VIEWPOINT

Lessons Learned from the Australian Bushfires

Climate Change, Air Pollution, and Public Health

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There is increasing scientific consensus that climate change is the underlying cause of the prolonged dry and hot conditions that have increased the risk of extreme fire weather in Australia.¹⁻³ With persistent droughts and record-breaking temperatures (2019 was Australia's warmest and driest year on record, <http://www.bom.gov.au/climate/current/annual/aus/>), it is unlikely that the extreme bushfires and smoke haze in Australia during the "Black Summer" (at the end of 2019 and the beginning of 2020) will be a one-off event. In recent years, other parts of the world, including California, Southern Europe, Southeast Asia, and the Amazon, have also been affected by catastrophic wildfires. We should be better prepared for more frequent and intense bushfire and wildfire events.^{3,4}

The immediate response to wildfires aims to prevent loss of life and may involve evacuation of people living in areas under threat. Although often necessary, evacuations can have health consequences for those who are displaced, particularly the poor and elderly, as was the case after the large-scale evacuations because of Hurricane Katrina in the US.

Away from the forests and towns devastated by the fires, millions of people have been exposed to unprecedented levels of smoke blanketing large parts of eastern Australia over days and even weeks. Sydney, Melbourne, and Canberra, cities with typically good air quality, have experienced record levels of air pollution. The air pollution has been compared with that of the most polluted Asian megacities, and the hazards of personal exposure to bushfire smoke have been compared with the hazards of smoking tobacco. Although some of these comparisons are debatable, they illustrate the level of anxiety about the short-term and longer-term health effects of prolonged exposure to extremely high levels of smoke.⁴

Health Effects of Bushfire Smoke

Bushfire smoke contains high concentrations of fine particulate matter ($PM_{2.5}$ <2.5 μm in diameter) that penetrate deeply into the alveoli, can translocate into the blood stream, and can cause systemic inflammatory effects. Bushfire smoke can exacerbate some respiratory conditions, such as asthma and chronic obstructive pulmonary disease, as well as cardiovascular events, such as myocardial infarction and cardiac arrest, in adults.⁵ Increases in pediatric respiratory visits were associated with wildfire smoke in San Diego, California, with younger children being particularly affected.⁶

Maternal exposure to fine particulate matter is associated with lower newborn birthweight. An interquartile range increase in $PM_{2.5}$ was associated with a 16-g lower birthweight in more than 700 000 singleton

births in Massachusetts.⁷ Traffic-related air pollution including $PM_{2.5}$ was related to impaired glucose tolerance in pregnant women.⁸ Maternal exposure to $PM_{2.5}$ from a prolonged coal mine fire in the Latrobe Valley, Australia, was shown to be associated with gestational diabetes.⁹ Therefore, it is likely that other landscape fires, such as bushfires, have similar effects during pregnancy and the perinatal period. The groups most vulnerable to smoke are thought to be pregnant women, young children, and the elderly, particularly those with long-term diseases, as well as people who are more likely to be exposed to smoke because of their occupations (eg, firefighters and outdoor workers).

The composition of bushfire smoke differs from that of urban background air pollution; urban air pollution is mainly attributable to the combustion of fossil fuels and is largely traffic related in Australian cities, yet also includes emissions from electricity generation and heavy industry. However, both bushfire smoke and urban air pollution contain combustion products including nitrogen oxides, which are irritants, and polycyclic aromatic hydrocarbons, which are carcinogenic. Theoretically, the absence of metallic particles from bushfire smoke might result in less toxic effects, but this has not been established empirically. Overall, most of the available evidence focuses on short-term health effects of episodic exposure to bushfire smoke, with little evidence available on the long-term effects of prolonged exposure.

Preventive Measures and Exposure Reduction

The immediate risk of catastrophic bushfires could be reduced through reduction of the amount of flammable material (potentially through prescribed burns and mechanical means), minimization of the area fires can spread to (by creating firebreaks, access roads, and water supply infrastructure), and use of early detection systems and rapid deployment of sufficient numbers of firefighters and equipment. However, prescribed burning is a controversial hazard reduction method because it exposes local populations to smoke, because it can only be safely conducted in certain vegetation types under specific weather conditions, and because climate change has potentially narrowed the safe time window for burns.¹⁰

Effective preventive measures and balanced health advice are needed to reduce exposure to bushfire smoke. Most current advice focuses on exposure reduction measures (such as staying indoors, reducing exercise outdoors, using air filtration/conditioning, wearing P2 or N95 face masks, and relocating to less polluted places) and consists in part of general advice about health maintenance, such as having an up-to-date asthma or chronic obstructive pulmonary disease management plan, regularly taking medication, eating well, and keeping well

hydrated. Although this advice is based on common sense, the evidence base is weak. For example, the evidence for face masks comes mainly from studies in occupational settings. Further, there is no specific evidence about how to protect vulnerable groups, such as pregnant women, young children, and the elderly. Current advice is most suitable for brief air pollution episodes rather than prolonged smoke events, such as the one in eastern Australia, and does not address the anxiety caused by extremely high levels of smoke persisting over weeks.

Some of these measures have important trade-offs and unintended consequences. For example, staying indoors and reducing physical activity over longer periods can decrease cardiovascular health. Face masks should fit properly to provide effective respiratory protection but may either give a false sense of security or cause discomfort. People with limited resources may live in substandard housing and may not be able to afford air conditioning units or portable air cleaners.

Building long-term resilience to prolonged bushfire smoke events requires a better understanding of the causes and effects of air pollution and of the behavioral factors determining personal exposure. As the catastrophic bushfires in eastern Australia have shown, fires and smoke can dramatically change speed and direction and move very quickly into populated areas. Thus, one of the most effective ways of protecting one's health is by closely following real-time information and forecasts on fires and air quality nearby and adjusting daily activities accordingly.⁴ This may involve staying indoors in a well-sealed room, with air conditioning/filtration if possible, or visiting a shopping center, library, or gym when air pollution levels are hazardous outside. Periods of the day when air quality is better are a good time to carry out normal outdoor activities

and to ventilate indoor spaces. It is also important to help others in the community who have less ability to take preventive action, such as the elderly and those with disabilities.

Lessons Learned

Australian cities enjoy relatively good air quality most of the year, but the extreme smoke haze events of late 2019 and early 2020 have been a wake-up call. The fires and smoke have exposed the vulnerability of the country to the effects of climate change. In many parts of the country, prolonged droughts have made the vegetation highly flammable and created the perfect conditions for bushfires. The smoke has traveled over long distances and affected large urban populations far away from the fire front.

Many older houses in Australia are very leaky and provide limited protection from outdoor air pollution. Some of the current health protection advice is impractical (eg, how long can you stay indoors?) or confusing (eg, do face masks offer effective protection or make things worse?). Health professionals, parents, employers, and the public at large should develop a better understanding of air pollution, its health effects, the protective measures available, and their trade-offs.

Most scientists agree that climate change has considerably increased the risk of extreme fire events. However, the political leadership of Australia is still divided on the issue, after 20 years of stalemate over international treaty obligations to reduce carbon emissions. Firefighting and hazard reduction measures should be combined with ambitious targets to curb carbon emissions from all sectors. These measures can mitigate climate change and reduce the risk of bushfires in the long term, as well as providing better local air quality and improved health in the short and medium terms.

ARTICLE INFORMATION

Published Online: February 28, 2020.
doi:10.1001/jamainternmed.2020.0703

Conflict of Interest Disclosures: Dr Vardoulakis reported grants, personal fees, and nonfinancial support from Dyson Ltd outside the submitted work. Dr Abramson reported grants from Pfizer, grants from Boehringer-Ingelheim, personal fees from Sanofi, nonfinancial support from Sanofi, and personal fees from GSK outside the submitted work. No other disclosures were reported.

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