Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia

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Weather conditions conducive to extreme bushfires are becoming more frequent as a consequence of climate change.[1] Such fires have substantial social, ecological, and economic effects, including the effects on public health associated with smoke, such as premature mortality and exacerbation of cardio-respiratory conditions.[2,3] During the final quarter of 2019 and the first of 2020, bushfires burned in many forested regions of Australia, and smoke affected large numbers of people in New South Wales, Queensland, the Australian Capital Territory and Victoria. The scale and duration of these bushfires was unprecedented in Australia. We undertook a preliminary evaluation of the health burden attributable to air pollution generated by bushfires during this period.

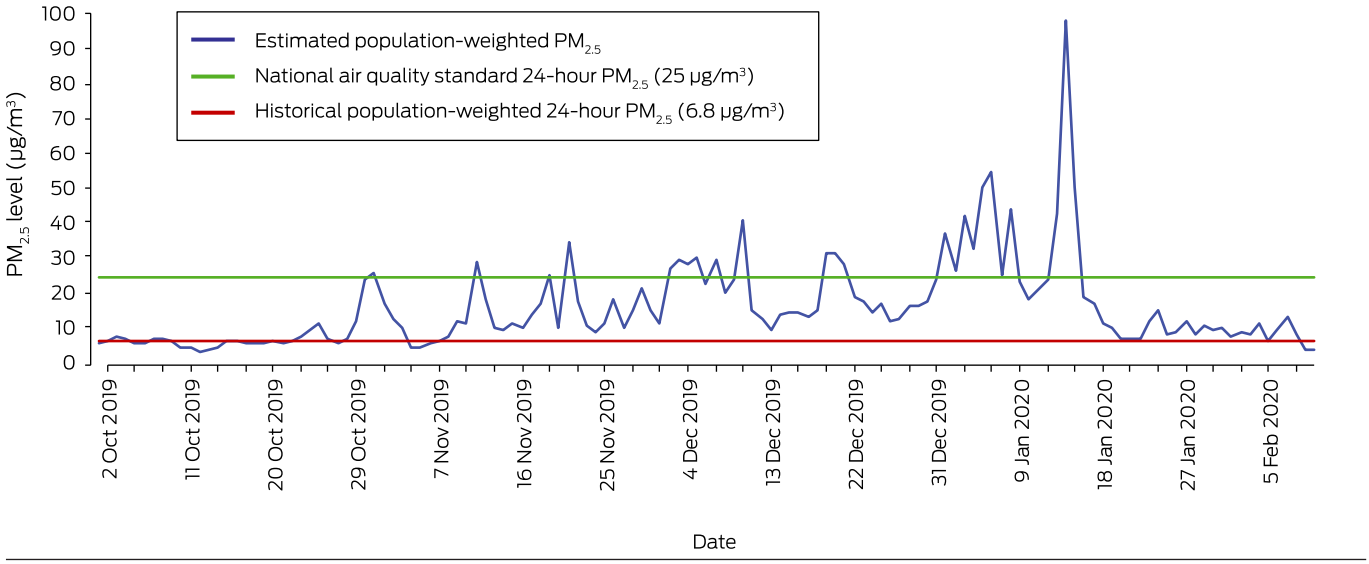
Using standard methods for assessing the health impact of air pollution,[4] we estimated the numbers of excess deaths, hospitalisations for cardiovascular and respiratory problems, and emergency department presentations with asthma in NSW, Queensland, the ACT and Victoria between 1 October 2019 and 10 February 2020 that could be attributed to bushfire smoke exposure.

We estimated population exposure to particulate matter less than 2.5 μm in diameter ($PM_{2.5}$) for the regions of NSW, Queensland, the ACT and Victoria for which publicly available air quality monitoring data were available (for about 90% of the total population of these states). Data were obtained from the NSW Department of Planning, Industry and Environment,[5] the Queensland Department of Science,[6] ACT Health,[7] and the Environmental Protection Agency Victoria.[8] We defined bushfire smoke-affected days as days on which the 24-hour mean $PM_{2.5}$ concentration exceeded the 95th percentile of historical daily mean values for individual air quality stations. We estimated daily mean $PM_{2.5}$ levels by Statistical Area Level 2 (SA2), using station level data whenever at least one monitoring station was within 100 km of the SA2 centroid, and applying inverse distance weighting.[9]

Published population and health data from the Australian Bureau of Statistics,[10,11] the Australian Institute of Health and Welfare,[12–15] and the NSW Ministry of Health were used.[16] We quantified health outcomes by combining baseline incidence rates[12–15] for each health outcome with daily exposure data and applying the relevant exposure–response risk coefficients for each outcome.[17,18] We also conducted sensitivity analyses with different $PM_{2.5}$ thresholds for defining bushfire smoke-affected days. Further methodological details, including underlying assumptions and limitations, are included in the online Supporting Information. Our analysis of publicly available aggregated data did not require ethics approval.

During the study period, $PM_{2.5}$ concentrations exceeding the 95th percentile of historical daily mean values were recorded by at least one monitoring station in the study area on 125 of 133 days (Box 1). We estimated that bushfire smoke was responsible

1 Population-weighted $PM_{2.5}$ levels, New South Wales, Queensland, the Australian Capital Territory and Victoria, 1 October 2019 – 10 February 2020*



* Data by state are included in the online Supporting Information. ◆

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2 Estimated health burden attributable to bushfire smoke, Queensland, New South Wales, the Australian Capital Territory and Victoria, 1 October 2019 – 10 February 2020

Outcome	Estimated number of cases (95% confidence intervals)				
	Queensland	New South Wales	Australian Capital Territory	Victoria	Total
Excess deaths (any cause)	47 (17–77)	219 (81–357)	31 (12–51)	120 (44–195)	417 (153–680)
Hospital admissions, cardiovascular	135 (25–246)	577 (108–1050)	82 (15–149)	331 (62–602)	1124 (211–2047)
Hospital admissions, respiratory	245 (0–513)	1050 (0–2204)	147 (0–308)	585 (0–1227)	2027 (0–4252)
Emergency department attendances, asthma	113 (61–165)	702 (379–1026)	89 (48–131)	401 (217–586)	1305 (705–1908)

for 417 (95% CI, 153–680) excess deaths, 1124 (95% CI, 211–2047) hospitalisations for cardiovascular problems and 2027 (95% CI, 0–4252) for respiratory problems, and 1305 (95% CI, 705–1908) presentations to emergency departments with asthma (Box 2). Applying lower thresholds for defining bushfire smoke-affected days (no threshold, 90th percentile of historical values) did not markedly alter our findings; a higher threshold (99th percentile) reduced the estimates by about 20%. The highest population-weighted $PM_{2.5}$ exposure level, 98.5 $\mu g/m^3$ on 14 January 2020 (Box 1), exceeded the national air quality 24-hour standard (25 $\mu g/m^3$)[19] and was more than fourteen times the historical population-weighted mean 24-hour $PM_{2.5}$ value of 6.8 $\mu g/m^3$.

We have estimated the excess health burden during 19 weeks' continuous fire activity in the states most severely affected by smoke. Our estimates are based on air quality data from monitoring stations in the four eastern states — that is, we did not include data for smoke from all extreme fires in Australia during the study period — and we did not attempt to estimate health effects for which exposure–response relationships are less well characterised, such as primary health care attendances and ambulance calls. Detailed epidemiological analysis of more comprehensive exposure estimation and empirical health data will provide more complete information about the harms attributable to the severe air pollution associated with these unprecedented fires, but our findings indicate that the smoke-related health impact was substantial. Smoke is just one of many problems that will intensify with the increasing frequency and severity of major bushfires associated with climate change. Expanded and diversified approaches to bushfire mitigation and adaptation to living in an increasingly hot and fire-prone country are urgently needed.[20]

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Supporting Information

Additional Supporting Information is included with the online version of this article.