

Submission
No 38

**INQUIRY INTO HEALTH IMPACTS OF EXPOSURE TO
POOR LEVELS OF AIR QUALITY RESULTING FROM
BUSHFIRES AND DROUGHT**

Organisation: Grattan Institute

Date Received: 13 March 2020

The health effects of smoke from the 2019-20 bushfires

**Submission to the Inquiry into the health impacts of exposure to poor levels of air
quality resulting from bushfires and drought. March 2020.**

Stephen Duckett and Will Mackey

Table of contents

1	Air quality in NSW during the 2019-20 bushfires	3
2	Response by the NSW Government	10

1 Air quality in NSW during the 2019-20 bushfires

1.1 The bushfires

Temperature, rainfall, fuel and wind affect the likelihood and spread of bushfires.¹ Hot weather and drought leading up to the summer of 2019-20 primed much of south-eastern Australia for bushfires.

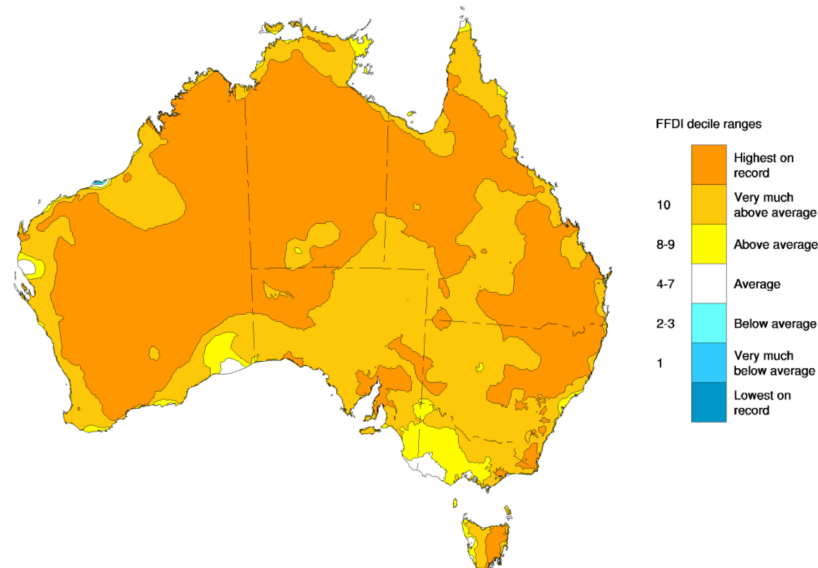
1.1.1 There was extreme fire risk leading up to the 2019-20 bushfires

Heatwaves throughout Australia the year before caused bushfires in most states around the country, including NSW.² Many continued to burn towards the end of the 2018-19 summer.³ With little rainfall and the warmest March on record, the fires in NSW continued to grow into Autumn.⁴

2019 went on to be Australia's hottest year on record.⁵ Temperatures across the country were, on average, 1.5 degrees warmer than the long-term trend. It was also its driest year.⁶ Areas of south-eastern Australia – areas that would go on to be most affected by the bushfires – had their lowest rainfall on record.

Hazard reduction burns reduce the fuel required for a bushfire,⁷ and these controlled burns had been conducted extensively in the decade leading up to the 2019-20 bushfire season.⁸ But extended drought in

Figure 1.1: Fire danger in the lead-up to 2019-20 was high
Forest Fire Danger Index (FFDI) on spring 2019



Source: Bureau of Meteorology (2019a, p. 11).

1. Dowdy et al (2009).
2. Bureau of Meteorology (2019b).
3. Ibid.
4. Bureau of Meteorology (2019c).
5. Bureau of Meteorology (2020).
6. Ibid.
7. Australian Parliamentary Library (2002).
8. RMIT ABC Fact Check (2020).

the south-east, combined with a shorter safe burning period, meant hazard reduction burns were lower than average in 2019.⁹

The fire season started up again in early September 2019, just five months after the previous season ended.¹⁰ More than 50 fires were active in NSW. The Bureau of Meteorology published a special climate statement titled *Dangerous weather in spring 2019* at the start of summer.¹¹ Figure 1.1 shows that fire danger in spring 2019 the highest-recorded for most of the country.

1.1.2 One-fifth of Australian forests burnt

December was hot and windy. The 17th was the hottest day recorded in Australia. That record was broken the following day. The Forest Fire Danger Index reached its peak, and the spread of the fires accelerated. Five million hectares had been burnt by the end of 2019.¹²

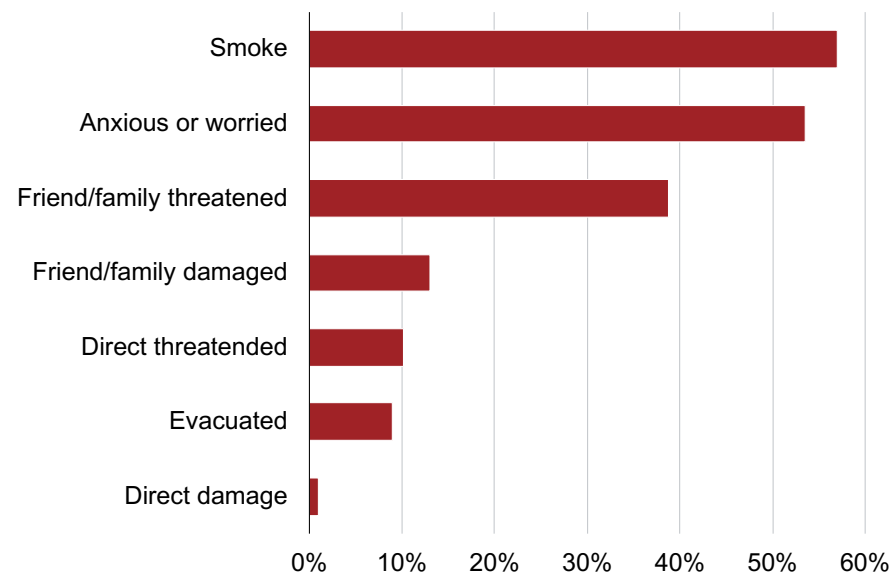
By the end of January, 21 per cent of all Australian forests had been burnt.¹³

The fires killed at least 34 people and destroyed 2,100 homes; a large portion of which was in NSW.

An ANU survey of 3,000 Australians conducted in January 2020 found that one-in-seven were directly affected by the bushfires through their property being damaged or threatened, or by being told to evacuate.¹⁴

Figure 1.2 shows that 10 per cent of Australians – 2 million people – reported being directly threatened by the fires. 1.8 million were forced to evacuate. Three out of every five people living in Australia reported being exposed to bushfire smoke.

Figure 1.2: Three-in-five Australians were affected by bushfire smoke
Proportion of Australian adults exposed



Source: Biddle et al (2020, p. iii).

9. Hannam and Mannix (2020).

10. Bureau of Meteorology (2019a).

11. Ibid.

12. Bureau of Meteorology (2020).

13. Boer et al (2020). This figure does not include Tasmania.

14. Biddle et al (2020, p. iii).

1.2 Poor air quality caused by smoke sent people to hospital

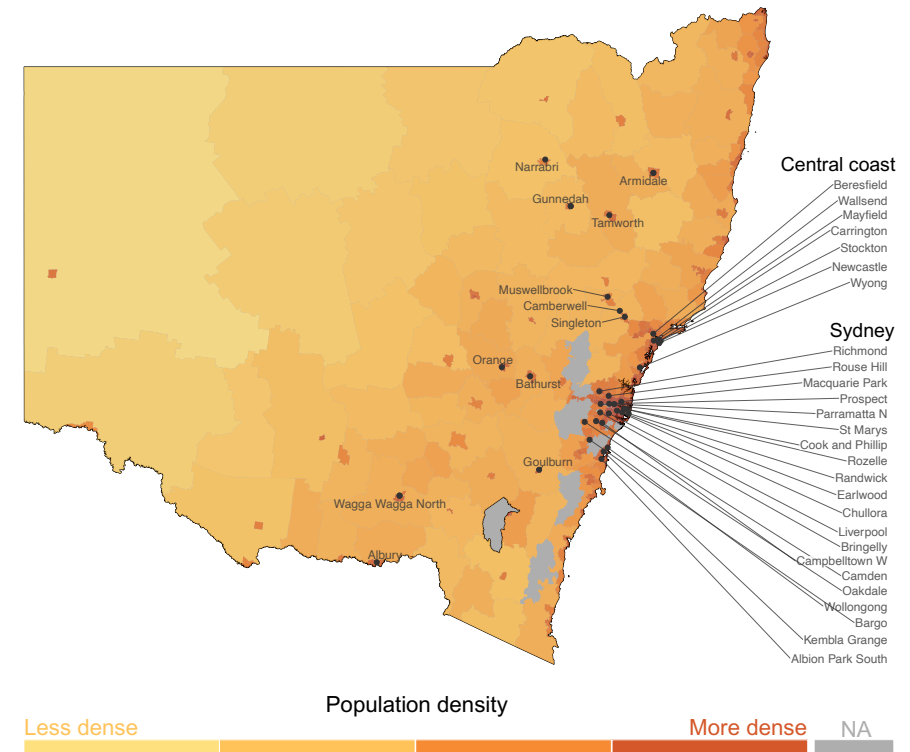
As fires burned in the bushlands of NSW, ACT and Victoria, smoke rose, drifted and blanketed towns and cities. The smoke drove air pollution to be many times the ‘hazardous’ thresholds set by environmental protection agencies. About 11 million Australians reported some exposure to smoke caused by the 2019-20 bushfires.¹⁵ It caused thousands of people to go to hospital.

1.2.1 The bushfires caused dangerous air quality for prolonged periods

Bushfire smoke is made up of small particles in the air. These particles are classified by size. ‘Particulate matter (PM) 2.5’ are particles less than 2.5 micrometres in diameter, about thirty times smaller than the width of a human hair.¹⁶ The micrograms of these small particles per cubic metre of air – PM2.5 $\mu\text{g}/\text{m}^3$ – is the key measurement to monitor air quality related to bushfires.¹⁷

In New South Wales, air quality is monitored throughout the state by the Department of Planning, Industry and Environment. 17 monitors are in Sydney and its surrounds, with the rest located in major towns, as Figure 1.3 shows. There is no PM2.5 monitoring in the state’s west, where population density is low.

Figure 1.3: Air quality stations monitoring PM2.5 in NSW
Air quality monitors and population density



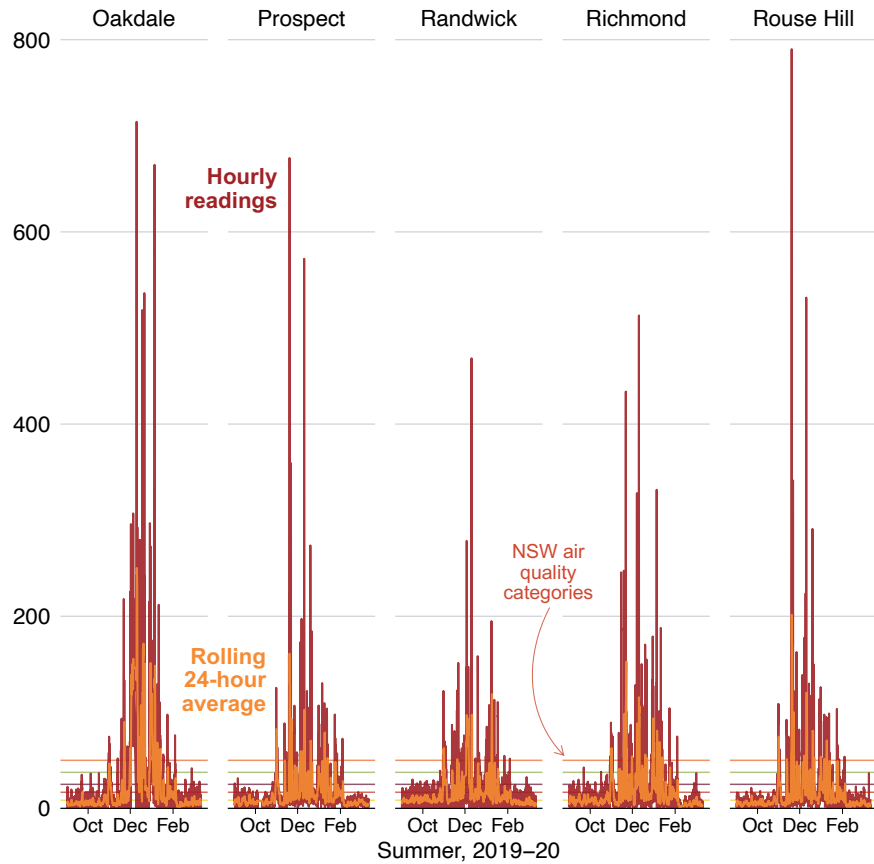
Source: Grattan analysis of NSW DPIE (2020); ABS (2020).

15. Ibid.

16. United States Environmental Agency (2018). Another common measure is PM10 $\mu\text{g}/\text{m}^3$, which measures particles less than 10 micrometres in diameter. But smaller particles, like those measured by PM2.5, penetrate deeper into the lungs and can be more harmful: Dennekamp and Abramson (2011), Englert (2004), World Health Organisation (2018) and World Health Organisation (2003, p. 21).

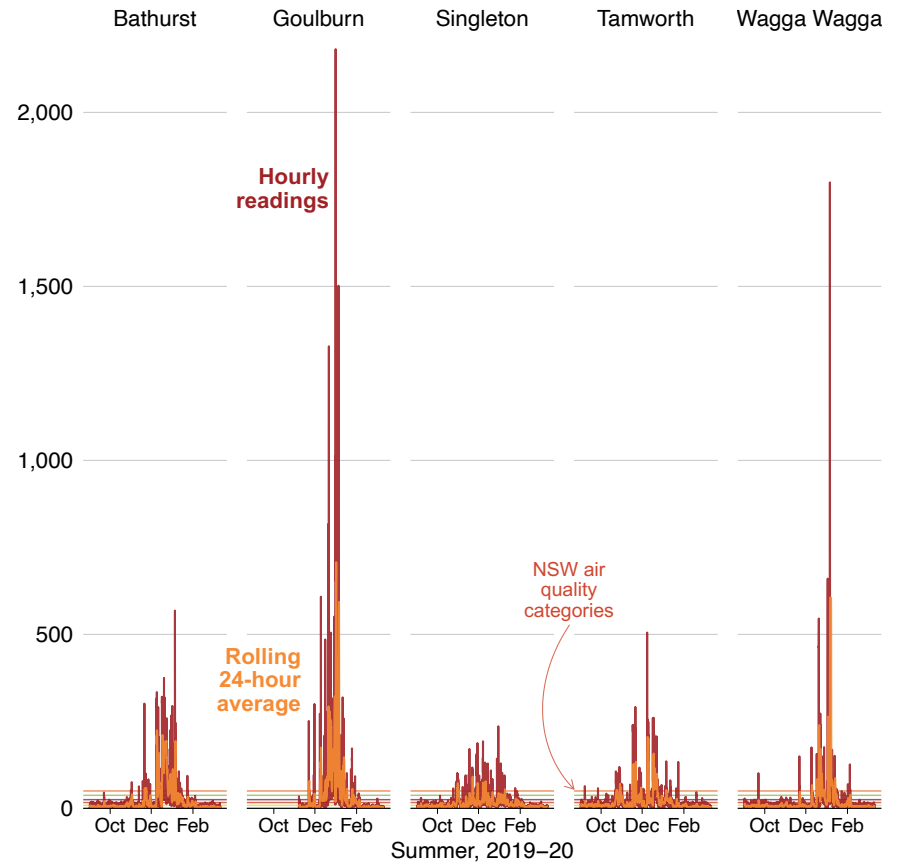
17. Particulate matter is predominately made up of mineral dust, water, black carbon, sodium chloride, sulphate, ammonia and nitrates: World Health Organisation (2018). The toxicity of PM2.5 from bushfire smoke can vary dramatically and will depend on what materials are being burnt: Johnston et al (2019).

Figure 1.4: Air pollution was many times the 'hazardous' level in Sydney
PM2.5 levels by hour and rolling 24-hour average



Source: Grattan analysis of NSW DPIE (2020).

Figure 1.5: Air pollution was worse in some parts of regional NSW
PM2.5 levels by hour and rolling 24-hour average



Source: Grattan analysis of NSW DPIE (2020).

There is no 'safe' level of PM2.5 exposure, as exposure to low levels has still been shown to be harmful, even in the short term.¹⁸ But the World Health Organisation and Australian national standards set a 'safe' threshold at 25 PM2.5 $\mu\text{g}/\text{m}^3$ on average over 24 hours.¹⁹

Presently, the 'hazardous' level of PM2.5 in NSW is 50 $\mu\text{g}/\text{m}^3$.

Figure 1.4 on the preceding page shows the air quality in Sydney during the 2019-20 bushfire season. Hourly spikes, shown in red, hit between 600 and 800 for many parts of the city.

The air quality categories used by NSW, from 'very good' to 'hazardous', are also shown (see Figure 2.1 on page 10 for details on these categories). A substantial minority of summer days were spent above the 'hazardous' level. Some days had peaks 10-14 times that of 'hazardous'.

There were prolonged periods of extreme air quality in areas of regional NSW, too. Figure 1.5 on the preceding page shows PM2.5 readings in Bathurst, Goulburn, Singleton, Tamworth and Wagga Wagga. Some days averaged more than 700 PM2.5 $\mu\text{g}/\text{m}^3$ in Goulburn. Hourly peaks topped 2,000.

1.2.2 The immediate health impact of poor air quality

The majority of people in NSW reported at least one minor symptom caused by bushfire smoke in December-January.²⁰ The most common of these were eye and throat irritation, coughing, headaches, and anxiety.

18. Wei et al (2019).

19. Environment Protection Authority Victoria (2019); and World Health Organisation (2018).

20. FluTracking (2020).

But inhalation of particulate matter from bushfire smoke can cause more serious and wide-ranging health problems²¹ And the link between respiratory issues and particulate matter is well established:²² small particles can be inhaled deep into the lungs, causing or triggering difficulty breathing.

Emergency department data was provided to Grattan Institute by health departments in ACT and Victoria. It shows that respiratory presentations increased significantly on days with poor air quality. While emergency department data from NSW was not available for this analysis, we are likely to observe similar effects.²³

Figure 1.6 on the next page shows that after controlling for seasonal, day, temperature and population effects,²⁴ days with PM2.5 $\mu\text{g}/\text{m}^3$ between 50-100 had 27% more respiratory emergency department visits than days with 'normal' PM2.5 (below 25).

Days with levels of PM2.5 greater than 200 saw a 70% increase.

Over the summer, there were 24 days on which the rolling 24-hour average PM2.5 level reached higher than 50 in Western Sydney.²⁵ There were 23 days with PM2.5 over 50 (the 'hazardous' level)²⁶ in Campbelltown in Sydney's southwest, and 19 days in Darlinghurst.²⁷

21. See Reid et al (2016, table 1) for a critical review of the health impacts of exposure to bushfire smoke. The wide-ranging health problems exacerbated by particulate matter include respiratory, cardiovascular, Parkinson's disease, diabetes, phlebitis, thrombophlebitis, and thromboembolism: Wei et al (2019).

22. See, for example, Borchers Arriagada et al (2019), Rappold et al (2017), Broome et al (2016), Reid et al (2016), Dennekamp and Abramson (2011), Ana G. Rappold et al (2011) and Tham et al (2009).

23. NSW is demographically similar to Victoria. Demand for health services due to poor air quality was also reported in NSW over the 2019-20 bushfire season: Nguyen and Bullen (2019) and Noyes (2020).

24. These controls are common in the literature. See technical appendix.

25. At the Richmond monitoring station.

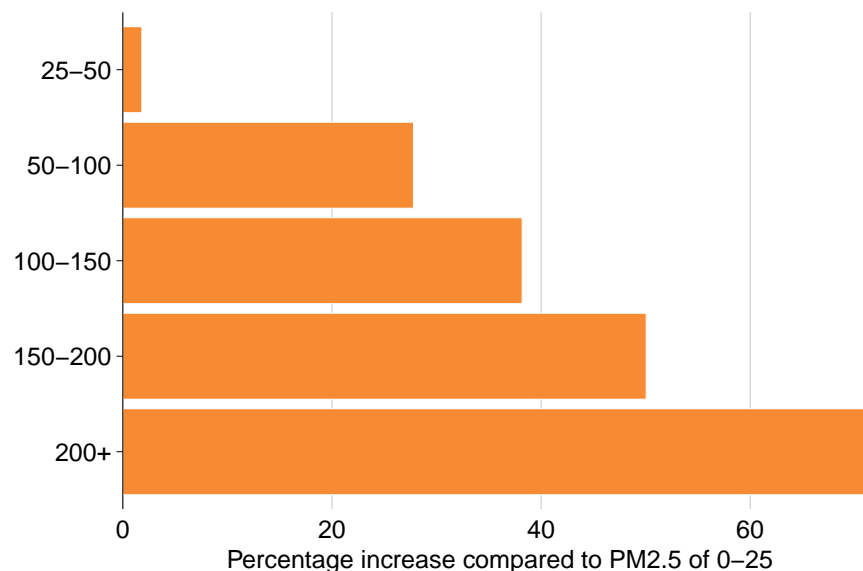
26. See Figure 2.1.

27. At the Campbelltown West and Cook & Phillip monitoring stations, respectively.

There were 18 days with average PM2.5 above 100 (twice the 'hazardous' level) in south-west Sydney,²⁸ and 10 in Camden.

In regional NSW, there were 24 days with PM2.5 above 100 in Goulburn, and 15 in Albury and Bathurst. There were many more days in which hourly spikes reached hazardous levels.

Figure 1.6: More people go to hospital for respiratory illness when PM2.5 levels are high



Source: Grattan analysis of emergency department data from ACT Health and Victorian Department of Health and Human Services.

28. At the Oakdale station.

1.3 Climate change is causing longer and more intense bushfires

A warming climate means rising temperatures, longer heatwaves and less rainfall. These conditions mean there are more days of extreme fire risk, which increase the chance of larger and longer fires.

Twelve years ago, in the 2008 Garnaut Climate Change Review, Ross Garnaut commented:

Recent projections of fire weather suggest that fire seasons will start earlier, end slightly later, and generally be more intense. This effect increases over time, but should be directly observable by 2020.

It is difficult to say whether an event like the 2019-20 summer bushfires were explicitly 'caused' by climate change.²⁹ Like heatwaves, cyclones, floods and droughts, bushfires have been a part of life in Australia since first came here tens-of-thousands of years ago.

But the developing field of 'attribution studies' looks to measure how much more likely extreme weather events are because of human-caused climate change. A recent attribution study, released in March 2020, found that the 2019-20 bushfires were 80 per cent more likely to happen because of climate change.³⁰

If global temperatures continue to rise to 2°C above pre-industrial levels, bushfire events in Australia like the summer 2019-20 are about eight times more likely.³¹

29. Garnaut (2011, p. 6).

30. Oldenborgh et al (2020, p. 26). The lower-bound estimate was 30%. Both estimates are likely to 'severely underestimate' the attribution (p. 26) due to underestimations of the main heatwave inputs (p. 1).

31. Ibid (p. 27).

As bushfires become more frequent and intense, they will impact more Australians more often.³² Repeated exposure to bushfire smoke will increase the likelihood of serious longer-term health risks like stroke.³³

The response of health authorities to foreseeable events like bushfires must improve.

32. As discussed after the 2003 fires in Canberra: Hennessy et al (2005); and after the 2009 bushfires in Victoria: CSIRO (2009) and Garnaut (2011); and after the 2013 fires in NSW: Hennessy (2013).

33. Huang et al (2019); and Yuan et al (2019).

2 Response by the NSW Government

NSW requires clearer, more detailed information to be made easily available to the public during high-pollution smoke events. This information should be actively delivered to residents.

Air quality in NSW reached many times above the level considered 'hazardous'. Figure 2.1 shows that current classifications of air quality in NSW (right panel) does not distinguish between very high levels PM2.5.

This means that the same *advice* is given to the public on days with PM2.5 $\mu\text{g}/\text{m}^3$ of 60 (like in Sydney during the start of summer) and 200 (at the peak of the bushfire smoke).

Current advice for 'hazardous' days in NSW provided on the DPIE website alongside air quality readings is:

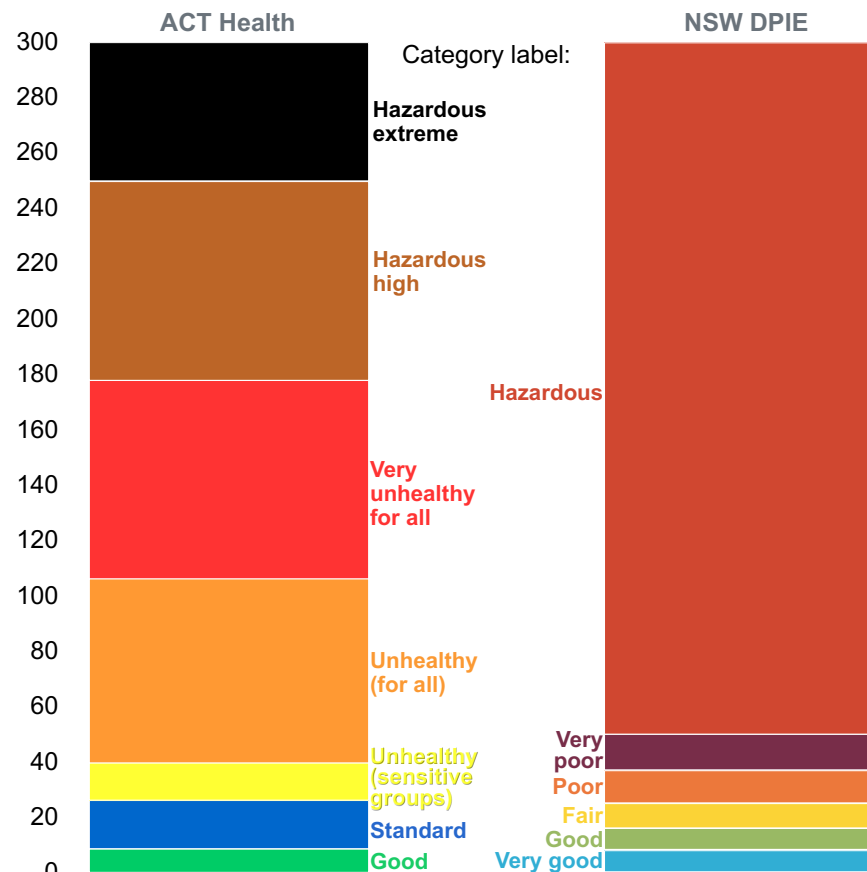
“Sensitive groups should avoid all outdoor activities. Other adults should avoid strenuous outdoor activities.”³⁴

While NSW Health provides detailed information about bushfire-caused air pollution, this information is separate from the DPIE air quality information.³⁵

ACT Health has updated and expanded the information it provided to the public about what they should do during various levels of PM2.5 air pollution (Figure 2.2 on the following page). On days of 'hazardous high' air quality, ACT Health recommended:

Everyone should avoid all physical activity outdoors. Sensitive groups should temporarily relocate to a friend or relative living

Figure 2.1: Air quality categories in NSW and ACT
PM2.5 $\mu\text{g}/\text{m}^3$



Source: NSW Department of Planning Industry and Environment (2020); ACT Health (2020).

34. NSW Department of Planning Industry and Environment (2020).

35. See <https://www.health.nsw.gov.au/environment/air/Pages/bushfire-protection.aspx>.

outside the affected area. If this is not possible, remain indoors and keep activity levels as low as possible.³⁶

This information should be provided by NSW DPIE *with* the air quality levels, as is now done in the ACT (Figure 2.2). In addition, NSW DPIE should provide guidance on:

- How to minimise air pollution in the home during short- and long-exposure periods.
- Clear advice on what type of face-masks to use, and when they should be used.
- How to minimise exposure to air pollution if staying at home is not possible.
- Advice to employers, schools and other organisations about reducing exposure risk, including whether outdoor activity should be prohibited.

The NSW DPIE should actively communicate these air quality risks with the public. This should include targeted, direct messaging to sensitive groups on days with forecasted dangerous air quality. The current system of direct messaging offered by NSW DPIE is commendable, but requires people to opt-in. If uptake of this service is low, alternative methods of delivery should be tried.

The messages should be targeted and tailored to at-risk groups. Messages to people with asthma should provide different relevant information than to pregnant women.³⁷

36. ACT Health (2020). Note that these instructions were updated in February, after the worst cases of bushfire smoke.

37. While inhaling particulate matter from smoke is dangerous to everyone, some groups have heightened risk: Borchers Arriagada et al (2019) and Abdo et al (2019).

There should also be clear communication about air quality *before* planned hazard reduction burns, which have been shown to increase PM2.5 significantly.³⁸

Figure 2.2: From February 2020, ACT Health provided more detailed guidance for high air pollution days
Screenshot of the ACT Health: Health advice for smoky air (PM2.5) website

Health advisory categories	PM _{2.5} (24 hour) µg/m ³	Potential health effects without following advice or actions	Cautionary health advice/actions**
Good	0-8.9	N/A – Below the relevant air quality standard	None
Meets air quality standard	9-25.9	N/A – Meets the relevant air quality standard	No tailored advice necessary
Unhealthy for sensitive groups	26-39.9	Symptoms may occur in sensitive groups	Sensitive groups^a should reduce prolonged or heavy physical activity. Where possible, these people in the community should also limit the time spent outdoors Anyone with a heart or lung condition should take their medication as prescribed by their doctor. People with asthma should follow their asthma action plan. Anyone with concerns about their health should seek medical advice from their doctor. Anyone experiencing wheezing, chest tightness or difficulty breathing should seek urgent medical attention
Unhealthy for all	40-106.9	Increased likelihood of effects for sensitive groups Symptoms may occur in the general population	Everyone should reduce prolonged or heavy physical activity Sensitive groups^a should avoid prolonged or heavy physical activity altogether Anyone with a heart or lung condition should take their medication as prescribed by their doctor. People with asthma should follow their asthma action plan. Anyone with concerns about their health should seek medical advice from their doctor. Anyone experiencing wheezing, chest tightness or difficulty breathing should seek urgent medical attention
Very unhealthy for all	107-177.9	Significant likelihood of effects for sensitive groups Symptoms among general population common	Everyone should avoid prolonged or heavy physical activity Sensitive groups^a should avoid all physical activity outdoors Anyone with a heart or lung condition should take their medication as prescribed by their doctor. People with asthma should follow their asthma action plan. Anyone with concerns about their health should seek medical advice from their doctor. Anyone experiencing wheezing, chest tightness or difficulty breathing should seek medical attention
Hazardous high	>177.9	Serious likelihood of effects for sensitive groups Symptoms among general population very common	Everyone should avoid all physical activity outdoors Sensitive groups^a should temporarily relocate to a friend or relative living outside the affected area. If this is not possible, remain indoors and keep activity levels as low as possible Anyone with a heart or lung condition should take their medication as prescribed by their doctor. People with asthma should follow their asthma action plan. Anyone with concerns about their health should seek medical advice from their doctor. Anyone experiencing wheezing, chest tightness or difficulty breathing should seek medical attention Anyone experiencing symptoms which may be due to smoke exposure should consider taking a break away from the smoky conditions
Hazardous extreme	> 250	Serious likelihood of effects for sensitive groups Symptoms among general population very common	Cautionary health advice and actions are the same as for Hazardous high above

Source: ACT Health (2020).

38. Broome et al (2016).

Bibliography

- Abdo et al (2019). Abdo, M., Ward, I., O'dell, K., Ford, B., Pierce, J. R., Fischer, E. V. and Crooks, J. L. "Impact of wildfire smoke on adverse pregnancy outcomes in Colorado, 2007–2015". *International Journal of Environmental Research and Public Health* 16.19, p. 3720. ISSN: 16604601. DOI: 10.3390/ijerph16193720. <https://www.mdpi.com/1660-4601/16/19/3720>.
- ACT Health (2020). *Health advice for smoky air (PM2.5)*. <https://www.health.act.gov.au/about-our-health-system/population-health/environmental-monitoring/monitoring-and-regulating-air-0> (visited on 13/03/2020).
- Ana G. Rappold et al (2011). Ana G. Rappold et al. "Peat Bog Wildfire Smoke Exposure in Rural North Carolina Is Associated with Cardiopulmonary Emergency Department Visits Assessed through Syndromic Surveillance". DOI: 10.1289/ehp.1003206. <http://dx.doi.org/10.1289/ehp.1003206>.
- Australian Parliamentary Library (2002). *Is Fuel Reduction Burning the Answer?* https://www.aph.gov.au/About%7B%5C_%7DParliament/Parliamentary%7B%5C_%7DDepartments/Parliamentary%7B%5C_%7DLibrary/Publications%7B%5C_%7DArchive/CIB/cib0203/03Cib08 (visited on 06/03/2020).
- Biddle et al (2020). Biddle, N., Edwards, B., Herz, D. and Makkai, T. *Exposure and the impact on attitudes of the 2019-20 Australian Bushfires*. Australian National University. DOI: 10.26193/S1S9I9. <http://dx.doi.org/10.26193/S1S9I9>.
- Boer et al (2020). Boer, M. M., Resco de Dios, V. and Bradstock, R. A. "Unprecedented burn area of Australian mega forest fires". *Nature Climate Change* 10.3, pp. 171–172. ISSN: 1758-678X. DOI: 10.1038/s41558-020-0716-1. <http://www.nature.com/articles/s41558-020-0716-1>.
- Borchers Arriagada et al (2019). Borchers Arriagada, N., Horsley, J. A., Palmer, A. J., Morgan, G. G., Tham, R. and Johnston, F. H. "Association between fire smoke fine particulate matter and asthma-related outcomes: Systematic review and meta-analysis". *Environmental Research* 179. ISSN: 00139351. DOI: 10.1016/j.envres.2019.108777. <https://doi.org/10.1016/j.envres.2019.108777%20https://linkinghub.elsevier.com/retrieve/pii/S0013935119305742>.
- Broome et al (2016). Broome, R. A., Johnston, F. H., Horsley, J. and Morgan, G. G. "A rapid assessment of the impact of hazard reduction burning around Sydney, May 2016". *Medical Journal of Australia* 205.9, pp. 407–408. ISSN: 13265377. DOI: 10.5694/mja16.00895.
- Bureau of Meteorology (2019a). *Dangerous bushfire weather in spring 2019*. Canberra: Bureau of Meteorology.
- _____ (2019b). *Widespread heatwaves during December 2018 and January 2019*. Canberra: Bureau of Meteorology.
- _____ (2019c). *Monthly Weather Review Australia, March 2019*. Bureau of Meteorology. www.bom.gov.au/climate/maps..
- _____ (2020). *Annual climate statement 2019*. Canberra: Bureau of Meteorology. <http://www.bom.gov.au/climate/current/annual/aus/%7B%5C#%7Dtabs=Events>.
- CSIRO (2009). *Bushfires in Australia Prepared for the 2009 Senate Inquiry into Bushfires in*. July. CSIRO.
- Dennekamp, M. and Abramson, M. J. (2011). "The effects of bushfire smoke on respiratory health". *Respirology* 16.2, pp. 198–209. ISSN: 13237799. DOI: 10.1111/j.1440-1843.2010.01868.x.

- Dowdy et al (2009). Dowdy, A. J., Mills, G. a., Finkele, K. and Groot, W. D. *Australian fire weather as represented by the McArthur Forest Fire Danger Index and the Canadian Forest Fire Weather Index*. June. The Centre for Australian Weather and Climate Research; CSIRO; Australian Bureau of Meteorology. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.307.8282%7B%5C&%7Drep=rep1%7B%5C&%7Dtype=pdf>.
- Englert, N. (2004). "Fine particles and human health-a review of epidemiological studies". *Toxicology Letters* 149, pp. 235–242. DOI: 10.1016/j.toxlet.2003.12.035.
- Environment Protection Authority Victoria (2019). *PM2.5 particles in the air*. <https://www.epa.vic.gov.au/for-community/environmental-information/air-quality/pm25-particles-in-the-air> (visited on 10/03/2020).
- FluTracking (2020). *Bushfire Smoke Symptoms Survey: December 30 to January 12, 2020*. FluTracking.
- Garnaut, R. (2011). *The Garnaut Review 2011: Australia in the Global Response to Climate Change*. New York: Cambridge University Press. ISBN: 9781107691681.
- Hannam, P. and Mannix, L. (2020). "Australia fires: What is back burning and will more reduce bushfire risks?" *The Sydney Morning Herald*. <https://www.smh.com.au/national/prescribed-burning-what-is-it-and-will-more-reduce-bushfire-risks-20200106-p53paf.html>.
- Hennessy, K. (2013). "Fire and climate change: fire risk needs to be managed". *The Conversation*. <https://theconversation.com/fire-and-climate-change-fire-risk-needs-to-be-managed-19552>.
- Hennessy et al (2005). Hennessy, K., Lucas, C., Nicholls, N., Bathols, J., Suppiah, R. and Ricketts, J. *Climate change impacts on fire-weather in south-east Australia*. CSIRO and Bureau of Meteorology. <http://www.bom.gov.au/climate/change>.
- Huang et al (2019). Huang, K. et al. "Long term exposure to ambient fine particulate matter and incidence of stroke: prospective cohort study from the China-PAR project". *BMJ*, p. l6720. ISSN: 1756-1833. DOI: 10.1136/bmj.l6720. <http://dx.doi.org/10.1136/bmj.l6720> <http://www.bmj.com/lookup/doi/10.1136/bmj.l6720>.
- Johnston et al (2019). Johnston, H. J., Mueller, W., Steinle, S., Vardoulakis, S., Tantrakarnapa, K., Loh, M. and Cherrie, J. W. "How Harmful Is Particulate Matter Emitted from Biomass Burning? A Thailand Perspective". *Current Pollution Reports* 5.4, pp. 353–377. ISSN: 2198-6592. DOI: 10.1007/s40726-019-00125-4. <https://doi.org/10.1007/s40726-019-00125-4> <http://link.springer.com/10.1007/s40726-019-00125-4>.
- Nguyen, K. and Bullen, J. (2019). "Sydney smoke three times worse this NSW bushfire season, but health effects from 'medium-term' exposure unclear - ABC News (Australian Broadcasting Corporation)". *ABC News*. <https://www.abc.net.au/news/2019-12-03/sydney-air-quality-smoke-haze-worse-this-bushfire-season/11755546>.
- Noyes, J. (2020). "More smoke haze for Sydney as bushfire conditions ease across NSW". *The Sydney Morning Herald*. <https://www.smh.com.au/national/nsw/sydney-chokes-through-more-smoke-haze-as-bushfire-conditions-ease-across-nsw-20200112-p53qr5.html>.
- NSW Department of Planning Industry and Environment (2020). *Current and forecast air quality*. <https://www.dpie.nsw.gov.au/air-quality> (visited on 13/03/2020).
- Oldenborgh et al (2020). Oldenborgh, G. J. V. et al. "Attribution of the Australian bushfire risk to anthropogenic climate change", pp. 1–46.
- Rappold et al (2017). Rappold, A. G., Reyes, J., Pouliot, G., Cascio, W. E. and Diaz-Sanchez, D. "Community Vulnerability to Health Impacts of Wildland Fire Smoke Exposure". DOI: 10.1021/acs.est.6b06200. <https://pubs.acs.org/sharingguidelines>.

- Reid et al (2016). Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R. and Elliott, C. T. "Critical review of health impacts of wildfire smoke exposure". *Environmental Health Perspectives* 124.9, pp. 1334–1343. ISSN: 15529924. DOI: 10.1289/ehp.1409277.
- RMIT ABC Fact Check (2020). *Has NSW seen more than twice the amount of prescribed burning in national parks this decade compared with the last? - Fact Check - ABC News (Australian Broadcasting Corporation)*. <https://www.abc.net.au/news/2020-01-22/prescribed-burning-nsw-backburning-hazard-reduction/11878316> (visited on 06/03/2020).
- Tham et al (2009). Tham, R., Erbas, B., Akram, M., Dennekamp, M. and Abramson, M. J. "The impact of smoke on respiratory hospital outcomes during the 2002-2003 bushfire season, Victoria, Australia". *Respirology* 14.1, pp. 69–75. ISSN: 13237799. DOI: 10.1111/j.1440-1843.2008.01416.x.
- United States Environmental Agency (2018). *Particulate Matter (PM) Basics*. <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics> (visited on 10/03/2020).
- Wei et al (2019). Wei, Y., Wang, Y., Di, Q., Choirat, C., Wang, Y., Koutrakis, P., Zanobetti, A., Dominici, F. and Schwartz, J. D. "Short term exposure to fine particulate matter and hospital admission risks and costs in the Medicare population: time stratified, case crossover study". *BMJ* 367, p. l6258. ISSN: 0959-8138. DOI: 10.1136/BMJ.L6258. <http://www.bmj.com/lookup/doi/10.1136/bmj.l6258>.
- World Health Organisation (2003). *Health Aspects of Air Pollution with Particulate Matter, Ozone and Nitrogen Dioxide*. Bonn: WHO. http://www.euro.who.int/%7B%5C_%7D%7B%5C_%7Ddata/assets/pdf%7B%5C_%7Dfile/0005/112199/E79097.pdf.
- _____ (2018). *Ambient (outdoor) air pollution*. [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health) (visited on 10/03/2020).
- Yuan et al (2019). Yuan, S., Wang, J., Jiang, Q., He, Z., Huang, Y., Li, Z., Cai, L. and Cao, S. "Long-term exposure to PM2.5 and stroke: A systematic review and meta-analysis of cohort studies". *Environmental Research* 177, p. 108587. ISSN: 00139351. DOI: 10.1016/j.envres.2019.108587. <https://doi.org/10.1016/j.envres.2019.108587%20https://linkinghub.elsevier.com/retrieve/pii/S0013935119303846>.