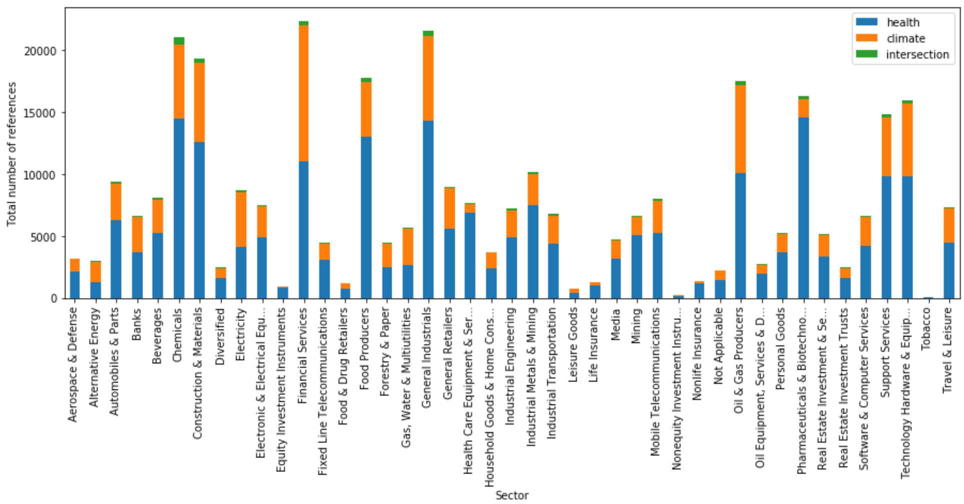


Figure 81: Total references to climate change, health, and the intersection of climate change and health by sector.

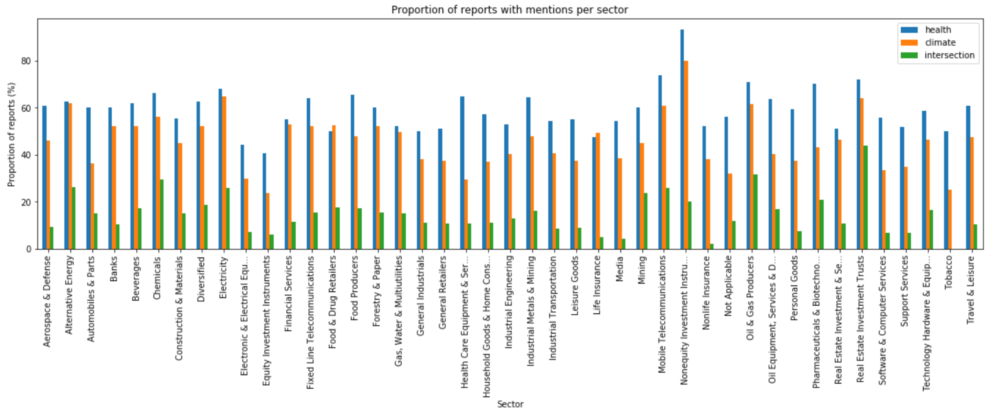


Figure 82: Proportion of corporations referring to climate change, health, and the intersection of climate change and health by sector.

As discussed in the main report, the highest level of engagement with the intersection of climate change and health can be seen in the alternative energy, chemicals, electricity, mobile telecommunications, oil and gas producers, and real estate investment sectors. In contrast, there were much lower levels of engagement in the healthcare sector.

Additional information on engagement with the climate change-health intersection in the healthcare sector is presented here. In addition to the total number of references to, and total proportion of reports that refer to, the climate change and health, Figure 83 shows the average number of references to climate change, health, and the intersection in COP reports from healthcare corporations. The figure again demonstrates the low level of engagement with the health impacts of climate change in healthcare sector COP reports.

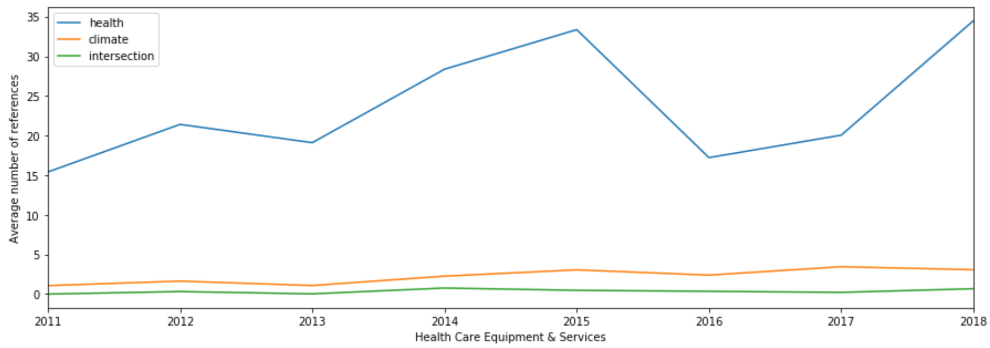


Figure 83: Average references to climate change, health, and the intersection of climate change and health in the healthcare sector COP reports, 2011-2018.

Figure 84 shows the proportion of healthcare sector corporations that engage with the climate change-health intersection by WHO region. As discussed in the main report, the figure shows that healthcare sector corporations based in Europe tend to engage much more with the climate change-health links than healthcare corporations based in other regions.

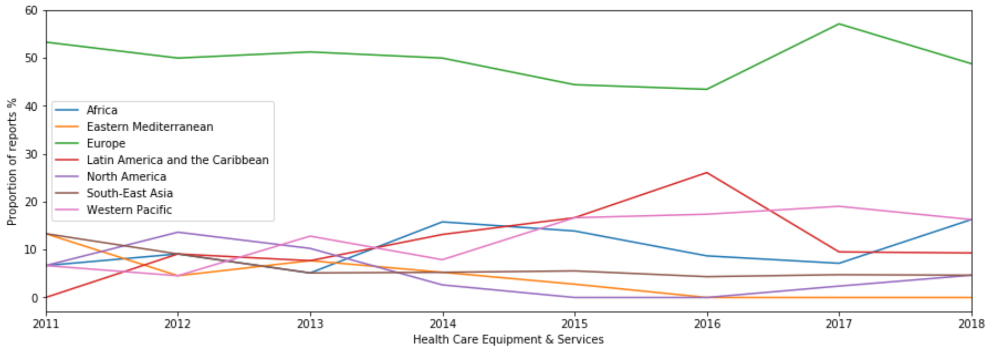


Figure 84: Proportion of corporations in the healthcare sector engaging with the climate change-health intersection by WHO region, 2011-2018.

Table 34 and Table 35 display the total number of references to each of the keywords related to climate change (Table 34) and health (Table 35) in the COP reports of corporations in the health care sector.

Table 34: Total references to climate change-related keywords in healthcare sector COP reports.

Keyword	Number of mentions
greenhouse	303
climate_change	191
renewable_energy	63
temperature	50
low_carbon	39
global_warming	14
carbon_emission	8
extreme_weather	5
green_house	4

Table 35: Total references to public health-related keywords in healthcare sector COP reports.

Keyword	Number of mentions
health	3407
healthcare	1991
health_care	440
disease	280
infection	133
malaria	117
infectious	104
public_health	90

illness	83
nutrition	72
mortality	52
pandemic	18
air_pollution	16
malnutrition	10
morbidity	10
communicable_disease	4
measles	4
stunting	4
epidemic	4
sars	2
pneumonia	1
epidemiology	1

Figure 85 displays a network graph of the co-occurrence of these key terms in COP reports in the healthcare sector. The figure shows that much of the emphasis is on the link between ‘climate change’ and ‘health’, as well as on ‘healthcare’.

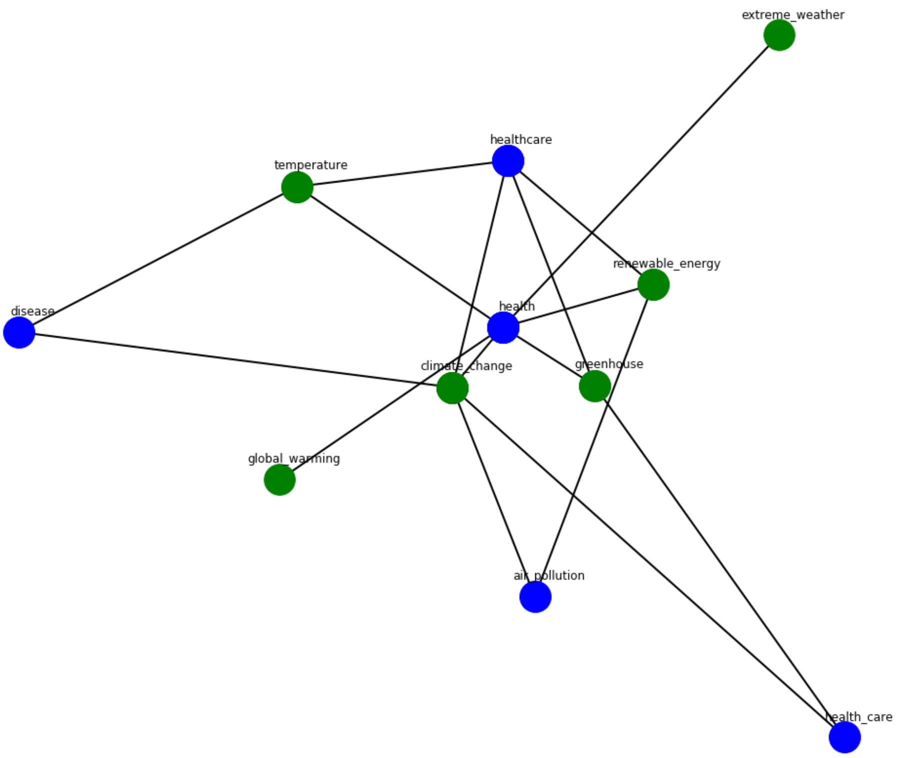


Figure 85: Network graph of co-occurrence of key words in healthcare sector COP reports.

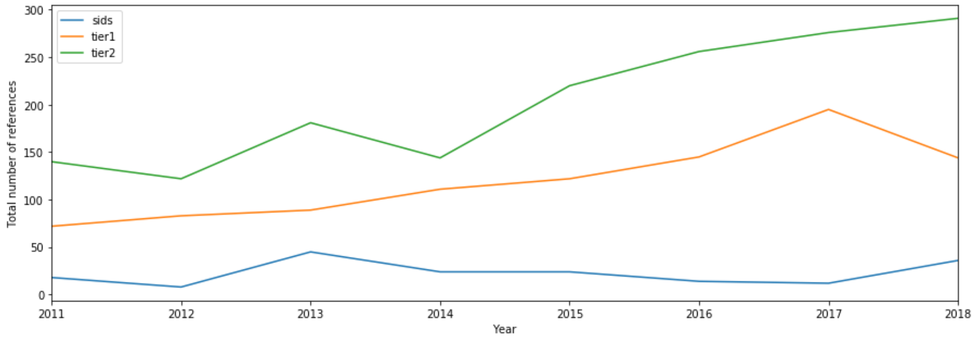


Figure 86: Total references to the climate change-health intersection in the healthcare sector by SIDS, Tier 1 countries, and Tier 2 countries, 2011-2018.

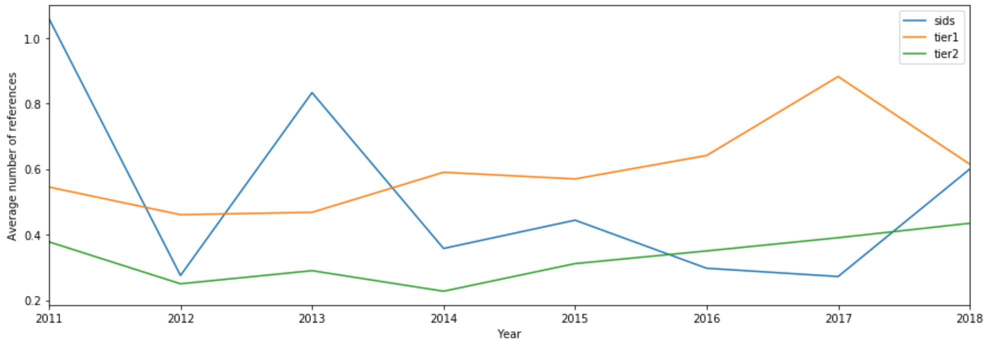


Figure 87: Average number of references to the climate change-health intersection in the healthcare sector by SIDS, Tier 1 countries, and Tier 2 countries, 2011-2018.

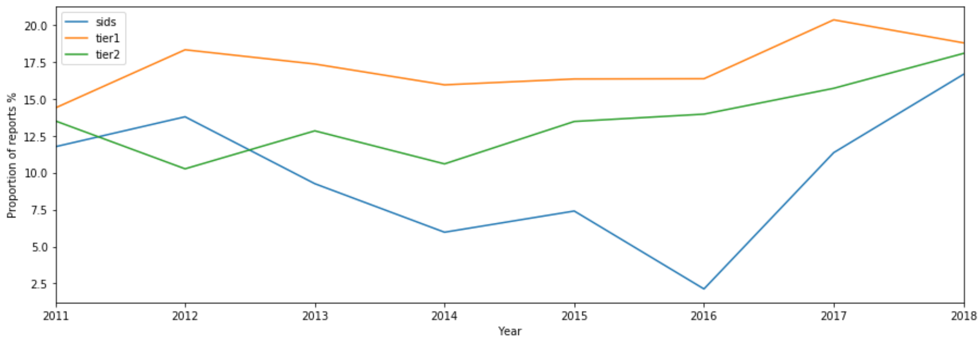


Figure 88: Proportion of corporations in the healthcare sector referring to the climate change-health intersection in the healthcare sector by SIDS, Tier 1 countries, and Tier 2 countries, 2011-2018.

References

1. Watts N, Amann M, Arnell N, et al. The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet* 2018; **392**(10163): 2479-514.
2. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2017 (GBD 2017) Population Estimates 1950-2017: Seattle, United States:Institute for Health Metrics and Evaluation (IHME), 2018.
3. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2017 (GBD 2017) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018.
4. United Nations DESA/Population Division. 2018 Revision of the World Urbanization Prospects. 2018.
5. ECMWF. ERA Interim, Daily. 2019.
6. NASA. Gridded Population of the World. 4 ed; 2019.
7. ILO. ILOSTAT. 2019.
8. IHME. Global Burden of Disease Study (2017) Data Resources. 2019.
9. NASA EarthData. Active Fire Data. 2019. https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/active-fire-data (accessed 4 February 2019).
10. Hayes M, Svoboda M, Wall N, Widhalm M. The Lincoln declaration on drought indices: universal meteorological drought index recommended. *Bulletin of the American Meteorological Society* 2011; **92**(4): 485-8.
11. Harris ICJ, P.D. . CRU TS4.02: Climatic Research Unit (CRU) Time-Series (TS) version 4.02 of high-resolution gridded data of month-by-month variation in climate (Jan. 1901- Dec. 2017). In: Analysis CfED, editor. University of East Anglia Climatic Research Unit; 2018.
12. Centre for Research on the Epidemiology of Disasters. EM-DAT The International Disaster Database. 2019.
13. Byass P. Cause-specific mortality findings from the Global Burden of Disease project and the INDEPTH Network. *The Lancet Global Health* 2016; **4**(11): e785-e6.
14. Stanaway JD, et al. The global burden of dengue: an analysis from the Global Burden of Disease Study 2013. *The Lancet: Infectious Diseases* 2016; **16**(6): 712–23.
15. Hales S, de Wet, N, Maindonald, J. and Woodward, A. Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. *The Lancet* 2002; **360**(9336): 830-4.
16. Rocklöv J, Tozan Y. Climate change and the rising infectiousness of dengue. *Emerging Topics in Life Sciences* 2019; **3**(2): 133-42.
17. Liu-Helmersson J, Quam M, Wilder-Smith A, et al. Climate change and Aedes vectors: 21st century projections for dengue transmission in Europe. *EBioMedicine* 2016; **7**: 267-77.
18. Weyant J. Report of 2.6 Versus 2.9 Watts/m2 RCPP Evaluation Panel John Weyant, Christian Azar, Mikiko Kainuma, Jiang Kejun, Nebojsa Nakicenovic, PR Shukla, Emilio La Rovere and Gary Yohe March 31, 2009. 2009.
19. Taylor KE, Balaji V, Hankin S, Juckes M, Lawrence B, Pascoe S. CMIP5 data reference syntax (DRS) and controlled vocabularies. PCMDI; 2011; 2011.
20. Warszawski L, Frieler K, Huber V, Piontek F, Serdeczny O, Schewe J. The inter-sectoral impact model intercomparison project (ISI–MIP): project framework. *Proceedings of the National Academy of Sciences* 2014; **111**(9): 3228-32.
21. Kraemer MU, Sinka ME, Duda KA, et al. The global distribution of the arbovirus vectors Aedes aegypti and Ae. albopictus. *elife* 2015; **4**: e08347.
22. Liu-Helmersson J, Stenlund H, Wilder-Smith A, Rocklöv J. Vectorial capacity of Aedes aegypti: effects of temperature and implications for global dengue epidemic potential. *PloS one* 2014; **9**(3): e89783.

23. Lindgren E, Andersson Y, Suk JE, Sudre B, Semenza JC. Monitoring EU emerging infectious disease risk due to climate change. *Science* 2012; **336**(6080): 418-9.
24. Grover-Kopec EK, Blumenthal MB, Ceccato P, Dinku T, Omumbo JA, Connor SJ. Web-based climate information resources for malaria control in Africa. *Malaria journal* 2006; **5**(1): 38.
25. Gilles HM. Protozoal diseases: Arnold; 1999.
26. Lyon B, Dinku T, Raman A, Thomson MC. Temperature suitability for malaria climbing the Ethiopian Highlands. *Environmental Research Letters* 2017; **12**(6): 064015.
27. KNMI. KNMI Climate Explorer. 2019.
28. JISAO. Elevation data in netCDF. University of Washington; 2014.
29. Patz JA, Olson SH. Malaria risk and temperature: influences from global climate change and local land use practices. *Proceedings of the National Academy of Sciences* 2006; **103**(15): 5635-6.
30. CDC. Malaria. 2019.
31. Newby G, Bennett A, Larson E, et al. The path to eradication: a progress report on the malaria-eliminating countries. *The Lancet* 2016; **387**(10029): 1775-84.
32. Snow RW, Sartorius B, Kyalo D, et al. The prevalence of Plasmodium falciparum in sub-Saharan Africa since 1900. *Nature* 2017; **550**(7677): 515.
33. Jacobs JM, Rhodes M, Brown CW, et al. Modeling and forecasting the distribution of Vibrio vulnificus in Chesapeake Bay. *Journal of Applied Microbiology* 2014; **117**(5): 1312-27.
34. Baker-Austin C, Trinanes JA, Taylor NG, Hartnell R, Siitonen A, Martinez-Urtaza J. Emerging Vibrio risk at high latitudes in response to ocean warming. *Nature Climate Change* 2013; **3**(1): 73-7.
35. McLaughlin JB, DePaola A, Bopp CA, et al. Outbreak of Vibrio parahaemolyticus Gastroenteritis Associated with Alaskan Oysters. *New England Journal of Medicine* 2005; **353**(14): 1463-70.
36. Martinez-Urtaza J, Lozano-Leon A, Varela-Pet J, Trinanes J, Pazos Y, Garcia-Martin O. Environmental determinants of the occurrence and distribution of Vibrio parahaemolyticus in the rias of Galicia, Spain. *Appl Environ Microbiol* 2008; **74**(1): 265-74.
37. Muhling BA, Gaitán CF, Stock CA, Saba VS, Tommasi D, Dixon KW. Potential salinity and temperature futures for the Chesapeake Bay using a statistical downscaling spatial disaggregation framework. *Estuaries and coasts* 2018; **41**(2): 349-72.
38. Parveen S, Hettiarachchi KA, Bowers JC, et al. Seasonal distribution of total and pathogenic Vibrio parahaemolyticus in Chesapeake Bay oysters and waters. *International journal of food microbiology* 2008; **128**(2): 354-61.
39. NOAA Earth System Research Laboratory. Physical Sciences Division 2019.
40. Copernicus. Marine Environment Monitoring Service. 2019.
41. Clemens J, Nair G, Ahmed T, Qadri F, Holmgren J. Cholera. The Lancet. *Cholera The Lancet* 2017; **390**(10101).
42. Ali M, Nelson AR, Lopez AL, Sack DA. Updated global burden of cholera in endemic countries. *PLoS neglected tropical diseases* 2015; **9**(6): e0003832.
43. Jutla AS, Akanda AS, Griffiths JK, Colwell R, Islam S. Warming oceans, phytoplankton, and river discharge: implications for cholera outbreaks. *The American journal of tropical medicine and hygiene* 2011; **85**(2): 303-8.
44. Escobar LE, Ryan SJ, Stewart-Ibarra AM, et al. A global map of suitability for coastal Vibrio cholerae under current and future climate conditions. *Acta tropica* 2015; **149**: 202-11.
45. Stewart Ibarra AM. Spatial and seasonal dynamics of cholera (Vibrio cholera) in an estuary in southern coastal Ecuador. 2016.
46. Flanders Marine Institute. The intersect of the Exclusive Economic Zones and IHO sea areas, version 3. 2018. http://www.marineregions.org/ (accessed 10 April 2019).
47. Johnson EE, Escobar LE, Zambrana-Torrelio C. An ecological framework for modeling the geography of disease transmission. *Trends in Ecology & Evolution* 2019; **In Press**.
48. Phillips SJ, Anderson RP, Dudík M, Schapire RE, Blair ME. Opening the black box: an open-source release of Maxent. *Ecography* 2017; **40**(7): 887-93.

49. Cobos ME, Peterson AT, Barve N, Osorio-olvera L. kuenm: A dynamic R package for detailed development of ecological niche models using Maxent. *PeerJ* 2019; **In Press**.
50. Muscarella R, Galante PJ, Soley-Guardia M, et al. ENM eval: An R package for conducting spatially independent evaluations and estimating optimal model complexity for Maxent ecological niche models. *Methods in Ecology and Evolution* 2014; **5**(11): 1198-205.
51. Qiao H, Feng X, Escobar LE, et al. An evaluation of transferability of ecological niche models. *Ecography* 2019; **42**(3): 521-34.
52. Peterson AT. Mapping disease transmission risk: enriching models using biogeography and ecology: JHU Press; 2014.
53. World Health Organisation. IHR Core capacity Monitoring Framework: Checklist and Indicators for Monitoring Progress in the Development of IHR Core Capacities in States Parties. 2013.
54. Nagarathinam S, Bhatta A. Coverage of climate change issues in Indian newspapers and policy implications. *Current Science* 2015; **108**(11): 1972-3.
55. Semenza JC, Sewe MO, Lindgren E, et al. Systemic Resilience to Cross-border Infectious Disease Threat Events in Europe. *Transboundary and emerging diseases* 2019.
56. Liu-Helmersson J, Stenlund H, Wilder-Smith A, Rocklov J. Vectorial capacity of Aedes aegypti: effects of temperature and implications for global dengue epidemic potential. *PloS one* 2014; **9**(3): e89783.
57. Liu-Helmersson J, Brännström Å, Sewe MO, Semenza JC, Rocklöv J. Estimating Past, Present, and Future Trends in the Global Distribution and Abundance of the Arbovirus Vector Aedes aegypti Under Climate Change Scenarios. *Frontiers in Public Health* 2019; **7**.
58. Challinor AJ, Koehler A-K, Ramirez-Villegas J, Whitfield S, Das B. Current warming will reduce yields unless maize breeding and seed systems adapt immediately. *Nature Climate Change* 2016; **6**(10): 954.
59. Gourdji SM, Sibley AM, Lobell DB. Global crop exposure to critical high temperatures in the reproductive period: historical trends and future projections. *Environmental Research Letters* 2013; **8**(2): 024041.
60. Lobell DB, Bänziger M, Magorokosho C, Vivek B. Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature climate change* 2011; **1**(1): 42.
61. Lobell DB, Schlenker W, Costa-Roberts J. Climate trends and global crop production since 1980. *Science* 2011; **333**(6042): 616-20.
62. Monfreda C, Ramankutty N, Foley JA. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. *Global biogeochemical cycles* 2008; **22**(1).
63. Weedon G, Gomes S, Viterbo P, et al. Creation of the WATCH forcing data and its use to assess global and regional reference crop evaporation over land during the twentieth century. *Journal of Hydrometeorology* 2011; **12**(5): 823-48.
64. Caesar L, Rahmstorf S, Robinson A, Feulner G, Saba V. Observed fingerprint of a weakening Atlantic Ocean overturning circulation. *Nature* 2018; **556**(7700): 191.
65. Thornalley DJ, Oppo DW, Ortega P, et al. Anomalously weak Labrador Sea convection and Atlantic overturning during the past 150 years. *Nature* 2018; **556**(7700): 227.
66. Gakidou E, Afshin A, Abajobir AA, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet* 2017; **390**(10100): 1345-422.
67. Berry P, Enright P, Shumake-Guillemot J, Villalobos Prats E, Campbell-Lendrum D. Assessing health vulnerabilities and adaptation to climate change: A review of international progress. *International journal of environmental research and public health* 2018; **15**(12): 2626.
68. WHO. International Health Regulations (2005) State Party Self-Assessment Annual Reporting Tool. Geneva, Switzerland: World Health Organization, 2018.

69. WHO. National Health Emergency Framework Data by country. Geneva, Switzerland: World Health Organization; 2019.
70. Bouchama A, Dehbi M, Mohamed G, Matthies F, Shoukri M, Menne B. Prognostic factors in heat wave related deaths: a meta-analysis. *Archives of internal medicine* 2007; **167**(20): 2170-6.
71. Miettinen OS. Proportion of disease caused or prevented by a given exposure, trait or intervention. *Am J Epidemiol* 1974; **99**(5): 325-32.
72. Watts N, Amann M, Ayeb-Karlsson S, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet* 2017.
73. kMatrix Ltd. Adaptation and Resilience to Climate Change dataset. 2019.
74. Department for Business Innovation & Skills. Adaptation and Resilience (Climate Change) (A&RCC) Report for 2011/12. London: Department for Business Innovation & Skills, 2013.
75. Jaikumar R. Postindustrial manufacturing. *Harvard Business Review* 1986; **64**(6): 69-76.
76. Georgeson L, Maslin M, Poessinouw M. The global green economy: a review of concepts, definitions, measurement methodologies and their interactions. *Geo: Geography and Environment* 2017; **4**(1): e00036.
77. Georgeson L, Maslin M, Poessinouw M, Howard S. Adaptation responses to climate change differ between global megacities. *Nature Climate Change* 2016; **6**(6): 584-8.
78. WHO. Global Health Observatory metadata. 2019. http://apps.who.int/gho/data/node.metadata.COUNTRY?lang=en (accessed 6 April 2019).
79. International Monetary Fund. World Economic and Financial Surveys: World Economic Outlook Database. 2019. https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/index.aspx (accessed 23/04/2019.
80. Huppmann D, Rogelj J, Kriegler E, Krey V, Riahi K. A new scenario resource for integrated 1.5 C research. *Nature climate change* 2018; **8**(12): 1027.
81. IEA. CO2 Emissions From Fuel Combustion: CO2 Emissions from Fuel Combustion Detailed Estimates (2018 Edition). UK Data Service; 2018.
82. IEA. World Energy Outlook 2018. Paris, France: International Energy Agency, 2018.
83. IEA. Global Energy & CO2 Status Report 2018. Paris, France: International Energy Agency, 2019.
84. IEA. World Extended Energy Balances. UK Data Service; 2019.
85. BEIS. Digest of UK Energy Statistics (DUKES): electricity, 2018.
86. Carbon Brief. Mapped: The world's coal power plants, 2019.
87. Global Energy Monitor. Boom or Bust 2019, 2019.
88. Powering Past Coal Alliance. Members. 2019. https://poweringpastcoal.org/about/Powering_Past_Coal_Alliance_Members (accessed 06/05 2019).
89. IEA. Methodology. Defining energy access. 2019. https://www.iea.org/energyaccess/methodology/ (accessed 6 June 2019).
90. WHO. Indicator 7.1.2: Proportion of population with primary reliance on clean fuels and technology. 19 July 2016 2016. https://unstats.un.org/sdgs/metadata/files/Metadata-07-01-02.pdf (accessed 8 June 2019).
91. Bonjour S, Adair-Rohani H, Wolf J, et al. Solid fuel use for household cooking: country and regional estimates for 1980–2010. *Environmental Health Perspectives* 2013; **121**(7): 784-90.
92. United Nations Statistics Division. SDG indicators. 2019.
93. IEA. Energy access database. Paris, France: International Energy Agency; 2019.
94. Amann M, Bertok I, Borken-Kleefeld J, et al. Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling & Software* 2011; **26**(12): 1489-501.
95. IEA. World Energy Outlook 2017. Paris, France: International Energy Agency; 2017.
96. Simpson D, Benedictow A, Berge H, et al. The EMEP MSC-W chemical transport model–technical description. *Atmospheric Chemistry and Physics* 2012; **12**(16): 7825-65.

97. WHO. WHO Global Urban Ambient Air Pollution Database (update 2016). Geneva, Switzerland: World Health Organization; 2016.
98. Kiesewetter G, Borken-Kleefeld J, Schöpp W, et al. Modelling street level PM 10 concentrations across Europe: source apportionment and possible futures. *Atmospheric Chemistry and Physics* 2015; **15**(3): 1539-53.
99. WHO. Ambient Air Pollution: A global assessment of exposure and burden of disease. Geneva, Switzerland: World Health Organization, 2016.
100. Forouzanfar MH, Alexander L, Anderson HR, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet* 2015; **386**(10010): 2287-323.
101. IHME. GBD Results Tool. 2019.
102. WHO European Centre for Environment and Health. Review of evidence on health aspects of air pollution - REVIHAAP Project. Copenhagen, Denmark: WHO Regional Office for Europe, 2013.
103. IEA. Global EB Outlook 2016: Beyond one million electric cars. Paris, France: International Energy Agency; 2016.
104. EPOMM. The EPOMM Modal Split (TEMS) tool. Leuven, Belgium: European Platform on Mobility Management; 2019.
105. Herrero M, Havlík P, Valin H, et al. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. *Proceedings of the National Academy of Sciences* 2013; **110**(52): 20888-93.
106. FAO. FAOSTAT. 2019.
107. Chang J, Ciais P, Herrero M, et al. Combining livestock production information in a process-based vegetation model to reconstruct the history of grassland management. *Biogeosciences* 2016; **13**(12): 3757-76.
108. Carlson KM, Gerber JS, Mueller ND, et al. Greenhouse gas emissions intensity of global croplands. *Nature Climate Change* 2017; **7**(1): 63.
109. Eckelman MJ, Sherman J. Environmental Impacts of the US Health Care System and Effects on Public Health. *PLoS ONE* 2016; **11**(6): e0157014.
110. Eckelman MJ, Sherman JD, MacNeill AJ. Life cycle environmental emissions and health damages from the Canadian healthcare system: An economic-environmental-epidemiological analysis. *PLoS Medicine* 2018; **15**(7): e1002623.
111. Malik A, Lenzen M, McAlister S, McGain F. The carbon footprint of Australian health care. *The Lancet Planetary Health* 2018; **2**(1): e27-e35.
112. Pichler P-P, Jaccard I, Weisz U, Weisz H. International comparison of health care carbon footprints. *Environmental Research Letters* 2019.
113. WHO. Global Health Expenditure Database. Geneva, Switzerland: World Health Organization; 2019.
114. WHO. Global Health Expenditure Database: Indicators and data. Geneva, Switzerland: World Health Organization; 2019.
115. UNSD. Basic Data Selection. United Nations Statistics Division; 2019.
116. WBG. Consumer price index (2010 = 100). Washington, DC, USA: World Bank Group; 2019.
117. Munich Re. NatCatSERVICE. 2019.
118. Munich RE. NatCatSERVICE Methodology, 2018.
119. European Commission. Part III: Annexes to Impact Assessment Guidelines. Brussels, Belgium: European Commission, 2009.
120. IEA. World Energy Investment 2019. Paris, France: International Energy Agency, 2019.
121. IRENA. Renewable Energy and Jobs: Annual Review 2019. Abu Dhabi, United Arab Emirates: International Renewable Energy Agency, 2019.
122. IBISWorld. IBISWorld Industry Report: Global Coal Mining. Los Angeles, CA: IBISWorld, 2018.

123. IBISWorld. IBISWorld Industry Report: Global Oil & Gas Exploration & Production. Los Angeles, CA: IBISWorld, 2019.
124. 350.org. Divestment Commitments. 2019. https://gofossilfree.org/divestment/commitments/ (accessed 7 May 2019).
125. IEA. Energy Subsidies. Paris, France: International Energy Agency; 2019.
126. WBG. Carbon Pricing Dashboard. Washington, DC, USA: World Bank Group; 2019.
127. JRC. GHG (CO2, CH4, N2O, F-gases) emission time series 1990-2012 per region/country. 2016.
128. Carl J, Fedor D. Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world. *Energy Policy* 2016; **96**: 50-77.
129. ERA. Ground Breakers: 2016/17 Annual Report. Edmonton, Canada: Emissions Reductions Alberta, 2017.
130. Government of Alberta. Carbon levy and rebates. 2018. https://www.alberta.ca/climate-carbon-pricing.aspx (accessed 24 May 2018).
131. Watts N, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet* 2017; **391**(10120): 581-630.
132. CCI. California Climate Investments Using Cap-and-Trade Auction Proceeds. Sacramento, CA: California Climate Investments, 2019.
133. CPLC. Carbon Pricing in Action. 2019. https://www.carbonpricingleadership.org/who (accessed 7 June 2019).
134. Velten EK, Duwe M, Zelljadt E, Evans N, Hasenheit M. Smart Cash for the Climate: Maximising Auctioning Revenues from the EU Emissions Trading System. Berlin, Germany: Ecologic Institute, 2016.
135. Pereira AM, Pereira RM, Rodrigues PG. A new carbon tax in Portugal: A missed opportunity to achieve the triple dividend? *Energy Policy* 2016; **93**: 110-8.
136. MDDELCC. Comptes Du Fonds Vert 2016-2017. Quebec, Canada: Ministere du Developpement Durable, De L'environnement et De La Lutte Contre Les Changements Climatiques 2017.
137. RGGI. The Investment of RGGI Proceeds in 2016: The Regional Greenhouse Gas Initiative, 2018.
138. Hirst D. Carbon Price Floor (CPF) and the price support mechanism. Briefing Paper Number 05927. London, UK: House of Commons Library; 2018.
139. Narassimhan E, Gallagher KS, Koester S, Alejo JR. Carbon pricing in practice: a review of the evidence. *Climate Policy Lab: Medford, MA, USA* 2017.
140. Graney E, French J. Cracking open the carbon tax: A look at where the money has been spent. 2019. https://edmontonjournal.com/news/politics/cracking-open-the-carbon-tax-a-look-at-what-albertas-most-controversial-tax-has-been-spent-on (accessed 7 June 2019).
141. ICAP. Korea Emissions Trading Scheme: International Carbon Action Partnership, 2019.
142. ICAP. Swiss ETS: International Carbon Action Partnership, 2019.
143. Wikipedia. Latent Dirichlet allocation. 2019. https://en.wikipedia.org/wiki/Latent_Dirichlet_allocation.
144. People's Daily. People's Daily. http://data.people.com.cn/rmrb/20190116/1?code=2.
145. Brooks J, McCluskey S, Turley E, King N. The Utility of Template Analysis in Qualitative Psychology Research. *Qualitative Research in Psychology* 2015; **12**(2): 202-22.
146. Giles J. Internet encyclopaedias go head to head. Nature Publishing Group; 2005.
147. Alexa. The top 500 sites on the Web. 2018. https://www.alexa.com/topsites.
148. Wikimedia. Research: Wikipedia clickstream. https://meta.wikimedia.org/wiki/Research:Wikipedia_clickstream.
149. Zachte E. Wikimedia Traffic Analysis Report - Wikipedia Page Views Per Country - Overview: Monthly requests or daily averages, for period: 1 Sep 2018 - 30 Sep 2018. 2018. https://stats.wikimedia.org/wikimedia/squids/SquidReportPageViewsPerCountryOverview.htm.

150. Wikipedia. Effects of global warming on human health https://en.wikipedia.org/wiki/Effects_of_global_warming_on_human_health.
151. Wikipedia. Global Warming. https://en.wikipedia.org/wiki/Global_warming.
152. Wikipedia. Malnutrition. https://en.wikipedia.org/wiki/Malnutrition.
153. Wikipedia. Malaria. https://en.wikipedia.org/wiki/Malaria.
154. Wikipedia. Wikimedia Dumps.
155. Zachte E. Wikimedia Traffic Analysis Report - Page Views Per Wikipedia Language - Breakdown. 2018. https://stats.wikimedia.org/wikimedia/squids/SquidReportPageViewsPerLanguageBreakdown.htm.
156. Baturo A, Dasandi N, Mikhaylov SJ. Understanding state preferences with text as data: Introducing the UN General Debate corpus. *Research & Politics* 2017; **4**(2): 2053168017712821.
157. Benoit K. quanteda: Quantitative Analysis of Textual Data. R package version 1.2.3. 2018. http://quanteda.io.