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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, Trueck S, Linnenluecke MK et al. The 2023 report of the *MJA–Lancet* Countdown on health and climate change: sustainability needed in Australia's health care sector. *Med J Aust* 2022; doi: 10.5694/mja2.52245.

Appendix: The 2023 report of the *MJA-Lancet* Countdown on health and climate change: sustainability needed in Australia's health care sector

This Appendix includes details of the data, methods, and caveats for each of the 25 indicators assessed in the 2023 *MJA-Lancet* Countdown. It also includes additional figures and tables 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 sixth *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: Health hazards, exposures, and impacts

1.1 Exposure of vulnerable populations to heatwaves

Data

Data for this indicator are the same as those used for "Indicator 1.1 Exposure of vulnerable populations to heatwaves" in Beggs et al. (2022). Specifically, the heatwave dataset employed for this calculation is the Bureau of Meteorology's national Excess Heat Factor (EHF) heatwave analysis (Nairn and Fawcett 2013; Nairn and Fawcett 2015).

Methods

0.25°-resolution national grids of EHF were extracted for three-day periods containing days during the heatwave seasons (November-March) of 1973-1974 to 2022-2023, 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 (1973-1974 to 2022-2023); and 20 heatwave seasons (2003-2004 to 2022-2023).

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 (ABS) 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, but it is anticipated that the underlying daily temperature analysis data set will have been upgraded by the time of the next report.

1.2 Heat and physical activity

Data

Hourly climate data used for this indicator were obtained from the European Centre for Medium-Range Weather Forecasts' ERA5 database, which provides global coverage at the resolution of 0.5x0.5 degree grid cells – Australian data were extracted. Reanalysis data from the years 1991 to 2021 were included. An overview of this global dataset can be found at: https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview (April 2022).

Analysis for the 2023 indicator was restricted to hours that the sun was above the horizon within each grid cell, calculated using a sun calendar. Polynomial functions were restricted to the observed humidity and temperature range.

Grid cell-based population data were obtained from NASA's Socioeconomic Data and Applications Center, hosted by the Center for International Earth Science Information Network at Columbia University, New York.

Methods

Data analysis applied the latest Sports Medicine Australia Extreme Heat Policy (Jay et al. 2021) released in February 2021, which provides a stratified heat stress risk estimation (moderate, high, extreme) based on combinations of ambient temperatures and relative humidity. The policy calculator provides five different risk estimation plots based on the activity or sport undertaken. Plot #1 (for leisurely walking) and Plot #3 (for soccer) were used for the present analysis.

Caveats

Heat stress risk will be underestimated for people engaging in higher intensity activities and/or people wearing heavy clothing or protective equipment. Similarly, heat stress risk is estimated only for the average member of the population and does not represent risk in more vulnerable individuals, e.g., elderly, pregnant women, people with co-morbidities that compromise thermoregulation.

Population data for 2021 and 2022 were not available, so the average growth rate within each grid cell from 2015-20 (inclusive) was used to estimate each cell population in 2021 and

2022. Next year's version and the indicator will be updated to reflect the accurate population numbers.

Future form of the indicator

The future form of this indicator may include regional analysis, the effects of changing solar radiation with time of day, and time of year. Physiological restrictions to sweat losses may also be integrated. This indicator could also measure/track the added risk levels for people engaging in higher-intensity activities and/or people wearing heavy clothing or protective equipment.

1.3 Bushfires

Data

Data for this indicator are the same as those used for "Indicator 1.2.1 Wildfires" in Romanello et al. (2023).

Methods

Methods for this indicator are the same as those used for "Indicator 1.2.1 Wildfires" in Romanello et al. (2023).

Caveats

Caveats for this indicator are the same as those for "Indicator 1.2.1 Wildfires" in Romanello et al. (2023).

Future form of the indicator

In subsequent years this indicator may evolve to include mean annual exposure to fire smoke fine particulate matter (fire $PM_{2.5}$).

1.4 Drought

Data

The data and methods are the same as we reported in the 2022 *MJA-Lancet* Countdown report. We used monthly rainfall and temperatures, calculated using the Australian Water Availability Project (AWAP) gridded data January 1950 - May 2023 at 0.05 × 0.05 degree resolution (Australian Government Bureau of Meteorology 2023).

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. (2021). We used the Standardised Precipitation-Evapotranspiration Index (SPEI) calculated on 6-month timescale. Due to a 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" by Beguería and Vicente-Serrano (2017). 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 panel A.

The levels of excess drought were notably higher than usual in the years 2019 and 2020. However, there was then a significant increase in rainfall during 2021 to 2023 shown by SPEI levels. Annual averages of monthly SPEI are shown in Figure A2 panel B for each jurisdiction of Australia, and the national average is plotted as a thick black line.

Caveats

The SPEI is a measure of relative dryness of interannual climatic conditions often used to characterise droughts. As explained in the previous *MJA-Lancet* Countdown reports, 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 development of the SPEI drought indicator to align with other measures of agricultural drought (such as Government Drought Declarations).

Section 2: Adaptation, planning, and resilience for health

2.1 Health adaptation plans and assessments

Data

Data for this indicator are largely the same as those used for "Indicator 2.1 Health adaptation plans and assessments" in Beggs et al. (2022).

Methods

Methods for this indicator are the same as those used for "Indicator 2.1 Health adaptation plans and assessments" in Beggs et al. (2022).

Caveats

Caveats for this indicator are the same as those for "Indicator 2.1 Health adaptation plans and assessments" in Beggs et al. (2022).

Future form of the indicator

As the scale of climate catastrophes in Australia is increasing and requires a national approach to planning for and responding to increasing risk to protect population health, future versions of this indicator will focus on the progress of a national health and climate change adaptation plan.

2.2 Climate information for health

Data

Data for this indicator are the same as those used for "Indicator 2.2 Climate information services for health" in Beggs et al. (2022).

Methods

Methods for this indicator are the same as those used for "Indicator 2.2 Climate information services for health" in Beggs et al. (2022).

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.

2.3 Detection, preparedness, and response to health emergencies

Data

Data for this indicator are the same as those used for "Indicator 2.2.5 Detection, preparedness, and response to health emergencies" in Romanello et al. (2023). Data obtained from the World Health Organization International Health Regulations Capacity Progress website (World Health Organization 2019).

Methods

Methods for this indicator are the same as those used for "Indicator 2.2.5 Detection, preparedness, and response to health emergencies" in Romanello et al. (2023).

Caveats

Caveats for this indicator are the same as those for "Indicator 2.2.5 Detection, preparedness, and response to health emergencies" in Romanello et al. (2023).

Future form of the indicator

The future form of this indicator is the same as that for "Indicator 2.2.5 Detection, preparedness, and response to health emergencies" in Romanello et al. (2023).

2.4 Migration and displacement

Data

Data for this indicator are the same as those used for "Indicator 1.5 Migration, displacement and rising sea levels" in Beggs et al. (2022).

Data sources:
Internal Displacement Monitoring Centre;
https://www.internal-displacement.org/countries/australia
https://www.internal-displacement.org/database/displacement-data
World Bank (2023).

Methods

Methods for this indicator are the same as those used for "Indicator 1.5 Migration, displacement and rising sea levels" in Beggs et al. (2022).

Caveats

Caveats for this indicator are the same as those for "Indicator 1.5 Migration, displacement and rising sea levels" in Beggs et al. (2022).

Future form of the indicator

As newer, higher spatial resolution, and more precise datasets become available, methods will be updated to produce more robust estimates of population exposure to sea-level rise and weather-related population displacement.

2.5 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 2022-23 were obtained from NAFC Annual Reports, a NAFC Booklet, and a NAFC Poster via the NAFC website (NAFC 2023), the Parliament of Australia (2020), 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 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, 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 numbers of volunteer firefighters and support staff in Australia per year from 2009-10 to 2021-22 were obtained from the Australian Government Productivity Commission's Report on Government Services 2023 (Australian Government Productivity Commission 2023). Specifically, data were obtained from Part D (Emergency management), Section 9 (Emergency services for fire and other events), Table 9A.4 (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 (Royal Commission into National Natural Disaster Arrangements 2020).

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 Energy system and health

Data

The data source for this indicator is the same as for "Indicator 3.1.1 Energy systems and health" in Romanello et al. (2023). Data for Australia were added.

Methods

Methods for this indicator are the same as those used for "Indicator 3.1.1 Energy systems and health" in Romanello et al. (2023).

Caveats

Caveats for this indicator are the same as those for "Indicator 3.1.1 Energy systems and health" in Romanello et al. (2023).

Future form of the indicator

Future reports can capture changes in each country's energy mix in greater detail as well as the speed at which the transition to a lower-carbon energy system occurs. The impact of decarbonisation efforts can be monitored to evaluate their impact on the carbon intensity of the energy system in various countries.

3.2 Clean household energy

Data

Data for Australia were sourced from Clean Energy Council (2023) and Clean Energy Council (2022).

Methods

This indicator offers a descriptive summary.

Caveats

Romanello et al. (2022) track the use of unhealthy and unsustainable fuels and technologies for cooking, heating, and lighting. This is less of an issue for Australia where large parts of the population can access safe alternatives. Again, we note a lack of data for Indigenous and remote communities where these issues are likely more prevalent.

Future form of the indicator

The indicator can be further developed to track the corresponding impacts on air pollutants. Again, we note a lack of data for Indigenous and remote communities.

3.3 Exposure to particulate matter air pollution in cities

Data

Data preparation for this indicator was improved since the method used for "Indicator 3.5.1. Exposure to air pollution in cities" in Zhang et al. (2020). In brief, we have included more up-to-date monitoring data with imputation to fill missing data gaps for the years prior to 2021 with additional data sharing agreements made with State and Territory Governments (Centre for Air Pollution, Energy and Health Research 2021). Data for the recent period 2021-2023 were obtained from a national database developed by the University of Tasmania and CSIRO for the AQFx near-real-time bushfire smoke forecasting project AQVx (Centre for Air Pollution, Energy and Health Research, and AirRater 2022).

Air pollution monitoring data are not available from a central repository for the country and so we accessed the combined data for each State and Territory for the period 2000-2020 produced by the CAR National Air Pollution Monitor Database (NAPMD; DOI:10.17605/OSF.IO/JXD98). Hourly data were imputed for missing hours by averaging the hours before and after (where there was no more than one consecutive missing hour). These data are owned by: Environment Protection Authority Victoria, New South Wales Department of Planning and Environment, Department of Environment and Science Queensland, Environment Protection Authority South Australia, Environment Protection Authority Tasmania, Department of Water and Environmental Regulation Western Australia, Australian Capital Territory Health Department, and Northern Territory Environment Protection Authority.

The years 2021-2023 were provided by the AQVx, AirRater and CAR project API (accessed 15 June 2023). Hourly $PM_{2.5}$, derived from web scraping the APIs of the regulatory monitor data from the state and territory bodies listed in the previous paragraph.

Spatial boundaries for cities with populations greater than 100,000 inhabitants 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 for calculating the monthly and annual exposure estimates are the same as those for "Indicator 3.5.1 Exposure to air pollution in cities" in Zhang et al. (2020). In summary, daily averages were calculated when more than 70% of hours were observed in the 24-hour period midnight to midnight. Monthly averages were calculated when more than 70% of days were observed in the month and annual averages were calculated when more than 70% of months were observed in a year.

Caveats

Access to monitored $PM_{2.5}$ air pollution data for Australian State and Territory government agencies varies over time and so we were not able to develop a consistent dataset especially in the earlier years. One limitation of using the AQFx data via the near-real-time API database is that these are derived from the publication of monitor data that has not undergone full Quality Assurance (QA) and Quality Control (QC) procedures. Therefore, the period covered by the NAPMD data (2000 to 2020) shows data that have been verified as meeting high quality standards whereas the possible errors around measurements from 2021-2023 are uncertain. The other caveats for "Indicator 3.5.1 Exposure to air pollution in cities" in Zhang et al. (2020) also apply to this indicator.

Future form of the indicator

Future improvements of this indicator are to acquire the quality-controlled databases rather than the near-real-time API database currently used as source information for 2021-2023.

3.4 Sustainable and healthy transport

Data

State of Electric Vehicles 2022 - Electric Vehicle Council (2022).
Australian Electric Vehicle Industry Recap 2022 - Electric Vehicle Council (2023).
VFACTS 2022 - Federal Chamber of Automotive Industries (FCAI) (2023).
Australian Energy Update 2022 – Australian Government Department of Climate Change, Energy, the Environment and Water (2022).

Methods

Methods for this indicator are the same as those used for "Indicator 3.4 Sustainable and healthy transport" in Beggs et al. (2022).

Caveats

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

Future form of the indicator

As the electric vehicle fleet begins to grow over the next decade, there is the potential to add electric vehicles that do not require registration like electric bikes and scooters. Other valuable data could include details of trip exposure specific to electric vehicles (e.g., average km travelled per trip, total km per year, the share of total km driven, etc.).

3.5 Emissions from agricultural production and consumption

Data

Data for this indicator are the same as those used for "Indicator 3.5.1 Emissions from agricultural production and consumption" in Romanello et al. (2023)."

Methods

Methods for this indicator are the same as those used for "Indicator 3.5.1 Emissions from agricultural production and consumption" in Romanello et al. (2023)."

Caveats

Caveats for this indicator are the same as those for "Indicator 3.5.1 Emissions from agricultural production and consumption" in Romanello et al. (2023)."

For this indicator, emissions from palm oil are included in "other crops" as they do not represent a substantial proportion of the total in Australia.

Future form of the indicator

The indicator will be developed to include estimates of emissions associated with the transport of food.

3.6 Diet and health co-benefits

Data

Data for this indicator are the same as those used for "Indicator 3.3.2 Diet and health co-benefits" in Romanello et al. (2023).

Methods

Methods for this indicator are the same as those used for “Indicator 3.3.2 Diet and health co-benefits” in Romanello et al. (2023).

Caveats

Caveats for this indicator are the same as those for “Indicator 3.3.2 Diet and health co-benefits” in Romanello et al. (2023).

3.7 Health-care sector emissions

Data

Data for this indicator are the same as those used for “Indicator 3.6 Mitigation in the healthcare sector” in Romanello et al. (2023).

Methods

Methods for this indicator are the same as those used for Indicator 3.6: Mitigation in the Healthcare Sector in Romanello et al. (2023).

Caveats

Caveats for this indicator are the same as those used for Indicator 3.6: Mitigation in the Healthcare Sector in Romanello et al. (2023).

Future form of the indicator

A future form of the indicator could include updated sector-level estimates of health sector’s indirect emissions.

Section 4: Economics and finance

4.1 Economic losses due to climate-related extreme events

Data

Reported data are based on figures on total insured economic losses from disaster events provided in the *Historical Catastrophe Data* of the Insurance Council of Australia (ICA 2023). The database includes recorded data from the ICA on disaster events that have occurred over the last 50 years in Australia.

Cumulative annual insured losses arising from bushfires, cyclones, flooding, hailstorms, storm flooding, tornados and other climate-related extreme events are considered. Extreme events related to earthquakes, arson, gas disruptions, etc. (that are also reported in the ICA database), have been excluded.

Methods

Methods for this indicator are the same as those used for "Indicator 4.1 Economic losses due to climate-related extreme events" in Beggs et al. (2022).

Caveats

Caveats for this indicator are the same as those for "Indicator 4.1 Economic losses due to climate-related extreme events" in Beggs et al. (2022).

Future form of the indicator

An ideal form of this indicator would allow attribution of economic losses to events induced by climate change.

4.2 Clean energy investment

Data

The data for this indicator are sourced from the annual *State of the Energy Market* reports by the Australian Energy Regulator (AER 2022), and the Australian Energy Market Operator (2023) *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 4.2 Coal and clean energy investment” in Beggs et al. (2022).

Caveats

Caveats for this indicator are the same as those for “Indicator 4.2 Coal and clean energy investment” in Beggs et al. (2022).

Future form of the indicator

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

4.3 Employment in low-carbon and high-carbon industries

Data

Data for this indicator are provided by the ABS.

Data for full-time equivalent (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, and 10 Exploration and other mining support.

Methods

Methods for this indicator are the same as those used for “Indicator 4.3 Employment in low carbon and high carbon industries” in Beggs et al. (2022).

Caveats

Caveats for this indicator are the same as those for "Indicator 4.3 Employment in low carbon and high carbon industries" in Beggs et al. (2022).

Future form of the indicator

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

4.4 Funds divested from fossil fuels

Data

The data for the first indicator are collected from the Global Fossil Fuel Divestment Commitments Database (2023). 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 is committed to avoiding 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.

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

Data for the second indicator are sourced from the 2022 Integrated System Plan of the Australian Energy Market Operator (2022) and the Generation Information page of the Australian Energy Market Operator (2023). 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 4.4 Funds divested from fossil fuels" in Beggs et al. (2022).

Caveats

Caveats for this indicator are the same as those for "Indicator 4.4 Funds divested from fossil fuels" in Beggs et al. (2022).

Future form of the indicator

Future forms of this indicator should report the actual value of funds divested from fossil fuels by an organisation. 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 is 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.

4.5 Net value of fossil fuel subsidies and carbon prices

Data

Data for this indicator are the same as those used for "Indicator 4.2.4 Net value of fossil fuel subsidies and carbon prices" in Romanello et al. (2023) except that the data available are

taken only for the more recent year of 2023 and are reported in AUD. The CO_2 emissions data are taken from the Australian Greenhouse Emissions Information System compiled by the Australian Government Department of Climate Change, Energy, the Environment and Water.

Methods

Methods for this indicator are the same as those used for "Indicator 4.2.4 Net value of fossil fuel subsidies and carbon prices" in Romanello et al. (2023).

Caveats

Caveats for this indicator are the same as those for "Indicator 4.2.4 Net value of fossil fuel subsidies and carbon prices" in Romanello et al. (2023).

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 Beggs et al. (2022).

Methods

Methods for this indicator are the same as those used for "Indicator 5.1 Media coverage of health and climate change" in Beggs et al. (2022). The search methods for the major Australian newspapers and ABC online programs were the same as we did last year, except for adding new data up to the end of 2022.

Caveats

Only English articles in mainstream media were included. The indicator could not examine the access to these media articles by individuals and the differences between subgroups across the country.

Future form of the indicator

Social media online engagement (e.g., Twitter, Facebook) on climate change and health topics may be included for future analysis.

5.2 Scientific engagement in health and climate change

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 Beggs et al. (2022).

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 Beggs et al. (2022). The search methods were the same as last year, except for adding the data between 1 January 2022 and 31 December 2022.

Caveats

The quality of the publications and the subjects focused by the studies were not analysed.

Future form of the indicator

No change is expected for next year to keep the continuity of the indicator.

5.3 Government engagement in health and climate change

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 indicator were derived from the Parliamentary websites of the Commonwealth of Australia and its eight States and Territories.

Jurisdiction	Parliamentary website
Commonwealth of Australia	https://www.aph.gov.au
Queensland	https://www.parliament.qld.gov.au/
New South Wales	https://www.parliament.nsw.gov.au/
Australian Capital Territory	https://www.parliament.act.gov.au/
Victoria	https://www.parliament.vic.gov.au/
Tasmania	https://www.parliament.tas.gov.au/
South Australia	https://www.parliament.sa.gov.au/
Western Australia	https://www.parliament.wa.gov.au/
Northern Territory	https://nt.gov.au/

The data collected were as follows: for the Commonwealth of Australia we looked for Bills and Legislation, Committees and Inquiries, and Chamber documents that included a consideration of climate change and health. For the States and Territories, we looked for relevant Bills and Legislation, Committees and Inquiries, and overall Hansard records. Hansard is the report of proceedings and verbatim record of what was said in Parliament.

Methods

National

The datasets of the Parliament of Australia public website (https://www.aph.gov.au/Parliamentary_Business) were searched for records from 1 January 2022 to 31 December 2022.

Bills and legislation were searched by whole document and included all current and previous Bills sponsored by Government and Private Members/Senators. Committees and inquiries were searched using titles and summaries 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. Terms have been updated to reflect the changing terminology used to discuss climate change.

(a) climate change:

"climate change", "changing climate", "climate energy", "climate action", "climate decay", "global warming", "temperature", "extreme weather", "global environmental change", "climate variability", "greenhouse", "low carbon", "ghge", "renewable energy", "carbon emission", "co2 emission", "carbon dioxide", "carbon-dioxide", "decarbonisation", "decarbonization", "carbon neutral", "carbon-neutral", "net-zero", "net zero", "climate pollutant", "air pollution", "drought", "flood", "bushfire", "heat", "cyclone".

(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", "malnutrition", "mental disorder", "mental health", "depression", "suicide", "obesity" "death", "injury", "food".

(c) climate change AND health:

"climate health", "'climate change' AND 'health'"

Any Bills and 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".

States and Territories

Parliamentary websites were searched for records from 1 January 2022 to 31 December 2022 using the datasets Bills & Legislation and Committees & Inquiries, as well as a total Hansard search. State and territory websites were searched using terms (c) only: i.e., "climate health", "climate change" AND "health". Documents identified were hand searched for relevance.

Caveats

We have used a number of new climate terms that were not used in Indicator 5.3 in Beggs et al. (2022). Terms were updated in line with Indicator 5.4 in Romanello et al. (2022) to reflect the changing terminology used to discuss climate change. The following new terms were added: “changing climate”, “climate energy”, “climate action”, “climate decay”, “carbon dioxide”, “carbon-dioxide”, “decarbonisation”, “decarbonization”, “carbon neutral”, “carbon-neutral”, “carbon neutrality”, “carbon-neutrality”, “net-zero”, and “net zero”.

Documents that did not use health in the context of human health (e.g., ecosystem, ecological or reef health) were excluded.

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

State and territory website search tools are quite variable and some do not have advanced search functionality, thereby requiring hand searching.

At the national level, search (c) did not yield many results (Table A1). As such, (a) and (b) results for Bills were hand searched to identify documents that referenced climate change and health.

Due to the large number of search results, we did not hand search chamber documents from the Parliament of Australia 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 2022.

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 (Australian Government NHMRC 2019).

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. In the future, this indicator could also track health and climate change research grant applications to the other major Australian Government funder of research, the Australian Research Council (ARC).

Contributions: PJB and YZ Co-Direct the MJA-Lancet Countdown. Section introductions and conclusions were drafted by: PJB, Section 1; HB, Section 2; MKL, Section 3; ST, Section 4; and AGC, Section 5. Author contributions of indicators were as follows: AM, 3.7; CM, 2.4; DG, 4.5; HK, 3.5; ICH, 1.4, 3.3; MH, 5.3; MKL, 3.1, 3.2; MS, 3.4; NBA, 1.3; OJ, 1.2; PJB, 2.3, 2.5, 3.6, 5.4; SF, 3.6; ST, 4.1-4.4; SV, 2.1; TJC, 1.2; YZ, 5.1, 5.2. VM, GG, and RL contributed Box 1, AJW contributed Box 2, and TND and DP contributed Box 3. PJB 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, MBR, and YZ made substantial contributions to the overall conception and design of the work.

References

Australian Bureau of Statistics. Employment in renewable energy activities, Australia, 2018-19 financial year. Canberra: ABS, 2020. https://www.abs.gov.au/statistics/labour/employment-and-unemployment/employment-renewable-energy-activities-australia/latest-release (viewed August 2023).

Australian Energy Market Operator. 2022 integrated system plan. Sydney: AEMO, 2022. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp (viewed August 2023).

Australian Energy Market Operator. Generation information. Sydney: AEMO, 2023. https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information (viewed August 2023).

Australian Energy Regulator. State of the energy market 2022. Melbourne: AER, 2022. https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2022 (viewed August 2023).

Australian Government Bureau of Meteorology. Australian Water Availability Project. Melbourne: BOM, 2023. http://www.bom.gov.au/jsp/awap/ (viewed July 2023).

Australian Government Department of Climate Change, Energy, the Environment and Water. Australian energy update 2022. Canberra: DCCEEW, Sep 2022. https://www.energy.gov.au/publications/australian-energy-update-2022 (viewed July 2023).

Australian Government National Health and Medical Research Council. Background paper: NHMRC's role in addressing health implications of environmental change. Canberra: NHMRC, 2019.

Australian Government Productivity Commission. Report on government services 2023. Part D, Section 9: Released on 31 January 2023. 9 Emergency services for fire and other events. Canberra: Australian Government, Productivity Commission, 2023.

https://www.pc.gov.au/ongoing/report-on-government-services/2023/emergency-management/emergency-services (viewed June 2023).

Beggs PJ, Zhang Y, McGushin A, et al. The 2022 report of the *MJA–Lancet* Countdown on health and climate change: Australia unprepared and paying the price. *Med J Aust* 2022; 217: 439-458. https://www.mja.com.au/journal/2022/217/9/2022-report-mja-lancet-countdown-health-and-climate-change-australia-unprepared

Beguería S, Vicente-Serrano SM. SPEI: calculation of the standardised precipitation-evapotranspiration index. R package version 1.7. 2017.

Centre for Air Pollution, Energy and Health Research. Daily average $PM_{2.5}$ and PM_{10} 2000-2020 from the National Air Pollution Monitors Database (NAPMD), derived from CARDAT's NAPMD of regulatory monitor data from NSW DPIE, Vic EPA, Qld DES, SA EPA, WA DEWR, Tas EPA, NT EPA, and ACT Health. 2021. https://doi.org/0.17605/OSF.IO/JXD98 (viewed July 2023).

Centre for Air Pollution, Energy and Health Research, and AirRater. AQVx Hourly PM2.5, derived from web scraping and formal APIs of the regulatory monitor data from NSW DPE, Vic EPA, Qld DES, SA EPA, WA DEWR, Tas EPA, NT EPA, and ACT Health. 2022. http://cardat.github.io/data_inventory/aqfx_pm25_hourly_data_from_apis.html (viewed August 2023).

Clean Energy Council. Clean energy Australia: report 2022. Melbourne: CEC, 2022. https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2022.pdf (viewed July 2023).

Clean Energy Council. Australian rooftop solar breaks new ground in 2022: Clean Energy Australia Report. Melbourne: CEC, 2023. https://www.cleanenergycouncil.org.au/news/australian-rooftop-solar-breaks-new-ground-in-2022-clean-energy-australia-report (viewed July 2023).

Electric Vehicle Council. State of electric vehicles: October 2022. Sydney: Electric Vehicle Council, 2022.

Electric Vehicle Council. Australian electric vehicle industry recap 2022. Sydney: Electric Vehicle Council, February 2023.

Federal Chamber of Automotive Industries. FCAI releases 2022 new car sales data (VFACTS 2022). Jan 2023. https://www.fcai.com.au/news/index/view/news/787 (viewed June 2023).

Global Fossil Fuel Divestment Commitments Database. 2023. https://divestmentdatabase.org/ (viewed August 2023).

Insurance Council of Australia. Data hub, historical catastrophe data – June 2023. 2023. https://insurancecouncil.com.au/industry-members/data-hub/ (viewed July 2023).

Jay O, Broderick C, Smallcombe J. Extreme heat policy issued by Sports Medicine Australia, v1.0, February 2021. https://sma.org.au/sma-site-content/uploads/2021/02/SMA-Extreme-Heat-Policy-2021-Final.pdf (viewed August 2023).

Nairn J, Fawcett R. Defining heatwaves: heatwave defined as a heat-impact event servicing all community and business sectors in Australia [CAWCR Technical Report No. 060]. CSIRO and Australian Government Bureau of Meteorology, 2013. https://www.cawcr.gov.au/technical-reports/CTR_060.pdf (viewed May 2022).

Nairn JR, Fawcett RJB. The excess heat factor: a metric for heatwave intensity and its use in classifying heatwave severity. *Int J Environ Res Public Health* 2015; 12: 227-253.

National Aerial Firefighting Centre. Fleet. Melbourne: NAFC, 2023. http://www.nafc.org.au/?page_id=168 (viewed July 2023).

Parliament of Australia. 2019–20 Australian bushfires—frequently asked questions: a quick guide. Canberra: Parliament of Australia, 2020. https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1920/Quick_Guides/AustralianBushfires (viewed May 2022).

Romanello M, Di Napoli C, Drummond P, et al. The 2022 report of the *Lancet* Countdown on health and climate change: health at the mercy of fossil fuels. *Lancet* 2022; 400: 1619–1654.

Romanello M, Di Napoli C, Green C, et al. The 2023 report of the *Lancet* Countdown on health and climate change: …. *Lancet* 2023; https://doi.org/10.1016/....

Royal Commission into National Natural Disaster Arrangements. Royal Commission into National Natural Disaster Arrangements: Report. Canberra: Commonwealth of Australia, 2020.

Watts N, Amann M, Arnell N, et al. The 2020 report of the *Lancet* Countdown on health and climate change: responding to converging crises. *Lancet* 2021; 397(10269): 129–170.

World Bank. Population, total – Australia. NW Washington, DC: The World Bank, 2023. https://data.worldbank.org/indicator/SP.POP.TOTL?end=2020&locations=AU&start=2008 (viewed June 2023).

World Health Organization. IHR capacity progress. Geneva: WHO, 2019. https://extranet.who.int/e-spar/Home/Capacity (viewed June 2023).

Zhang Y, Beggs PJ, McGushin A, et al. The 2020 special report of the *MJA–Lancet* Countdown on health and climate change: lessons learnt from Australia's "Black Summer". *Med J Aust* 2020; 213: 492-492.e10. https://www.mja.com.au/journal/2020/213/11/2020-special-report-mja-lancet-countdown-health-and-climate-change-lessons

Tables

Table A1. Total number of national Parliament of Australia documents related to climate change, health, and climate change and health

		(a) Climate change	(b) Health	(c) Climate change AND health
Bills & legislation	Passed	9	18	0
	Not passed	5	3	0
	Before parliament	3	3	0
	Sub-total	**17**	**24**	**0**
Committees & inquiries	Committees	1	3	0
	Inquiries	4	8	0
	Hearings	4	17	0
	Sub-total	**9**	**28**	**0**
Chamber documents*		2186 (98 title only)	5184 (540 title only)	330 (0 title only)

Note: * 1 Bill was identified using both (a) and (b) search terms – Regulator Performance Omnibus Bill 2022. There were 16 separate issues discussed in the included inquiries and hearings. The number of chamber documents may contain duplicates across different search terms.

Table A2. Total number of bills, committees and inquiries, and Hansard results related to climate change and health in Australian State and Territory Parliaments

Jurisdiction	Bills	Committees & Inquiries	Hansard results
Queensland	0	8	45
New South Wales	2	3	84
Australian Capital Territory	3	9	76
Victoria	0	0	139
South Australia	0	2	48
Tasmania	0	2	117
Western Australia	0	7	76
Northern Territory	0	0	35
All States and Territories	**5**	**31**	**620**

Table A3. Climate health related bills and inquiries before Australian State and Territory Parliaments

Jurisdiction	Bill or Inquiry title	Sponsor/Committee*
QLD	Inquiry into the Environmental Protection and Other Legislation Amendment Bill 2022	Health and Environment Committee
	2022-23 Budget Estimates	Health and Environment Committee; Community Support and Services Committee; Economics and Governance Committee; Education, Employment and Training Committee; Legal Affairs and Safety Committee; Transport and Resources Committee; State Development and Regional Industries Committee
	Inquiry into the Auditor-General Reports on The Water Sector (No. 3: 2021-22—Water 2021)	State Development and Regional Industries Committee
	Inquiry into the Nature Conservation and Other Legislation Amendment Bill 2022	State Development and Regional Industries Committee
	Inquiry into the Animal Care and Protection Amendment Bill 2022	State Development and Regional Industries Committee
	Inquiry into the Agency Annual Reports	Transport and Resources Committee
	Inquiry into the Auditor-General Report 10: 2021-22—Transport 2021	Transport and Resources Committee
	Inquiry into the Economic and Regulatory Frameworks for Queensland's Island Resorts	Transport and Resources Committee
NSW	Environmental Planning and Assessment Amendment (Climate Change Response) Bill 2022	Minor Party (GRN)
	Greater Cities Commission Bill 2022	Government (LP)

	Inquiry into Embedded Networks in NSW	Legislative Assembly Committee on Law and Safety
	Inquiry into Emission Free Modes of Public Transport	Legislative Assembly Committee on Transport and Infrastructure
	Inquiry into the Auditor General's performance audit reports June - December 2020	Public Accounts Committee
ACT	Health Legislation Amendment Bill 2022	Government (ALP/ GRN)
	Planning Bill 2022	Government (ALP/ GRN)
	Urban Forest Bill 2022	Government (ALP/ GRN)
	Inquiry into Annual and Financial Reports 2021–2022	Standing Committee on Economy and Gender and Economic Equality; Standing Committee on Education and Community Inclusion; Standing Committee on Environment, Climate Change and Biodiversity; Standing Committee on Health and Community Wellbeing; Standing Committee on Justice and Community Safety; Standing Committee on Planning, Transport and City Services
	Inquiry into Environmental Volunteerism	Standing Committee on Environment, Climate Change and Biodiversity
	Inquiry into Climate Change and Greenhouse Gas Reduction (Natural Gas Transition) Amendment Bill 2022	Standing Committee on Environment, Climate Change and Biodiversity
	Inquiry into the waste management of absorbent hygiene products	Standing Committee on Environment, Climate Change and Biodiversity
	Inquiry into the West Belconnen supercell thunderstorm	Standing Committee on Health and Community Wellbeing
	Inquiry into Dangerous Driving	Standing Committee on Justice and Community Safety
	Inquiry into Planning Bill 2022	Standing Committee on Public Accounts

	Inquiry into Auditor-General's Report: 4/2020 – Residential Land Supply and Release	Select Committee on Estimates 2022-2023
	Inquiry into Appropriation Bill 2022-2023 and Appropriation (Office of the Legislative Assembly) Bill 2022-2023	Standing Committee on Public Accounts
SA	Inquiry into Public and Active Transport	Select Committee on Public and Active Transport
	Inquiry into Health Services in South Australia	Select Committee on Health Services in South Australia
TAS	Inquiry into Government Business	Government Businesses Scrutiny Committees
	Inquiry into Appropriation Bills (No. 1 and No. 2) and budget papers	Estimates Committees
WA	Inquiry into Western Australia's bilateral trade relationship with the Republic of Indonesia	Economics and Industry Standing Committee
	2021-22 Annual Reports Inquiry	Estimates and Financial Operations Committee; Joint Standing Committee on the Commissioner for Children and Young People
	Independent review of DBCA prescribed burning practices	Environment and Public Affairs Committee
	Inquiry into the most effective ways for Western Australia to address food insecurity for children and young people affected by poverty	Joint Standing Committee on the Commissioner for Children and Young People
	Inquiry into the response of Western Australian schools to climate change	Education and Health Standing Committee
	2022-23 Budget Estimates Inquiry	Estimates and Financial Operations Committee
	2020-21 Annual Reports	Estimates and Financial Operations Committee

* ALP: Australian Labor Party; LP: Liberal Party; NP: National Party; GRN: Greens Party.

Figures

Figure A1. Average of monthly standardised precipitation evapotranspiration index (SPEI) values from Autumn (March – May) 2023. Negative values indicate drier conditions. Levels below -1.3 are considered droughts. Areas that experienced extremely dry weather are shown as red, whereas those areas that did not are shown as blue

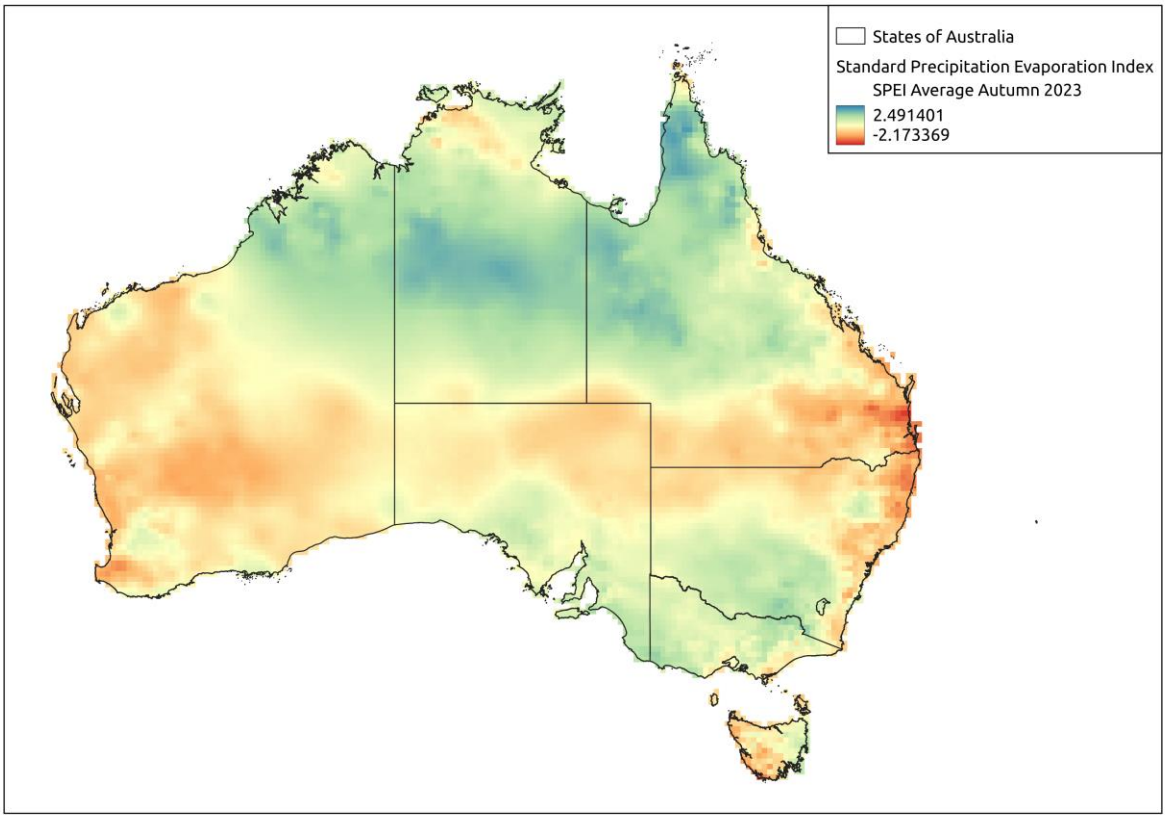

Figure A2. Annual time-series plot of drought affected area in Australia January 1950 - May 2023 shown as A) percentage of area in “excess severe drought”, “excess extreme drought” and “excess exceptional drought” where an excess event is classified as exceeding 2 standard deviations above mean annual counts (1950-2005 baseline); and B) annual average Standardised Precipitation-Evapotranspiration Index (SPEI) showing hotter/drier months as scores below zero and wetter/cooler months as scores above zero

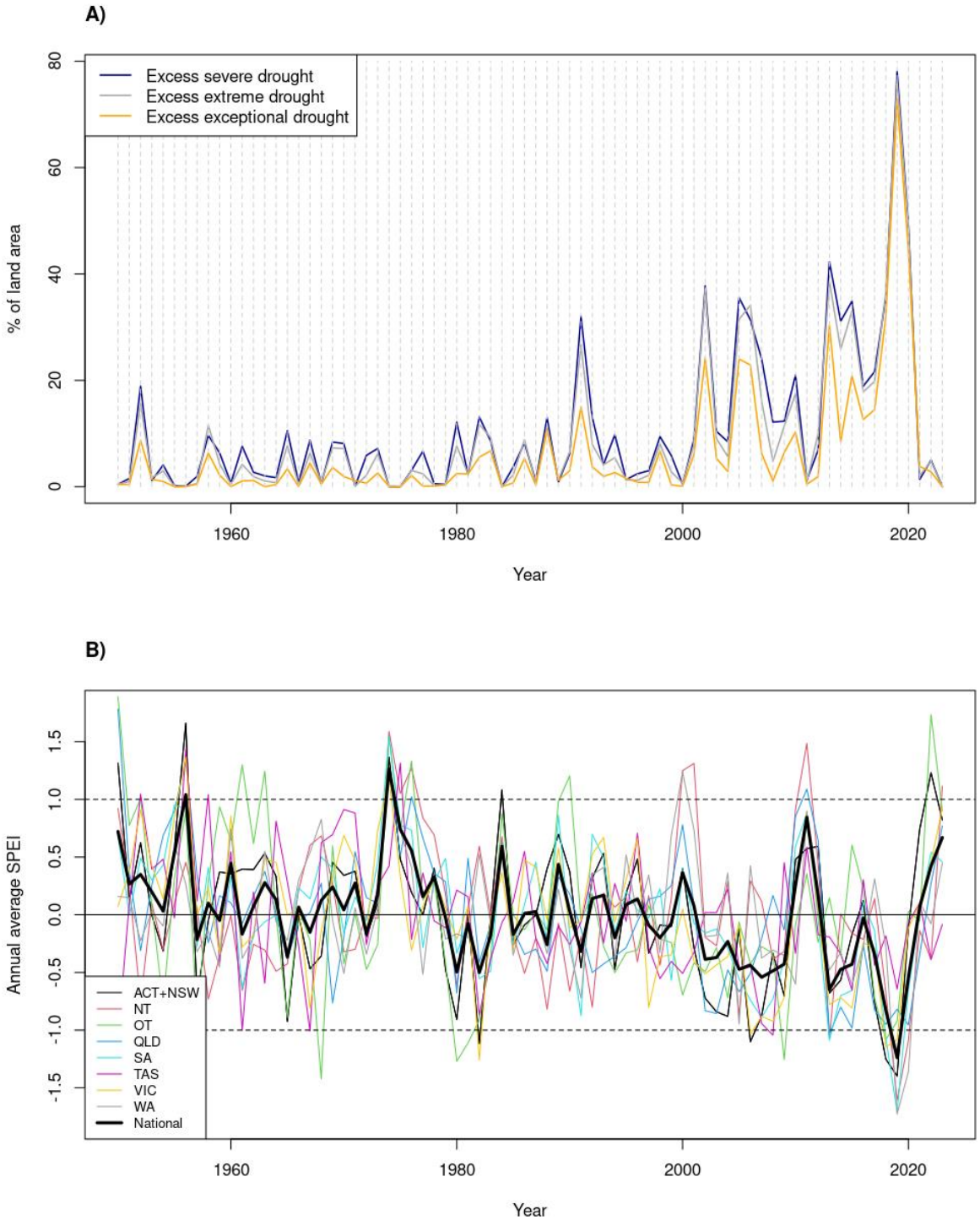

Figure A3. Carbon intensity of total primary energy supply for Australia, selected countries and the world, and corresponding total carbon dioxide (CO_2) emissions from fuel combustion, 1971–2021. Data source: International Energy Agency

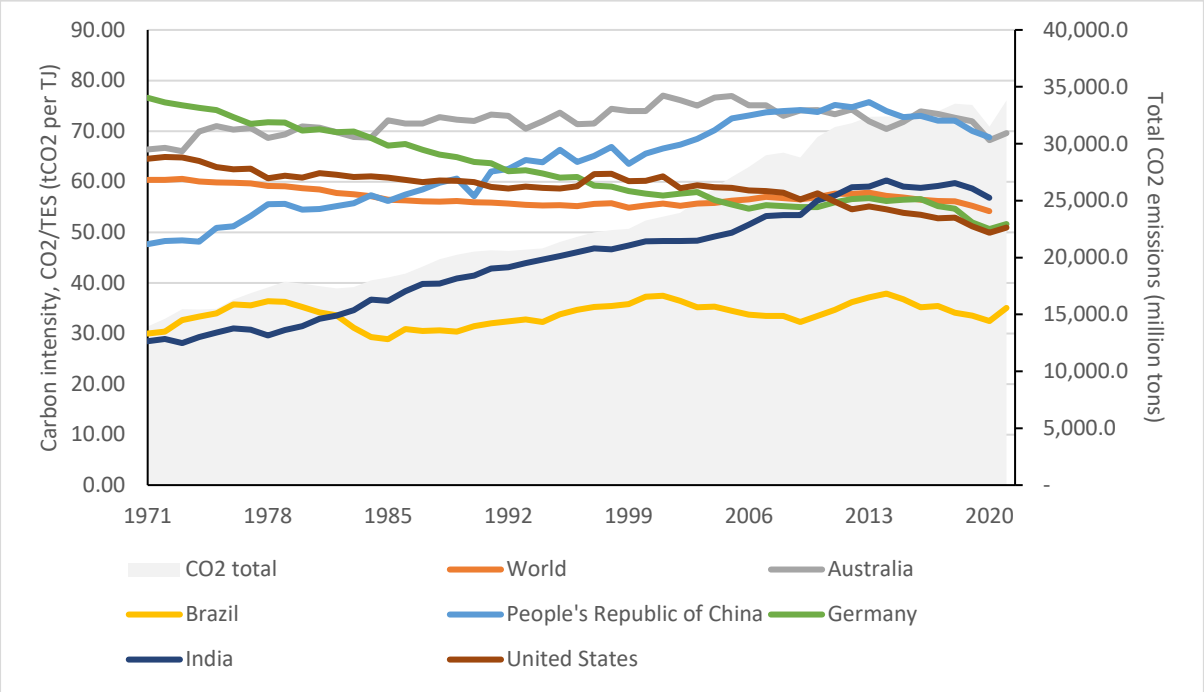

Figure A4. Annual direct full-time equivalent (FTE) employment in renewable energy activities for Australia, New South Wales, South Australia, Queensland, and Victoria, 2009–10 to 2018–19. Source: Australian Bureau of Statistics (2020)

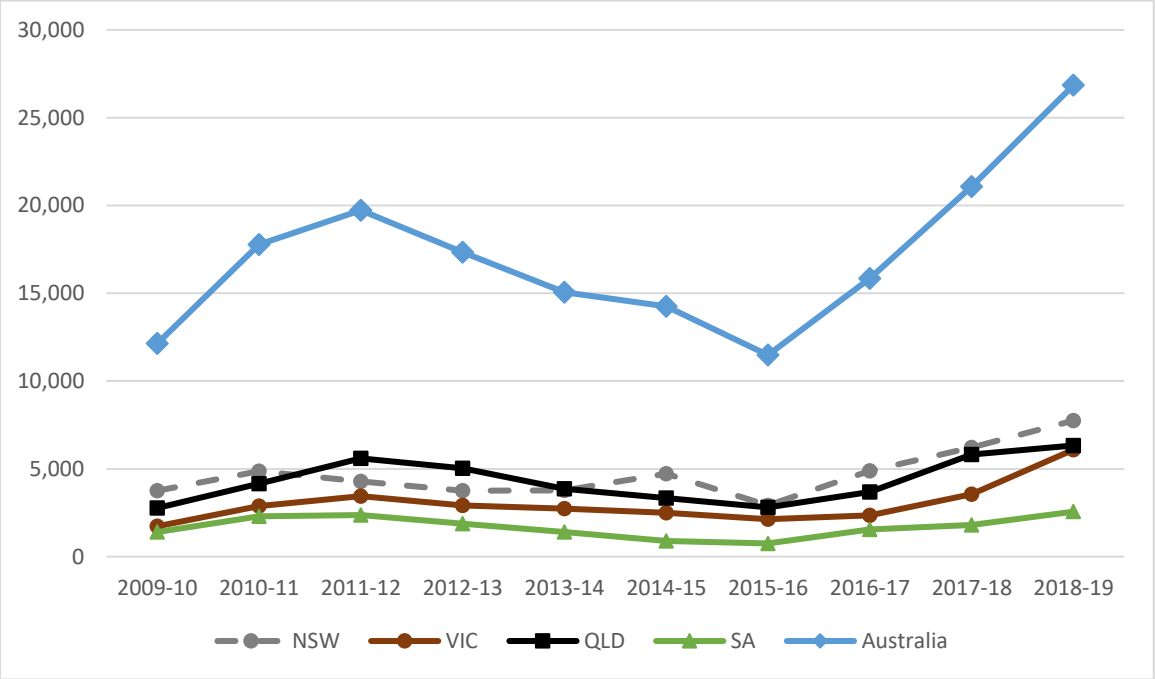

Figure A5. Number of scientific publications on climate change and health in Australia, 1 January 2008-31 December 2022