













Asthma and landscape fire smoke: A Thoracic Society of Australia and New Zealand position statement

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Abstract

Landscape fires are increasing in frequency and severity globally. In Australia, extreme bushfires cause a large and increasing health and socioeconomic burden for communities and governments. People with asthma are particularly vulnerable to the effects of landscape fire smoke (LFS) exposure. Here, we present a position statement from the Thoracic Society of Australia and New Zealand. Within this statement we provide a review of the impact of LFS on adults and children with asthma, highlighting the greater impact of LFS on vulnerable groups, particularly older people, pregnant women and Aboriginal and Torres Strait Islander peoples. We also highlight the development of asthma on the background of risk factors (smoking, occupation and atopy). Within this document we present advice for asthma management, smoke mitigation strategies and access to air quality information, that should be implemented during periods of LFS. We promote clinician awareness,

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and the implementation of public health messaging and preparation, especially for people with asthma.

KEYWORDS

asthma, exacerbation, impacts risk, landscape fire smoke, management, mitigation, pathogenesis

INTRODUCTION

The power and devastation of major landscape fire events have been vividly apparent with destructive megafires being experienced in many regions of the world and exemplified by the Australian bushfires of 2019–2020. While landscape fire smoke (LFS) events from bushfires and planned burns have always been a part of the Australian environment, further increases in the risk of catastrophic fires, are predicted in association with climate change acceleration.^{1,2} The anomalous Australian 2019–2020 bushfire season which exposed >10 million people to increased concentrations of particulate matter (PM) over 3 months was an example.³ This event was especially concerning for people with asthma,⁴ and with the high prevalence of asthma in Australia and New Zealand⁵ and increasing LFS events, clinicians, patients and carers need clear guidance on how to best manage these exposures. In response, the Thoracic Society of Australia and New Zealand (TSANZ) commissioned this position statement.

For this statement, landscape fires include vegetation fires (bushfires, prescribed and cultural burns, forest, savanna, grassland and shrubland fires, agricultural burning), open coal mine and peat fires. The main air pollutants in LFS include PM_{2.5} (<2.5 µm in diameter),³ PM₁₀ (<10 µm), carbon monoxide, oxides of nitrogen, volatile organic compounds and polycyclic aromatic hydrocarbons. Most of these compounds have well-documented health risks.³ Ozone is a major component of photochemical smog in cities, and regional concentrations may be increased following injection of precursors from LFS, but will not be considered in this document.

LFS has a wide range of adverse effects on human health, with organ systems adversely affected by air pollution.⁶ For example, the 2019/2020 Australian bushfires directly caused 33 deaths, including 9 fire fighters and more than 400 deaths were attributable to the associated smoke.^{3,7} Exposure to LFS during the period of October 2019 and March 2020 was associated with an estimated 1523 emergency department (ED) asthma presentations.³ There were increased dispensing and sales of asthma medications including reliever (short-acting β-agonists) and combination controller (inhaled corticosteroids and long-acting β-agonists) inhalers and increased medical benefits scheme (MBS) claims for respiratory services. There was also increased use of mental health services such as Lifeline. Furthermore, the longer-term impacts of such crises, for example, post-traumatic stress disorder and substance abuse can be delayed, so the true impact is not yet known. A survey by Asthma Australia demonstrated that people with asthma were also more likely

TAKE HOME MESSAGE

We provide a position statement from the TSANZ on the impacts of landscape fire smoke exposure on people with asthma, and risk mitigation, exposure management and interventions promoting clinician awareness, public health messaging and further research.

to experience financial impacts, anxiety and depression compared to those without asthma.⁴

Until recently each jurisdiction in Australia had its own public health advice for smoke events, which varied slightly between states and territories. In 2020, the Royal Commission into National Natural Disaster Arrangements, recommended a nationally consistent approach for air quality information, health advice and interventions.⁸ Therefore, the Environmental Health Standing Committee (enHealth) published national guidelines for managing prolonged exposure to LFS.⁹ This included air quality categories and accompanying public health advice for 1- and 24-h average PM_{2.5} concentrations.

This position statement communicates the impacts of LFS, highlights strategies to mitigate the risks, and provides clinicians with appropriate advice to communicate to people with asthma in future events.

METHODS

The writing group was convened by TSANZ following a call to members, and external experts were identified and invited. Applications were reviewed based on TSANZ policy, and multidisciplinary members and a consumer representative were selected based on experience and complementary skills. A range of professions and disciplines with relevant expertise across four Australian states were included: respiratory medicine and research, environmental science, paediatrics, nursing, epidemiology and a community representative with asthma. Conflict of interest declarations were made by all members and reviewed by TSANZ. The group was chaired by VMMcD and MJA.

An outline of the position statement was prepared by the Chairs and circulated. All members gave input and changes were made after discussion. Based on their areas of expertise, members were assigned specific writing tasks. The group held regular videoconferences to discuss the articles and prepare the position statement.

BOX 1 Search strategy

‘(Asthma OR wheez*) AND (bushfire OR wildfire OR wildland fire OR landscape fire OR open fire OR forest fire OR coal mine fire OR peat fire OR crop burn* OR stubble burn* OR forest fire OR habitat fire OR agricultur* fire OR grass fire OR savanna* fire OR prescribed burn* OR prescribed fire OR vegetation fire OR hazard reduction burn* OR planned burn* OR fuel reduction burn* OR controlled burn* OR cool burn*).'

Search terms were developed by two members (TB, BB) and approved by the working group. Search terms are presented in Box 1. Medline was used to identify relevant research articles for relevant sections. ‘Grey’ literature was searched for articles pertaining to existing asthma management guidelines. The inclusion of articles was determined as being the most relevant to the position statement. Members revised the drafted sections using a shared drive. The final draft was compiled and edited by the chairs and circulated. Peer review was conducted jointly by TSANZ and *Respirology* and the final position statement was approved by the TSANZ Board and Editors of *Respirology*.

IMPACT OF LFS**Impact on adults with asthma, including vulnerable groups**

There is mounting evidence reporting the association between LFS and asthma symptoms and healthcare service utilization.^{10–12} A study of the impact of the 2019–2020 Australian bushfires found that people with asthma reported significantly higher rates of respiratory symptoms and poor asthma outcomes (ED visits, hospitalization and oral corticosteroid use) during the fire period compared to those without asthma.⁴ Gan et al. found that the risk of asthma diagnosis at EDs, asthma-related primary care visits, outpatient hospital admissions and asthma rescue inhaler medication dispensing was significantly associated with increases in LFS-related PM_{2.5}.¹³ Vertigan et al. also demonstrated that adults with laryngeal hypersensitivity had a greater symptom burden during the 2019/2020 Australian bushfire period. Furthermore, these symptoms persisted in the months following exposure and were associated with worse asthma control.¹⁴

These findings suggest that LFS increased the risk of asthma morbidity and healthcare service utilization, which warrants the need for public health intervention.

A systematic review and meta-analysis of 20 studies that examined the association between LFS-related PM_{2.5} and asthma-related outcomes, found that older people (>65 years) were particularly vulnerable with a higher risk of asthma-

related outcomes when exposed to LFS PM_{2.5} compared to younger adults and children.¹⁵ Similarly, other studies found a greater impact of LFS on ED visits and hospitalization for asthma among older people.^{12,16,17} A study of the 2003 catastrophic fires in Southern California found that asthma admissions were increased during the LFS period compared to periods before or after among all age groups.¹⁸ However, the greatest increase in asthma admissions was observed in the older age group (aged 65–99 years, 10.1%), followed by children (0–4 years, 8.3%) and adults (20–64 years, 4.1%).¹⁸ A study of the health outcomes of smoke exposure during the 2011 landscape fire in New Mexico reported that the risk of asthma exacerbations increased for all ages by 8% during the fire smoke period, while the risk increased by 73% in the older population (≥65 years).¹⁷ Collectively, these studies indicate that older people are more susceptible to the effects of LFS. Reduced health literacy and the higher prevalence of comorbidities in older people makes this group particularly vulnerable.¹⁹

Pregnant women with asthma are another vulnerable group. Normal physiological changes during pregnancy increase their vulnerability to exacerbations generally, and LFS in particular.^{20,21} Exposure to LFS in pregnant women may have a direct impact on asthma, increasing airway inflammation and reducing lung function causing asthma exacerbations, which may increase the risk of adverse pregnancy outcomes including low-birth weight and preterm birth.^{22,23} A study of the health impact of the 2019–20 Australian bushfire period found that pregnant women with asthma were more likely to report respiratory and non-respiratory symptoms during compared to after this periods.²⁴ Moreover, pregnant women with asthma also had higher anxiety scores during compared to after the fires.²⁴ This indicates that LFS has significant effects on the health of pregnant women and identifies the need for adequate preparation, clear messaging and avoidance of LFS exposures during these events.

Impact of LFS on children with asthma

Children are also at increased risk of the harmful effects of LFS exposure compared to adults, due to smaller airways, higher metabolic rate and ongoing development.^{25,26} A systematic literature review of LFS exposure and respiratory-related healthcare visits in children included studies up to December 2020.²⁷ Of the limited number of suitable studies, published between 2006 and 2020 in North America and Australia, five used a pre-post design and 11 were cross-sectional.²⁷ Data were included on >500,000 children under the age of 20 years. This review demonstrated increased risks between LFS exposure and outpatient clinic visits for any respiratory problem (increased risk in all 3 studies; total 9777 participants), ED visits for any respiratory cause (5/8 studies; 557,454 participants) and hospitalization for any respiratory cause (3/4 studies; 13,258 participants). However, results for asthma-related healthcare visits were unclear: asthma-related clinic visits (increased risk in only 1/3 studies, 9777 participants), ED visits (3/8 studies,

577,454 participants) and hospitalization (2/4 studies, 9777 participants). Any observed effects occurred within the first 3 days of smoke exposure. Hutchinson et al. reported dose-effects and increased impact by LFS exposure on participants with existing asthma or rhinitis.²⁸

Following the systematic review, several notable studies have been published. Aguilera et al. studying the wildfires of 2011–2017 in San Diego county California, observed that young children (<5 years) were more at risk of a hospital respiratory visit during LFS periods, with visit rates up to 10 times higher than a comparable 10 µg/m³ increase in non-wildfire smoke PM_{2.5}.²⁹ The main symptoms were cough, and visits for asthma were not significantly higher. Whether this failure to show a difference specific to asthma visits reflects a greater preference to stay indoors, increase their asthma medication in response to the change in the environmental conditions, or preferential evacuation of higher-risk people is unclear.

TABLE 1 Quotes from people exposed to the 2019/2020 Australian landscape fire smoke period.⁵⁸

Negative feelings/experiences from smoke exposure—‘It’s also been awful for my mental health. I have had to increase my dose of sertraline to manage the anxiety’.

Challenges in avoiding exposure to smoke—‘Even working inside a shopping centre gave no relief as the smoke could still be smelt inside. It has been near impossible to avoid’. ‘Staying indoors for a 3-year-old is hard. He wants to go out to play. Restricted time at friends [sic] birthday party due to outdoors’.

Costs and future resilience landscape fire events—‘Financial support would be huge for me, offering free P2 masks, offering discounted Ventolin, an air quality update app, discounted air cleaners...’

The respiratory vulnerability of very young children to LFS was also observed by Hutchinson et al. who found that LFS was associated with both respiratory and asthma visits in children <4 years.²⁸ Delfino et al. also observed an increase in respiratory hospitalizations in children <4 years.¹⁸ Canadian investigators reported increased ED admissions for asthma during the 2014 landscape fires in Canada’s high subarctic (OR 1.07, 95% CI 1.01–1.14, age 5–19 years).³⁰ Mahsin et al., observed that the 2015 landscape fires in the Pacific Northwest were associated with excessive asthma-related outpatient visits in children and adolescents (RRR range 1.60–1.92).³¹ Australian investigators in a single-centre cohort of children with asthma attending scheduled outpatient reviews during a pronounced LFS season, reported a 5% reduction in FVC on LFS days compared to non-LFS days which reversed with short-acting bronchodilator.³²

Aboriginal and Torres Strait Islander peoples may also be at greater risk of symptoms during LFS exposure periods. In one study of both children and adults, a 15% (95% CI 3%–28%) greater risk of hospitalization was described in Indigenous Australians compared to non-indigenous people.³³

Impact of short- and long-exposures to LFS including new onset of asthma and risk-factors

There is growing evidence that exposure to urban air pollution, which is relatively constant, increases the risk of new-onset asthma in both children^{34,35} and adults.^{36,37} However, the risk of intermittent and transient LFS exposure on asthma is unknown. Firefighters are regularly exposed to LFS, but there is no consistent evidence of increased adult-onset asthma in this group.^{38,39} However, a study of firefighters with prolonged

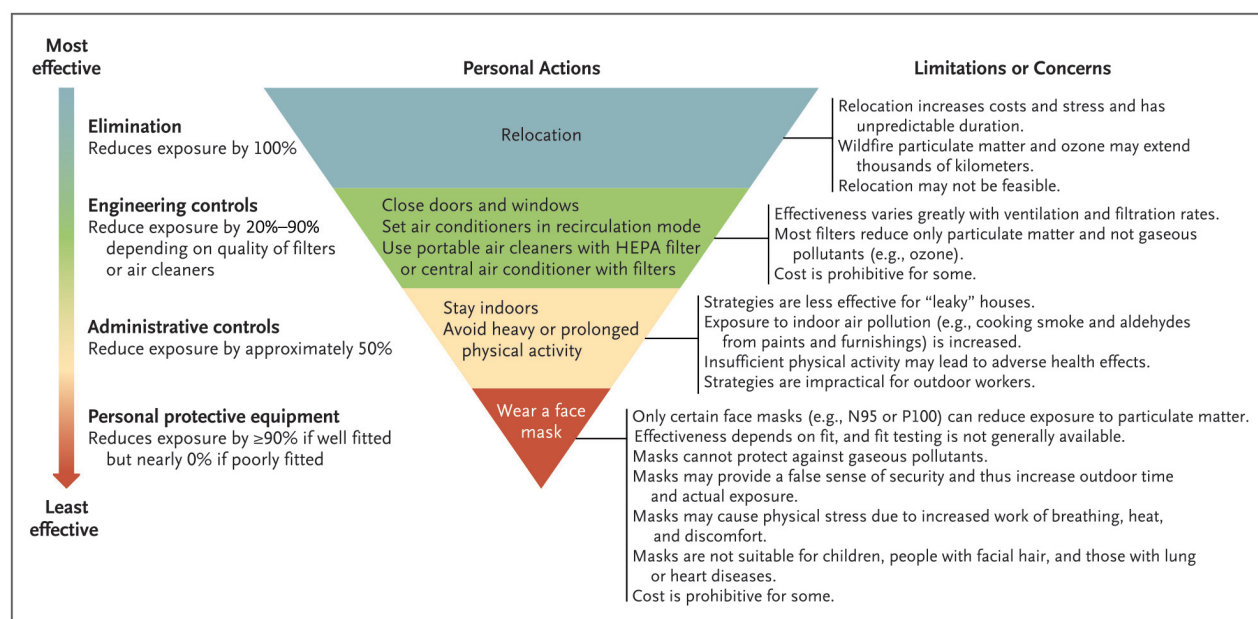


FIGURE 1 Actions that people with asthma can take to reduce exposure to landscape fire smoke and its health effects. From Xu et al. Wildfires, global climate change, and human health. N Engl J Med. 2020. 383: 2173–81. Copyright ©2020 Reprinted with permission from Massachusetts Medical Society.²

TABLE 2 Benefits and drawbacks of personal risk reduction measures during landscape fire smoke events Adapted with permission.⁶⁶

Risk reduction measure	Benefits	Drawbacks
Staying indoors (at home, workplace or school) ⁶⁷	<ul style="list-style-type: none"> Effective in reducing personal exposure to PM_{2.5} in relative well-sealed rooms with⁶⁸: <ul style="list-style-type: none"> air conditioning (on recirculating mode) air filtration (with HEPA filters) no indoor pollution sources (e.g., cigarette smoking)⁶⁷ 	<ul style="list-style-type: none"> Building overheating and low air exchange rates resulting in high indoor temperatures and carbon dioxide levels^a Significant upfront cost for installation of air conditioning/filtration systems⁶⁹ Ineffective over longer periods of time (i.e., several days) without additional air filtration⁶⁹
Reducing strenuous physical exercise outdoors ⁶⁷	<ul style="list-style-type: none"> Effective in reducing personal exposure to bushfire smoke^a Limiting exertion in children may be especially important for reducing their exposure to particles⁶⁷ 	<ul style="list-style-type: none"> Could be detrimental to cardiovascular and mental health if air pollution persists over longer periods, unless other opportunities for exercising are provided (e.g., indoor sports centres)⁶⁷
Using a clean air facility or public building with good indoor air quality (e.g., air-conditioned shopping centre, public library, community centre and sports centre) ^a	<ul style="list-style-type: none"> Effective in reducing exposure to outdoor air pollution over short periods (i.e., hours)⁷⁰ 	<ul style="list-style-type: none"> Impractical over longer periods of time (ie. several hours) At-risk individuals may need onsite medical assistance or ambulance transport Large numbers of facilities will be required in cities^a Facilities may need retrofits for airtightness or installation of HEPA filters for air intake^a
Portable air cleaners (air purifiers) ⁶⁷	<ul style="list-style-type: none"> Effective in reducing indoor air pollution levels if fitted with HEPA filters^{67,69,71} Highly effective in well-sealed rooms of certain size as recommended by manufacturer^{67,69,71} 	<ul style="list-style-type: none"> Less effective in less airtight houses, which are common in Australia^a PM_{2.5} removal rate dependent on flow rate of air cleaner^{67,72} Significant upfront purchase cost Availability may be limited in areas heavily affected by bushfire smoke
Face masks, including professional masks and surgical masks ^{73–75}	<ul style="list-style-type: none"> Well-fitted professional (e.g., P2/N95) masks offer effective protection from PM_{2.5} exposure⁷³ Professional masks are generally suitable for outdoor workers^a Exhalation valves can reduce build-up of humidity and carbon dioxide within masks^a 	<ul style="list-style-type: none"> Difficult to achieve good facial fit with professional masks (e.g., due to small face, facial hair etc.)⁷³ No professional masks are made for children Surgical masks offer only moderate protections⁷³ Improvised cloth masks, bandanas or T-shirts offer no protection⁷³ Face masks may give false sense of security⁷⁵ Uncomfortable to wear over longer periods⁷⁶
Antioxidant supplements, fish oils (omega-3 fatty acids) and other dietary advice ^{77,78}	<ul style="list-style-type: none"> A healthy diet, rich in fruits and vegetables, is generally beneficial. However, there is no direct evidence of protective effects of diet against air pollution⁷⁷ 	<ul style="list-style-type: none"> Dietary supplements can provide long term and potentially short-term health benefits, but may be costly^a Supplements should not be used as substitute for a healthy and balanced diet More research is needed to prove effectiveness of supplementation in reducing health risks from air pollution exposure
Asthma medication	<ul style="list-style-type: none"> Asthma preventive medication can attenuate exacerbations of the condition 	Patients require knowledge that they have asthma and/or are at risk of exacerbation during exposure. Therefore, adherence to prescribed controllers is necessary
Aspirin, statins and other medications ⁶⁷	<ul style="list-style-type: none"> There is very little evidence that aspirin, statins or any other medication have direct protective effects against air pollution⁶⁷ 	
Smoke forecasts, near real-time air quality data (PM _{2.5}), air pollution and health alerts ⁶⁹	<ul style="list-style-type: none"> Mostly free to use and can enable individuals to develop personal smoke exposure reduction plans⁷⁹ Localized hourly air quality information more useful than 24-h rolling averages or spatially averaged data^a 	<ul style="list-style-type: none"> Use information services that have been validated for Australian conditions such as jurisdictional environment agency websites or the Australian app AirRater Information in electronic media may not reach some sensitive groups (e.g., older people)
Temporary relocation ⁸⁰	Can provide health protection to at-risk groups, such as pregnant women, or people with serious lung or heart disease, affected by localized but persistent smoke episodes ^a	<ul style="list-style-type: none"> Impractical when large population centres are affected Difficult and expensive to relocate many people² Socio-economically deprived individuals, older people and those who are very ill have lower ability to relocate safely⁸⁰ Cognitive impairment and restricted mobility could compound the stress of relocation⁸⁰

Abbreviations: HEPA, high-efficiency particulate air; PM_{2.5}, atmospheric particulate matter with a diameter <2.5 µm.^aBased on the authors' expert opinion.

(3-month) exposure to catastrophic landscape fires found that compared to community members, firefighters had increased likelihood of physician-diagnosed new-onset asthma, as well as reduced lung function, within 3 years of the fires.⁴⁰

While no studies have specifically addressed community exposure to LFS and the risk of developing asthma, recent studies from an extreme exposure event in Australia point to a possible link, particularly with early-life exposure. An open-cut coal mine fire in Hazelwood, Victoria in 2014 caused severe fluctuating air pollution over 6 weeks.⁴¹ Studies of the exposed population showed mild impairments in peripheral lung function 3 years post-exposure in adults,⁴² children born just prior to the fire,⁴³ increased parent-reported and doctor-diagnosed respiratory infections in children exposed in utero, and increased use of asthma inhalers in children exposed post-natally.⁴⁴ These observations suggest that LFS may have direct effects on dysregulation of immune responses and lung development in post-natally exposed children, and through maternal systemic effects in in utero exposed children.⁴⁵

Combinations of in vitro/ex vivo human cell studies with in vivo mouse and other animal models are valuable in defining the impact of short and long-LFS exposures on asthma onset.⁴⁶ Studies in mice and rats showed that acute and chronic LFS exposures promote allergic sensitization, increase asthma-like severity and reduce responses to pathogens through increasing innate (uric acid, inflammasomes and oxidative stress)^{47–49} and adaptive (Th1 and Th2 cytokine) immune responses.^{50,51} In a natural experiment, rhesus macaques exposed to LFS smoke during the first months of life in the California fires of 2008 developed asthma-like symptoms, and reduced lung volume and function and peripheral IL-6 and IL-8 responses compared to macaques born after the fires.⁵²

These data suggest that early life exposure to LFS may impair immune responses and lung function in childhood and increase the risk of developing asthma. Furthermore, longer-duration fires, expected in the future, may be a greater risk for asthma development than repeat short-term exposures. However, research remains sparse. An American Thoracic Society Workshop Report outlined the future challenges and policy opportunities for the respiratory impacts of LFS. It highlighted the importance of future research on the effects of long-term and repeated LFS pollution on respiratory, cardiovascular, neurological and psychological health across life stages, including developing fetuses and children.³⁹

CONSUMER EXPERIENCE

There is substantial literature on the environmental, economic and health burden of landscape fires.^{53–55} Still, understanding patients' experiences is important. Studies reporting on psychological impacts of LFS exposures have consistently found negative impacts on mental health.⁵⁴ Negative outcomes in pregnancy due to pre-natal stress from LFS exposure are reported.^{23,56} A study from Broder et al. demonstrated distress caused to residents of Latrobe Valley, after the Hazelwood mine fire caused substantial PM release. Using self-reported

data from health surveys they demonstrated psychological distress in people with self-reported respiratory symptoms.⁵⁷

The 2019–2020 Australian bushfires prompted Asthma Australia to undertake an online survey during December and January; a period of high smoke impacts.⁵⁸ There were 12,152 responses received of whom 7285 (61%) reported a prior doctor diagnosis of asthma. Overall people with asthma reported substantial increases in the requirement for asthma treatment, a deterioration in symptoms and quality-of-life, including an increase in anxiety and depression, and greater healthcare utilization. The need for increased medication and protective equipment, time off work and increased doctor visits led to greater financial burden in those with asthma.⁴

In another survey of 240 people with asthma who were enrolled in the Severe Asthma Web-based Database, conducted after the 2019/2020 Australian bushfires, adults with severe asthma experienced substantial health impacts from the intense and prolonged exposure.⁵⁹ These data indicate a clear need to improve the messaging for people with asthma. Table 1 highlights illustrative quotes from these studies.

These Australian surveys demonstrate that beyond the well-documented health impacts of LFS from various international studies, people with asthma experience a range of impacts on their wellbeing and relationships from LFS exposure and desire further support and information. More research should be undertaken to further understand the needs of people with asthma to reduce the impacts of LFS. The Australian Commonwealth Royal Commission into National Natural Disaster Arrangements further highlighted this need calling for more support to vulnerable groups and a prioritization of mental health assistance.⁸



FIGURE 2 Core components of asthma management.

FIGURE 3 Landscape Fire Smoke Asthma Checklist. Information for people with asthma to manage their asthma during the LFS period. Adapted with permission from the Centre of Excellence in Severe Asthma <https://toolkit.severeasthma.org.au>.⁸⁵

Landscape fire smoke leads to poor air quality and the potential for a sudden emergency evacuation

Landscape Fire Asthma Checklist

- 1 A landscape fire plan**

 - Ensure you know what to do in the event of a landscape fire
 - Visit: www.rfs.nsw.gov.au/resources/bush-fire-survival-plan to create a bushfire plan
- 2 Optimise your asthma management**

 - Contact your health care provider for an up-to-date written asthma action plan and ask if there should be any variations for heavy smoke exposure
 - Use your inhalers correctly and as prescribed
- 3 A medication plan**

 - Ensure relievers & controller asthma medications are in date
 - Have a 30 day supply in case of shortages or evacuations
 - Know how to communicate your medication requirements to volunteers in the event of an evacuation
- 4 Keep your medications in a central place**

 - In case of an emergency evacuation keep your medications together and in a central place for easy access
 - Using the same pharmacist can help with continuity in the event of lost medication prescriptions
- 5 Have an asthma companion**

 - A person who knows what medications you need, when you need them and provide a written plan for them
 - Educate your companion to know when you need urgent medical care
- 6 Try to minimise stress during an evacuation and keep informed**

 - Have a plan and easy access to your medications
 - Access regular updates via local media and monitor air quality information via the AirRater application

Infographic developed as part of the:





toolkit.severeasthma.org.au

These data and experiences of people with asthma also highlight the need for effective communication and partnership between people with asthma and their health care team. Shared decision-making is known to improve adherence and asthma outcomes among people with asthma.^{60,61} During periods of increased stress and environmental trigger exposure effective therapeutic alliances, and planning may lead to better outcomes.

MITIGATION STRATEGIES AND EXPOSURE REDUCTION

Reducing exposure to LFS can be achieved at varying levels of effectiveness by implementing personal mitigation

strategies. A theoretically effective strategy, but one that is often not feasible is relocation.² In a survey of people with asthma following the 2019–2020 Australian bushfire period, only 11/240 (4.6%) of participants indicated that they relocated elsewhere.⁵⁹ Engineering controls such as setting air-conditioners to recirculation mode, closing windows and doors and using air-purifiers with high-efficiency particle air (HEPA) filters, potentially achieves 20%–90% exposure reduction. The most effective of these options is use of a HEPA filter that is sized appropriately for the room.^{62,63} In a cross-sectional survey of people with asthma, some of these strategies were frequently implemented, 83% of participants reported staying indoors, 92.9% kept their windows closed and 72.1% used home air-conditioners.⁵⁹ However, Australian houses are more leaky (less airtight with poorer

TABLE 3 Summary of guidelines/recommendations and resources from reputable sources.

Authority	Recommendation/resource
The Commonwealth Department of Health	Fact sheets recommend staying indoors when there is visible smoke haze. In particular, they recommend avoiding exercise outdoors and monitoring air quality information via the state-based network of agencies and provide general information about N95/P2 masks and air purifiers. ⁸⁶ The Department also provides a document advising action for vulnerable groups that includes asthma. ⁸⁶ This document flags the possibility of an exacerbation over several days of exposure and the need to have a personalized action plan.
The Australian Institute of Sport	A position paper on exercise and smoke that, while not specific to asthma, mentions asthma and respiratory infection as risk factors. This is useful as a practical guide to activity. ⁸⁷
Asthma Australia	Provides web-based advice in a user-friendly format emphasizing avoidance of LFS, checking landscape fire and prescribed burn information, N95/P2 mask protection when outdoors for people with asthma and a personal asthma action plan. There are very clear, concise and downloadable documents for both patients and healthcare providers and numerous relevant links to government agency and monitoring websites. ⁸⁸
NHMRC Centres of Research Excellence in Severe Asthma	Infographics on asthma management and LFS.
NHMRC Centre of Research Excellence for Air Pollution, Energy and Health Research	Fact sheet on the health impacts of bushfires. ⁸⁹

insulation) compared to other countries including the USA, the UK and Canada, allowing smoke to permeate reducing the effectiveness of mitigation strategies.⁶⁴ Smoke can remain trapped indoors for many hours after outside conditions have improved. For this reason, tracking of smoke impacts and ventilating homes when conditions are good is an important environmental intervention.⁶⁵ We recommend that HEPA filter air-purifiers be subsidized for at risk people with asthma.

N95/P2 or P100 face masks can reduce exposure significantly, but fit-testing for these masks can be limited for community members, and effectiveness depends on well-fitting masks.^{2,59} N95 is a NIOSH (US) standard whereas P2 is the Australian standard. After the 2019–2020 Australian bushfires only 20.4% of people with asthma indicated they wore a mask, and the type was not specified.⁵⁹ We anticipate that the rate of mask-wearing would be higher in future events following the experience of the COVID-19 pandemic. Real-time monitoring of air quality for Australian conditions is also recommended and can be achieved using mobile applications such as AirRater. Figure 1² and Table 2⁶⁶ present the personal mitigation strategies that are recommended, their effectiveness, as well as limitations and concerns.

ASTHMA MANAGEMENT

In addition to LFS exposure reduction strategies, optimal asthma management is critical. To achieve this the areas that need to be addressed are optimizing self-management skills, ensuring appropriate management with asthma medication, effective avoidance and management of triggers and effective planning. The core asthma management skills required are asthma knowledge, proficient inhaler device technique and delivery, good adherence to asthma treatments and possession of a written asthma action plan with education on when

to implement it, how to implement it, when to go back to maintenance treatment, and when to seek emergency assistance (Figure 2). Written asthma action plans should be prescribed by the general practitioner in a shared decision partnership with the patient or parent.⁸¹ Using relievers to manage symptoms of asthma is necessary and international guidelines have recently evolved to promote the concurrent use of SABA and anti-inflammatory reliever therapy in appropriate age-groups where evidence of benefit exists (www.ginasthma.org).⁸²

Adherence in asthma is frequently sub-optimal,⁸³ but a critical self-management skill. Strategies for improving adherence to therapy are reviewed in McLoughlin et al.⁶¹ In brief these include asthma education, electronic trackers/reminders and simplification to treatment regimens.⁸⁴ Planning response to LFS exposure is also necessary and can include ensuring that patients have up-to-date written asthma action plans and sufficient supply of medications for optimal asthma management. A landscape fire checklist has been developed to guide patients with asthma (Figure 3). These and other useful strategies for people with asthma are listed in Figures 1 and 2, and are available for download.⁸⁵

Ensuring patients achieve good asthma control, optimal adherence to their treatment and have satisfactory asthma management skills are key goals in the treatment of asthma at any time and may lead to fewer impacts during periods of LFS exposure.

LFS guidelines

Whilst we were unable to source any clinical practice guidelines specifically for the management of asthma during landscape fires, there are several generic recommendations available from government health authorities around Australia, these are summarized in Table 3.

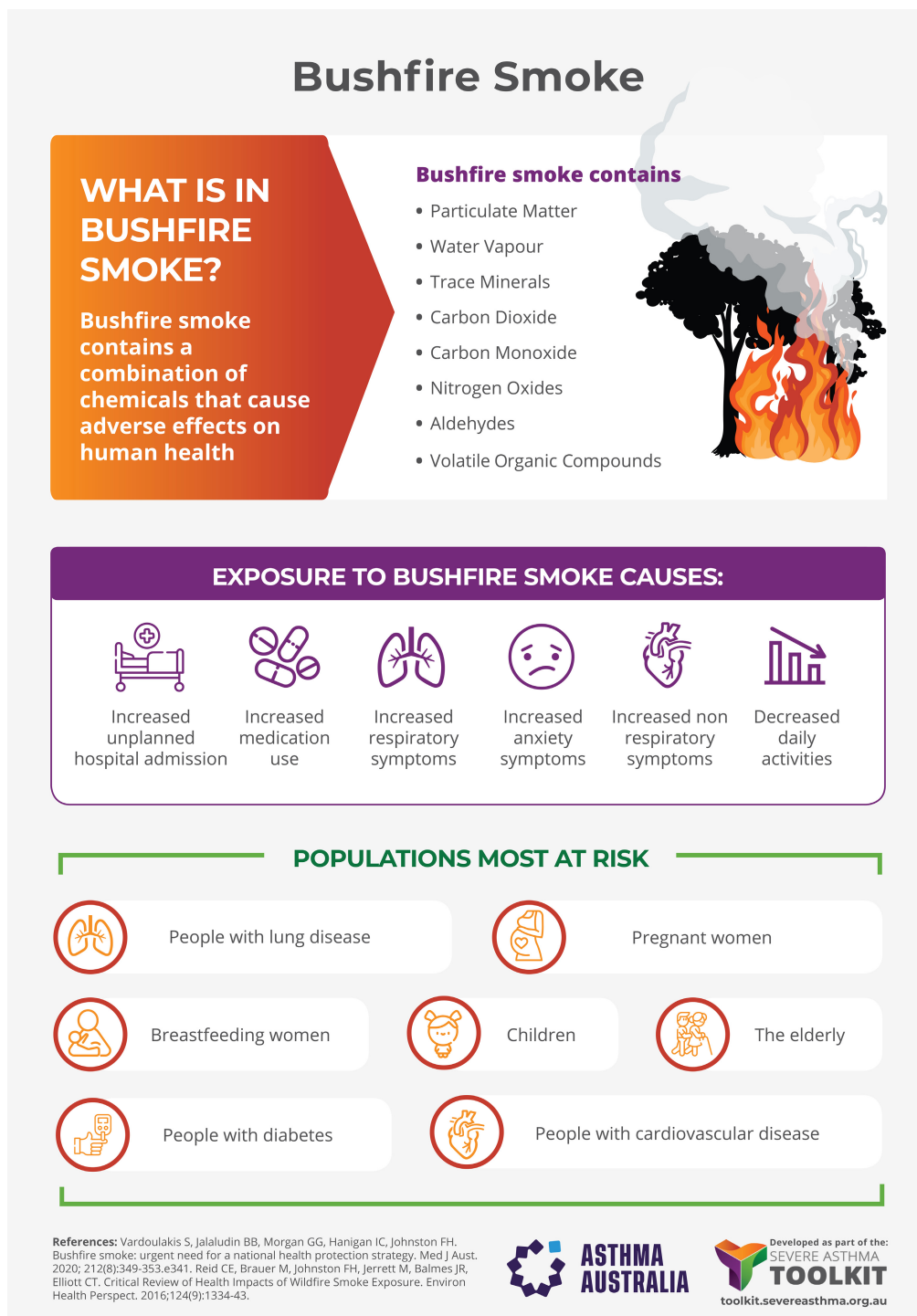


FIGURE 4 Impacts of Landscape fire events and populations at risk. Adapted with permission from the Centre of Excellence in Severe Asthma <https://toolkit.severeasthma.org.au>.⁸⁵

SUMMARY

We have summarized the health impacts of LFS exposure for people with asthma and identified the vulnerable populations most at risk of adverse outcomes (Figure 4). We have highlighted key points, recommendations and strategies that should be implemented during landscape fire

periods and in planning for such events, and identified important future areas for research. The recommendations are summarized in Figures 1 and 3 and future research needs in Figure 5.

Landscape fires affect all continents except Antarctica and due to climate change, their size, duration and frequency are increasing, with more severe impacts. LFS has

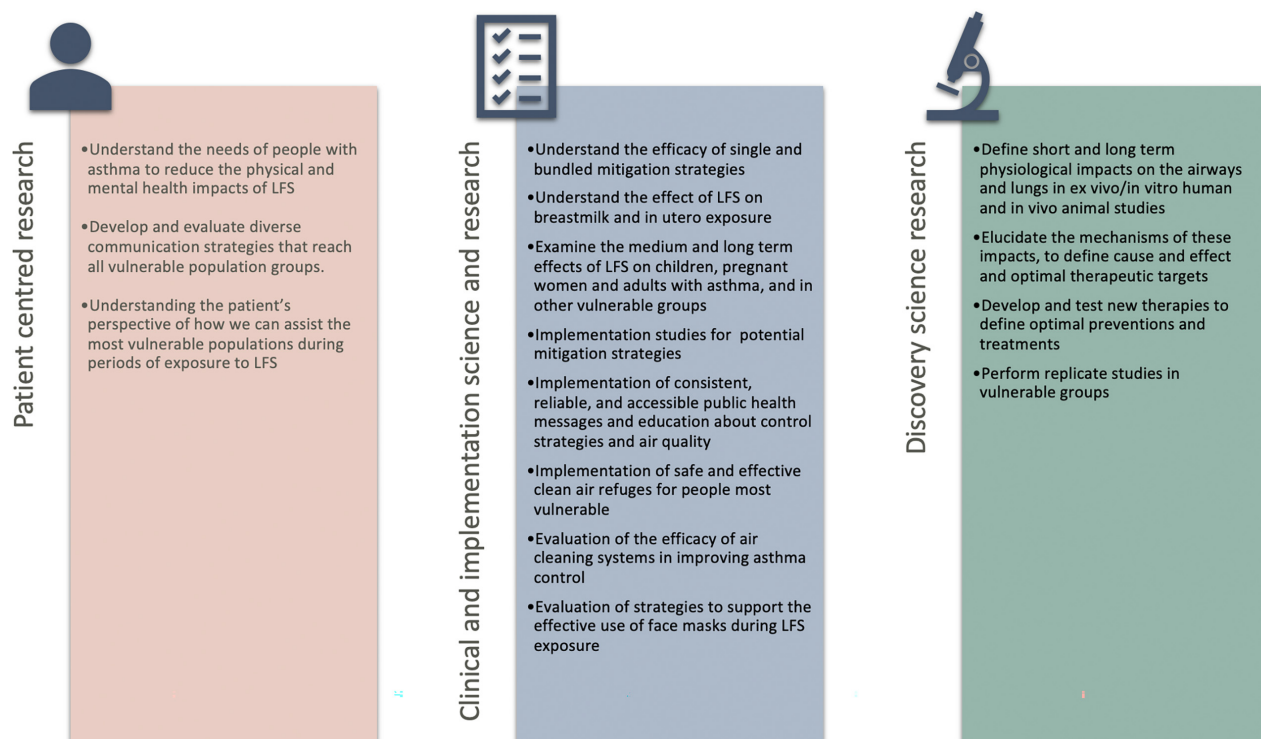


FIGURE 5 Future research recommendations for asthma and landscape fire.

many adverse physical and mental health effects, as well as economic and health system consequences. In this position statement, we have summarized the impacts to draw clinician awareness and to prepare them and other interested people for future events. The challenge is to ensure public health messages are implemented into clinical practice and are accessible to patients via reputable online and printed sources. We draw attention to the impact of LFS on people with asthma and promote better communication and preparation for future events.

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CONFLICT OF INTEREST STATEMENT

Vanessa M. McDonald, Philip M. Hansbro and Michael J. Abramson are Editorial Board members of *Respirology* and co-authors of this article. They were excluded from all

editorial decision-making related to the acceptance of this article for publication. Vanessa M. McDonald reports unrelated advisory board and speaker fees from AstraZeneca, GlaxoSmithKline and Novartis. Vanessa M. McDonald is a board member of the Thoracic Society of Australia and New Zealand. Michael J Abramson holds investigator-initiated grants from Pfizer, Boehringer-Ingelheim, Sanofi and GSK for unrelated research. He has undertaken an unrelated consultancy for Sanofi. He has also received a speaker's fee from GSK. Peter G. Gibson reports speaker fees from AstraZeneca, GlaxoSmithKline and Novartis. John Harrington reports speaker fees from AstraZeneca, GlaxoSmithKline and Novartis. Fay H. Johnston led the development of the air quality service AirRater. Peter Franklin works for WA Department of Health and prepares advice around public health messaging for air pollution events such as landscape fires. The other authors have nothing to disclose.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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REFERENCES

- Canadell JG, Meyer CP, Cook GD, Dowdy A, Briggs PR, Knauer J, et al. Multi-decadal increase of forest burned area in Australia is linked to climate change. *Nat Commun*. 2021;12(1):6921.
- Xu R, Yu P, Abramson MJ, Johnston FH, Samet JM, Bell ML, et al. Wildfires, global climate change, and human health. *N Engl J Med*. 2020;383(22):2173–81.
- Johnston FH, Borchers-Arriagada N, Morgan GG, Jalaludin B, Palmer AJ, Williamson GJ, et al. Unprecedented health costs of smoke-related PM_{2.5} from the 2019–20 Australian megafires. *Nature Sustainability*. 2021;4(1):42–7.
- Bui D, Davis S, Flynn A, Bell R, Dharmage S. Impact of recent catastrophic bushfires on people with asthma in Australia: health, social and financial burdens. *Respirology*. 2021;26(4):296–7.
- Asher MI, Garcia-Marcos L, Pearce NE, Strachan DP. Trends in worldwide asthma prevalence. *Eur Respir J*. 2020;56(6):2002094.
- Schraufnagel DE, Balmes JR, Cowl CT, De Matteis S, Jung SH, Mortimer K, et al. Air pollution and noncommunicable diseases. *Chest*. 2019;155:2–416.
- Australian Institute of Health & Welfare. Australian bushfires 2019–20: exploring the short-term health impacts. 2020. Available from: <https://www.aihw.gov.au/reports/environment-and-health/short-term-health-impacts-2019-20-bushfires>
- Binskin M, Bennett A, Macintosh A. The Royal Commission into National Natural Disaster Arrangements Report. 2020. Available from: <https://naturaldisaster.royalcommission.gov.au/>
- Guidance for Public Health Agencies. Managing prolonged smoke events from landscape fires. 2021. Australian Government Department of Health and Aged Care. Available at: <https://www.health.gov.au/resources/publications/enhealth-guidance-guidance-for-public-health-agencies-managing-prolonged-smoke-events-from-landscape-fires?language=en>
- Reid CE, Jerrett M, Tager IB, Petersen ML, Mann JK, Balmes JR. Differential respiratory health effects from the 2008 northern California wildfires: a spatiotemporal approach. *Environ Res*. 2016;150:227–35.
- Kiser D, Metcalf WJ, Elhanan G, Schnieder B, Schlauch K, Joros A, et al. Particulate matter and emergency visits for asthma: a time-series study of their association in the presence and absence of wildfire smoke in Reno, Nevada, 2013–2018. *Environ Health*. 2020;19(1):92.
- Johnston FH, Purdie S, Jalaludin B, Martin KL, Henderson SB, Morgan GG. Air pollution events from forest fires and emergency department attendances in Sydney, Australia 1996–2007: a case-crossover analysis. *Environ Health*. 2014;13(1):105.
- Gan RW, Liu J, Ford B, O'Dell K, Vaidyanathan A, Wilson A, et al. The association between wildfire smoke exposure and asthma-specific medical care utilization in Oregon during the 2013 wildfire season. *J Expo Sci Environ Epidemiol*. 2020;30(4):618–28.
- Vertigan AE, Harvey ES, Beyene T, Van Buskirk J, Holliday EG, Bone SL, et al. Impact of landscape fire smoke exposure on patients with asthma with or without laryngeal hypersensitivity. *J Allergy Clin Immunol Pract*. 2023.
- Borchers Arriagada N, Horsley JA, Palmer AJ, Morgan GG, Tham R, Johnston FH. Association between fire smoke fine particulate matter and asthma-related outcomes: systematic review and meta-analysis. *Environ Res*. 2019;179:108777.
- Alman BL, Pfister G, Hao H, Stowell J, Hu X, Liu Y, et al. The association of wildfire smoke with respiratory and cardiovascular emergency department visits in Colorado in 2012: a case crossover study. *Environ Health*. 2016;15(1):64.
- Resnick A, Woods B, Krapf H, Toth B. Health outcomes associated with smoke exposure in Albuquerque, New Mexico, during the 2011 Wallow fire. *J Public Health Manag Pract*. 2015;2015(Suppl 21):S55–61.
- Delfino RJ, Brummel S, Wu J, Stern H, Ostro B, Lipsett M, et al. The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003. *Occup Environ Med*. 2009;66:3–197.
- Health Literacy, 2022. Australian Institute of Health and Welfare. Available from: <https://www.aihw.gov.au/reports/australias-health/health-literacy>
- Koman PD, Hogan KA, Sampson N, Mandell R, Coombe CM, Tetteh MM, et al. Examining joint effects of air pollution exposure and social determinants of health in defining “at-risk” populations under the clean air act: susceptibility of pregnant women to hypertensive disorders of pregnancy. *World Med Health Policy*. 2018;10:1–54.
- Melchiorre K, Sharma R, Khalil A, Thilaganathan B. Maternal cardiovascular function in normal pregnancy. *Hypertension*. 2016;67:4–762.
- Robijn AL, Brew BK, Jensen ME, Rejnö G, Lundholm C, Murphy VE, et al. Effect of maternal asthma exacerbations on perinatal outcomes: a population-based study. *ERJ Open Res*. 2020;6(4):00295–2020.
- Murphy VE, Karmaus W, Mattes J, Brew BK, Collison A, Holliday E, et al. Exposure to stress and air pollution from bushfires during pregnancy: could epigenetic changes explain effects on the offspring? *Int J Environ Res Public Health*. 2021;18:18.
- Beyene T, Murphy VE, Gibson PG, McDonald VM, Van Buskirk J, Holliday EG, et al. The impact of prolonged landscape fire smoke exposure on women with asthma in Australia. *BMC Pregnancy Childbirth*. 2022;22:22.
- Dietert RR, Etzel RA, Chen D, Halonen M, Holladay SD, Jarabek AM, et al. Workshop to identify critical windows of exposure for children's health: immune and respiratory systems work group summary. *Environ Health Perspect*. 2000;108(Suppl 3):483–90.
- Mirabelli MC, Kunzli N, Avol E, Gilliland FD, Gauderman WJ, McConnell R, et al. Respiratory symptoms following wildfire smoke exposure. *Epidemiology*. 2009;20:3–459.
- Henry S, Ospina MB, Dennett L, Hicks A. Assessing the risk of respiratory-related healthcare visits associated with wildfire smoke exposure in children 0–18 years old: a systematic review. *Int J Environ Res Public Health*. 2021;18(16):8799.
- Hutchinson JA, Vargo J, Milet M, French NHF, Billmire M, Johnson J, et al. The San Diego 2007 wildfires and Medi-Cal emergency department presentations, inpatient hospitalizations, and outpatient visits: an observational study of smoke exposure periods and a bidirectional case-crossover analysis. *PLoS Med*. 2018;15:7.
- Aguilera R, Corringham T, Gershunov A, Leibel S, Benmarhnia T. Fine particles in wildfire smoke and pediatric respiratory health in California. *Pediatrics*. 2021;147:4.
- Howard C, Rose C, Dodd W, Kohle K, Scott C, Scott P, et al. SOS! Summer of Smoke: a retrospective cohort study examining the cardio-respiratory impacts of a severe and prolonged wildfire season in Canada's high subarctic. *BMJ Open*. 2021;11(2).
- Mahsin MD, Cabaj J, Saini V. Respiratory and cardiovascular condition-related physician visits associated with wildfire smoke exposure in Calgary, Canada, in 2015: a population-based study. *Int J Epidemiol*. 2022;51(1):166–78.
- Da Silva Sena CR, Lines O, Latheef MS, Amarasinghe GG, Quah WH, Beyene T, et al. Reduction in forced vital capacity in asthmatic children on days with bushfire smoke exposure in the Australian 2019/2020 bushfire. *Pediatr Allergy Immunol*. 2022;33:11.
- Hanigan IC, Johnston FH, Morgan GG. Vegetation fire smoke, indigenous status and cardio-respiratory hospital admissions in Darwin, Australia. *Environ Health*. 2008;7:42.
- Gowers AM, Cullinan P, Ayres JG, Anderson HR, Strachan DP, Holgate ST, et al. Does outdoor air pollution induce new cases of

- asthma? Biological plausibility and evidence: a review. *Respirology*. 2012;17(6):887–98.
35. Khreis H, Kelly C, Tate J, Parslow R, Lucas K, Nieuwenhuijsen M. Exposure to traffic-related air pollution and risk of development of childhood asthma: a systematic review and meta-analysis. *Environ Int*. 2017;100:1–31.
36. Bowatte G, Lodge CJ, Knibbs LD, Erbas B, Perret JL, Jalaludin B, et al. Traffic related air pollution and development and persistence of asthma and low lung function. *Environ Int*. 2018;113:170–6.
37. Kunzli N, Bridevaux PO, Liu LJ, Garcia-Esteban R, Schindler C, Gerbase MW, et al. Traffic-related air pollution correlates with adult-onset asthma among never-smokers. *Thorax*. 2009;64(8):664–70.
38. Groot E, Caturay A, Khan Y, Copes R. A systematic review of the health impacts of occupational exposure to wildland fires. *Int J Occup Med Environ Health*. 2019;32(2):121–40.
39. Rice MB, Henderson SB, Lambert AA, Cromar KR, Hall JA, Cascio WE, et al. Respiratory impacts of wildland fire smoke: future challenges and policy opportunities. An official American Thoracic Society workshop report. *Ann Am Thorac Soc*. 2021;18:6–930.
40. Cherry N, Barrie JR, Beach J, Galarneau JM, Mhonde T, Wong E. Respiratory outcomes of firefighter exposures in the Fort McMurray fire. *J Occup Environ Med*. 2021;63(9):779–86.
41. Melody SM, Wheeler AJ, Dalton M, Williamson GJ, Negishi K, Willis G, et al. Cohort profile: the Hazelwood health study Latrobe Early Life Follow-up (ELF) study. *Int J Epidemiol*. 2021;49(6):1779–80.
42. Holt NR, Gao CX, Borg BM, Brown D, Broder JC, Ikin J, et al. Long-term impact of coal mine fire smoke on lung mechanics in exposed adults. *Respirology*. 2021;26(9):861–8.
43. Shao J, Zosky GR, Hall GL, Wheeler AJ, Dharmage S, Melody S, et al. Early life exposure to coal mine fire smoke emissions and altered lung function in young children. *Respirology*. 2020;25(2):198–205.
44. Willis GA, Chappell K, Williams S, Melody SM, Wheeler A, Dalton M, et al. Respiratory and atopic conditions in children two to four years after the 2014 Hazelwood coalmine fire. *Med J Aust*. 2020;213:6–275.
45. Melody SM, Ford JB, Wills K, Venn A, Johnston FH. Maternal exposure to fine particulate matter from a large coal mine fire is associated with gestational diabetes mellitus: a prospective cohort study. *Environ Res*. 2020;183:108956.
46. Dharwal V, Paudel KR, Hansbro PM. Impact of bushfire smoke on respiratory health. *Med J Aust*. 2020;213:6.
47. Bolling AK, Totlandsdal AI, Sallsten G, Braun A, Westerholm R, Bergvall C, et al. Wood smoke particles from different combustion phases induce similar pro-inflammatory effects in a co-culture of monocyte and pneumocyte cell lines. *Part Fibre Toxicol*. 2012;9:45.
48. Gold MJ, Hiebert PR, Park HY, Stefanowicz D, Le A, Starkey MR, et al. Mucosal production of uric acid by airway epithelial cells contributes to particulate matter-induced allergic sensitization. *Mucosal Immunol*. 2016;9(3):809–20.
49. Hirota JA, Gold MJ, Hiebert PR, Parkinson LG, Wee T, Smith D, et al. The nucleotide-binding domain, leucine-rich repeat protein 3 inflammasome/IL-1 receptor I Axis mediates innate, but not adaptive, immune responses after exposure to particulate matter under 10 μm . *Am J Respir Cell Mol Biol*. 2015;52(1):96–105.
50. Barrett EG, Henson RD, Seilkop SK, McDonald JD, Reed MD. Effects of hardwood smoke exposure on allergic airway inflammation in mice. *Inhal Toxicol*. 2006;18(1):33–43.
51. Bazett M, Biala A, Huff RD, Zeglinksi MR, Hansbro PM, Bosiljic M, et al. Attenuating immune pathology using a microbial-based intervention in a mouse model of cigarette smoke-induced lung inflammation. *Respir Res*. 2017;18(1):92.
52. Brown AP, Cai L, Laufer BI, Miller LA, LaSalle JM, Ji H. Long-term effects of wildfire smoke exposure during early life on the nasal epigenome in rhesus macaques. *Environ Int*. 2022;158:106993.
53. Rappold AG, Reyes J, Pouliot G, Cascio WE, Diaz-Sanchez D. Community vulnerability to health impacts of wildland fire smoke exposure. *Environ Sci Technol*. 2017;51(12):6674–82.
54. Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. Critical review of health impacts of wildfire smoke exposure. *Environ Health Perspect*. 2016;124(9):1334–43.
55. Liu JC, Pereira G, Uhl SA, Bravo MA, Bell ML. A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. *Environ Res*. 2015;136:120–32.
56. O'Donnell MH, Behie AM. Effects of wildfire disaster exposure on male birth weight in an Australian population. *Evol Med Public Health*. 2015;2015(1):344–54.
57. Broder JC, Gao CX, Campbell TCH, Berger E, Maybery D, McFarlane A, et al. The factors associated with distress following exposure to smoke from an extended coal mine fire. *Environ Pollut*. 2020;266.
58. Goldman M, Flynn A, Cartwright A, Bell R, Davis S, Bui D, et al. Bushfire smoke impact survey 2019–2010. *Asthma Australia*. 2020. Available from URL: https://asthma.org.au/wp-content/uploads/Resources/AA6_Smoke-Impact-Survey-1920_Revised.pdf
59. Beyene T, Harvey ES, Van Buskirk J, McDonald VM, Jensen ME, Horvat JC, et al. 'Breathing Fire': impact of prolonged bushfire smoke exposure in people with severe asthma. *Int J Environ Res Public Health*. 2022;19(12):7419.
60. Wilson SR, Strub P, Buist AS, Knowles SB, Lavori PW, Lapidus J, et al. Shared treatment decision making improves adherence and outcomes in poorly controlled asthma. *Am J Respir Crit Care Med*. 2010;181(6):566–77.
61. McLoughlin RF, McDonald VM. Complex breathlessness: assessment of treatment adherence and treatable traits. In: James HH, Jemma H, editors. *Complex breathlessness (ERS Monograph)*. Sheffield, European Respiratory Society, 2022; pp. 186–205.
62. Laumbach RJ. Clearing the air on personal interventions to reduce exposure to wildfire smoke. *Ann Am Thorac Soc*. 2019;16(7):815–8.
63. Barn PK, Elliott CT, Allen RW, Kosatsky T, Rideout K, Henderson SB. Portable air cleaners should be at the forefront of the public health response to landscape fire smoke. *Environ Health*. 2016;15(1):116.
64. Ambrose M, Syme M. Air tightness of new Australian residential buildings. *Procedia Eng*. 2017;180:33–40. <https://10.1016/j.proeng.2017.04.162>
65. Wheeler AJ, Gibson MD, MacNeill M, Ward TJ, Wallace LA, Kuchta J, et al. Impacts of air cleaners on indoor air quality in residences impacted by Wood smoke. *Environ Sci Technol*. 2014;48(20):12157–63.
66. Vardoulakis S, Jalaludin BB, Morgan GG, Hanigan IC, Johnston FH. Bushfire smoke: urgent need for a national health protection strategy. *Med J Aust*. 2020;212:8.
67. Laumbach R, Meng Q, Kipen H. What can individuals do to reduce personal health risks from air pollution? *J Thorac Dis*. 2015;7:1.
68. Reisen F, Powell JC, Dennekamp M, Johnston FH, Wheeler AJ. Is remaining indoors an effective way of reducing exposure to fine particulate matter during biomass burning events? *J Air Waste Manag Assoc*. 2019;69(5):611–22.
69. Lodovici M, Bigagli E. Oxidative stress and air pollution exposure. *J Toxicol*. 2011;2011:1–9.
70. Wheeler AJ, Allen RW, Lawrence K, Roulston CT, Powell J, Williamson GJ, et al. Can public spaces effectively be used as cleaner indoor air shelters during extreme smoke events? *Int J Environ Res Public Health*. 2021;18:4085.
71. Brook RD, Rajagopalan S, Pope CA 3rd, Brook JR, Bhatnagar A, Diez-Roux AV, et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation*. 2010;121(21):2331–78.
72. United States Environmental Protection Agency. Residential air cleaners: a technical summary, EPA 402-F-09-002.
73. Cherrie JW, Apsley A, Cowie H, Steinle S, Mueller W, Lin C, et al. Effectiveness of face masks used to protect Beijing residents against particulate air pollution. *Occup Environ Med*. 2018;75(6):446–52.
74. McDonald F, Horwell CJ, Wecker R, Dominelli L, Loh M, Kamanyire R, et al. Facemask use for community protection from air

- pollution disasters: an ethical overview and framework to guide agency decision making. *Int J Disaster Risk Reduct*. 2020;43:43.
75. Huang W, Morawska L. Face masks could raise pollution risks. *Nature*. 2019;574(7776):29–30.
 76. Polivka BJ, Eldeirawi K, Huntington-Moskos L, Nyenhuis SM. Mask use experiences, COVID-19, and adults with asthma: a mixed-methods approach. *J Allergy Clin Immunol Pract*. 2022;10(1):116–23.
 77. Whyand T, Hurst JR, Beckles M, Caplin ME. Pollution and respiratory disease: can diet or supplements help? A review. *Respir Res*. 2018;19(1):79.
 78. Lin Z, Chen R, Jiang Y, Xia Y, Niu Y, Wang C, et al. Cardiovascular benefits of fish-oil supplementation against fine particulate air pollution in China. *J Am Coll Cardiol*. 2019;73(16):2076–85.
 79. Campbell SL, Jones PJ, Williamson GJ, Wheeler AJ, Lucani C, Bowman DMJS, et al. Using digital technology to protect health in prolonged poor air quality episodes: a case study of the AirRater app during the Australian 2019–20 fires. *Fire*. 2020;3:3.
 80. Willoughby M, Kipsaina C, Ferrah N, Blau S, Bugeja L, Ranson D, et al. Mortality in nursing homes following emergency evacuation: a systematic review. *J Am Med Dir Assoc*. 2017;18(8).
 81. McDonald VM, Gibson PG. In: Bernstein JA, Levy ML, editors. *Clinical asthma: theory and practice*. Boca Raton, FL: CRC Press Inc; 2014.
 82. Global Initiative for Asthma. 2023 [accessed 21 Jun 2023]. www.ginaasthma.org
 83. Lee J, Tay TR, Radhakrishna N, Hore-Lacy F, Mackay A, Hoy R, et al. Nonadherence in the era of severe asthma biologics and thermoplasty. *Eur Respir J*. 2018;51(4):1701836.
 84. Normansell R, Kew KM, Stovold E. Interventions to improve adherence to inhaled steroids for asthma. *Cochrane Database Syst Rev*. 2017;4(4):CD012226.
 85. Bushfire Asthma Checklist Infographic, Centre of Excellence in Severe Asthma. Available from: <https://toolkit.severeasthma.org.au/resources/infographics/>
 86. Protect Yourself from Bushfire Smoke, Australian Government Department of Health. Available from: <https://www.health.nsw.gov.au/environment/air/Pages/bushfire-smoke.aspx>
 87. Smoke Pollution and Exercise, Australian Institute of Sport. Available from: https://www.ais.gov.au/position_statements/content/smoke-pollution-and-exercise
 88. Health Burden of Bushfire Smoke in Australia, Asthma Australia. Available from: <https://asthma.org.au/research/our-research-results/wildfire-risk-reduction-assessment-framework-nicolas-borchers/>
 89. Bushfire Smoke Factsheet 2022, Centre of Excellence for Air Pollution and Health Research. Available from: <https://www.car-cre.org.au/factsheets>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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