Wildfire smoke: Health effects and protective strategies

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Citation: UBCMJ. 2018: 10.1 (5-6)

The wildfire season of 2017 was one of the worst on record in British Columbia, with over 1.2 million hectares of land burned.[1] Intense media coverage focused attention across the province on the impacts of these fires, including property loss, evacuations, and air quality. With British Columbia (B.C.) expected to have a warmer and drier climate in the future due to global climate change, these impacts will become more severe and more frequent as wildfires increase. In this article, we review the impact that wildfire smoke and its constituents have on public health, and suggest strategies for physicians to protect those under their care from these harms.

Smoke from forest and wildfires is a mixture of fine particles and gases such as volatile organic compounds, nitrogen oxides, and carbon monoxide.[2] It is clear that these constituents are harmful to human health. Hospital admissions and deaths increase during and shortly after widespread wildfire smoke exposure, due primarily to exacerbations of respiratory illnesses such as asthma, chronic obstructive pulmonary disease (COPD), and bronchitis.[3] These effects result from irritation of the respiratory tract, which in turn causes inflammation with shortness of breath and wheezing. Children, the elderly, and those with chronic illnesses are especially vulnerable.[4]

The effects of suspended particles of solids and liquids, called particulate matter, have received particular attention as a human health hazard. Particulate matter (PM) has different health impacts depending on its size. Particles over 10 micrometers in size typically do not penetrate into the lungs, but can irritate the nose, eyes, or throat. Particles under 10 micrometers (called PM_{10}) enter the lungs, are deposited in the bronchi, and contribute to lung inflammation and respiratory symptoms. Particles under 2.5 micrometers in size (called $PM_{2.5}$) penetrate more deeply into the alveoli, where they prompt further inflammation. In B.C. specifically, physician visits for respiratory conditions, as well as medication dispensations for asthma,[5] increase following forest fires releasing high $PM_{2.5}$ levels.[6,7]

Due to its small size, $PM_{2.5}$ can translocate into the bloodstream. Here, these particles can cause systemic inflammatory responses, endothelial dysfunction, and release of free radicals, as well as impair function of the autonomic nervous system.[8] As a result, cardiovascular disease, including acute coronary syndromes and strokes, are increased during and after exposure to wildfire smoke.[4,9] In children, exposure to $PM_{2.5}$ can exacerbate asthma and impair lung development, and has also been associated with neurodevelopment disorders via similar system effects.[10,11]

Given these health effects, how should physicians respond to wildfires? First, they should be aware of the air quality in their community and how it may be impacted by nearby fires. An important measure is the Air Quality Health Index, which combines measures of air pollutants into a single, easy–to–interpret measure of risk.[12] Many communities will also have $PM_{2.5}$ level measurements available separately. Most of the air quality regulatory agencies use 24–hour and annual average $PM_{2.5}$ levels to set air quality objectives. For example, in B.C., the $PM_{2.5}$ quality objectives are 25μg/m^3 averaged over 24 hours and 8μm 3 averaged over one year. However, research currently cannot identify an exposure level to $PM_{2.5}$ below which there are no negative effects. Physicians should also be aware of those patients in their care who are most at risk: those with existing chronic cardiovascular disease and the elderly.[13] Physicians should keep in mind that the effects of smoke may be magnified during times of unusual heat.[14]

Solid evidence on what interventions should be recommended to those at risk of wildfire smoke is lacking. There are good a priori reasons to believe that remaining indoors and reducing activity reduces the effects of smoke. $PM_{2.5}$ levels are lower indoors than out, and can be up to 80% lower.[15] During physical exercise, air intake may increase 10-20 fold and enter more deeply into the lungs, worsening the effects of PM.[16] Reducing outdoor activities and increasing time indoors seems to protect asthmatic children against some effects of fire smoke,[17] but evidence for the general population is lacking.[15] Remaining indoors and reducing activity has the additional benefit of keeping individuals cooler and out of summer heat, which can exacerbate the negative effects of wildfire smoke.[14] During heat waves, however, vulnerable individuals should be reminded not to try to avoid smoke by keeping all windows closed. This can exacerbate the health risks of high heat.

Evidence on the use of masks to protect against wildfire smoke is mixed. Appropriate masks (N95) do reduce exposure to harmful $PM_{2.5}$, but overall effects are mixed due to the need for education on correct mask usage and proper mask fit.[18,19] Studies have reported that mask use gives no benefit,[17] but also that mask use can confer decreased odds of respiratory symptoms.[20] Surgical or procedural masks offer no protection and should not be encouraged.[18]

There is good evidence that using portable high efficiency particulate air (HEPA) filtration units in homes is effective at reducing exposure to PM associated with adverse health effects. HEPA filters reduce PM 2.5 by up to 55-85% within homes[21-23] and roughly halved the odds ratio of worsening chronic respiratory illnesses due to smoke.[17] They also decreased markers of cardiovascular stress in those exposed to fire smoke.[23] Ideally, homes should include HEPA filters as well as air conditioning to protect against the dual effects of smoke and heat. There has been no study that directly evaluated the use of community shelters (shopping centres, community centres) to protect against smoke, but PM levels are generally lower than in homes without air filters.[24] There is also no direct evidence that enhancing filtration within institutions such as schools or hospitals reduces negative health impacts of smoke.[2]

Overall, it is reasonable for physicians to rely on the health messages that accompany the Air Quality Health Index, which guide individuals at risk to reduce their time outdoors and reduce exercise as air quality deteriorates. Particularly when high levels of smoke occur during a heat wave, physicians should consider recommending patients at risk visit indoor air–conditioned public spaces such as malls or libraries. When necessary, local Medical Health Officers may make further recommendations, and physicians should be prepared to discuss these with their patients at risk. Physicians may also want recognize the current Air Quality Health Index, as well as temperature, as part of a COPD action plan or other related health planning for their patients with chronic disease. At a systemic level, physicians should be aware of the impact of air quality on the health of their patients and consider how community actions, such as those that decrease other sources of air pollution, may reduce the burden of pollutants.

Physicians should also be aware of other important sources of particulate matter in addition to wildfires. In urban areas, particulate matter is associated with vehicle traffic and includes not only the emissions from combustion but also products of mechanical wear including tire and brake pad degradation.[25] In rural areas, wood–fired stoves and fireplaces are a significant source of particulate matter.[26] The likelihood of exposure to these different types of particulate matter varies across British Columbia, but good evidence of how they

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may affect health differently is lacking.

Many resources are available to physicians regarding air quality and wildfire smoke. Metro Vancouver (which manages air quality in the Vancouver region) and the B.C. Ministry of Environment and Climate Change (which manages air quality in the remainder of B.C.) have real–time readings of air quality available online. Air quality advisories and/or Smoky Skies Bulletins, issued by the Ministry of Environment and Climate Change in conjunction with local health authorities, contain details of the expected severity and duration of smoke events. The B.C. Lung Association has many resources online including reports, webinars, and videos, and the BC Centre for Disease Control has produced a set of detailed evidence summaries of the health impacts of wildfire smoke and effectiveness of interventions.

With a warmer, drier climate, wildfires will be larger and more frequent. British Columbia's physicians can be key advocates for their patients and communities by being aware of this increasing risk, how it impacts their patients, and how to best reduce it.

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