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Title:
Submission to Royal Commission Inquiry on Australia's preparedness for, and response to, natural disasters

Date:
2020-06-01

Citation:
Schofield, R., Silver, J. & Ryan, R. (2020). Submission to Royal Commission Inquiry on Australia's preparedness for, and response to, natural disasters

Persistent Link:
https://hdl.handle.net/11343/276271

Royal Commission into National Natural Disaster Arrangements

Submission Form

Please complete this form if you would like to provide input or comments about coordination, preparedness for, response to and recovery from the 2019-20 'Black Summer' bushfires.

Personal and Background Information

1. **Full Name** **Robyn Schofield**
2. **Email** [redacted]
3. **Mobile/Telephone** [redacted]
4. **What is your preferred method of contact if we want to follow up with you?**

Email.

5. **The Commission would like to understand the views of community groups based on their respective experiences and background.**
    a. Please select Option 1 if you are providing input and comments primarily based on your personal situation.
    b. Please select Option 2 if you are providing input and comments primarily based on your professional knowledge, qualifications or experience, or on behalf of a group or organisation

Option 1: Based on your personal situation, please complete the following.

a. What was your personal situation in relation to the 2019-20 Bushfires? Please choose all that apply.

- ☐ I was not living in an area affected by bushfire
- ☐ I lived in an area affected by bushfires but was not evacuated, and didn't suffer personal or financial loss
- ☐ I lived in an area affected by bushfires and was evacuated, but didn't suffer personal or financial loss
- ☐ I lived in an area affected by bushfires and was evacuated, and I suffered personal or financial loss
- ☐ I was part of the emergency response as a fire fighter on the ground
- ☐ I was part of the emergency response as an aerial fire fighter

- ☐ I was part of the emergency response as health professional
- ☐ I was part of the emergency response as an Australian Defence Force member
- ☐ I was part of the emergency response as a Commonwealth or State government employee
- ☐ I assisted the emergency response as a community support volunteer
- ☐ I assisted the emergency recovery (i.e. after the fire event) as a community support volunteer
- ☐ Other

b. Where do you live? Please provide your Local Government Area, town name and post code.

Local Government Area Choose an item.
Town name
Post code

Option 2: Based on your knowledge, qualifications or experience, or your role representing a group or organisation, what is your area of expertise? Please choose all that apply.

- ☐ Emergency/disaster response and/or management
- ☒ Environment/land management
- ☐ Land use, planning, building standards
- ☒ Impacts of changes in climatic conditions
- ☐ Wildlife conservation
- ☐ Traditional land and fire management practices of Indigenous Australians
- ☐ Community welfare
- ☒ Other

Input / Comments

6. In your experience, what areas of the bushfire emergency response worked well?

The information provided for meteorology and fire location to both emergency response planners and firefighters was fantastic. The use of the Himawari satellite products and collaboration between the Japanese space agency and the Bureau of Meteorology was great and almost certainly can be credited for the low number of resultant direct fire related deaths for the Black Summer period.

The information dissemination to the public concerning fire danger and evacuation notifications and ABC reporting was extremely respected and adhered to. This is a great example of when the emergency response coordination results in clear messaging, to avoid confusion.

7. In your experience, what areas of the bushfire emergency response didn't work well?

The air quality observations, advisories, readiness with clean air shelters and public confusion around smoke action plans were insufficient to avoid smoke related mortality.

Our attached atmospheric chemistry expert response deals with this.

8. In your experience, what needs to change to improve arrangements for preparation, mitigation, response and recovery coordination for national natural disaster arrangements in Australia?

Our attached atmospheric chemistry expert response deals with this.

9. Is there anything else you would like to tell the Royal Commission?

Our attached atmospheric chemistry expert response deals with this.

10. Do you intend to provide supporting material?

☒ Yes
☐ No

If you are providing any supporting material, please include it with your Submission if possible. If you need to send it separately (e.g. if you make a Submission over the phone), please ensure supporting material can be clearly identified as relating to your Submission by including your name or other identifier so that it can be considered with your Submission.

11. Do you agree to your submission being published? (Mandatory)

- ☒ Yes, I agree to my submission being published in my name
- ☐ Yes I agree to my submission being published anonymously
- ☐ No I don't agree to my submission being published

Once you have completed this form, email it to rcnda.submissions@royalcommission.gov.au or print the form and post it to the Royal Commission at:

National Natural Disaster Royal Commission
Locked Bag 2000
Manuka ACT 2603

Dear Air Chief Marshal Mark Binskin, The Honourable Dr Annabelle Bennett and Professor Andrew Macintosh,

We apologize that our submission comes after the consultation closing date, as we have been recently engaged in atmospheric chemistry research related to COVID19 as well as balancing working from home and online teaching commitments.

We wish to submit this response to the Commissioners' request for further submissions from the air quality / atmospheric chemistry sector and hope that it will still be useful. We are happy to expand on any points should this be of interest.

Yours sincerely,

Dr Robyn Schofield, Director of Environmental Science, University of Melbourne
Dr Jeremy Silver, School of Earth Sciences, University of Melbourne
Mr Robert Ryan, School of Earth Sciences, University of Melbourne

Cite as: Schofield, R., Silver, J., Ryan, R., submission to Royal Commission Inquiry on Australia's preparedness for, and response to, natural disasters, June 2020

We respond under the areas requested by the Terms of Reference for the Extreme bushfires experienced in Australia 2019/2020:

a) The responsibilities of, and coordination between, the Commonwealth and State, Territory and local Governments relating to preparedness for, response to, resilience to, and recovery from, natural disasters, and what should be done to improve these arrangements, including with respect to resource sharing;

Advisories

Annually, particulate matter and ozone pollution in Australia is estimated to cause ~4880 excess deaths (2017, Global Burden of Disease[1]) – far exceeding road traffic and skin cancer injuries – this occurs outside of natural disasters, and clearly points to lack of resilience in terms of air currently. The early evidence is that during the Black Summer, fine aerosols ($PM_{2.5}$, or particulate matter with a diameter of 2.5 μm or smaller) from smoke caused an immediate 417 excess deaths in NSW, VIC, QLD and ACT (Arriagada et al., 2020). Our commentary on responses to poor air quality will focus (though not exclusively) on fine aerosols, as this is responsible for the bulk of adverse health outcomes attributable to air pollution.

The advisories provided using **air quality categories**, **action plans** and how this **information** is **disseminated** should be nationally coordinated, with state and expert representation.

1 https://www.stateofglobalair.org/data/#/health/plot screenshot of plot for air pollution deaths for Australia provided at end of document.

Air Quality Categories

There is a confusing number of categories across the States and Territories, and in the public realm for air quality. Figure 1 presents the hourly and 24 hourly $PM_{2.5}$ data for a single station – the Melbourne CBD – in January 2020. We have translated individual state Air Quality Indices (AQI - just for $PM_{2.5}$ values) and provided these as a scale alongside. It is immediately evident that the different state language and thresholds being used for AQI categories resulted in the confusing 'air' messaging we experienced this summer across the country.

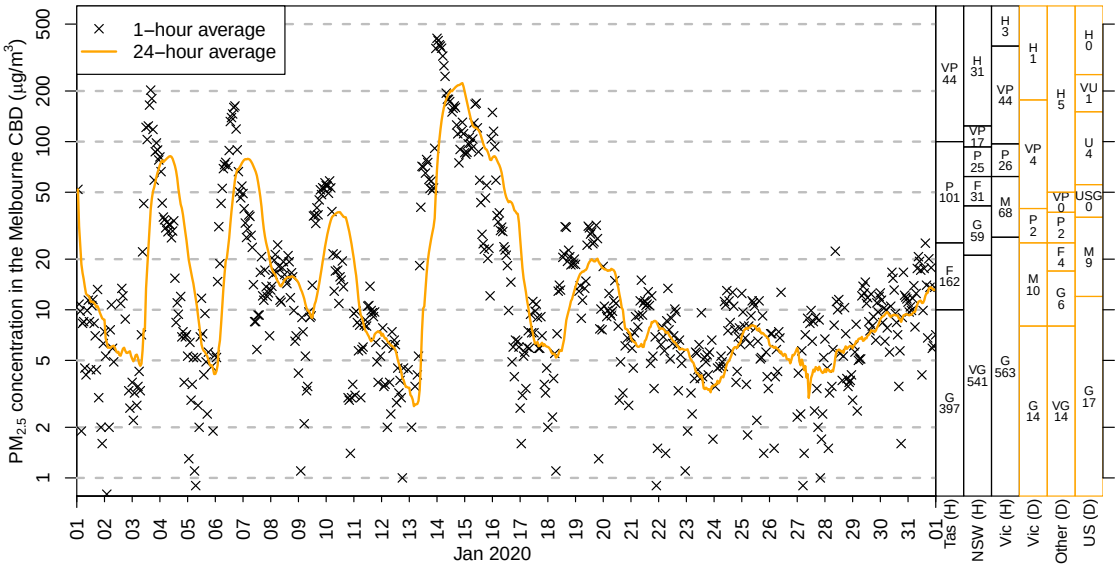


Figure 1: PM2.5 hourly data (black crosses), 24 hour rolling average to the last hour (orange) for the Melbourne CBD from 1st January to 1st February 2020. The right hand panel translates this in Air Quality Index advisories based on NEPM for each hour (H) given as black categories: for Tasmania, New South Wales and Victoria. The 24 hour average (D) in orange provided by Victoria and Other (combining the states NSW, ACT, NT, WA(Extreme replaces Hazardous) and SA & QLD (who don't have a Hazardous category with Very Poor being their worst category)) and the World Health Organization categories. G=Good, F=Fair, P=Poor, VP=Very Poor, H=Hazardous, M=Moderate, USG=Unhealthy for Sensitive Groups, U=Unhealthy, VU=Very Unhealthy are all the terminology used across the states and world for these AQ categories. The numbers in the right hand panel represent the total number of Hours or Days within each category (i.e where VIC would have reported just 3 hours of hazardous conditions, NSWs would have reported 31 hours for the same dataset).

There is a current lack of clarity between states on what is considered 'hazardous' and there is no clear advisory on what actions to take when this level of pollution occurs (see action section below for more detail).

The US EPA provides very clear health based guidelines, they define 'Smoke waves' as PM2.5 > 20 μgm^{-3} for more than 2 consecutive days. Figure 2 has been developed using the nationally consistent US category system.

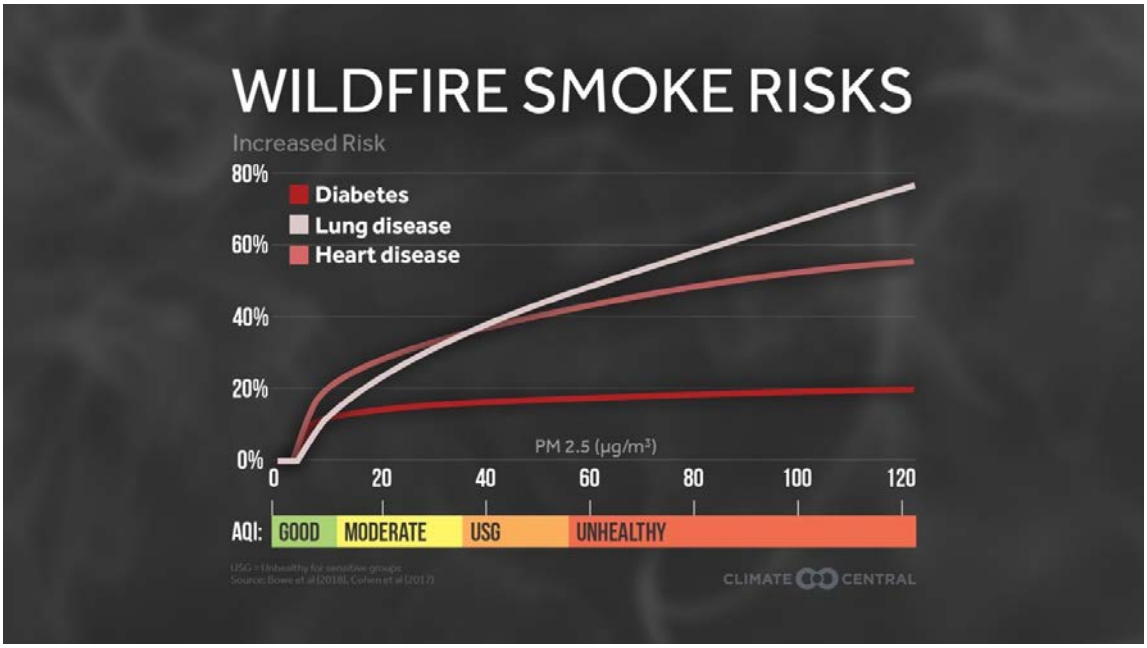


Figure 2: Clear messaging about health associated risks from 24 hour average exposures to PM2.5 to smoke. Accessed from https://medialibrary.climatecentral.org/resources/wildfire-smoke-waves-2018 on the 4th June 2020.

KEY RECOMMENDATIONS:
- A nationally consistent PM2.5 category system is to be established for smoke, dust and other air hazards with agreed upon language, for both hourly and daily exceedance categories.

Actions

The actions to be taken should be consistent across Australia when air quality thresholds are crossed.

There needs to be a clear health based nationally consistent 'air plan' advisories. This will avoid that organisers of outdoor events, outdoor sport, outdoor work / education are independently expected to develop plans, which is clearly a role only for health experts. For example, this summer Tennis Australia, Auskick, Cricket, Pools, Surf life-saving Australia, music festivals, individual schools, Universities (to name a few) were all making their own decisions (without Worksafe, the department of Education or the department of Health or the state EPAs providing consistent or complete action plan information).

What activity can I do?

Air Quality Index (AQI)	Colour indicator	What does it mean?
0-33	Very good	Enjoy normal activities.
34-66	Good	Enjoy normal activities.
67-99	Fair	People unusually senstive to air pollution should reduce or reschedule strenuous outdoor activities. Others are are not likely to be affected when the AQI is in this range.
100-149	Poor	Sensitive groups should reduce or reschedule strenuous outdoor activities. Other adults are not likely to be affected when the AQI is in this range.
150-199	Very poor	Sensitive groups should avoid strenuous outdoor activities. Other adults should reduce or reschedule strenous outdoor activities.
200+	Hazardous	Sensitive groups should avoid all outdoor activities. **Other adults should avoid strenous outdoor activities.**

Figure 3: Activity advisory from NSW. Accessed from https://www.health.nsw.gov.au/environment/air/Pages/aqi.aspx on the 5 June 2020.

Figure 3 provides the activity advisory of the NSW government, in contrast the VIC EPA has individual advisories for staying indoors, following action plans, moving to air-conditioned buildings etc. Both of these advisories fall short of information required by employers, event organisers and education providers. In contrast, the clarity provided by an advisory such as provided in Figure 4 would be very welcome clear guidance on when cancellation of outdoor activities and outside work etc would occur. Mask wearing also needs to be part of the advisory provided.

Table 3. Recommended Actions for Public Health Officials

Category	$PM_{2.5}$ or PM_{10} Levels ($\mu g/m^3$, 1- to 3-hr avg.)	Visibility - Arid Conditions (miles)	Recommended Actions
Good	0 - 40	▲ 10	If smoke event forecast, implement communication plan
Moderate	41 - 80	6 – 9	- Issue public service announcements (PSAs) advising public about health effects/symptoms and ways to reduce exposure - Distribute information about exposure avoidance
Unhealthy for Sensitive Groups	81 - 175	3 – 5	- If smoke event projected to be prolonged, evaluate and notify possible sites for clean air shelters - If smoke event projected to be prolonged, prepare evacuation plans
Unhealthy	176 - 300	1.5 - 2.5	- Consider "Smoke Day" for schools (i.e., no school that day), possibly based on school environment and travel considerations - Consider canceling public events, based on public health and travel considerations
Very Unhealthy	301 - 500	1 – 1.25	- Consider closing some or all schools (However, newer schools with a central air cleaning filter may be more protective than older, leakier homes. See "Closures", below) - Cancel outdoor events (e.g., concerts and competitive sports)
Hazardous	> 500	▸ 0.75	- Close Schools - Cancel outdoor events (e.g., concerts and competitive sports) - Consider closing workplaces not essential to public health - If PM level projected to continue to remain high for a prolonged time, consider evacuation of sensitive populations

Figure 4: Advisories for Health professionals accessed from *https://www3.epa.gov/ttnamti1/files/ambient/smoke/wildgd.pdf accessed 5 June 2020*

When air is hazardous, safe air shelters (i.e. public spaces where HEPA filtered air can be assured) need to be provided. All work places with staff over 500 people should provide a space suitable for use in extreme smoke conditions. Event centres, hospitals, schools, libraries and evacuation centres should be readied as 'safe air shelters' for resilience of communities.

KEY RECOMMENDATIONS:

- Air Quality categories need to have clear actions associated with them for public messaging (health based and co-developed with Worksafe, state-based regulators, health departments and first responders).
- Safe Air shelters need to be established in order to provide access to safe air for vulnerable members of our communities and under extremely hazardous conditions all community members

Information dissemination / Coordination between states / Commonwealth

Ambient Air Quality in Context: 2011-16 website outlining the state of the environment 2016 https://soe.environment.gov.au/theme/ambient-air-quality/topic/2016/ambient-air-quality-2011-16-context highlights:

"Work is progressing on the roll-out of a National Air Quality Data Service to be run by the Bureau of Meteorology, which will provide much better access to data for the community and a wide range of users."

As far as we are aware this had not happened in time for the 2019/2020 Black Summer however this is exactly the type of system of coordination that is required for Air Quality information dissemination.

The same State of the Environment report in 2016 noted:
"The revision also added a new requirement for a $PM_{2.5}$ population exposure metric to be reported annually from 2018. But review of standards for the other pollutants—ozone, nitrogen dioxide and sulfur dioxide—continues more than 10 years after the review was initiated in 2005."

All of these criteria pollutants are produced by bushfires either directly or indirectly (i.e through atmospheric chemistry), and our current NEPM standards for ozone, NO_2 and SO_2 set in 1998, are not based on our most up to date health knowledge (these standards are still in 2020, under review). In bushfire smoke there are many other compounds that firefighters and community members are exposed to, such as mercury, formaldehyde and toluene (see MacSween et al., (2019) for a comprehensive list). As such, both building standards and personal protective equipment (masks) need to be examined for noxious gas exposure standards (there is an absence of formaldehyde standards for example) as well as ventilation/filtration provisions to provide protection against hazardous exposures to particulate matter.

None of the state based EPAs, nor a nationally endorsed information source, provided smartphone Apps for air quality information (EPAs did update their websites hourly). The current situation in Australia is that there is a plethora of Smartphone Apps that have filled the vacuum of public information because they provide an individualised personal, map browsing or forecasting capabilities. A non-exhaustive list of these apps are provided in Table 1.

Table 1: Non-exhaustive list of free Smartphone Apps useful to find your locations' air quality. Bold are the most informative Apps, or elements that make them attractive to users:

	Data source / Units	Data / Advice
Plume labs	EPA monitoring AQI (USA); CAQI (Europe); AQI (China) ADAQI (Abu Dhabi)	• AQI, NO_2, $PM_{2.5}$; PM_{10}; O_3; Met • Ability to add air quality monitor from Plume Labs • 3 day forecast; • Tips for running, cycling, babies/sensitive, outdoor dining
IQAir Air Visual	**EPA monitoring** AQI (USA); AQI (CN)	• **AQI, $PM_{2.5}$, modelled using satellite data, EPA sites; IQAir Earth; Met**

		• **AirVisual Pro (Indoor & Outdoor) monitor ($USD 295)** • **2 day forecast**
My AQI Air	EPA monitoring Criteria Pollutants	• $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2, CO
AirRater	**EPA monitoring** **AQI (TAS) categories**	• **Monitoring stations,** $PM_{2.5}$**, Pollen, Met** • **Model used when >15km from monitoring stations (updated every 10 mins for TAS; hourly for VIC and NSW)**
Windy	**Satellite -** NO_2 **(μg/m³),** $PM_{2.5}$ **(μg/m³), aerosol (AOD) and total ozone column (DU)**	• **Air Quality prediction system – assimilation of satellite observations into a global model (coarse) ECMWF based model CAMS** • **3 day forecast**
Air Matters	**EPA monitoring station data** **Criteria Pollutants and historical** **AQI (Australia = NSW)**	• **AQI (Australia) = NSW** • **$PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2, CO** • **Advice for health (purifier, kids/elderly, ventilation, mask, outdoor)** • **Weather forecast**
Air Quality	EPA monitoring and met station data Criteria Pollutants AQI (US)	• AQI (US) • $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2, CO • **Advice for health (purifier, kids/elderly, ventilation, mask, outdoor)** • Weather forecast
Air Checker	EPA monitoring and met station data $PM_{2.5}$	• AQI (US) • $PM_{2.5}$ • Advice for health (masks, outdoor)
BreezoMeter	Model Criteria pollutants, and BAQI	• BAQI (Breezometer's own using CAQI, US AQI and CN AQI) • **Personal exposure, using phone's GPS location** • Weather • Advice for health (masks, outdoor) • 5 hour AQ forecast

KEY RECOMMENDATIONS:

- A national Emergency App needs to be developed delivering weather, fire and air observations and predictive capability (windy app is an exemplary example if fire information added) – this would be useful for emergency response teams, event organisers and community/business leaders to plan / cancel / advise their workers/communities.

Observations

EPA air quality data availability for pollutants 1/11/2019 to 28/2/2020

Site ID	Site name	PM10	PM2.5	O3	CO	NO2
10001	Alphington					
10003	Footscray					
10239	Melbourne CBD					
10136	Mooroolbark					
10169	Melton					
10022	Dandenong					
10213	Brooklyn					
10107	Geelong Sth					
10011	Traralgon					
10217	Morwell Sth					
10017	Morwell East					
10218	Moe					
10219	Churchill					
10352	Newborough					

Key
>75 % data available
25 % < data available < 75 %
<25 % data available

Figure 5: Data availability for air quality criteria pollutants for Victoria from the Victorian EPA sites between November 2019 and February 2020.

$PM_{2.5}$ observations are made by state agencies (TAS EPA, VIC EPA, NSW OEH etc). Figure 5 illustrates the data availability of criteria pollutants monitored by the Victorian EPA. Only two stations in the entire state measured all pollutants consistently. It is clear that the data scarcity and ability to create AQI advisories valid for the urban areas was challenged and significant regional populations centres such as Bendigo, Ballarat etc do not have AQ monitoring at all. This means that most of the state relied on satellite or global modelling (internationally produced products) for AQ information and advisories. Satellites observe Aerosol Optical Depth (AOD), requiring ground-based validation. Australia's ground-based AOD observations are part of the under-resourced network of Aerospan network (Bureau of Meteorology / CSIRO). This network is insufficient to accurately validate satellite AOD products for our region, i.e. there is no urban based Aerospan reporting monitors in Canberra, Sydney, Brisbane or Melbourne, none shown to report in Victoria though one was recently established at Aspendale, CSIRO we believe):
https://research.csiro.au/acc/capabilities/aerospan/aerospan-data/

There is no routine monitoring of the composition of the aerosols in most of our states (outside of ANSTO's and CSIRO's weekly filter analyses). High time resolution particulate composition monitoring is required to determine the health implications of air pollution. $PM_{2.5}$ observations are a mass based measurement, whereas the number, size and composition of the aerosol particles is most directly related to the poorest health outcomes (i.e. ultrafines (<0.1 microns) in smoke and diesel exhaust etc). Ultrafines are not measured routinely across Australia. We do not know the iron content of particulate matter from dust storms, we do not know the actual size of smoke and aged-smoke in air from fires mixing with urban pollution – such information is required to link to population exposure estimations and build the knowledge base for health driven action plans.

There are international ground-based networks which attempt to validate the health relevant composition of $PM_{2.5}$ – such as the SPARTAN network: https://www.spartan-network.org/ Australia currently does not contribute to this network, therefore our region's dust, pollen and fire aerosols remain unvalidated for satellite observations of $PM_{2.5}$ and AOD.

KEY RECOMMENDATIONS:

- Augmentation of BoM weather stations with $PM_{2.5}$ sensors (like the TAS BLANKET monitors) would significantly expand observations into regional centres.
- Air quality supersites should be established so air composition, aerosol composition, bioaerosols (viruses, bacteria, pollen) and AOD satellite product validation can occur for all our state and territory capitals. This will improve the use of satellite products, and move toward air hazard prediction system capability for Australia.

b) Australia's arrangements for improving resilience and adapting to changing climatic conditions, what actions should be taken to mitigate the impacts of natural disasters, whether accountability for natural disaster risk management, preparedness, resilience and recovery should be enhance, including through a nationally consistent accountability and reporting framework and national standards;

KEY RECOMMENDATIONS:

- NEPM standards for reporting of surface ozone, NO_2 and SO_2 is currently still under review, there is the need for these standards to be consistent with WHO recommendations.
- $PM_{2.5}$ and surface ozone should be predicted and provided with weather information, in order for emergency planning to adequately account for air risks.
- Nationally consistent, multi-day air quality forecasts (already produced internally at the Bureau of Meteorology) be disseminated, and the emissions inventory published as an open-access dataset.

e) the finding and recommendations (including any assessment of the adequacy and extent of their implementation) of other reports and inquiries that you consider relevant, including any available State or Territory inquiries relating to the 2019/2020 bushfire season to avoid duplication wherever possible;

The discussion documents for air quality and the health based responses around Better fuel for Cleaner Air discussion and consultation documents found here: https://www.environment.gov.au/protection/fuel-quality/better-fuel-cleaner-air-discussion-paper-2016 (our submission https://www.environment.gov.au/submissions/fuel-quality/better-fuel/caul-mei.pdf outlines the health cost aspects).

AQIs are determined from standards set by the National Environmental Protection Measure http://www.nepc.gov.au/nepms/ambient-air-quality/proposed-variation/consultation-2019 These standards for ozone, NO_2 and SO_2 are under review (haven't been updated since 1998). In particular, the ozone standard is inconsistent with WHO recommendations of an 8 hour 100 $\mu g\ m^{-3}$ standard which is equivalent to ~50 ppb (ppb = parts per billion; the new proposed 8 hour standard of 65 ppb will not provide a health based reference standard). Further health based evidence is provided here:

https://www.dea.org.au/wp-content/uploads/2019/09/Expert-Position-Statement-PDF-7.pdf

f) Ways in which Australia could achieve greater national coordination and accountability – through common national standards, rule-making, reporting and data-sharing – with respect to the key preparedness and resilience responsibilities, including for the following

A network of all Australian air composition monitoring, modelling and prediction be established to collect, validate, publish and report internationally our air monitoring data and to provide planning tools. This would go beyond criteria pollutants, (i.e. toluene, formaldehyde, mercury, and bioaerosols) be capable of providing ground-based satellite validation, and generating satellite air pollution products for our regions and cities. This could be funded in a similar way and magnitude (i.e. through NCRIS funding) to the ocean observation network IMOS, carbon flux TERN, geoscience AUSCOPE, AURIN, NCI networks that provide ongoing maintenance and technical support for research infrastructure, data collation, national connectivity and visibility of data by delivering international research standard, quality controlled and high traceability observations quickly to the public. This would coordinate the currently very disparate monitoring and data delivery performed by private industry, state government, state EPAs, CSIRO, ANSTO, BoM and Universities. By streamlining best observational practice, creating a pool of instruments and building a research community (creating atmospheric monitoring test-beds in our states) our resilience and ability quickly address the many air and smart city sensor challenges will be met. AIRBOX http://airbox.earthsci.unimelb.edu.au/ is an example of a coordination across university and governmental institutions of a platform for air monitoring – it demonstrates that there is sufficient capability and community, but it lacks technical support dedication and long-term funding to provide data delivery that a national program could.

National coordination of air quality thresholds, and action advisories as outlined above will aid in clear public messaging.

Establishment of building guidelines for clean air shelters will aid in national resilience to air disasters (smoke, dust, volcanic, chemical or pathogen based).

KEY RECOMMENDATIONS:

- Create a National Collaborative Research and Infrastructure Strategy (https://www.education.gov.au/national-collaborative-research-infrastructure-strategy-ncris) program for Air.
- Coordinate a nationally consistent air quality categories, advisories and actions.
- Establish building standard requirements for clean air shelters.

iii) land-use planning, zoning and development approval (including building standards), urban safety, construction of public infrastructure, and the incorporation of natural disaster considerations.

Ventilation and filtration needs careful consideration in building clean air shelters. When the threat is external (eg, smoke, aerosols) then the air conditioning systems need to be able to re-circulate indoor air as HEPA filtration of outdoor air would not remove unhealthy levels of carbon monoxide, formaldehyde and ozone indoors (HEPA filters only filter particulate not gas threats).

HEPA filtration needs to be built into filtration systems to remove bioaerosol and smoke particles if the air inside is contaminated. Air conditioning and building ventilation needs to be able to 'flush' buildings with fresh, outside air when appropriate.

Public buildings should monitor the health of indoor air (for CO, NO_2, HCHO and bioaerosols) in real-time.

KEY RECOMMENDATIONS:

- Building filtration and ventilation standards need to be clear and protect from smoke and gaseous air hazards – both indoor and outdoor (train stations, libraries, convention centres, hospitals, schools, aged care facilities etc)
- Monitoring of indoor air quality needs to be performed for large indoor public spaces and sensitive populations

References

Arriagada, N. B., Palmer, A. J., Bowman, D. M. J. S., Morgan, G. G., Jalaludin, B. B., & Johnston, F. H. (2020). Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia. *Medical Journal of Australia*, 2019–2020. https://doi.org/10.5694/mja2.50545

MacSween, K., Paton-Walsh, C., Roulston, C., Guérette, E. A., Edwards, G., Reisen, F., … Kubistin, D. (2019). Cumulative Firefighter Exposure to Multiple Toxins Emitted During Prescribed Burns in Australia. *Exposure and Health*, (0123456789). https://doi.org/10.1007/s12403-019-00332-w

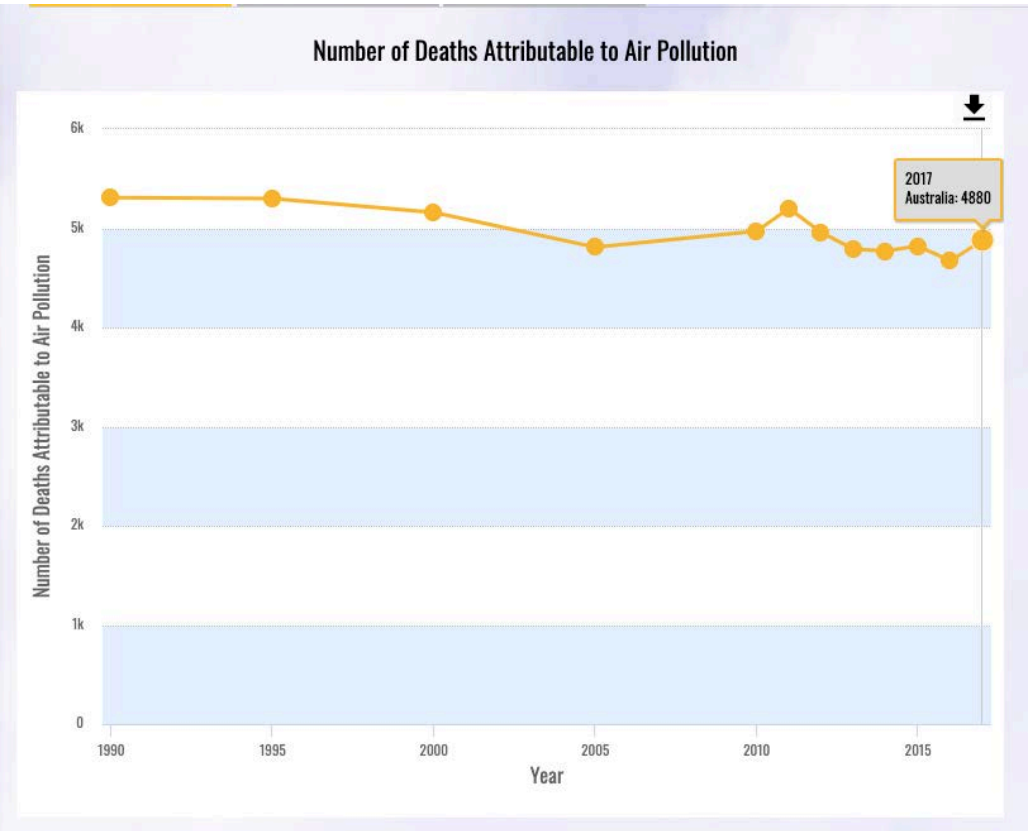


Figure A1: from https://www.stateofglobalair.org/data/#/health/plot from Global Burden of Disease data, accessed June 2020.