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Adverse Health Effects in People with and without Preexisting Respiratory Conditions during Bushfire Smoke Exposure in the 2019/2020 Australian Summer

To the Editor:

Australia had unprecedented bushfires affecting multiple states in the summer of 2019/2020. Prolonged exposure to bushfire smoke over December 2019 and January 2020 is estimated to have resulted in over 400 excess deaths and over 3,000 additional hospitalizations (1). Some evidence has suggested that people with asthma are at higher risk for adverse health effects after bushfire or wildfire smoke exposure (2–5), although others suggest individuals with asthma are more inclined to take protective measures (6). We aimed to understand the impact of the 2019/2020 bushfire season on the health and behavior of people with and without preexisting respiratory conditions in affected Australian states.

A cross-sectional study was conducted to compare health effects of the 2019/2020 bushfires in people with and without respiratory conditions. Respiratory conditions were defined as self-reported asthma, emphysema, chronic bronchitis, chronic obstructive pulmonary disease, bronchiectasis, and any other chronic lung conditions. Participants 18 years or over with and without respiratory conditions were recruited from postcodes affected by bushfire smoke in the summer of 2019/2020 in six states (New South Wales, Victoria, South Australia, Tasmania, Australian Capital Territory, and Queensland) in Australia during August 2020. *A priori* power analysis was conducted using large sample approximation in G*Power 3.1.9.7 (7). To detect at least 20% difference in risk of adverse health effects after smoke exposure among people with and without respiratory conditions (i.e., odds ratio of 1.2), the sample size necessary to achieve in a two-sided test with $\alpha = 0.05$ and power of 80% is 961.

A market research company, Dynata, distributed the survey link by email to a randomly selected sample of their panel members in the affected areas in selected states. We aimed to recruit 500 people with preexisting (self-reported) respiratory conditions and 500 without preexisting respiratory conditions, on the basis of responses to the survey. Surveys were deidentified and no identifying information was provided or collected. Eligible participants were asked to provide

Table 1. Differences in Mask Use, Health System Access, and Health Effects during the 2019/2020 Bushfire Season between People with and without Respiratory Conditions

Factor	With Respiratory Conditions [n (%)] (N = 490)	Without Respiratory Conditions [n (%)] (N = 527)	Odds Ratio		
			Estimate	95% CI	P Value
Exposed to bushfire smoke in the last 12 mo	343 (70.0)	337 (63.9)	1.32	1.0–1.7	0.04*
Wore a mask or P2 respirator during fires	98 (20.0)	51 (9.7)	2.3	1.6–3.4	<0.0001*
Experienced breathing difficulties	172 (35.1)	53 (10.1)	5.2	3.5–7.5	<0.0001*
Developed chest infection within 1 wk of BFSE	65 (13.3)	21 (4.0)	3.7	2.2–6.2	<0.0001*
Urgent visit to GP for breathing difficulties	51 (10.4)	4 (0.8)	15.2	5.5–42.2	<0.0001*
Visit to ED for breathing difficulties	21 (4.3)	6 (1.1)	3.9	1.6–9.7	0.0040*
Admitted to hospital for breathing difficulties	12 (2.4)	3 (0.6)	4.4	1.2–15.8	0.0200*
Increased use of reliever inhalers	207 (42.2)	13 (2.5)	28.9	15.6–53.7	<0.0001*
Increased use of controller or controller/reliever combination inhalers	149 (30.4)	11 (2.1)	20.5	10.2–41.1	<0.0001*
Increased use of corticosteroids	39 (8.0)	6 (1.1)	7.5	3.2–17.6	<0.0001*
Prescribed antibiotics	30 (6.1)	6 (1.1)	5.7	2.3–13.9	0.0002*
Any adverse health effect	294 (60.0)	80 (15.2)	8.4	6.1–11.5	<0.0001*

Definition of abbreviations: BFSE = bushfire smoke exposure; CI = confidence interval; ED = emergency department; GP = general practitioner.
*Significant at $\alpha = 0.05$.

informed consent before completing the survey. The survey was launched on August 3, 2020, and closed on August 21, 2020. The study was approved by the Human Research Ethics Committee of the University of New South Wales (project number HC200477).

The online survey collected data on sociodemographic characteristics, preexisting conditions, self-reported bushfire smoke exposure (BFSE) within the last 12 months, use of masks, outdoor air avoidance, and other nonpharmaceutical interventions undertaken. An adverse health effect is defined as any of the following occurring between December 2019 and February 2020: increased use of reliever, controller, or combination inhalers; increased use of corticosteroids; receiving antibiotics; an urgent visit to a general practitioner; admission to an emergency department (ED) or a hospital for breathing difficulties; or developing a chest infection, all within a week of BFSE. State of residence was determined on the basis of reported postcode. Age was recorded as a continuous variable and converted to a binary variable (<65 yr old) for analysis. Similarly, smoking status and household income were recorded as categorical and converted to binary variables ("current smoker" and "income <$18,200 per annum"). All other factors in regression analysis are binary variables.

We calculated cluster (postcode)-level sampling weights using data for age group, sex, area socioeconomic status, remoteness, and the prevalence of chronic disease using data from the 2017–2018 Australian National Health Survey (8). Each participant was assigned a sampling weight on the basis of their unique combination of attributes, calculated as the ratio of the number of participants with that combination of attributes in the surveyed sample to the expected number of people with the same combination of attributes in the Australian Health Survey. These factors were selected for adjustment on the basis of previous evidence, which shows that older adults and people of low socioeconomic status may be at an increased risk of mortality and ED/hospital admission after short-term exposure to bushfire smoke (9, 10).

We used descriptive statistics to summarize sociodemographic characteristics, preexisting conditions, avoidance behaviors, health effects, and smoke exposure. Logistic regression (with and without sampling weights) was performed to quantify the association of potential risk factors with respiratory conditions and with the occurrence of adverse health effects. Stratified analysis was conducted for subpopulations with and without preexisting respiratory conditions for the association between BFSE and adverse health

Table 2. Logistic Regression Analysis for Predictors of Adverse Health Effects during the 2019/2020 Bushfire Season, Adjusted for the Australian Population

Factor	Reporting Adverse Effects [n (%)] (N = 374)	Reporting No Adverse Effects [n (%)] (N = 643)	Odds Ratio (Unweighted)			Adjusted Odds Ratio (Weighted)*		
			Estimate	95% CI	P Value	Estimate	95% CI	P Value
Residing in NSW	228 (61.0)	267 (41.5)	2.20	1.7–2.9	<0.0001[†]	1.27	0.6–2.6	0.51
Age <65	278 (74.3)	454 (70.6)	1.21	0.9–1.6	0.17	2.88	1.2–7.2	0.02[†]
Annual household income <$18,200	17 (4.5)	32 (5.0)	0.91	0.5–1.7	0.75	0.68	0.3–1.8	0.45
Current smoker	88 (23.5)	129 (20.1)	1.23	0.9–1.7	0.24	2.37	0.9–6.2	0.08[†]
History of cardiovascular disorders	129 (34.5)	208 (32.3)	1.10	0.8–1.5	0.51	1.53	0.7–3.4	0.29
Avoided outdoor air during the bushfire	209 (55.9)	262 (40.7)	1.84	1.4–2.4	<0.0001[†]	0.74	0.4–1.4	0.36
Reduced physical activity during the bushfire	186 (49.7)	179 (27.8)	2.56	1.9–3.5	<0.0001[†]	2.11	1.0–4.7	0.07[†]
Used masks or face covering during the bushfire	79 (21.1)	17 (2.6)	9.86	5.7–16.9	<0.0001[†]	34.77	13.0–93.4	<0.0001[†]
Used P2 respirators during the bushfire	56 (15.0)	20 (3.1)	5.49	3.2–9.5	<0.0001[†]	7.28	2.5–21.5	0.0004[†]
Exposed to bushfire smoke in the last 12 mo	305 (81.6)	375 (58.3)	3.16	2.3–4.3	<0.0001[†]	2.05	0.7–6.1	0.19
Preexisting respiratory conditions	294 (78.6)	196 (30.5)	8.38	6.1–11.5	<0.0001[†]	34.59	11.3–106.3	<0.0001[†]
Participants with ≥1 preexisting respiratory conditions								
Exposed to bushfire smoke in the last 12 mo	238 (81.0)[‡]	105 (41.5)[§]	3.68	2.5–5.4	<0.0001[†]	4.12	1.8–9.6	0.001[†]
Participants without preexisting respiratory conditions								
Exposed to bushfire smoke in the last 12 mo	67 (83.4)[‖]	270 (60.4)[¶]	3.38	1.7–6.6	0.0004[†]	0.93	0.3–3.5	0.92

Definition of abbreviations: CI = confidence interval; NSW = New South Wales.
*All analyses are clustered at postcode level. Adjusted odds ratios are calculated using the weighted sample, standardized to the 2017–2018 Australian National Health Survey data for age group, sex, area socioeconomic status, remoteness, and the prevalence of chronic diseases.
[†]Significant at $\alpha = 0.05$.
[‡]N = 294.
[§]N = 196.
[‖]N = 80.
[¶]N = 447.

effects. Interaction between BSFE and preexisting respiratory conditions was assessed using SAS's joint test. Statistical significance was defined at α-level of 0.05. Analysis was completed using SAS software (version 9.4; SAS Institute).

Of 1,017 participants, 490 (48.2%) had preexisting respiratory conditions, 680 (66.8%) were exposed to bushfire smoke during the preceding summer, and 553 (54.4%) reported a bushfire within 50 km of their home. The median age was 54 years (range 18–89 yr) and sex distribution was close to 50%. Nonrespiratory medical conditions were present in 686 (67.5%) participants, most commonly hypertension (n = 284, 27.9%), allergies (n = 274, 26.9%), diabetes (n = 132, 13.0%), and dermatitis (n = 124, 12.2%).

Participants reported that, after bushfire smoke exposure, they experienced "chest infection" (n = 86, 8.5%), breathing difficulties (n = 225, 22.1%), urgent primary care visit for breathing difficulties (n = 55, 5.4%), and ED visit or admission to hospital (n = 15, 1.5%). Increased use of oral corticosteroids occurred in 45 (4.4%), and 36 (3.5%) were prescribed antibiotics; 221 (21.7%) reported increased use of reliever medication and 161 (15.8%) stated that they increased their use of controller or combined controller/reliever medication.

Table 1 shows that participants with respiratory conditions were significantly more likely to experience adverse health effects, wear a mask or P2 respirator during fires, or be prescribed antibiotics or oral corticosteroids. People older than 65 years reported fewer visits to health facilities than people younger than 65 years (6.0% vs. 7.4%) and were more likely to report outdoor air avoidance (50.9% vs. 44.6%).

Table 2 shows the predictors of adverse health effects. After adjusting for sociodemographic characteristics of the Australian population, the effect of BFSE on the risk of adverse effects was greater in people with preexisting respiratory disease than in people without preexisting respiratory disease (P for interaction = 0.0427). Younger age (<65 yr) was associated with higher probability of adverse effects. Cardiovascular disease was not a risk factor. Adverse health effects were more common among people who use respirators and masks. This may be attributable to confounding by indication, in that those with preexisting conditions, or who were experiencing symptoms due to the smoke, were more likely to use respiratory protection. In stratified analysis among people without preexisting respiratory conditions, the rate of adverse health effects was higher in people exposed to bushfire smoke (19.9%) than in people not exposed (6.8%) (P = 0.0001). Among

people with preexisting respiratory conditions, a similar trend was observed (69.4% for BFSE and 38.1% for nonexposure, $P < 0.0001$).

The primary limitation of our study is its cross-sectional design, which did not allow us to measure temporal changes in outcome. Participants with preexisting respiratory conditions are more likely to remember adverse events than participants without these conditions, which may lead to recall bias and overestimation of the risk of adverse events. Future studies would benefit from a cohort design, which would overcome these limitations. Nonetheless, the chance of participants without respiratory conditions not recalling these events is partially mitigated by the fact that the 2019–2020 bushfire was a major natural disaster and the adverse effects surveyed were relatively uncommon.

In conclusion, smoke exposure was significantly associated with adverse health effects during the Australian bushfire season in 2019/2020 not only among people with respiratory conditions but also among healthy people. Surprisingly, older age (65 yr and above) was associated with a significantly lower risk of adverse health effects. Our data suggest older people may be more cautious and less mobile in outdoor settings than younger people during bushfires. Younger people (<65 yr) may benefit from public health messaging about outdoor air avoidance and respirator use. Adverse health effects due to smoke exposure also impacted people without respiratory conditions. However, people with respiratory conditions are at greater risk and should be a priority for mitigation measures into the future. ∎

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Optimism with Caution: Elexacaftor–Tezacaftor–Ivacaftor in Patients with Advanced Pulmonary Disease

To the Editor:

We read with great interest the article by Burgel and colleagues, which described significant and rapid improvements in outcomes of patients with severe cystic fibrosis (CF)-related lung disease after commencing