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# Bushfires and human health in a changing environment

Bushfires are an integral part of the Australian environment. While the immediate health impacts of these fires can be devastatingly obvious, there are many other serious aspects of bushfires that remain less well understood. A holistic perspective of bushfires is essential for minimising harm and ensuring public safety in an environment that is becoming increasingly conducive to major bushfire catastrophes. This review summarises the current evidence about the immediate health risks of bushfires and the special health needs of survivors. It also looks at the health risks of smoke haze and other environmental hazards associated with bushfires.

■ **Large, destructive bushfires, such as those that experienced by Victoria in February 2009, are often beyond human control, despite technologically advanced fire fighting services and the resources allocated to bushfire control. The immediate impact of bushfires can be devastating, with loss of life, livelihoods and infrastructure at the fire fronts; and increased morbidity and mortality in smoke affected regions, which can often be far from the fires themselves. The indirect effects of bushfires are more subtle, and include the social and economic costs of rebuilding damaged infrastructure; long term adverse effects on physical and mental health; and environmental impacts, such as damage to water catchments and potential effects on the global carbon cycle.<sup>1</sup> Preventing harm to individuals and populations in this context remains a major challenge; it requires an understanding of the health risks and the complex interactions between society and the environment.**

## Understanding our environment

Australia is the quintessentially flammable continent. From the tropical to the arid and temperate zones, fire plays a fundamental role in the functioning of our ecosystems. Our vegetation is dominated by fire loving species. For example, recurrent fires over millennia have allowed eucalypt forests to thrive. (Indeed, eucalypt forests, which have used fire to gradually expand and replace the fire sensitive rainforests that once covered most of the country, have been called 'flame forests'.<sup>2</sup>)

The available evidence suggests that when pyrophobic Europeans colonists displaced Australia's original inhabitants, they unintentionally ended longstanding traditions of skilful landscape burning and actively attempted to suppress fires. As a result, fuel loads built up and the existing pattern of frequent small fires was replaced by a pattern of less frequent fires that were characteristically larger and more intense.<sup>3</sup>

Understanding of the deliberate use of fire to manage lands has steadily increased among non-Indigenous Australians;

however, the issue remains far from straightforward. While we now understand more about the fire loving nature of our vegetation and the need to use fire to manage fuel loads, we have also dramatically increased infrastructure and human habitation in and around the bush. Furthermore, there are only a limited number of days each year in which weather conditions are safe enough to set deliberate fires.<sup>4</sup> This limited window means that a major return to Aboriginal burning practices is not possible, except in sparsely populated regions such as our tropical savannas. Against this volatile backdrop we are now being forced to come to terms with a warmer climate that is drying out much of the landscape and increasing the frequency of severe fire weather. In view of all this, it is not surprising that Australia has a fire problem. Indeed, the frequency of severe wildfires is increasing on every vegetated continent on the planet.<sup>1</sup>

## Health issues for individuals

Of all the types of natural disaster in Australia, bushfires are associated with the greatest loss of life. The majority of these casualties occur among people fleeing their homes at short notice.<sup>4</sup> Those at a fire front face the immediate health risks of radiant heat injuries, dehydration, heat exhaustion and smoke exposure.

### Radiant heat

Of these risks, radiant heat poses the greatest threat. For example, temperatures of 300°C have been recorded at the centre of 9 m diameter clearings burnt by a fire with 25 m flame heights (much smaller than the height of flames recorded in Victoria in early 2009). While data is limited, the available evidence indicates that exposure to 300°C air will cause severe burns to the face, skin and larynx within minutes, and that survival is unlikely. However, a study has shown that humans can survive without injury and perform simple tasks in temperatures of 150°C for at least 10 minutes.<sup>5</sup> This highlights the lifesaving potential of appropriate clothing and fire shelters (such as bunkers) that can considerably reduce exposure to radiant heat and provide essential protection for the 5–20 minutes it might take for a fire front to pass. (It should be noted, however, that heavy protective gear can pose a secondary thermal risk when ambient air temperatures are high and physical exertion is required.)

### Dehydration and heat exhaustion

Dehydration and heat exhaustion are both well recognised health risks for active fire fighters.<sup>6</sup> These risks need to be minimised through frequent fluid intake and frequent breaks, which allow people to cool down after periods of physical exertion.

### Smoke inhalation

Smoke inhalation at a fire front, either by itself or in the presence of respiratory tract burns, causes severe respiratory tract injury. Indeed, respiratory failure is now the most common cause of death in

specialised burn treatment centres.<sup>7</sup> The components in smoke causing injury include toxic gases (carbon monoxide, cyanide gas, acids, aldehydes and oxidants) and microscopic particles, all of which result in local airway injury and inflammation and impair oxygenation.<sup>7</sup>

In studies of fire fighters, masks that filter particles, organic vapours and formaldehyde have been shown to be effective in reducing respiratory symptoms.<sup>8</sup> However, specialised breathing equipment is not readily available to members of the public and simple surgical or improvised cloth masks are unlikely to be useful. The effectiveness of specific particle filtering masks for use by the public has not been thoroughly evaluated. Only a properly fitted mask has the potential to reduce particle exposure. Even if fitted properly, however, particle filtering masks will not reduce exposure to other, nonparticle components of smoke. Also, particle filtering masks currently available cannot be adequately fitted to children or to people with facial hair. Further research into practical and effective strategies for members of the public who might have to protect themselves from exposure to extreme levels of smoke is needed.

### Trauma

Those who survive a fire may require treatment for serious injuries from burns, car accidents and other physical trauma. Those who escape injury might have lost friends, relatives, homes or livelihoods. As they come to terms with their losses and go about rebuilding their lives, they may face many long term challenges.

## Public health issues

The immediate public health issues that face affected communities are similar for all natural disasters. These include:

- sanitation and water safety
- food security
- infection control
- disease surveillance
- accommodation, and
- access to health care and community services.<sup>9</sup>

Infections of particular concern are those related to suboptimal sanitation and crowded accommodation, such as gastrointestinal infections and respiratory viral illness. These increase in importance in direct proportion to the number of people needing emergency accommodation.

## Long term health effects

In the longer term, people affected by bushfire disasters are at increased risk of many ongoing physical and mental health issues. In South Australia, 1526 survivors of the Ash Wednesday fires of 1983 were surveyed 1 year after the event. In comparison to the general population, the survivors had a significantly higher prevalence of a range of conditions, including hypertension, gastrointestinal disorders, diabetes, and mental illness.<sup>10</sup> Forty-two percent of respondents met the criteria for a psychiatric diagnosis,

in particular anxiety, depression and post-traumatic stress disorder – a much greater proportion than in communities that had not experienced a natural disaster. Another follow up, 20 months after the fires, demonstrated that the psychiatric morbidity from this event was ongoing.<sup>11</sup> Similarly, a school based screening program conducted 6 months after the Canberra fires of 2003 found that younger children and those with greater exposure to, or perception of, threat, experienced higher levels of post-traumatic stress disorder and emotional distress.<sup>12</sup>

One of the most comprehensive investigations of a post-disaster cohort was conducted in the Netherlands following a fireworks factory explosion in 2002. The impact of this disaster was comparable to a severe bushfire, given that 22 people were killed, approximately 1000 were injured, 1200 lost their homes and 10 000 were temporarily evacuated. The research conducted after this urban disaster has some useful lessons for Australia. It clearly demonstrated the value of rapidly defining and identifying people affected by the disaster, defining and establishing an appropriate control group and collecting baseline data. Such actions help overcome the major technical limitations of many disaster follow up studies, including those from Australia, for which control groups and baseline data are lacking.

The Dutch studies provide useful information about the magnitude and duration of excess morbidity attributable to the disaster; they also identify risk factors for ongoing mental or somatic symptoms. For example, at 18 months, the prevalence of both general health and mental health symptoms in the affected group was almost double that in controls. Additionally, of the 26% who fulfilled the criteria for post-traumatic stress disorder, less than half were actually receiving treatment.<sup>13</sup> Risk factors for ongoing symptoms included the need to relocate following the disaster, migrant status, previous psychological diagnoses, and female gender.<sup>14,15</sup>

The Australian Centre for Posttraumatic Mental Health emphasises the need for general practitioners to be aware of the high risk of ongoing mental health disorders in people affected by any major trauma. With effective interventions now available, current guidelines recommend the screening of individuals after major disasters or incidents. They also recommend that people who present to primary care services with repeated nonspecific physical health problems should be asked if they have ever experienced a traumatic event.<sup>16</sup>

## Public health impacts

The main ways in which bushfires pose threats to public health are through smoke pollution, degradation of water supplies and the destruction of major infrastructure, such as power lines to major cities.

### Bushfire smoke pollution

Major bushfires usually push particulate air pollution concentrations well beyond the threshold National Environment Protection Measure

level of 50 µg/m<sup>3</sup> for particulate matter 10 microns in diameter or less (PM<sub>10</sub>), with Australian cities often experiencing PM<sub>10</sub> levels of 150–200 µg/m<sup>3</sup> in association with bushfire smoke episodes.<sup>4</sup> Severe smoke haze can travel for hundreds of kilometres and affect large population centres far from the fires. Several studies have demonstrated direct associations between bushfire or forest fire smoke exposure and exacerbations of chronic diseases such as asthma and chronic obstructive pulmonary disease (COPD),<sup>17,18</sup> as well as increases in hospital admission rates<sup>19–21</sup> and neonatal and all cause mortality rates.<sup>22,23</sup> For example, Australia's Environment Protection Association (EPA) estimated that particulate pollution generated by the 2001 Sydney fires – to which no direct deaths were attributed – would have been responsible for 16 deaths and at least 30 hospital admissions for cardiovascular and respiratory conditions among Sydney residents.<sup>24</sup> A more extreme example was the severe haze associated with the 1997–1998 fires in South East Asia, which exposed millions of people to PM<sub>10</sub> levels in excess of 500 µg/m<sup>3</sup> for weeks at a time, with levels peaking near 3000 µg/m<sup>3</sup> in some regions.<sup>25</sup> The infant and perinatal death toll directly attributed to the excess air pollution was estimated to be 16 400 in Indonesia alone, representing a 1% decrease in the size of the expected birth cohort.<sup>23</sup>

Airborne particles, the major component of bushfire and wood smoke, exacerbate ischaemic heart disease and chronic lung diseases by promoting inflammation and coagulation and increasing oxidative stress.<sup>26,27</sup> For most health outcomes, these associations are similar in magnitude to those from air pollution from industrial and motor vehicle sources. However, in the only two studies that directly compared bushfire derived particulate matter with background urban particulate air pollution, adverse respiratory outcomes were greater in those exposed to bushfire smoke.<sup>19,21</sup> The risks are greater for several groups including the elderly; the very young; socially disadvantaged groups, including Indigenous Australians; and people with chronic diseases including diabetes and heart and lung disease.<sup>26,28</sup> Measurable worsening of asthma control occurs even with mild smoke haze, when particulate levels remain within Australian air quality standards.<sup>17</sup> If smoke haze has reduced visibility to less than 20 km, it is probable that Australia's air quality standards have been breached and individuals in higher risk groups will be at increased risk (see *Resource*).

### Risk reduction strategies for smoke pollution

On days with increased smoke haze, people at risk can best protect themselves by seeking out clean air environments, including air conditioned buildings such as office spaces or public libraries. Reverse cycle air conditioners filter particles from the air; these should be set to recycle mode. Although staying indoors is commonly advised, in the absence of air conditioning, this does not offer much protection.

A written Asthma Action Plan is an important management tool. While they have not been directly tested in the context of bushfire

smoke episodes, they do improve health outcomes.<sup>29</sup> To avoid increased exposure to pollution, people are commonly advised to avoid exercise during times of bushfire, although the harm avoided by this strategy is not amenable to direct research. As discussed earlier, the effectiveness of face masks in minimising the impact of nonoccupational exposure to smoke has not been thoroughly evaluated. Further research on the role of face masks in managing the public health impacts of episodes of bushfire smoke pollution is needed. Two studies from communities affected by wildfire smoke in the United States have evaluated face masks. One of the studies, which was conducted in an indigenous community, did not find that mask use reduced symptoms or health care attendances, and attributed this to inconsistent use, poor fit testing and variation in mask effectiveness.<sup>30</sup> The other study found that the use of masks was associated with a reduction in symptoms attributable to wildfire smoke.<sup>31</sup> The use of face masks is not a routine part of current public health advisories in Australia. However, in a survey following a severe episode of smoke pollution in Albury associated with bushfires in early 2003, approximately 5% of respondents reported using them.<sup>32</sup> The Albury study also highlighted the potential value of public health advisories. Seventy-four percent of people reported being aware of the health advisory messages, and people who heard the messages were significantly more likely to change their behaviour to reduce their exposure to the smoke pollution.

### **Bushfires and water security**

The decision to pump 10 billion litres of Melbourne's drinking water to safer storages during the recent Victorian fire emergency graphically illustrated the threat that bushfires pose to water catchments. Extreme erosion, such as that experienced after bushfires, immediately accelerates the runoff of sediments that increase turbidity, as well as the runoff of nutrients such as iron, phosphorus and manganese, which heighten the risk of toxic algae blooms. Excessive sedimentation and nutrient loads can both render water supplies undrinkable.<sup>33</sup>

The problems faced by water catchments are long term. In addition to the direct impacts on water quality, the probability of major floods occurring in the post-fire season increases up to an order of magnitude, further raising sediment yields, which then reduce long term water storage capacity. Finally, regrowing eucalypts consume far more water than mature trees, which means in the years following the fires there is a reduction in catchment runoff of approximately 30%, compromising the replenishment of supplies.<sup>34</sup>

### **Bushfires and climate change**

Severe bushfires are occurring more often than ever before, both in Australia and around the world. As global warming produces more droughts and high fire danger weather conditions, these bushfires are expected to become even more frequent and

intense.<sup>35</sup> Fires release huge quantities of stored carbon, and this carbon might not be resequenced because the regrowth of vegetation is prevented by ongoing drought conditions or by human intervention. Deforestation fires are occurring on a massive scale throughout tropical regions of the world and have been estimated to account for approximately 20% of anthropogenic greenhouse gas emissions.<sup>1</sup> Landscape fires thus have the potential to further accelerate global warming, driving a positive feedback of ever more serious fires.

### **Conclusion**

Given our climate, our fire promoting vegetation and the ubiquity of ignition sources (including both humans and lightning), eliminating fire from Australia's landscapes is an ecological impossibility. Instead, we need to minimise its harms by learning how to live with, and how to manage, fire. Well designed longitudinal studies are crucial for understanding the health impacts of bushfires and, given the recurring nature of these disasters, should be a priority for Australia.

While in depth discussion of these issues is beyond the scope of this article, it is important to acknowledge that living with fire requires cooperative action from a number of sectors in the community. For example, the management of our eucalypt 'flame forests', which is crucial to mitigating the impacts of fires, requires a balance between the often competing agendas of biodiversity conservation, fuel reduction and managing the potential hazards associated with deliberate burnoffs. Minimisation of bushfire risk also needs to be an integral part of housing and community design, with particular focus given to the interface between urban and rural settings. High levels of community education, preparedness and communication with fire management services are all essential. Those in the health sector need to understand the full range of health issues associated with bushfires, from the direct physical and mental health harms to the risks associated with severe air and water pollution. Health professionals also have an important role in advocating for mitigation strategies, including the urgent need for action to reduce the rate of global warming. Adaptation to climate change demands that we are better prepared to manage all aspects of bushfire disasters.

### **Resource**

The Victorian EPA has produced a public guide for assessing the risk from smoke haze. The guide also advises on appropriate action. It can be found at [www.epa.vic.gov.au/air/bushfires/default.asp#self](http://www.epa.vic.gov.au/air/bushfires/default.asp#self). This is a useful resource considering many areas affected by fires will not have air quality monitoring in place.

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