Supporting Information

Supplementary material

This appendix was part of the submitted manuscript and has been peer reviewed. It is posted as supplied by the authors.

Appendix to: Beggs PJ, Zhang Y, McGushin A, et al. The 2021 report of the *MJA–Lancet* Countdown on health and climate change: Australia increasingly out on a limb. *Med J Aust* 2021; doi: 10.5694/mja2.51302.

Appendix: The 2021 report of the *MJA-Lancet* Countdown on health and climate change: Australia increasingly out on a limb

This Appendix includes details of the data, methods and caveats for each of the 37 indicators assessed in the 2021 *MJA-Lancet* Countdown. It also includes additional tables and figures that further illustrate some of the indicators. Finally, it includes, for several indicators, current thoughts regarding the potential future form of the indicator. This is provided in the context of this being the fourth *MJA-Lancet* Countdown annual report and the acknowledgement that its indicators, like those of the *Lancet* Countdown, will likely continue to develop in future annual assessments.

Data, methods and caveats

Section 1: Climate change impacts, exposures, and vulnerability

1.1 Vulnerability to extremes of heat

Data

The data on the proportion of the population aged 65 years or above were downloaded for 1990-2019 from Global Burden of Disease Study 2019 (GBD 2019, http://ghdx.healthdata.org/record/ihme-data/gbd-2019-population-estimates-1950-2019). Major Non-Communicable Disease prevalence is the prevalence of cardiovascular, diabetes and chronic respiratory diseases among population aged 65 years or above. These data for 1990-2019 were also sourced from GBD 2019 (http://ghdx.healthdata.org/gbd-results-tool). Urbanisation rate is the proportion of people living in urban areas, a measure of exposure to the urban heat island. Urbanisation data according to population census in Australia for 1991, 1996, 2001, 2006, 2011, and 2016 came from the Australian Bureau of Statistics (https://www.abs.gov.au/). Since the urbanisation rate showed a very good linear relationship with year, we used a linear regression model to estimate the urbanisation rate for other years during 1990-2019.

Methods

This Heat Exposure Vulnerability Index (HEVI) was calculated using the equation below:

HEVI=100*(Pop65plus+Major NCD Prevalence+Urbanisation Rate)/3. In this equation, Pop65plus is the proportion of the population aged 65 years or above. Major NCD Prevalence is the prevalence of cardiovascular, diabetes and chronic respiratory diseases among population aged 65 years or above. Urbanisation Rate is the proportion of people living in urban areas.

Caveats

Caveats for this indicator are the same as those for Indicator 1.1. (Vulnerability to the heat-related risks of climate change) in Beggs et al.[1]

1.2 Indigenous health and climate change

Data

Data for this indicator are taken from the Australian Government’s Australian Institute of Health and Welfare *Aboriginal and Torres Strait Islander Health Performance Framework* report.[2]

Methods

Methods for this indicator are to take a representative, climate impacts-relevant measure from each of the report's three tiers: 1) health status and outcomes, 2) determinants of health, and 3) health system performance, and track its performance over time.

Caveats

Caveats for the data associated with this indicator are detailed in the AIHW[2] report. Additionally, more general caveats include that the direct and indirect impacts of climate on Indigenous health and well-being are complex and interconnected. Despite this difficulty, the need to explicitly recognise that climate change disproportionately affects Indigenous Australians suggests that this qualitative and quantitative analysis needs to be condensed into a simple and replicable quantitative format.

Future form of the indicator

The indicator could evolve with further input from additional nationwide metrics on Indigenous disadvantage.

1.3 Health effects of heatwaves

Data

Data for this indicator are the same as those used for Indicator 1.2 Health effects of heatwaves in Zhang et al.[3] In summary, the heatwave dataset employed for this calculation is the Bureau of Meteorology's national Excess Heat Factor (EHF) heatwave analysis.[4,5]

Methods

0.25°-resolution national grids of EHF were extracted for three-day periods containing days during the heatwave seasons (November-March) of 1971-1972 to 2020-2021, with tapered down-weighting for the four three-day periods (two at each end) which are only partially within the November-March season. The data from each season were accumulated over the season to create grids of annual heat load. Only positive values of the EHF (positive values indicating the presence of heatwave, negative values its absence) are included in the accumulation. The annual grids were area-averaged to produce a time series of nationally averaged annual heat load. Ordinary least squares linear regressions were calculated over the last 50 heatwave seasons (1971-1972 to 2020-2021); and 20 heatwave seasons (2001-2002 to 2020-2021).

Additional calculations were performed, replacing the area weighting in the area averaging process with a population-weight matrix grid obtained from gridded population data released by the Australian Bureau of Statistics from its 2011 national census. The population weighting in the calculation assumes that the relative population distribution across the country remains unchanged, without assuming explicitly that the national-total population remains unchanged.

Future form of the indicator

No changes proposed at this time.

1.4 Heat impact on physical and sporting activities

Data

Climate data for this indicator have been acquired from CustomWeather.com, and include hourly ambient temperature (shaded) and concurrent relative humidity values from 2001 to 2019 (inclusive) for the following Australian cities: Sydney, Brisbane, Melbourne, Perth, Hobart, Adelaide, Alice Springs, and Canberra. All climate data are reported for airport locations.

Methods

Data analysis applied the new Sports Medicine Australia Extreme Heat Policy[6] released in February 2021, which provides a stratified heat stress risk estimation (moderate, high, extreme) based on combinations of ambient temperature and relative humidity. The policy calculator provides five different risk estimation plots based on the activity or sport undertaken. Plot #4 (for cricket, bushwalking, and rugby) was used for the present analysis.

For each city, the number of days that each heat stress risk threshold (moderate, high, and extreme) was exceeded for at least 1 hour was determined for each year from 2001 to 2019, inclusive. Within a given day only the highest heat stress risk threshold reached was counted.

Caveats

Caveats for this indicator include: airport weather data are applied for an entire city; data are only provided for select cities, which may not be representative of the climatic conditions at other locations across each state/territory.

Future form of the indicator

The future form of this indicator will likely be the same as reported here.

1.5 Change in labour capacity

Data

Data for this indicator are the same as those used for "Indicator 1.1.4: Change in labour capacity" in Romanello et al.[7]

Methods

Methods for this indicator are the same as those used for "Indicator 1.1.4: Change in labour capacity" in Romanello et al.[7]

Caveats

Caveats for this indicator are the same as those for "Indicator 1.1.4: Change in labour capacity" in Romanello et al.[7]

Future form of the indicator

The future form of this indicator will likely be the same as that for "Indicator 1.1.4: Change in labour capacity" in Romanello et al.[7]

1.6 Cold- and heat-related mortality

Data

Daily data on mortality and temperature in 750 cities were collected from multi-country multi-city (MCC) network for environmental health effects. Daily minimum and maximum temperatures at 0·5°×0·5° grid from 2000 to 2019 were collected from the Climate Prediction Center Global Gridded Temperature data set (https://www.psl.noaa.gov/data/gridded/). Daily mean temperature was calculated by averaging daily minimum and maximum temperatures. Annual data on Gross Domestic Product (GDP) (standardised to the 2005 rate) and population were provided by the Global Carbon Project at a spatial resolution of 0·5°×0·5° per ten years from 1980 to 2010, which were used to calculate GDP per capita for each cell. In addition, GDP and population data at the central coordinate of each location were inter/extrapolated to the middle year of data collection to calculate the average location-specific GDP per capita during the period. Annual mortality rate of each country in 2010 was extracted from the World Bank (https://data.worldbank.org/indicator).

Methods

Three-stage analysis strategy was used.

First stage: We estimated the temperature-mortality association for each of the 750 locations from MCC network.

Second stage: We collected location-specific predictors that could explain the majority of heterogeneity in the temperature-mortality associations across locations. We selected predictors including the continents, indicators for Köppen-Geiger climate classification, GDP per capita, and average and range of daily mean temperature. We then built a meta-regression between location-specific temperature-mortality association and those location-specific predictors.

Third stage: We collected data on predictors aforementioned at the cell level and used the coefficients of each predictor from the meta-regression of the second stage to predict the cell-specific temperature-mortality association. Then the predicted cell-specific temperature-mortality association, cell-specific daily temperature and cell-specific mortality are combined to calculate the cell-specific mortality burden attributable to low and high temperatures.

We extracted the results of Australia from these global estimates.[8]

1.7 Bushfires

Data

Data for this indicator are the same as those used for “Indicator 1.3: Exposure to wildfire” in Romanello et al.[7]

Data were provided by NASA EarthData[9] and NASA Socioeconomic Data and Applications Center.[10] Collection 6 active fire product from the Moderate Resolution Imaging Spectroradiometer (MODIS). 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 (GPW v4.11).

Methods

Methods for this indicator are the same as those used for “Indicator 1.3: Exposure to wildfire” in Romanello et al.[7]

The change in population exposure to bushfires is represented as the change in the average annual number of days people were exposed to bushfire. Satellite-observed active fire spots were aggregated and spatially joined with gridded population data on a 10 km x 10 km resolution grid. Grid cells with a population density ≥ 400 persons/km^2 were excluded to remove urban heat sources unrelated to bushfires.

Caveats

The Bushfires indicator includes all landscape fire activity including bushfires and planned burns. Other caveats for this indicator are the same as those listed for “1.3 Exposure to wildfire” in Romanello et al.[7]

Future form of the indicator

The team is working towards indicators that better reflect human health impacts, including the development of indices for severe, rather than all landscape fires, and indices for population bushfire smoke exposure.

1.8 Health effects of drought

Data

We used monthly rainfall and temperatures, calculated using the Australian Water Availability Project (AWAP) gridded data at 0.05 × 0.05 degree resolution.[11]

Methods

This indicator represents the area impacted by excess drought events compared to the 1950-2005 baseline. The drought method follows that outlined in Watts et al.[12] We used the Standardised Precipitation-Evapotranspiration Index (SPEI) calculated on 6-month timescale. Due to lack of wind speed data, the potential evapotranspiration (PET) was calculated using the Thornthwaite method rather than the FAO-56 Penman-Monteith method.

We used the algorithm provided in the R package "SPEI" (Santiago Beguería and Sergio M. Vicente-Serrano (2017). SPEI: Calculation of the Standardised Precipitation-Evapotranspiration Index. R package version 1.7). The SPEI is a multiscalar index, which takes into account both precipitation (using the basis of the more commonly used SPI index) and temperature, to estimate potential evapotranspiration. More information on this index and its calculation can be found here: https://CRAN.R-project.org/package=SPEI.

Drought severity was defined according to three severity levels: < -1.3 severe drought; < -1.6 extreme drought; and < - 2.0 exceptional drought.

In order to detect excess drought events at the different severity levels we defined years where the counts of months in drought for each grid cell exceeded 2 standard deviations above the mean of the yearly counts of months in drought for that grid cell over the baseline period (1950-2005). We then calculated the percentage of land area exposed to excess drought events at the different severity levels as shown in Appendix Figure A2. The levels of excess drought were notably higher than usual in the year 2019 and the spatial distribution is shown in the maps in Appendix Figure A3.

Caveats

This indicator does not reflect population exposure adequately. It is not clear how to improve the exposure measure because droughts can affect human populations in a variety of ways both in proximity to their residence (especially at the location of farms, for example) or at a large distance (through the impact on fresh food availability felt at urban locations).

Future form of the indicator

Future improvements of this indicator include the development of a flood indicator and development of the SPEI drought indicator to align with other measures of agricultural drought (such as Government Drought Declarations).

1.9 Migration, displacement, and environmental change

Data

Data for this indicator are from the Internal Displacement Monitoring Centre,[13] CoastalDEM and LandScan (2019).

Methods

Methods for this indicator include those used for "Indicator 1.5: Migration, displacement, and sea-level rise" in Romanello et al.[7] The SLR-related data use a Coastal Digital Elevation Model (CoastalDEM) and current population distribution data (LandScan 2019). The weather-related displacement data are from the Internal Displacement Monitoring Centre (IDMC) (https://www.internal-displacement.org/).

Caveats

Caveats for the SLR component of this indicator are the same as those for "Indicator 1.5: Migration, displacement, and sea-level rise" in Romanello et al.[7] The weather-related displacement data cannot be understood to represent displacements due solely to anthropogenic climate change; climate change operates as a risk amplifier. Importantly, since the 1970s there has been a greater increase in the number of weather-related disasters (eg, floods) than non-weather-related disasters (eg, earthquakes), suggesting that the upward trajectory in recorded weather-related disasters reflects a real trend.

Future form of the indicator

As newer and higher spatial resolution and more precise datasets become available, methods will be updated to produce more robust estimates of population exposure to SLR and displacement due to weather-related disaster. Australia-focused estimates of exposure to SLR could use higher-resolution datasets, rather than global datasets (as per the *Lancet* Countdown global report).

1.10 Mosquito-borne diseases

Data

Case data were extracted from the National Notifiable Diseases Surveillance System (NNDSS).[14]

Data are available either by month nationally or by year for each state and territory, ie, there is no monthly data by state/territory available publicly.

For dengue virus infection, data are available from 1991 (1993 for the ACT), and for Ross River virus infection, data are available from 1993. The last complete year available is 2020, however dengue data only to 2019 are used here (see Caveats).

Methods

Descriptive analyses using linear regression to illustrate long-term trends, if any, in case notifications of Dengue and RRV.

Caveats

Only Dengue and Ross River virus were investigated. Other significant mosquito-borne diseases in Australia are Barmah Forest virus (about 1200 cases per annum) which occupies a similar ecological niche to Ross River virus, and then Murray Valley Encephalitis, Japanese Encephalitis and Kunjin virus, which are very rare.

Dengue is not endemic to Australia and local transmission only occurs following its introduction via an infected traveller. Since Australia closed its borders to international travellers in March 2020 (with only returning Australians allowed to arrive), there has been a marked decline in dengue notifications in all states and territories, with a total of only 222 recorded in all of 2020 and only a single case in 2021 as at end of February, in Queensland. Because of the COVID-19 disruption to travel, only data to end of 2019 were used to explore the longer term trends, pre-pandemic disruption.

Temperature, rainfall and humidity set the parameters for potential transmission and determine geographic and seasonal ranges for possible transmission,[1] but actual transmission within these bounds is determined by other factors, including surveillance and vector control measures. While warmer, wetter weather generally favours mosquito and virus transmission,[1] the different mosquito ecologies for dengue (urban dwelling mosquito, human to human transmission) and for RRV (multiple species, and complex transmission cycle involving non-human host populations) meant that transmission risk is not uniformly affected by particular climate drivers.

Future form of the indicator

The indicator could evolve to include the costs of surveillance and control of mosquito-borne disease in Australia, as the number of cases that eventuate is heavily mediated by preventive public health measures.

Section 2: Adaptation, planning, and resilience for health

2.1 Australian adaptation plans for health

Data

Health adaptation strategies and reports produced by Australian states and territories; reports noted previously in Zhang et al.[15] and Beggs et al.[1]; other Non-Governmental Organisation reports.

Methods

As health service delivery is a state responsibility, each state and territory government website was searched for plans for health adaptation, using ‘climate change health adaptation’, with the exception of Tasmania where the main government site did not have a search function; here the Department of Health was searched instead. The Federal Government’s Department of Health website was also similarly interrogated.

Caveats

Only public-facing websites were observed. It is possible that there are health adaptation plans in development. For states and territories, broader state plans (ie, not specific to health) that refer to health may have been missed in this analysis.

Future form of the indicator

This indicator could be merged with 2.2 National assessments of climate change impacts, vulnerability, and adaptation for health.

2.2 National assessments of climate change impacts, vulnerability, and adaptation for health

Data

National level assessments of vulnerability, impacts and adaptation for health in Australia.

Data for this indicator are the same as those used for Indicator 2.5 National assessment of vulnerability, impacts, and adaptation for health in Zhang et al.[15] and Beggs et al.,[1] with the addition of new major reports published by The Climate Council.

Methods

Methods for this indicator are the same as those used for Indicator 2.5 National assessment of vulnerability, impacts, and adaptation for health in Zhang et al.[15] and Beggs et al.[1]

Caveats

There may be government or other assessments in progress or assessments that are not publicly available.

Future form of the indicator

This indicator could be merged with 2.1 Australian adaptation plans for health.

2.3 City-level climate change risk assessments

Data

Climate change risk assessment reports and/or adaptation strategies from local governments for capital cities; Cities Power Partnership,[16] member councils.

Methods

Search of local government websites for each Australian capital city for updated climate risk assessments since those included in the first *MJA-Lancet* Countdown in 2018, searching each council's website for 'climate change' and interrogating the results. The local councils participating in the Cities Power Partnership were as listed at 12 March 2021.

Caveats

Only risk assessments for Australian capital cities were included. Participation in the CPP is used as a marker for overall engagement of city councils nationally in climate change action.[17]

Future form of the indicator

Current form remains useful. With adequate resourcing a nationwide audit of all city council risk assessments and plans could be informative, but this would be a major undertaking well beyond the scope of this report.

2.4 Climate information services for health

Data

Data for this indicator are the same as those used for "Indicator 2.4 Climate information services for health" in Zhang et al.[15]

Data on visits to the Bureau of Meteorology's heatwave and UV websites are from Google Analytics.

Methods

The Bureau of Meteorology provides weather and climate products that are directly targeted or tailored to the public health sector. This indicator counts the types of products that are currently available and the unique visits to the relevant public website.

Future form of the indicator

The Bureau of Meteorology is improving its capability to provide information relevant to the public health sector, and additional services may be possible in future.

2.5 Detection, preparedness, and response to health emergencies

Data

Data for this indicator are the same as those used for "Indicator 2.3.1: Detection, preparedness, and response to health emergencies" in Romanello et al.[7] Data obtained from the World Health Organization IHR Capacity Progress website.[18]

Methods

Methods for this indicator are the same as those used for "Indicator 2.3.1: Detection, preparedness, and response to health emergencies" in Romanello et al.[7]

Caveats

Caveats for this indicator are the same as those for "Indicator 2.3.1: Detection, preparedness, and response to health emergencies" in Romanello et al.[7]

Future form of the indicator

The future form of this indicator is the same as that for "Indicator 2.3.1: Detection, preparedness, and response to health emergencies" in Romanello et al.[7]

2.6 Urban green space

Data

Data for this indicator are the same as used for "Indicator 2.3.3: Urban green space" in Watts et al.[12] including:

Urban boundaries and urban statistics from the Global Human Settlement program of the European Commission,[19] population size per urban centre from the Center for International Earth Science Information Network - CIESIN - Columbia University,[20] and MODIS/Terra Vegetation Indices 16-Day L3 Global 250 m from the NASA Earth Science Data Systems (ESDS) Program.[21]

Methods

Methods for this indicator followed those from “Indicator 2.3.3: Urban green space” in Watts et al.[12] including:

Urban bounding boxes were taken from those defined in the Global Human Settlement dataset. Normalised Difference Vegetation Index (NDVI) was extracted across four seasons (January, April, July, and October) within each city’s bounding box. Metrics were calculated for each city, a peak NDVI across the four seasons and an average NDVI across the four seasons. Then peak and four-season averages were calculated by weighting each NDVI pixel by population density of each pixel.

Caveats

Caveats for this indicator are the same as for “Indicator 2.3.3 Urban green space” in Watts et al.[12]

Future form of the indicator

Population density weighted greenness levels are helpful to understand the unequal distribution of urban greening across Australian cities. Another level of analysis to calculate the distributions and allocations of greenness across each individual city, a Gini Coefficient for green space, could be derived to allow comparisons of cities and regions across global cities.

2.7 Bushfire adaptation

Data

This indicator reports two sets of data related to bushfire adaptation, as detailed below.

Number of Australian National Aerial Firefighting Centre (NAFC) aircraft contracts/Services per year on behalf of state and territory governments. Data for the period 2007-08 to 2020-21 were obtained from NAFC Annual Reports, a NAFC Booklet, and a NAFC Poster via the NAFC website,[22] the Parliament of Australia,[23] as well as through a direct request to NAFC which provided the datum for a missing year (2017-18) and confirmation of the data from all other years. NAFC aircraft Services represent the number of aircraft in Australia available to fight bushfires. It should be noted that some aircraft double up for the north and south of the country, so for example an aircraft may run in Queensland then move to Tasmania as a separate Service. A Service is usually exclusive to NAFC’s use, mostly for 84 or 96 days each summer (some Services run longer).

The number of volunteer firefighters and support staff in Australia per year from 2009-10 to 2018-19 were obtained from the Australian Government Productivity Commission’s Report on Government Services 2020.[24] Specifically, data were obtained from Part D (Emergency management), Section 9 (Emergency services for fire and other events), Table 9A.3 (Fire service organisations human resources).

Volunteer data were used because bushfire fighting and bushfire mitigation are primarily conducted by volunteers in Australia.

Methods

To track progress on bushfire adaptation in Australia this indicator analyses aerial and terrestrial firefighting capacity.

Caveats

While the two areas examined in this indicator are important with regard to bushfire adaptation in Australia, there are many other important aspects of bushfire adaptation in Australia, including those described and recommended in the Royal Commission into National Natural Disaster Arrangements Report.[25]

Future form of the indicator

The indicator could evolve through the development of a bushfire adaptation index which integrates the two separate aspects considered here into a single annual number.

Section 3: Mitigation actions and health co-benefits

3.1 Carbon intensity of the energy system

Data

Data for this indicator are the same as those used for Indicator 3.1.1 Carbon intensity of the energy system in Beggs et al.[1]

Methods

Methods for this indicator are the same as those used for Indicator 3.1.1 Carbon intensity of the energy system in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those for Indicator 3.1.1 Carbon intensity of the energy system in Beggs et al.[1]

Future form of the indicator

The indicator can be developed to capture changes in Australia's energy mix in greater detail. The impact of the COVID-19 pandemic and the impact of green recovery programs can be monitored to evaluate their impact on the carbon intensity of the energy system in various countries.

3.2 Coal phase-out

Data

Data for this indicator are the same as those used for Indicator 3.2: Coal phase-out in Beggs et al.[1]

Methods

Methods for this indicator are the same as those used for Indicator 3.2: Coal phase-out in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those for Indicator 3.2: Coal phase-out in Beggs et al.[1]

Future form of the indicator

The indicator can be further developed to convert reductions in coal use to reduction in air pollutants.

3.3 Zero-carbon emission electricity

Data

Data for this indicator are the same as those used for Indicator 3.3: Renewable and low carbon emission electricity in Beggs et al.[1]

Methods

Methods for this indicator are the same as those used for Indicator 3.3: Renewable and low carbon emission electricity in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those for Indicator 3.3: Renewable and low carbon emission electricity in Beggs et al.[1]

Future form of the indicator

The indicator can be further developed to include direct impacts on air pollutants. Again, we note a lack of data for Indigenous and remote communities and progress should be tracked.

3.4 Clean household energy

Data

Data for this indicator are the same as those used for Indicator 3.4: Access to clean energy in Beggs et al.[1]

Methods

Methods for this indicator are the same as those used for Indicator 3.4: Access to clean energy in Beggs et al.[1] However, note that we found some updated reports which we are also citing in the text for purposes of completeness.

Caveats

Caveats for this indicator are the same as those for Indicator 3.4: Access to clean energy in Beggs et al.[1]

Future form of the indicator

The indicator can be further developed to include direct impacts on air pollutants. Again, we note a lack of data for Indigenous and remote communities and progress should be tracked.

3.5 Exposure to air pollution in cities

Data

Data for this indicator were prepared in the same way as those used for indicator 3.5.1. “Exposure to air pollution in cities” in Zhang et al.,[3] however we have included more up-to-date monitoring data for the year 2019 for Victoria, South Australia and Northern Territory. New data for the year 2020 are now available for New South Wales and Northern Territory. Therefore this indicator is too limited by data availability issues for national comparisons.

Data were provided by the responsible agency in each state and territory as follows: Environment Protection Authority Victoria, New South Wales Department of Planning, Industry and Environment, Queensland Department of Environment and Science, Environment Protection Authority South Australia, Environment Protection Authority Tasmania, Department of Water and Environmental Regulation Western Australia, Environment Protection and Water Regulation Australian Capital Territory and Northern Territory Environment Protection Authority.

Spatial boundaries were obtained from the ABS dataset “1270.0.55.001 - Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas, July 2016”.

Methods

Methods used are the same as those for “Indicator 3.5.1: Exposure to air pollution in cities” in Zhang et al.[3]

Caveats

We were not able to access data for all government agencies to provide updated monitored $PM_{2.5}$ data. The other caveats for “Indicator 3.5.1: Exposure to air pollution in cities” in Zhang et al.[3] also apply to this indicator.

Future form of the indicator

Future improvements of this indicator are the same as those described for “Indicator 3.5.1: Exposure to air pollution in cities” in Zhang et al.[3]

3.6 Premature mortality from ambient air pollution by sector

Data

Data for this indicator were prepared in the same way as those used for “Indicator 3.5.2: Premature mortality from ambient air pollution by sector” in Zhang et al.[15] and “Indicator 3.5: Premature mortality from ambient anthropogenic air pollution” in Beggs et al.[1] We have now used a high resolution spatiotemporal air pollution model[26] that was produced using better data inputs than the global air pollution model we had previously used.

Methods

Methods used are the same as those for “Indicator 3.5.2” in Zhang et al.[15] and Beggs et al.[1]

Caveats

In previous reports we compared annual changes in the attributable number of deaths from year-to-year. However, the US EPA and the UK Committee on the Medical Effects of Air Pollution have considered this issue in detail and recommended that, when assessing the impact of changing exposure, only 30% of the long-term effect estimates should be assumed in the first year after the change. Therefore, reporting year-to-year variation may give a misleading account of the health effects of $PM_{2.5}$. Therefore we have now calculated the average impact from 11 years of data 2006-2016.

The other caveats for this indicator in Zhang et al.[15] and Beggs et al.[1] also apply to this indicator.

Future form of the indicator

Due to limited resources available for additional data collection, no change is planned for this indicator.

3.7 Sustainable and healthy transport

Data

The State of Electric Vehicles 2020 - Electric Vehicle Council.[27]

Motor Vehicle Census, Australia, 2020 - Australian Bureau of Statistics.[28]

VFACTS December 2020 - Federal Chamber of Automotive Industries.[29]

Electric vehicles sales 2020 – CarAdvice.[30]

Australian Energy Statistics 2020 Energy Update – Australian Government Department of Industry, Science, Energy and Resources.[31]

Methods

Methods for this indicator are the same as those used for “Indicator 3.6: Clean fuel use for transport” in Zhang et al.[3]

Caveats

Data of transport energy consumption by fuel types include road transport, rail transport, water transport, air transport and other transports.

Electric vehicle (EV) sales figures include the EV Tesla sales estimate only. The estimate is compiled from CarAdvice using national registration data and Tesla shipping data. Tesla does not disclose local sales figures.

Future form of the indicator

As the electric vehicle fleet begins to grow, with rapidly increasing uptake predicted over the next decade, there is potential to stratify this indicator further (ie, by examining proportions of hybrid vehicles and full electric), and to add electric vehicles that do not require registration like electric bikes and scooters. Other valuable data could include details of trip characteristics specific to electric vehicles (eg, average km travelled per trip, total km per year, share of total km driven, etc.).

3.8 Emissions from agricultural production and consumption

Data

Data for this indicator are obtained from the Australian Bureau of Statistics[32,33] and the National Greenhouse Gas Inventory.[34]

Methods

The results for this indicator are produced using a consumption-based accounting approach in the Australian Industrial Ecology Virtual Laboratory (IELab). The IELab is a cloud-computing platform that enables the construction of customised input-output tables. For this indicator, an input-output table featuring a total of 345 sectors was constructed. Considering the final consumption monetary data on 33 primary-agricultural sectors and 36 secondary-agricultural sectors, the total emissions from Agricultural and Food Consumption were obtained by subjecting the input-output table to Leontief calculus.[35] Production-based emissions for the agricultural sector were taken directly from the National Greenhouse Gas Inventory.[34]

Caveats

The table used for quantifying the consumption-based accounts is a result of an experiment undertaken in the Australian IELab, where an initial table (known as the initial estimate) constructed in the lab is revised based on superior data (known as constraints). Stochastic uncertainty exists in input-output tables.[36]

Future form of the indicator

The year-coverage of the indicator should be improved for a more-recent assessment of the production- and consumption-based emissions. Current data are only available until year 2018.

3.9 Diet and health co-benefits

Data

Data for this indicator are the same as those used for "Indicator 3.5.2: Diet and health co-benefits" in Romanello et al.[7]

Methods

Methods for this indicator are the same as those used for "Indicator 3.5.2: Diet and health co-benefits" in Romanello et al.[7]

Caveats

Caveats for this indicator are the same as those for "Indicator 3.5.2: Diet and health co-benefits" in Romanello et al.[7]

Future form of the indicator

The future form of this indicator will likely be the same as that for "Indicator 3.5.2: Diet and health co-benefits" in Romanello et al.[7]

3.10 Mitigation in the healthcare sector

Data

Data for this indicator are based on a sub-national supply chain model developed in the Australian Industrial Ecology Virtual Laboratory (IELab), and data on health expenditure are from the Australian Institute of Health and Welfare.[37]

Methods

This indicator considers sub-national multi-regional input-output modelling for over 8 Australian states and 360 sectors in each region. This economic data-set is then coupled with data on emissions. The Australian IELab offers a graphical user interface for construction of customised multi-regional input-output tables. These tables feature data on more than one region. Quantification of supply chain impacts are undertaken using methodology documented in Leontief[35] and Miller and Blair.[38]

Caveats

The multi-regional input-output table used for quantifying the health sector's emissions was constructed in the Australian IELab. Uncertainty related to input-output tables is documented elsewhere.[36]

Future form of the indicator

The future form of this indicator could include a detailed expenditure data-set that further breaks down the health system's expenditure according to specific consumption categories, in addition to breakdown of expenditure according to health sectors.

Section 4: Economics and finance

4.1 Costs of heat-related mortality

Data

Data on annual average excess deaths, excess deaths ratio (%) and deaths per 100,000 residents due to non-optimal temperatures based on information reported in indicator 1.6. In particular, we use information reported in Table A1 on excess deaths, excess deaths ratio (%) and deaths per 100,000 residents due to non-optimal temperatures (heat component) from 2000 to 2019 in Australia.

Data on the Value of a Statistical Life Year (VSLY) in 2015 is derived, based on the *Best Practice Regulation Guidance Note – Value of statistical life*.[39] The note provides guidance on how officers preparing the cost-benefit analysis in Regulation Impact Statements should treat the benefits of regulations designed to reduce the risk of physical harm.

Methods

The annual heat-related mortality burden in Australia for the 2000–2019 period is calculated based on Indicator 1.6 Cold- and heat-related mortality, suggesting 2300 - 95% empirical CI (501, 5031) - annual heat-related excess deaths for Australia. This number is then multiplied by the average remaining number of years expected prior to death for a person who dies from the heat component of non-optimal temperature. The estimate for the average age of a person suffering a heat-related death in Australia is based on numbers provided by Semenza et al.[40] and Herbst et al.[41] The average remaining number of years expected prior to death can then be determined based on medium mortality rates used by the Australian Bureau of Statistics in "Population Projections 2006–2101".

The estimate for the Value of a Statistical Life Year (VSLY) in 2020 is derived, based on the *Best Practice Regulation Guidance Note – Value of statistical life*.[39] The Office of Best Practice Regulation recommends that departments and agencies use the estimate of $151,000 for the VSLY (measured in 2007 dollars). CPI data for Australia (ABS 6401.0 Consumer Price Index Series for Australia, Series ID A2325846C) is then used to express these estimates in 2020. The method yields an estimate of the VSLY of approximately $197,000 measured in 2020 dollars.

Caveats

Estimators for the number of deaths, fatal and non-fatal burden attributable to heat-waves for Australia vary significantly in the literature.

Actual information on the age distribution of people suffering from heat-related mortality are not available. Such information would help to improve the estimate of economic cost from heat-related deaths in Australia.

Future form of the indicator

Actual information on the number of deaths and age distribution of people suffering from heat-related mortality might be available in the future. Such information would help to improve the estimate of economic cost from heat-related deaths in Australia.

4.2 Investment in new coal capacity

Data

The data for this indicator are sourced from the annual State of the Energy Market reports by the Australian Energy Regulator[42] and the Australian Energy Market Operator[43] Generation Information Page. Numbers are reported as generation of MW capacity and not as investment in AUD.

Methods

Methods for this indicator are the same as those used for "Indicator 4.3: Investments in coal capacity" in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those used for "Indicator 4.3: Investments in coal capacity" in Beggs et al.[1]

Future form of the indicator

It is not envisaged that the form of this indicator will change over time.

4.3 Investments in zero-carbon energy and energy efficiency

Data

The data for this indicator are sourced from the annual State of the Energy Market reports by the Australian Energy Regulator.[42] Numbers are reported as installed capacity and not as investment in AUD. The investment is attributed to the year in which a new plant or the upgrade of an existing one became operational. Other areas of expenditure, including operation and maintenance, research and development, financing costs, mergers and acquisitions or public markets transactions, are not included.

Methods

Methods for this indicator are the same as those used for "Indicator 4.2: Investments in zero carbon energy and energy efficiency" in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those used for “Indicator 4.2: Investments in zero carbon energy and energy efficiency” in Beggs et al.[1]

Future form of the indicator

It is not envisaged that the form of this indicator will change over time. However, actual figures for investment into energy efficiency or small-scale photovoltaic installation for private households or companies could be added.

4.4 Employment in low-carbon and high-carbon industries

Data

Data for this indicator are provided by the Australian Bureau of Statistics (ABS).

Data for FTE employment in renewable energy activities are sourced from:

https://www.abs.gov.au/statistics/labour/employment-and-unemployment/employment-renewable-energy-activities-australia/latest-release

FTE employment in mining operations is taken as a proxy for employment in high-carbon industries. The data for FTE employment in mining operations are sourced from:

https://www.abs.gov.au/statistics/industry/industry-overview/australian-industry/latest-release#data-download

This indicator includes the sub-categories 06 Coal mining, 07 Oil and gas extraction, 08 Metal ore mining, 09 Non-metallic mineral mining and quarrying, 10 Exploration and other mining support.

Methods

Methods for this indicator are the same as those used for “Indicator 4.4: Employment in low-carbon and fossil fuel energy industries” in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those used for “Indicator 4.4: Employment in low-carbon and fossil fuel energy industries” in Beggs et al.[1]

Future form of the indicator

An ideal future form of this indicator would track both direct and indirect employment from renewables and fossil fuel extraction industries.

4.5 Funds divested from fossil fuels

Data

The data for the first indicator are collected from 350.org and https://gofossilfree.org.au.[44] 350.org is a Boston-based non-profit organisation registered in the United States. Fossil Free is one of its projects. Organisations are committed to divestment if they fall 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 (eg, 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.

More details on the list of organisations, including banks, pension funds, local governments, universities, and corporations is available from the following website: https://gofossilfree.org.au/

Data for the second indicator are sourced from the annual State of the Energy Market reports by the Australian Energy Regulator[42] and the Australian Energy Market Operator[43] Generation Information Page. Numbers are reported in MW of generation that have been retired, placed into cold storage or mothballed.

Methods

Methods for this indicator are the same as those used for “Indicator 4.5: Funds divested from fossil fuels” in Beggs et al.[1]

Caveats

Caveats for this indicator are the same as those used for “Indicator 4.5: Funds divested from fossil fuels” in Beggs et al.[1]

Future form of the indicator

Future forms of this indicator should report the actual value of funds divested from fossil fuels by the organisations. The ideal future form of this indicator would have two elements. The first element would track the value of institutional investments in fossil fuels assets, both in absolute terms and as a proportion of their total portfolios. This would also allow for tracking of associated funds that are moved out of fossil fuels, but are not explicitly advertised as 'divesting'. However, such data are unlikely to be available in the near future. The second element of this indicator would more explicitly track the value of funds divested from fossil fuels by for-profit organisations and educational, government, healthcare etc. institutions.

It is not envisaged that the form of the second indicator (historical and announced withdrawals of coal- and gas-fired power plants) will change over time.

4.6 Net value of fossil fuel subsidies and carbon prices

Data

Data for this indicator are the same as those used for "Indicator 4.2.5: Net value of fossil fuel subsidies and carbon prices" in Romanello et al.[7] except that the data available are taken only for the more recent year of 2018 and are reported in AUD. The CO_2 emissions data are taken from the Australian Greenhouse Emissions Information System compiled by the Federal Government Department of Industry, Science, Energy and Resources.

Methods

Methods for this indicator are the same as those used for "Indicator 4.2.5: Net value of fossil fuel subsidies and carbon prices" in Romanello et al.[7] for the calendar year 2018.

Caveats

Caveats for this indicator are the same as those for "Indicator 4.2.5: Net value of fossil fuel subsidies and carbon prices" in Romanello et al.[7]

Future form of the indicator

Updates in the World Bank Dashboard information for Australia would be beneficial to improve this indicator.

Section 5: Public and political engagement

5.1 Media coverage of health and climate change

Data

Data for this indicator are the same as those used for “Indicator 5.1: Media coverage of health and climate change” in Zhang et al.[3]

Methods

Methods for this indicator are the same as those used for “Indicator 5.1: Media coverage of health and climate change” in Zhang et al.[3] The search methods for the major newspapers in Australia were the same as we did last year except adding new data up to the end of 2020. We note that the 13 included newspapers cover all leading newspapers in all capital cities, and they are widely accessed by Australian people. Research by Roy Morgan suggests that over 15.7 million Australians read newspapers in print or online.[45]

Caveats

Caveats for this indicator are the same as those for “Indicator 5.1: Media coverage of health and climate change” in Zhang et al.[3]

5.2 Coverage of health and climate change in scientific journals

Data

Data for this indicator are the same as those used for “Indicator 5.2: Coverage of health and climate change in scientific journals” in Zhang et al.[3]

Methods

Methods for this indicator are the same as those used for “Indicator 5.2: Coverage of health and climate change in scientific journals” in Zhang et al.[3] The search methods were the same as we did last year except adding the data between 1 January 2020 and 31 December 2020.

Caveats

Caveats for this indicator are the same as those for “Indicator 5.2: Coverage of health and climate change in scientific journals” in Zhang et al.[3]

5.3 Government engagement in health and climate change in Australia

Data

This indicator sought to identify the extent to which Australian governments were working on climate change as a health issue, and/or health was being addressed as an issue affected by climate change. The data used for this report were derived from the Australian Parliament and the Australian Government Department of Health websites, plus from the Parliamentary websites and Government pages of the eight States and Territories. This is the first time that the state and territory governments have been included within the Government engagement indicator.

The data collected were as follows: for the Australian Government we looked for Bills and Legislation, Committees and Inquiries, and Chamber documents that included a consideration of climate change and health. For the State and Territory Governments, we looked for relevant Bills and Legislation, Inquiries, and Government reports. In addition the Australian Government Department of Health website was searched for programs, policies and statements on climate change.

Methods

National

The datasets of the Parliament of Australia public website were searched (https://www.aph.gov.au/Parliamentary_Business) for records from 1 January 2020 to 31 December 2020. The datasets searched included *Bills & legislation, Committees & inquiries*, and *Chamber documents*.

Bills & legislation were searched by whole document and included all current and previous Bills sponsored by Government and Private Members/Senators. *Committees & inquiries* were searched using titles and summary and included all Senate, House and Joint committees, inquiries and hearings. *Chamber documents* were searched by whole document and included notice papers, tabled papers, votes and proceedings from the House and journals of the Senate.

Datasets were searched using each key search term for (a) climate change and for (b) health, as listed below. Searches were then conducted for (c) climate change AND health.

(a) climate change:

"climate change", "global warming", "temperature", "extreme weather", "global environmental change", "climate variability", "greenhouse", "low carbon", "ghge", "renewable energy", "carbon emission", "co2 emission", "climate pollutant", "air pollution", "drought", "flood", "bushfire", "heat".

(b) health:

"malaria", "dengue", "diarrhoea", "infection", "disease", "pneumonia", "epidemic", "pandemic", "public health", "health care", "healthcare", "epidemiology", "health", "mortality", "morbidity", "nutrition", "illness", "infectious", "ncd", "non-communicable disease", "noncommunicable disease", "chronic disease", "communicable disease", "nutrition", "malnutrition", "mental disorder", "mental health", "depression", "suicide".

(c) climate change AND health:

"climate health", "climate change AND health".

Duplicates were hand removed for Bills & legislation, and Committees & inquiries but not for Chamber documents. Any Bills & legislation identified through searches (a) and (b) were further analysed for overlap between climate change and health by key word searching within the legislation and explanatory memorandum. Documents identified through (a) climate change were searched using the term "health" and documents identified through (b) health were searched using the term "climate change".

In addition to the health terms used by the *MJA-Lancet* Countdown 2019 report, we added the term "chronic disease" which is more commonly used in Australia. As there was an increase in the number of relevant documents compared to previous years, a third search strategy was introduced for the first time, which combined climate and health terms.

State and Territory

Parliamentary websites were searched for records from 1 January 2020 to 31 December 2020 using the datasets *Bills & Legislation,* and *Inquiries*. Government websites were searched for records of strategies and reports contained within the first 20 results listed in the search database. State and territory websites were searched using terms (c) only: ie, climate change AND health, "climate health", "climate change" AND "health".

State or Territory	**Parliamentary website**	**Government website**
Queensland	https://www.parliament.qld.gov.au/	https://www.qld.gov.au/
New South Wales	https://www.parliament.nsw.gov.au/	https://www.nsw.gov.au/
Australian Capital Territory	https://www.parliament.act.gov.au/	https://www.act.gov.au/
Victoria	https://www.parliament.vic.gov.au/	https://www.vic.gov.au/
Tasmania	https://www.parliament.tas.gov.au/	https://www.health.tas.gov.au/
South Australia	https://www.parliament.sa.gov.au/	https://www.sa.gov.au/

Western Australia	https://www.parliament.wa.gov.au/	https://www.wa.gov.au/
Northern Territory	https://parliament.nt.gov.au/	https://nt.gov.au/

Caveats

We have used a number of health terms that were not used in the *Lancet* Countdown 2020, as follows: dengue; public health; mental health; depression; and suicide.

The 2020 *Lancet* Countdown report used a lot more climate terms for this indicator that we haven't used, as follows: Changing climate; Climate emergency; Climate action; Climate crisis; Climate decay; Greenhouse-gas; Ghges; Carbon emissions; Carbon dioxide; Carbon dioxides; Co2 emissions; Decarbonisation; Climate pollutants; Carbon neutral; Carbon neutrality; Climate neutrality; Net zero.

There are also several health terms we didn't include, as follows: Diseases; Sars; Measles; Epidemics; Pandemics; Illnesses; Ncds; Malnourishment; Mental disorders; stunting.

Due to time constraints we only used terms in category (c) for the states and territories.

State and territory websites search differently.

Including new search terms under (c) as significantly more data were coming back for (a) and (b) compared to previous years. However, search (c) did not provide many results perhaps due to the way the database functions. As such, (a) and (b) results for Bills were hand searched to identify documents that referenced climate change and health.

We could not hand search chamber documents to remove duplicates.

5.4 Health and climate change research funding

Data

The Australian National Health and Medical Research Council's (NHMRC's) Research Grants Management System (RGMS) was analysed by NHMRC personnel for research funding applications with a focus on health and climate change over the years 2000 to 2020.

Methods

The indicator tracks the annual number of health and climate change grant applications that are funded and not funded, and the corresponding success rate.

Caveats

The number of applications is likely to be an underestimate due to the choice of category descriptors for areas of research in the RGMS.[46]

Future form of the indicator

There is potential to develop this indicator by also reporting the annual dollar amounts funded and not funded, funding by funding program, funding by broad research area, funding by field of research, and other more detailed analysis of the data.

Author contributions

PJB and YZ Co-Chair the *MJA–Lancet* Countdown. HLB leads Section 1; HB leads Section 2; MKL leads Section 3; ST leads Section 4; and AGC leads Section 5.

Author contributions of indicators were as follows: AMa, 3.8, 3.10; CM, 1.9; DG, 1.2, 4.6; FHJ, 1.7; GGM, 1.8, 3.5, 3.6; HB, 1.10, 2.1-2.3; ICH, 1.8, 3.5, 3.6; LR, 5.3; MKL, 3.1-3.4; MS, 2.6, 3.7; OJ, 1.4, 1.5; PJB, 2.5, 2.7, 5.4; ST, 4.1-4.5; YG, 1.1, 1.6; YZ, 3.9, 5.1, 5.2.

PJB, AMc, and YZ drafted the manuscript and all authors contributed to revising it critically for important intellectual content. All authors provided final approval of the version to be published and agreement to be accountable for all aspects of the work. PJB, YZ, IH, AMc, and AGC made substantial contributions to the overall conception and design of the work.

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Tables

Table A1. Annual average excess deaths, excess deaths ratio (%) and deaths per 100,000 residents (with 95% empirical Confidence Intervals) due to non-optimal temperatures (overall and cold/heat components) from 2000 to 2019 in Australia

	Overall	**Cold**	**Heat**
Annual excess deaths	16495 (10116, 23872)	14198 (9235, 19876)	2296 (501, 5031)
Excess deaths ratio (%)	11.40 (6.99, 16.50)	9.81 (6.38, 13.74)	1.59 (0.35, 3.48)
Deaths per 100,000 residents	74 (45, 107)	64 (41, 89)	10 (2, 23)

Table A2. Person-days exposed to landscape fire by year in Australia, 2001 to 2020

Year	**Person-days exposed to landscape fire**
2001	139,486
2002	187,555
2003	169,815
2004	186,949
2005	175,707
2006	183,085
2007	141,173
2008	147,846
2009	187,850
2010	139,503
2011	202,488
2012	158,124
2013	180,386
2014	174,035
2015	196,175
2016	161,288
2017	202,639
2018	199,603
2019	270,997
2020	190,774
Average 2001-2020	**179,774**

Table A3. Normalised Difference Vegetation Index (NDVI) and levels of greenness for all Australian urban centres over 2020

City	City type	Peak NDVI	Peak Greenness	Ave NDVI	Ave Greenness	Peak Weighted NDVI	Peak Weighted Greenness	Ave Weighted NDVI	Ave Weighted Greenness	Population
Sydney	NSW capital	0.58	High	0.52	High	0.46	Moderate	0.37	Low	3745335
Melbourne	VIC capital	0.57	High	0.53	High	0.45	Moderate	0.38	Low	3468084
Perth	WA capital	0.45	Moderate	0.38	Low	0.42	Moderate	0.36	Low	1258344
Brisbane	QLD capital	0.54	High	0.49	Moderate	0.50	High	0.46	Moderate	990070
Adelaide	SA capital	0.53	High	0.45	Moderate	0.44	Moderate	0.38	Low	930903
Gold Coast	QLD regional	0.59	High	0.54	High	0.31	Low	0.21	Very Low	319510
Newcastle	NSW regional	0.58	High	0.52	High	0.57	High	0.48	Moderate	198972
Werribee	VIC regional	0.50	Moderate	0.43	Moderate	0.50	Moderate	0.43	Moderate	187269
Wollongong	NSW regional	0.68	Very High	0.63	Very High	0.35	Low	0.31	Low	150185
Geelong	VIC regional	0.52	High	0.46	Moderate	0.49	Moderate	0.44	Moderate	144531
Campbelltown	Greater Sydney	0.64	Very High	0.58	High	0.58	High	0.51	High	107634
Penrith	Greater Sydney	0.62	Very High	0.54	High	0.59	High	0.51	High	106063
Old Reynella	Greater Adelaide	0.58	High	0.47	Moderate	0.52	High	0.41	Moderate	104071
Aitkenvale	QLD regional	0.44	Moderate	0.37	Low	0.44	Moderate	0.38	Low	92067

Thorneside	Greater Brisbane	0.57	High	0.51	High	0.54	High	0.49	Moderate	91329
Toowoomba	QLD regional	0.50	Moderate	0.43	Moderate	0.45	Moderate	0.39	Low	81049
Belconnen	Greater Canberra	0.59	High	0.51	High	0.57	High	0.50	High	73525
Hobart	TAS capital	0.63	Very High	0.56	High	0.55	High	0.48	Moderate	71988
Maroochydore	QLD regional	0.53	High	0.50	Moderate	0.52	High	0.43	Moderate	68725
Ballarat	VIC regional	0.56	High	0.52	High	0.51	High	0.47	Moderate	67144
Rockingham	WA regional	0.43	Moderate	0.39	Low	0.42	Moderate	0.38	Low	66696
Mandurah	WA regional	0.44	Moderate	0.39	Low	0.36	Low	0.30	Low	62493
River Glen Village	Greater Brisbane	0.50	High	0.45	Moderate	0.50	Moderate	0.44	Moderate	56992
Redcliffe	QLD regional	0.47	Moderate	0.42	Moderate	0.39	Low	0.34	Low	55604
Cairns	QLD regional	0.57	High	0.51	High	0.59	High	0.53	High	53527
Woden	Greater Canberra	0.58	High	0.51	High	0.57	High	0.50	High	53472
Lindum	Greater Brisbane	0.49	Moderate	0.44	Moderate	0.47	Moderate	0.43	Moderate	53261

Table A4. Levels of greenness for all Australian urban centres over 2020 by percent of population in urban areas

Level	Peak Greenness	Ave Greenness	Peak Weighted Greenness	Ave Weighted Greenness
Exceptionally low (≤0.19)	0.00	0.00	0.00	0.00
Very low (0.20-0.29)	0.00	0.00	0.00	2.52
Low (0.30-0.39)	0.00	11.69	4.64	78.29
Moderate (0.40-0.49)	14.67	21.11	79.66	16.07
High (0.50-0.59)	81.89	66.01	15.69	3.11
Very high (0.60-0.69)	3.44	1.19	0.00	0.00
Exceptionally high (≥0.70)	0.00	0.00	0.00	0.00

Table A5. Annual average $PM_{2.5}$ for cities in each Australian state and territory, 2000-2020. All cities with greater than 100,000 people in each state/territory contributed to the annual average

Year	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
2000		6.0						7.6
2001		7.6						8.2
2002		9.5						8.6
2003		7.8			8.9			8.5
2004		7.6			8.2			8.0
2005		6.9			7.8			7.8
2006		6.9		6.4	8.3			8.3
2007		6.2		5.0	7.9			7.3
2008		6.1		5.0	7.7			7.5
2009		7.3		7.8	8.0			8.0
2010		5.3		5.6	7.5	5.2		8.3
2011		5.2		6.5	7.1			7.5
2012		6.0	11.1	5.8	7.3			8.3
2013		7.5	7.4	6.4	7.2	5.1		7.8
2014	5.1	7.1	8.3	6.0	7.4	5.9	8.5	8.0
2015	6.6	7.2	8.1	5.3	7.5	4.6	7.9	8.6
2016	6.3	7.3	6.8	6.0	7.6	3.9	7.0	7.7
2017	6.6	7.3	6.8	5.6	7.7	3.5	8.3	8.5
2018	7.2	7.8	8.7	5.9	7.2	3.4	7.8	8.0
2019	13.0	11.0	9.2	7.6	6.1	3.7	7.5	
2020		8.3	7.2					

Table A6. Total number of Australian national Parliamentary documents related to climate change, health, and climate change and health

		Climate change	**Health**	**Climate change AND health**
Bills & legislation	Passed	2	14	0
	Not passed	4	1	0
	Before parliament	4	4	0
	Sub-total	**10**	**20**	**0**
Committees & inquiries	Committees	0	5	0
	Inquiries	6	9	0
	Hearings	8	20	0
	Sub-total	**14**	**34**	**0**
Chamber documents*		3602 (132 title only)	7207 (597 title only)	733 (0 title only)

Note: * number of chamber documents may contain duplicates across different search terms

Table A7. Australian national Bills identified under searches for (a) climate change and (b) health, with hand searching for climate and health relevance

Topic	**Key words**	**Bill title**	**Status**	**Inquiry**
Climate change and health relevant identified by hand searching	"climate change", "greenhouse"	Climate Change (National Framework for Adaptation and Mitigation) (Consequential and Transitional Provisions) Bill 2020	Before Parliament	Yes
	"climate change"	Climate Change (National Framework for Adaptation and Mitigation) Bill 2020	Before Parliament	Yes
	"climate change"	Climate Emergency Declaration Bill 2020	Not Passed	No
	"renewable energy"	Coronavirus Economic Support and Recovery (No-one Left Behind) Bill 2020	Before Parliament	No
	"drought"	Farm Household Support Amendment (Relief Measures) Bill (No. 1) 2020	Passed	No
	"health"	Recycling and Waste Reduction Bill 2020	Passed	
Climate change only	"climate change", "greenhouse"	Liability for Climate Change Damage (Make the Polluters Pay) Bill 2020	Not Passed	No
	"greenhouse"	Offshore Petroleum and Greenhouse Gas Storage Amendment (Benefit to Australia) Bill 2020	Before Parliament	Yes
	"greenhouse", "carbon emission"	National Greenhouse and Energy Reporting Amendment (Transparency in Carbon Emissions Accounting) Bill 2020	Not Passed	Yes
	"renewable energy"	Green New Deal (Quit Coal and Renew Australia) Bill 2020	Not Passed	No
	"bushfire"	Treasury Laws Amendment (2019-20 Bushfire Tax Assistance) Bill 2020	Passed	No
Health only	"pandemic"	Migration Amendment (Common Sense Partner Visa) Bill 2020	Before Parliament	No

	"pandemic"	Social Services and Other Legislation Amendment (Coronavirus and Other Measures) Bill 2020	Passed	No
	"pandemic"	Fair Work Amendment (One in, All in) Bill 2020 [No. 2]	Before Parliament	No
	"pandemic"	Fair Work Amendment (One in, All in) Bill 2020	Not Passed	No
	"pandemic", "public health", "health"	Privacy Amendment (Public Health Contact Information) Bill 2020	Passed	No
	"health care", "health"	Aged Care Legislation Amendment (Serious Incident Response Scheme and Other Measures) Bill 2020	Passed	No
	"health care", "health"	Aged Care Amendment (Aged Care Recipient Classification) Bill 2020	Passed	No
	"health care", "health"	Aged Care Legislation Amendment (Improved Home Care Payment Administration No. 2) Bill 2020	Passed	No
	"health care", "health"	Aged Care Legislation Amendment (Emergency Leave) Bill 2020	Passed	No
	"health care", "health"	Aged Care Legislation Amendment (Improved Home Care Payment Administration No. 1) Bill 2020	Passed	No
	"health"	Therapeutic Goods Amendment (2020 Measures No. 2) Bill 2020	Passed	No
	"health"	Australian Immunisation Register Amendment (Reporting) Bill 2020	Passed	No
	"health"	Health Insurance Amendment (Compliance Administration) Bill 2020	Passed	Yes
	"health"	Health Insurance Amendment (Administration) Bill 2020	Passed	No
	"health"	Health Insurance Amendment (Continuing the Office of the National Rural Health Commissioner) Bill 2020	Passed	No

	"health"	Therapeutic Goods Amendment (2020 Measures No. 1) Bill 2020	Passed	No
	"health"	Health Insurance Amendment (General Practitioners and Quality Assurance) Bill 2020	Passed	No
	"suicide"	National Commissioner for Defence and Veteran Suicide Prevention (Consequential Amendments) Bill 2020	Before Parliament	Yes
	"suicide"	National Commissioner for Defence and Veteran Suicide Prevention Bill 2020	Before Parliament	Yes

Table A8. Australian State and Territory bills, inquiries, and government strategies and reports related to climate change and health

State/territory	Bills	Inquiry	Government strategy & reports
Qld	0	0	1 (action plan on climate health)
NSW	0	1	1 (bushfire awareness guide)
ACT	0	0	0
Vic	0	0	0
Tas	0	0	2 (1 roundtable report on climate health, 1 report on state of public health)
SA	0	1 (public health act review)	9 (7 regional plans mentioning climate and health, 1 summer cooling guide, 1 guidelines for urban development)
WA	2 (1 introduced in 2020, 1 in Nov 2019 but still before the house in 2020)	0	3 (1 report from inquiry into climate health, 1 climate change policy, 1 climate change issues paper)
NT	0	0	0

Figures

Figure A1. Estimated shaded work hours lost in Australia combined across all industry sectors, stratified by state/territory, from 1990-2019

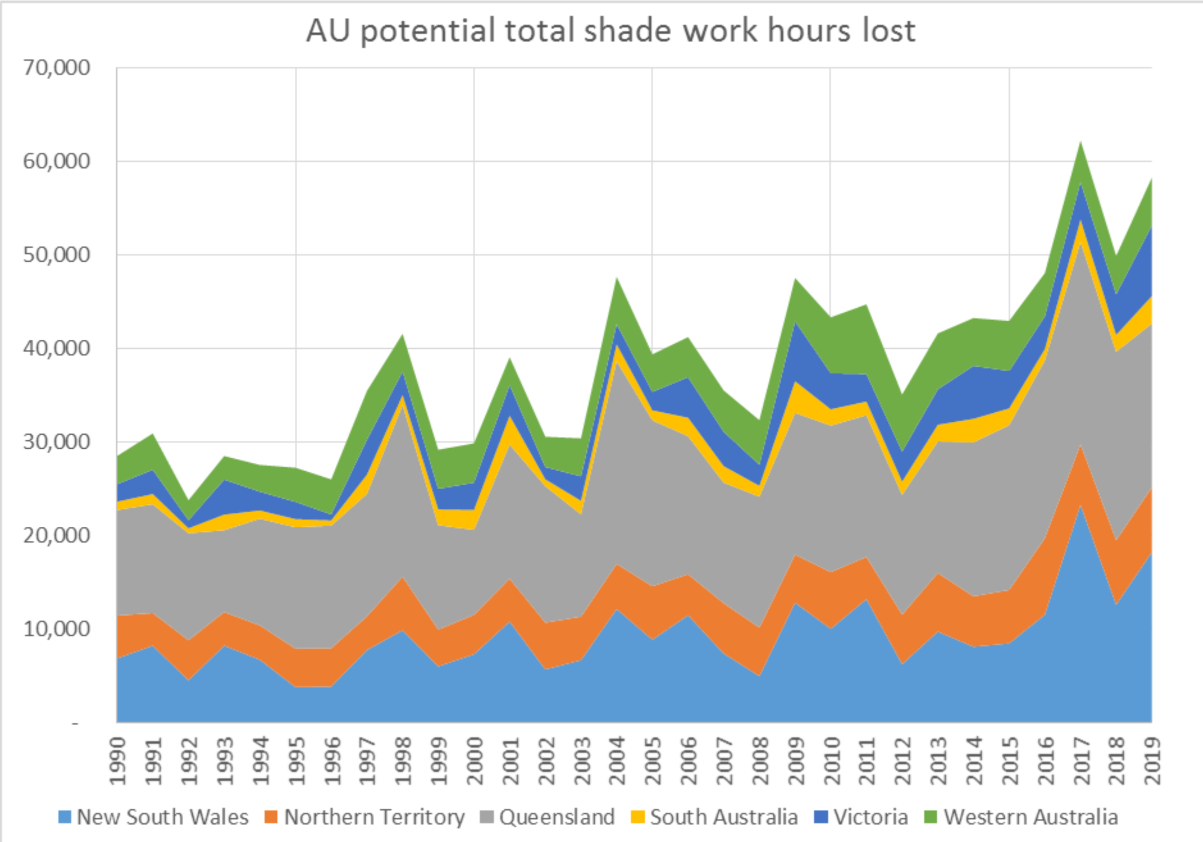
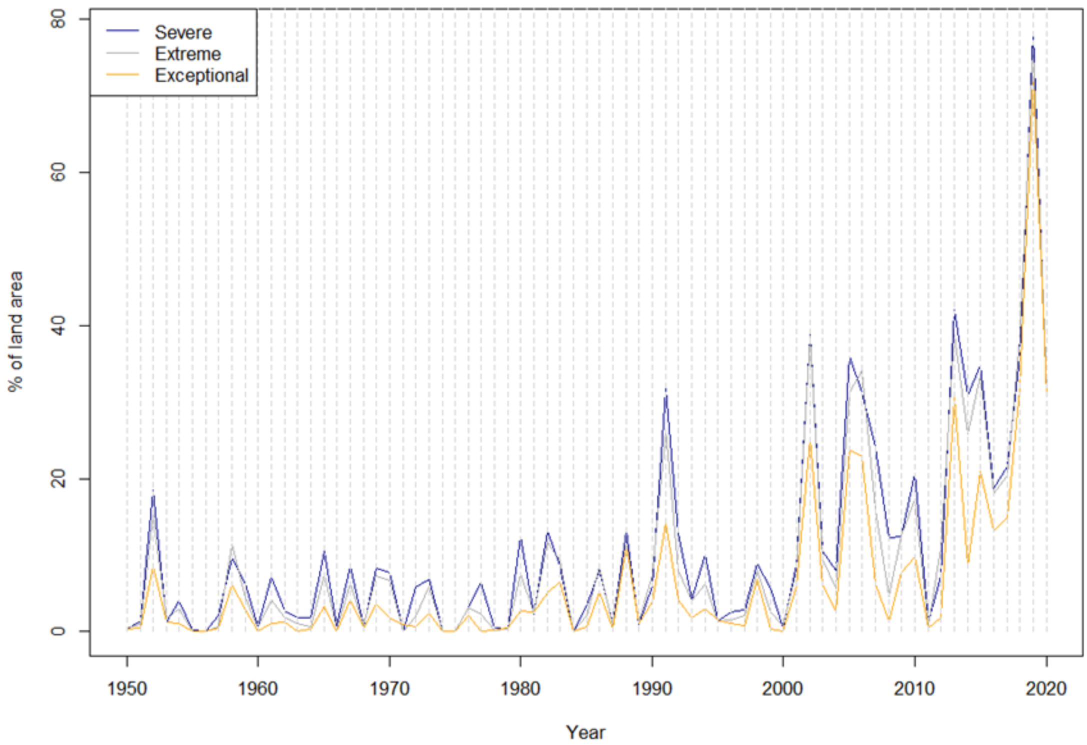


Figure A2. Annual time-series plot of drought affected area in Australia shown as A) percentage of area in "excess severe drought", "excess extreme drought" and "excess exceptional drought" where an excess event is classified as exceeding 2 standard deviations above mean annual counts (1950-2005 baseline); and B) national average Standardised Precipitation-Evapotranspiration Index (SPEI) showing hot/dry months as scores below zero

A)



B)

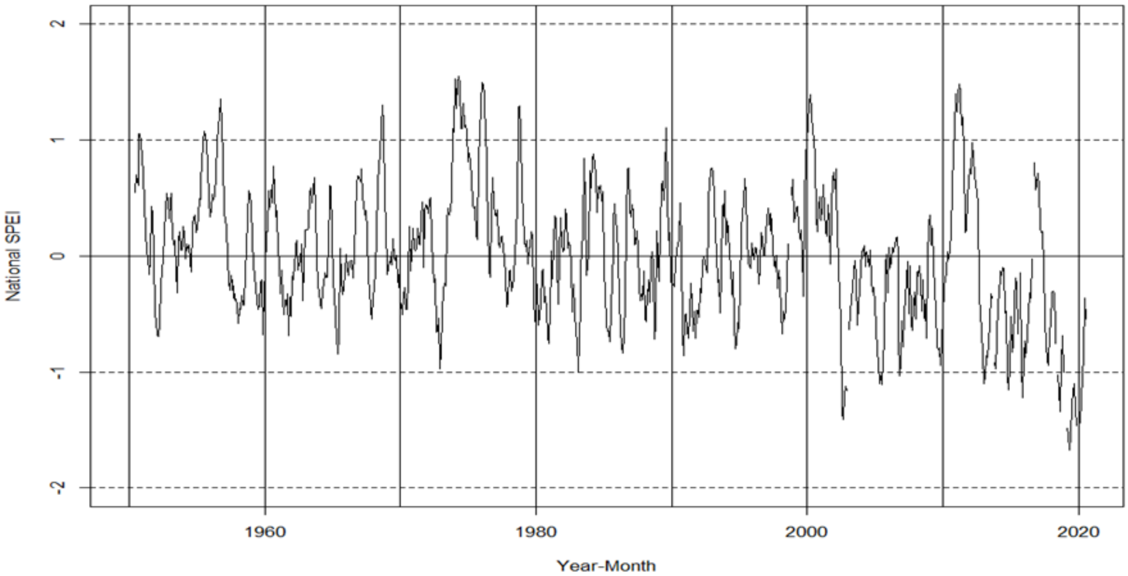
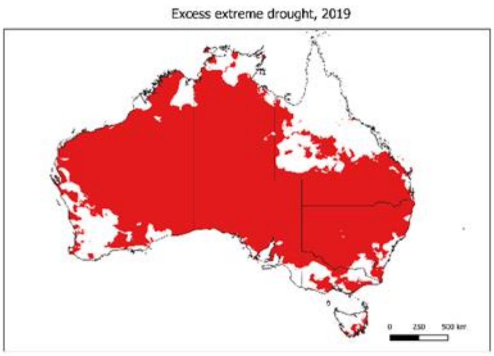
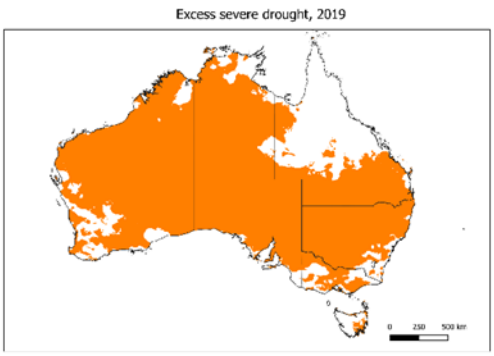


Figure A3. Maps of drought affected area in Australia in 2019 for A) "excess extreme drought", B) "excess severe drought" and C) average Standardised Precipitation-Evapotranspiration Index (SPEI)

A)



B)



C)

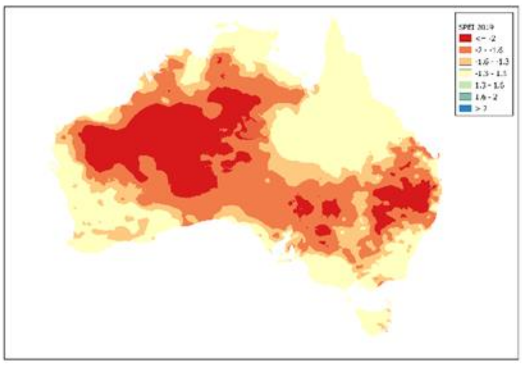


Figure A4. Annual Ross River virus notifications per 100,000 population (1993-2020) by Australian state and territory

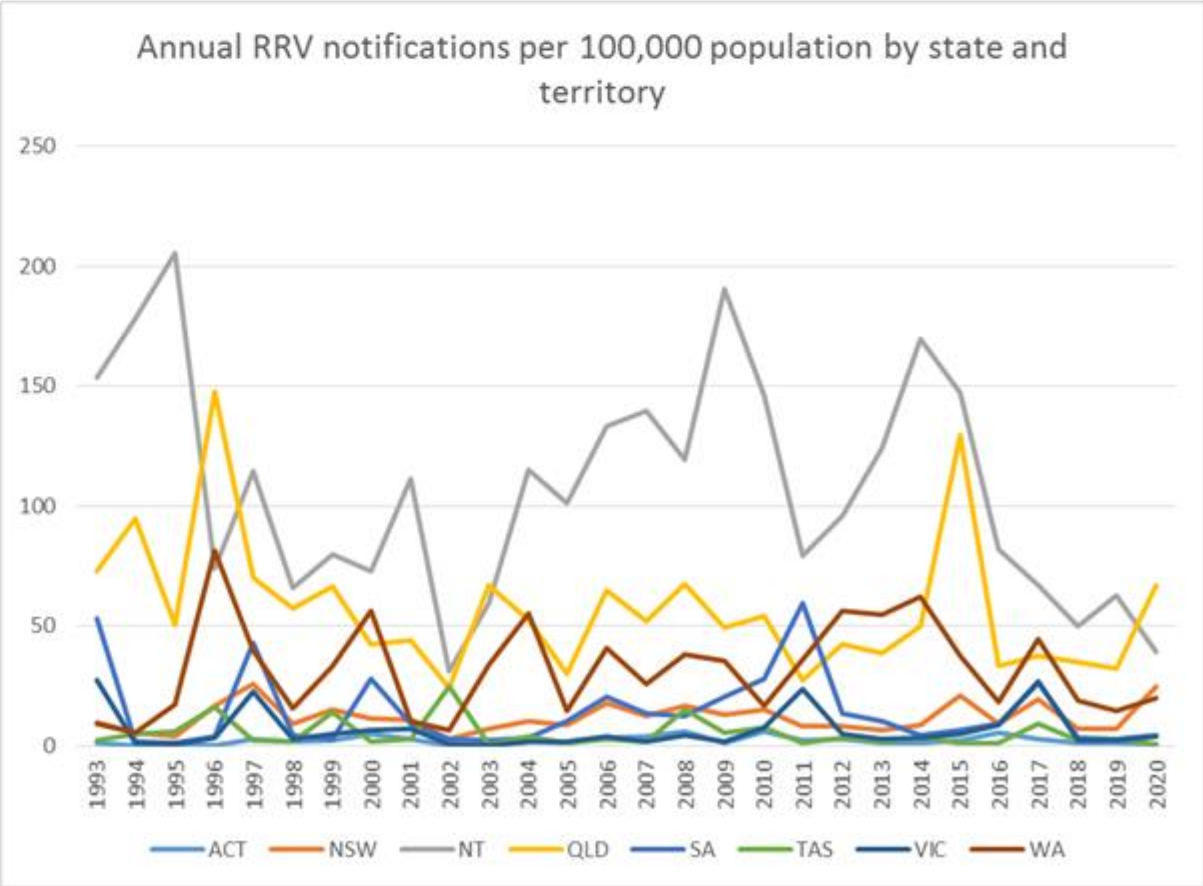
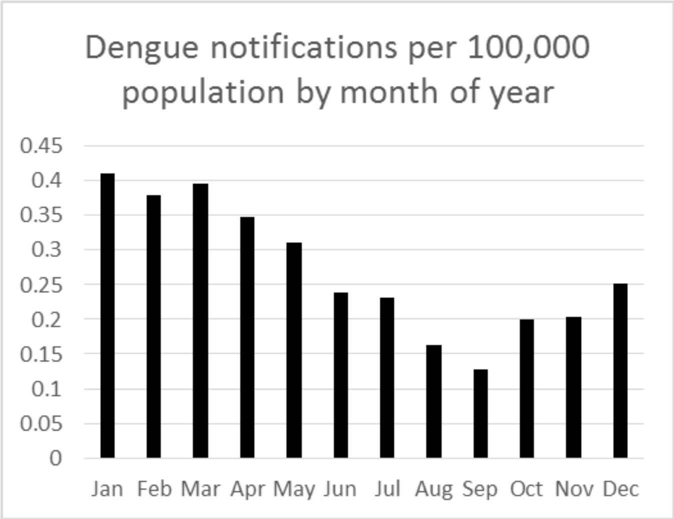


Figure A5. Seasonality of dengue and Ross River virus infection (notifications per 100,000 population) in Australia. N.B. The number of RRV infections outstrip dengue infections by an order of magnitude



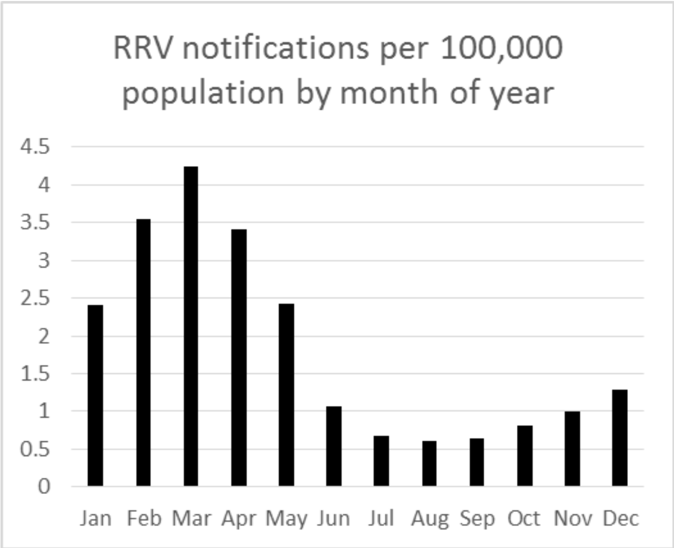


Figure A6. Annual national dengue notifications per 100,000 population over time (solid line), with linear trend (dotted line) in Australia, 1991-2019

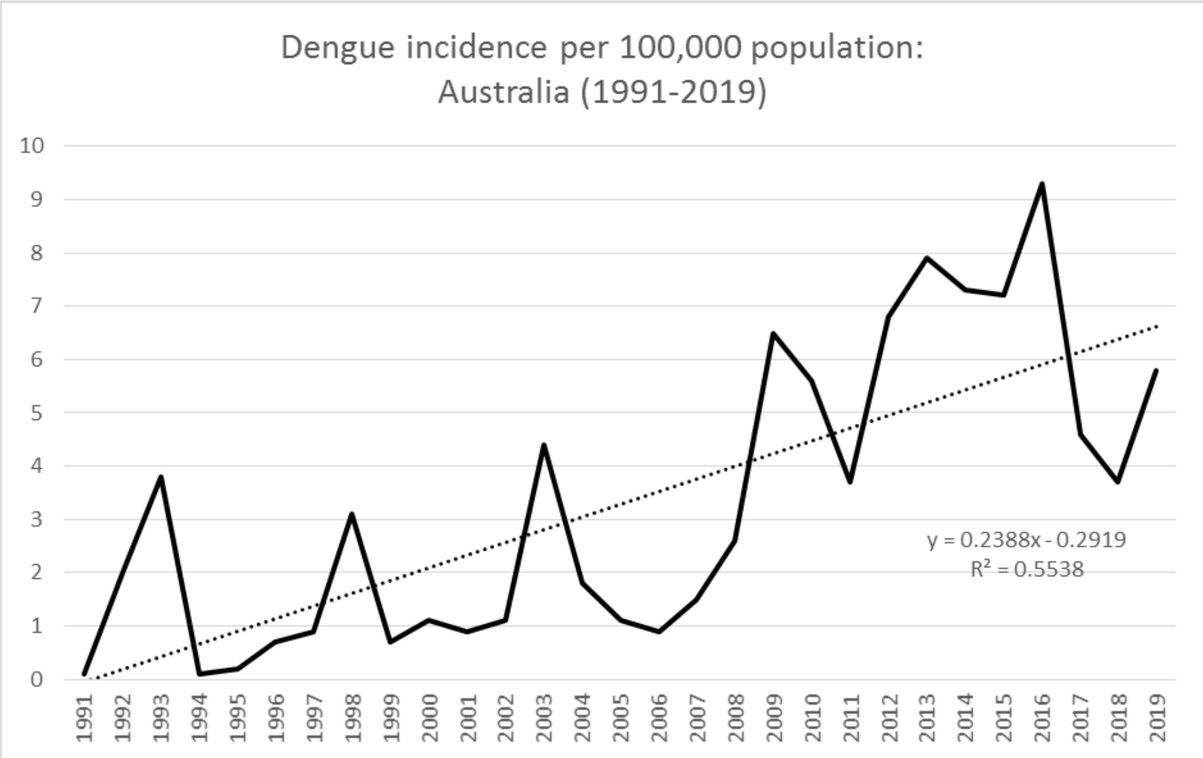


Figure A7. Annual national Ross River virus notifications per 100,000 population over time (solid line), with linear trend (dotted line) in Australia, 1993-2020

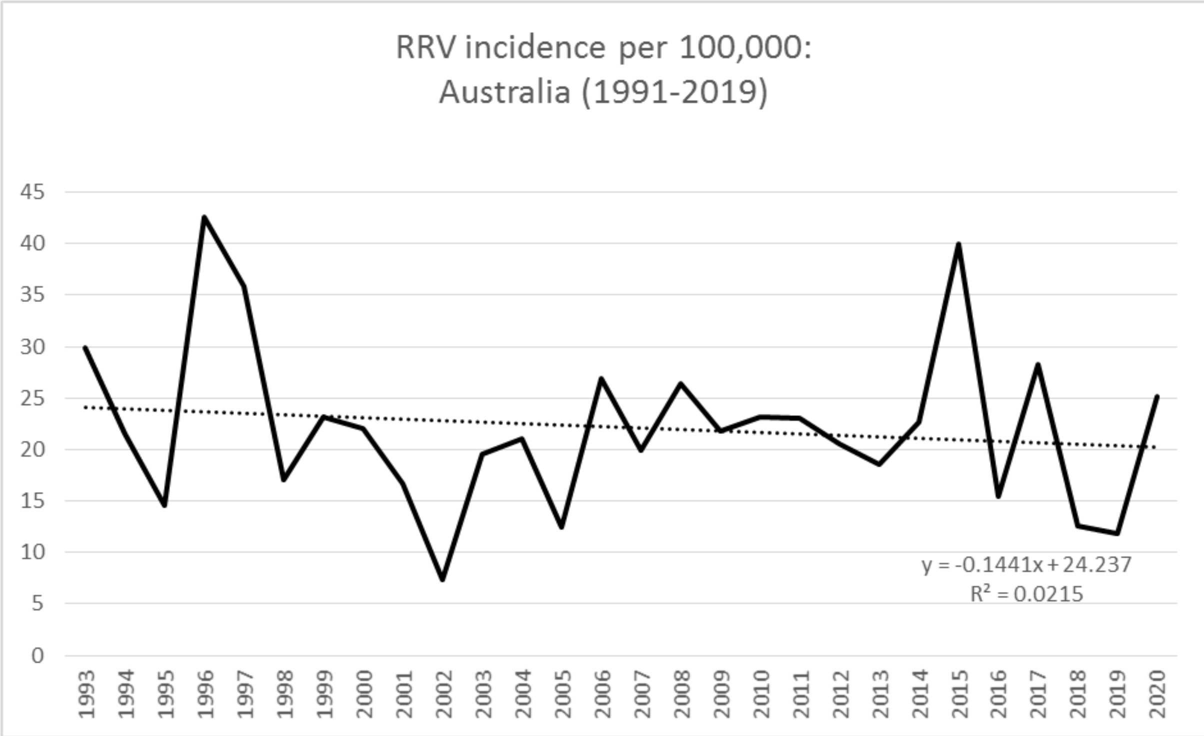


Figure A8. Annual and monthly average fine particulate matter less than 2.5 μm in diameter ($PM_{2.5}$) for cities in each Australian state and territory from 2000 to 2020

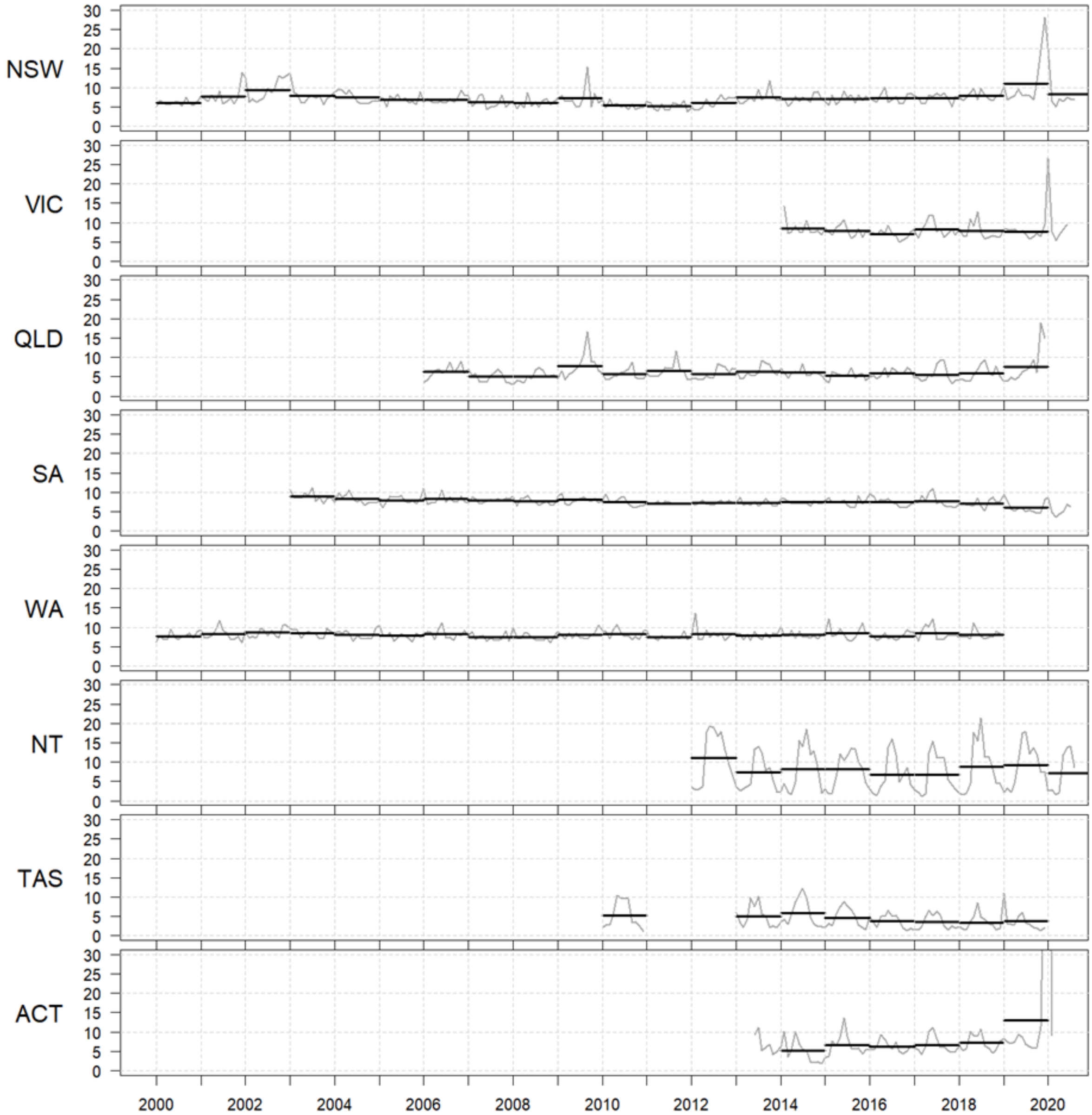


Figure A9. Consumption-based footprint of primary-agricultural sectors, showing the contribution of the top-10 primary-agricultural sectors to the overall footprint (17,021 kilotonnes)

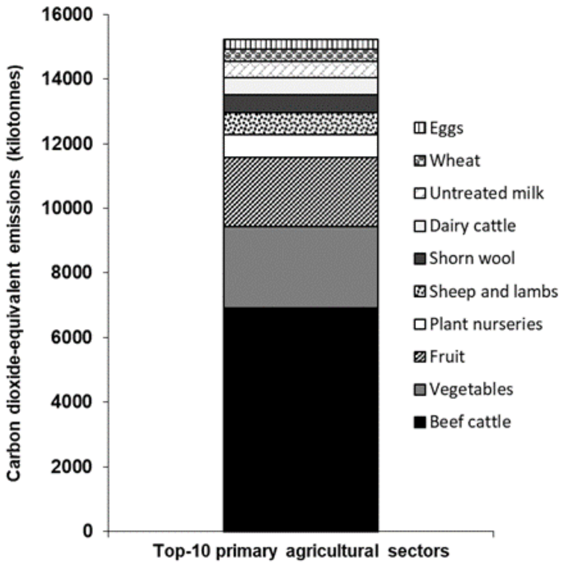


Figure A10. Deaths due to excess red meat consumption in Australia, Germany, the UK and the US, 2000-2017

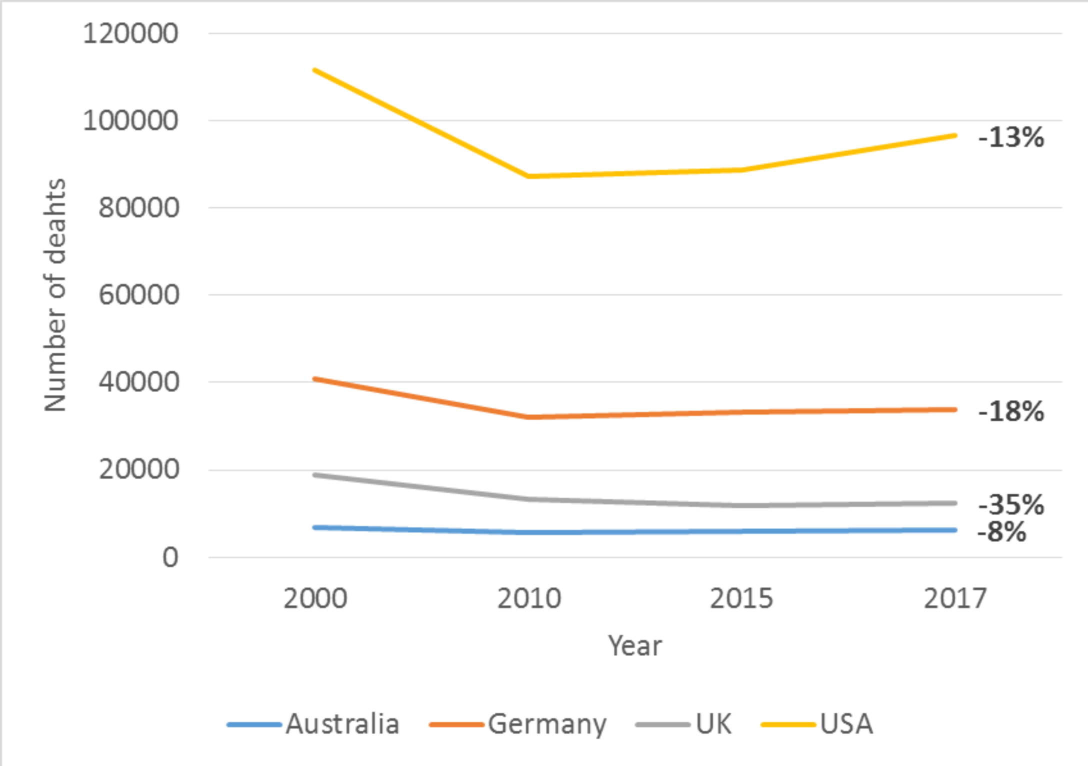


Figure A11. Annual number of media articles on health and climate change by Australian regions, 1 January 2008-31 December 2020

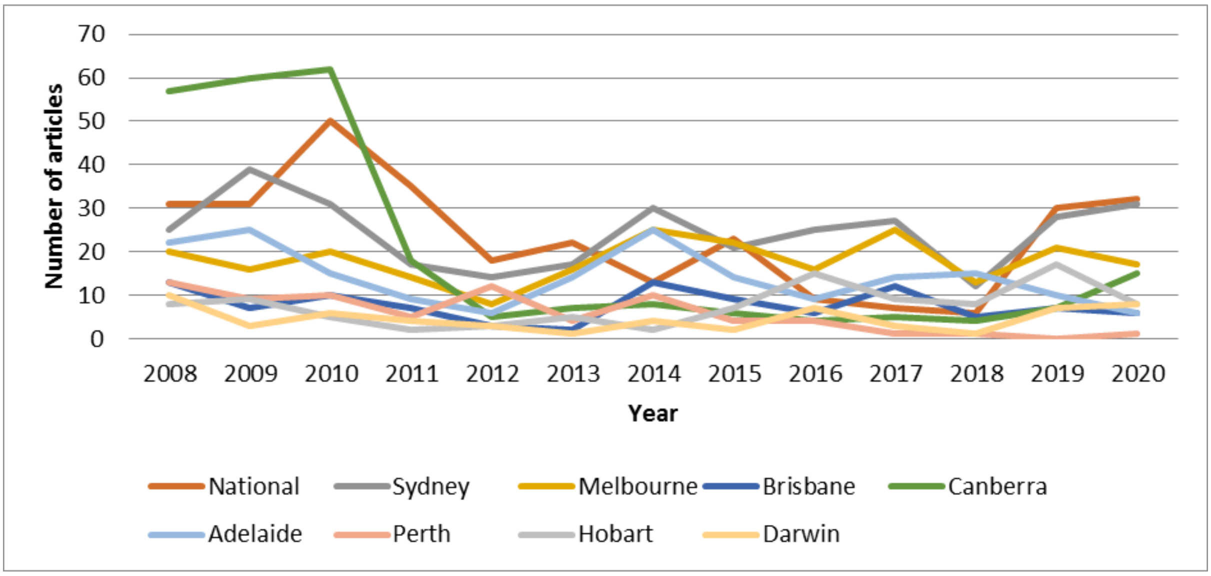


Figure A12. Australian Broadcasting Corporation (ABC) coverage of health and climate change topics, 1 January 2008-31 December 2020