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Guidance for BC Public Health Decision Making During Wildfire Smoke Events

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Background

Wildfires in Canada are expected to increase in size, severity and duration.[1,2] BC has experienced four of the worst fire seasons on record in the past decade.[3] With warming temperatures, the mountain pine beetle has left 170,000 km^2 of dead standing timber in BC that is particularly susceptible to fire.[4] Wildfire smoke is increasingly recognized as an important health hazard. Approximately 100 wildfire evacuation events and 21,000 people were evacuated due to *smoke* in Canada over a 27-year period (1980-2007). This represents 19% of all evacuations and 10% of all evacuees for smoke and fire hazard combined.[5] Public health response must be rapid, effective and informed by the best available evidence.

In 2009, a hot and dry spring and summer combined with an unusual number of lightning storms led to one of the worst fire seasons on record.[3] Public health decision makers throughout the province were called upon to protect public health with limited local information (e.g., no fixed PM monitors) and in unusual circumstances (e.g., wildfire smoke inundating local hospital). In such events rapid assessment and rational response is required. Environmental Health Services at BCCDC (EHS) was called upon to provide expertise. We noted a gap in current evidence based guidance for public health decision making during wildfire smoke events and began a multi-year process to develop such guidance. The process started with an international scientific panel that identified key evidence gaps in the areas: wildfire smoke, health effects, situational awareness and effectiveness of interventions. The project team at EHS led nine systematic evidence reviews with guidance from international scientists and practitioners with relevant expertise and experience. We are now in the process of drafting the detailed evidence based guidance.

The objective of this *preliminary BC guidance* is to provide public health decision makers in British Columbia with a summary of the current evidence in time for the 2014 wildfire season.[a]

This guidance describes the wildfire smoke hazard, identifies which health effects are associated with wildfire smoke exposure and which populations are susceptible. It provides BC-specific guidance about tools for situational awareness: smoke and health surveillance. Then it summarizes the evidence for effectiveness of intervention measures to protect public health. Systematic evidence reviews of each of these topics can be found on the BCCDC website.[6]

[a] This guidance provides evidence to support preparedness and planning for wildfire smoke events, but is not a preparedness plan.

Wildfire smoke

Wildfire smoke is a complex mixture of particles and gasses. Particulate matter (PM) in wildfire smoke is much finer than PM in urban air pollution, with the bulk of wildfire smoke PM less than one micrometre in diameter. Gasses in wildfire smoke include carbon monoxide, nitrogen oxides, and volatile organic compounds. Some of the compounds in wildfire smoke are known to be carcinogenic, such as polycyclic aromatic hydrocarbons (PAHs), benzene and free radicals. Secondary pollutants are also produced in wildfire smoke, for example a photochemical reaction between volatile organic compounds and nitrogen oxides produces ozone. Wildfire smoke is highly variable in space and time. The concentration and the composition of wildfire smoke can be different from fire to fire and the composition of a smoke plume from a single fire changes as the plume ages.

More information about wildfire smoke is found in the evidence review: *Wildfire Smoke* and *Public Health*.[6]

Health Effects

A number of health effects are associated with wildfire smoke. This is an active area of research, because there is still much to be learned about how wildfire smoke affects health and about any differences between the health effects of wildfire smoke versus those of air pollution from other sources.

There are several reasons why wildfire smoke may have different health effects than other types of pollution including: pollutant concentration and duration of exposure, and composition of smoke. When wildfires are near communities, people may be exposed to very high concentrations of PM over short durations. In contrast, urban PM exposure tends to be of lower duration over longer periods. Another reason that wildfire smoke may have different health effects than urban PM is that the constituents that make up wildfire smoke may have different effects on the body. Wildfire smoke tends to have finer PM than urban air pollution, and also to contain a different mix of organic gasses. When wildfire smoke mixes with urban air pollution the hazard can increase. For example, in certain urban areas where ozone concentrations are already elevated, the addition of wildfire smoke can push them to hazardous levels. Scientists are still uncertain exactly how these differences between wildfire smoke and urban air pollution may lead to different health effects.

A cautious approach is generally taken in public health guidance for wildfire smoke situations. Lists of health effects associated with wildfire smoke include: (1) health effects with demonstrated associations with wildfire smoke and (2) health effects with demonstrated associations for other PM, but where association with wildfire smoke is lacking. In our review we separated these two categories.

Health effects that are known or suspected to be caused by wildfire smoke, based on the current state of the evidence:

- Asthma and COPD exacerbations
- Bronchitis and pneumonia

- All-cause mortality
- Cardiovascular outcomes
- Anxiety
- Symptoms such as: eye irritation, sore throat, wheeze and cough

Health effects that are known to be caused by short-term exposure to PM-air pollution, but where evidence specific to wildfires is limited or lacking:

- Atherosclerosis
- Adverse birth outcomes
- Childhood respiratory disease
- Lung cancer[b]

There is also emerging evidence that links long-term exposure to PM to impaired neurodevelopment and cognitive function, as well as other chronic diseases, such as diabetes. The relevance to short-term exposures to wildfire smoke is not clear.

Wildfire smoke events often occur during hot periods. Health risks may be compounded if heat waves and smoke occur concurrently as many of the same populations are vulnerable to both heat and smoke.

Susceptible Populations

A number of factors may make certain populations more susceptible to the effects of air pollution. Some such factors are biologic, such as: age, gender, genetic makeup, and pre-existing disease. Other factors are non-biologic, such as socioeconomic status. Furthermore, certain populations are more likely to be exposed to air pollution. For example, children may be more exposed because they have higher respiratory rates and they spend more time outdoors. Such factors may be called 'sensitivity' (biologic factors), 'vulnerability' (non-biologic and/or exposure factors) or 'susceptibility' (multiple definitions). However, in research studies, it can be difficult to tease apart biologic, non-biologic or other factors because one population may have multiple factors. For example, older adults may be more susceptible to air pollution due to biologic factors (e.g., physiologic changes associated with age), or non-biologic factors (e.g., limited capacity to respond to air pollution advice due to financial or other constraints). When an epidemiologic study demonstrates increased effects among older adults, it is usually not possible to discern whether it was due to biologic, non-biologic or other factors. In this section we use

[b] The International Agency for Research on Cancer (IARC) has classified outdoor air pollution as carcinogenic to humans. This classification is based on epidemiological and experimental evidence in humans and toxicological evidence in experimental animals. Epidemiologic evidence consistently demonstrated an increased risk of lung cancer in case-control studies in Europe, North America and Asia. Most of the exposure in these studies is to urban air pollution from a variety of sources (e.g. transport, power generation, industrial activity, biomass burning). There was limited evidence of an association between outdoor air pollution and bladder cancer. There is no reason to believe that wildfire smoke exposure did not contribute to the overall exposures in these studies, however, it is not possible to estimate the effect of exposure of a single wildfire event.

the term 'susceptible' as inclusive of all populations who are more likely to suffer adverse effects from wildfire smoke, regardless of the underlying cause.

There is limited research on susceptibility to wildfire smoke in particular. However it is reasonable to assume that those with susceptibility to PM-related air pollution in general are likely to be susceptible to wildfire smoke.

Populations that are known or suspected to be susceptible to wildfire smoke based on current evidence:

- Unborn children
- Children
- Adults 65 years of age and older
- Populations with pre-existing respiratory disease
- Populations with pre-existing cardiovascular disease
- Populations with lower socio-economic status

Populations that are known or suspected to be susceptible to PM-related health effects:

- Populations with chronic inflammatory diseases (e.g., diabetes, obesity)
- Populations with specific genetic polymorphisms that mediate physiologic response to air pollution

Situational awareness during a wildfire smoke event

Assessing wildfire smoke in British Columbia

BC Ministry of Environment publishes near real-time local air quality monitoring results on their website.[7] These results provide a good assessment of smoke conditions in monitored areas. Where monitors are not available, immediate assessment can be made by visual acuity, a measure of one's ability to see objects at known distances (see resources for a link to a visual acuity scale). BCCDC also runs an air quality model that estimates ground level PM using measures from satellites, PM from nearby monitors and measures of air mixing (i.e., venting index). This is provided in the weekly BC Asthma Monitoring System (BCAMS) report from BCCDC Environmental Health Services. In the absence of monitors, an immediate smoke assessment may be made by using visual assessment of markers at known distances (a simple visual acuity scale may be found in Wildfire Smoke a Guide for Public Health Officials[8]).

Wildfire smoke forecasts for up to 48 hours in the future are produced by the Western Canada BlueSky Smoke Forecasting System and available on the BC Ministry of Environment website.[9]

Assessing health effects in British Columbia

The BC Asthma Monitoring System (BCAMS) monitors smoke and asthma in BC communities during wildfire season. We use asthma as an indicator of wildfire smoke because: (1) asthma exacerbations are known to be caused by exposure to wildfire smoke and (2) measures of asthma exacerbations change quickly during wildfire smoke events. BCAMS compares daily physician visits for asthma to historical

averages using an iterative regression technique. It displays alerts when physician visits are beyond what is expected based on the historical data. BCAMS reports are sent out weekly to BC public health officials.

Actionable information/ triggers for action

In many current guidelines, particulate matter concentration thresholds and forecast duration are used to recommend when to take certain measures to protect health. These thresholds are derived from air quality standards, based on evidence for health effects for non-wildfire PM. It is not clear whether these thresholds are appropriate for wildfire smoke because: (1) they are derived from studies based on health effects of urban PM rather than wildfire smoke and wildfire smoke contains a different mix of air toxins, (2) thresholds for short timeframes, necessary for public health response, are derived from 24-hour thresholds rather than evidence of health impacts over these very short intervals.

In Canada, the Air Quality Health Index (AQHI) is used to identify hazardous air quality conditions. However, the AQHI is not sensitive to the differences between high and very high PM, as occurs in wildfire situations.

Given current knowledge, concentration and forecast duration of $PM_{2.5}$ is most useful to inform decisions about how best to protect public health. However, at EHS (BCCDC) we are currently working on how best to interpret smoke and health surveillance data for public health decision making during wildfire smoke events.

More information about surveillance is found in the evidence reviews: *Smoke Surveillance* and *Health Surveillance*.[6]

Interventions

A number of measures can be used to protect the public during wildfire smoke events (Box 1). The overriding objective of these interventions is to decrease exposure to wildfire smoke.

There are five BCCDC Wildfire Smoke Evidence Reviews.[6] These systematic reviews synthesize evidence from a number of sources (e.g., peer-reviewed publications, government publications, technical reports) and a number of study types (e.g., wildfire science, epidemiology, exposure assessment). Overall we found that there is a paucity of research that specifically evaluates the efficacy or effectiveness of interventions to reduce adverse health effects of wildfire smoke. However, combining different types of evidence, we can make some general statements about effectiveness of such interventions.

Public health practitioners may use such evidence to support their own guidance at the regional or local level. Wildfire smoke situations are highly variable and the public health response plan must be flexible and nimble. Decision makers may prepare individualised response plans including intervention, thresholds and timelines for decision making to enable adaptation as smoke conditions change. In addition, they may help members of the population develop informed individualized responses. Such is achieved by teaching members of the public to assess smoke conditions and make personalized decisions based on their own susceptibilities and resources. A community that has achieved effective wildfire preparedness is known as a ‘fire smart community’.

Box 1. Interventions to protect the public during wildfire smoke events.

Communications advising people to:

- **stay indoors**: reduce time spent outdoors in order to protect health
- **reduce outdoor physical activity**: decrease physical exertion outdoors in order to protect health
- **wear an N95 respirator**: properly use a certified N95 half face respirator to reduce exposure to smoke
- **activate asthma/COPD action plans**: ensure that plans for self-management of asthma/COPD are in place, up-to-date, and adequate supplies (e.g., medication) is available
- **use a home clean air shelter**: spend time in a room in your home with cleaner air to reduce smoke exposure

Cancelling outdoor events: Decision that group activities that occur outside will not take place. Such activities include school activities (e.g., recess, outdoor classes and events), sporting events (e.g., tournaments, practices) and mass gatherings (e.g., arts and cultural events, athletic events).

Providing community clean air shelter(s): Spend time in a community based facility such as a mall or school that has cleaner air than outdoor air.

Augmenting air filtration in institutions: The use of in-duct or portable filtration to improve air quality and protect people in institutional settings including hospitals, nursing homes, long term care facilities, day cares, schools, and other institutions.

Evacuating: The urgent removal of individuals from a community in order to protect them from exposure to wildfire smoke.

Communications

Communication with the public is one of the key methods to achieve public health protection during wildfire smoke events. Public service announcements (PSAs) are widely used to provide updates on fire and smoke and advice on what actions people can take to protect themselves. A few studies evaluate the effectiveness of PSAs. Evaluations in three different wildfire smoke events in the US (2) and Australia (1) show that the majority of people (74-88%) recalled hearing advice provided in PSAs. Non-technical advice (e.g., stay indoors) was more frequently recalled and heeded than technical advice (e.g., use a HEPA filter). There is limited evidence that some populations are more likely to hear and follow advice than others:

- Populations with chronic respiratory disease
- Populations of higher socio-economic status (SES)
- Young and middle aged adults as compared with the elderly
- People who speak English as a first language

More information about communications is found in the evidence review: *Reducing Time Outdoors*.[6]

Advising people to stay indoors and to reduce outdoor physical activity

Staying indoors reduces exposure to smoky air when people move to a location with good indoor air quality. During wildfire smoke events clean indoor air is achieved by:

- Limiting infiltration from outdoors –closing doors and windows and putting air conditioning on re-circulate
- Limiting sources of indoor air pollution – combustion activities (e.g., cooking with gas, smoking), painting, certain cleaning products, et cetera
- Cleaning indoor air – central air conditioning or portable air cleaners (more information available in section on clean air shelters)

The rate of smoke infiltration into homes is highly variable. For example, homes in colder regions tend to more tightly sealed against infiltration in order to limit heat loss during the winter.

There are few studies that evaluate the effectiveness of staying indoors at reducing adverse health effects of wildfire smoke. The existing evidence suggests that staying indoors reduces asthma symptoms in children, but the effectiveness in other populations has barely been studied. If good quality indoor air is achieved, then staying indoors even part of the time is likely to provide some benefit for everyone. The benefits of staying indoors must be weighed against potential harms such as disruption of normal activities and associated health, social and economic costs.

More information about advising people to stay indoors and to reduce outdoor physical activity is found in the evidence review: *Reducing Time Outdoors*.[6]

Advising people to wear an N95 respirator

A number of masks are available to the general public; however, few are effective at filtering wildfire smoke. Filtering half face-piece respirators, such as N95 masks, are most feasible for public use because:

- They provide a ten-fold reduction in inhaled fine particulate matter, the component of wildfire smoke that is most associated with adverse health effects
- They are widely available and relatively inexpensive
- Most regions have people trained to fit-test users in health care and other occupational settings

However, N95 respirators require a good fit and proper use in order to be effective. In occupational settings this is achieved through fit-testing and instruction on proper use of the respirator. Some populations cannot achieve an adequate fit due to face size and shape (e.g., children) or facial hair. Therefore respirators may have a role for adults who must be exposed to wildfire smoke, and where proper mask use can be ensured. For example, N95 respirators may be useful for workers who must remain outdoors during smoke events (e.g., police involved in traffic control), provided that they have fit testing and training. There are currently no peer-reviewed evaluations of effectiveness of N95 respirators in protecting against wildfire smoke.

More information about mask use to protect from wildfires is found in the evidence review: *Using Masks*.[6]

Advising people to use a home clean air shelter (home-CAS)

A home-CAS is an entire home, or an area of the home with filtration that reduces indoor wildfire smoke concentrations. Use may be part time (e.g., several hours per day) or full time (e.g., day and night) for the duration of the smoke event. A home-CAS is created by using high efficiency particulate air (HEPA) filtration or electrostatic precipitators (EPs) either within existing home heating, ventilation and air conditioning (HVAC) systems or as portable units. Portable units must be placed in an appropriately sized room with limited air infiltration from outdoors (e.g., windows and doors closed) and little indoor air pollution (e.g., smoking and other combustion, paint fumes).

The evidence supports the use of home-CASs in reducing indoor particulate matter concentrations during wildfire smoke events. In the absence of HEPA filtration or EP, increased filtration may be achieved by using a higher efficiency filter within existing HVAC systems or even by running HVAC systems with standard filtration, provided that they are on recirculation mode.

There is limited published research demonstrating that HEPA filters and EPs improve health outcomes during wildfire events. The evidence is suggestive of improved markers of cardiac effects in adults and reduced asthma symptoms in children. Given that improved filtration provided by home-CAS reduces exposures, an associated health benefit is expected, however there is limited research in this area.

A brief Q&A about home-CAS is provided in Appendix 1. More information about home-CAS is found in the evidence review: *Clean Air Shelters*.[6]

Cancelling outdoor events

Outdoor events may be cancelled in order to reduce exposures to wildfire smoke. Such activities include school activities (e.g., recess, outdoor classes and events), sporting events (e.g., tournaments, practices) and mass gatherings (e.g., arts and cultural events, athletic events). Cancellation may occur through a number of means including by event organisers or through health authorities, and may be voluntary or mandatory. There are no studies that evaluate the effectiveness of cancelling events at reducing exposure or improving health outcomes. In order to achieve exposure reduction by cancelling events, people must move to a place with cleaner air instead of attending the event (e.g., to an indoor environment with air conditioning on re-circulate mode).

A number of options are available to modify outdoor events rather than cancel them. For example:

- an outdoor event could be moved to a location with cleaner air if available (i.e., another outdoor venue, an indoor venue)
- an option of reduced participation could be provided (e.g., switching from a marathon to a half-marathon)
- an option for informed participation (i.e., participants are provided information about health risks and advised to make their own decision about participating)
- provide a clean air option at the event (e.g., a clean air tent at an outdoor concert)

If the event is not cancelled, then it is prudent to advise participants to monitor their health and seek cleaner air if symptoms arise.

More information about cancelling outdoor events is found in the evidence review: *Reducing Time Outdoors*.[6]

Providing community clean air shelters (community-CAS)

A community-CAS is a building, or area of a building with filtration that is suitable for reducing wildfire smoke exposure. Use may be part time (e.g., several hours per day) or full time (e.g., day and night) for the duration of the smoke event. As for home-CAS, the greatest reduction in PM is achieved by using HEPA filtration or EPs. However, HVAC systems may not have sufficient power or structural support to accommodate such changes in air treatment. HVAC engineers can advise on how to achieve the best smoke reduction given the existing systems. Such preparation is best done prior to the event. A summary of the evidence for exposure reduction and health gains is presented in the section on home-CAS (above) and a comprehensive review available in the review *Clean Air Shelters.*[6]

More information about community-CAS is found in the evidence review: *Clean Air Shelters*.[6] Technical information about HVAC systems is found in the evidence review *Filtration in Institutions*. [6]

Augmenting air filtration in institutions

There are two main populations that can be exposed to wildfire smoke in hospitals and other institutional settings: workers and patients/clients. It is feasible to alter filtration in institutions to improve indoor air quality during a wildfire smoke event, but a systematic literature review did not uncover any evaluation of the effectiveness of this approach. Whether and how to make such alterations depends on a number of technical and non technical factors and is therefore best determined prior to a smoke event, and with a professional trained in ventilation engineering.

Many health care institutions have augmented filtration, for example filters with a Minimum Efficiency Reporting Value (MERV) between 8 and 15 are required for normal operating conditions in US health care settings in comparison to MERV 3 to 8 in most residential and commercial buildings. Increasing filtration is not as simple as changing the filter. Higher MERV rated filters have higher pressure loss than lower rated filters and therefore may require additional power and structural support in addition to the filter. A ventilation engineer or similar professional can assess a building's vulnerability to smoke infiltration and minimise unwanted effects of any filtration changes (e.g., potential for reduction in airflow and heating/cooling capacity, likelihood of filter bypass, life-cycle cost, building envelope and infiltration). In the absence of adequate in-duct filtration in an institution, the development of clean air shelters using portable HEPA filters is a reasonable approach (for more detailed information, please refer to section on home-CAS, above). Ongoing examination of any filtration system during a wildfire smoke event is critical because heavy particulate load from wildfire smoke can quickly overload filters and hinder the effectiveness of a filtration system.

It is theoretically possible to set up clean air shelters in areas of institutions with positive pressure and higher filtration efficiency (e.g., operating rooms); however, it is not clear how the necessary alterations

in the HVAC system may affect air flow and filtration in other areas of the hospital. Therefore each such alteration should be individually designed, with the assistance of a qualified professional, to ensure important HVAC functions, including infection control, are maintained. Furthermore it may be challenging to provide adequate patient care in such alternate settings.

More information about augmenting filtration in institutions is found in the evidence review: *Filtration in Institutions*.[6]

Evacuation

Evacuation is the urgent removal of individuals from a community to protect them from exposure to wildfire smoke. Evacuation may be voluntary or mandatory, or may begin as a voluntary measure and evolve into a mandatory order. Evacuation may be partial (i.e., involving a subgroup of the population) or complete (i.e., involving the entire population). Evacuation has significant potential to cause harm due to the disruption of normal activity, social and economic ties and health care provision among other factors. There is only one evaluation of the effectiveness of evacuation from wildfire smoke, which found that evacuation was less effective than provision of HEPA filters for residents to use at home. In this case the evacuation occurred after the main smoke event. Evacuation has been associated with a number of harms[c] including: mortality among nursing home residents, anxiety and exacerbation of mental illness among adults and children. Therefore evacuation is often conducted only when other measures have failed, and in progressive stages from partial to complete and voluntary to mandatory. Clean air shelters in homes and community settings may be offered for those individuals remaining in smoky communities. Factors that favour evacuation over other interventions include:

- Severe smoke hazard lasting longer than a week
- Wildfire smoke that is particularly toxic (e.g., contamination by hazardous substances within the fire zone)
- Current measures (e.g., home-CAS and community-CAS) are not capable of providing adequate exposure reduction
- An exposed population subgroup that is particularly susceptible to smoke (refer to section on susceptible populations for specifics) or real-time evidence of adverse health effects from existing surveillance systems, health professionals or other sources

An exposed population subgroup may be evacuated early/preferentially if they require special care to evacuate (e.g., people with mobility impairment), enhanced care (e.g., those in long term care facilities), or specialized healthcare that cannot be provided in the smoke-exposed community (e.g., dialysis patients).

More information about evacuation is found in the evidence review: *Evacuation*.[6]

[c] This evidence is derived from evacuations for events other than wildfires (e.g., floods).

Preparing for wildfire smoke events

Preparedness and planning is beyond the scope of this document. The BC Ministry of Health has produced Draft Wildfire Smoke Planning Considerations Guide which outlines roles and responsibilities of various agencies and preparedness measures.

The following steps are recommended as part of preparedness:

- Coordinate with partners (e.g., local government, public health agencies at local/provincial/regional levels and First Nations Health Authority, Ministries of BC government: health, natural resources, environment, emergency management, Ministries of federal government)[d]
- Identify regions/communities at risk for wildfire smoke events
- Identify susceptible populations in these regions
- Determine which interventions would be used under which circumstances
- Prepare communications for general population and susceptible individuals
- Prepare to selected interventions (e.g., engineer evaluation of HVAC system, stockpile or rapid procurement system for HVAC filters; specific preparedness recommendations are made in each intervention section)
- Agree upon which surveillance data streams and which data thresholds/ranges will guide decisions (e.g., smoke surveillance: PM concentration and duration, health surveillance: increase in physician visits for respiratory disease)
- Respond and document response
- Evaluate

Environmental Health Services at BCCDC provides smoke and health surveillance through our weekly BCAMS reports and expert staff are available to provide augmented surveillance and expertise in the event of a wildfire smoke situation. We are also engaged with our partners in provincial wildfire smoke preparedness.

[d] Specific agencies and contacts are well outlined in Draft Health Sector Planning Considerations for Extreme Wildfire Events. August 2012, Ministry of Health, Province of British Columbia.

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Appendix 1: Advising people to use a home clean air shelter

Information for public health practitioners in British Columbia

What is a home clean air shelter (home-CAS)?

A home-CAS is an entire home, or area of the home with filtration that is suitable for reducing wildfire smoke exposure. Use may be part time (e.g., several hours per day) or full time (e.g., day and night) for the duration of the smoke event.

What is the objective and how is it achieved?

The goal of a home air shelter is to reduce exposure to wildfire smoke by creating a space with reduced smoky air from outdoors and little indoor air pollution. This is achieved by several actions:

- Limiting infiltration of outdoor air by closing doors and windows, sealing cracks around doors and windows, and putting air conditioners on re-circulate
- Limiting indoor air pollution by avoiding combustion activities (e.g., smoking, gas stoves, unvented kerosene cookers and wood stoves), avoiding other sources of indoor air pollution (e.g., certain cleaning products, indoor paints, certain hobbies)
- Filtering indoor air using a portable (stand alone) air cleaners or in duct air filters which are installed within central air systems

Is a home-CAS effective at reducing exposure to wildfire smoke?

Home-CAS efficacy is based on reduction of indoor particulate matter (PM) concentrations. Filtration can be achieved through the use of (1) high efficiency in-duct air filters, (2) conventional, less efficient in-duct filters, and (3) portable filters. The most effective filters at reducing indoor particulate matter (the smoke component most associated with health effects) PM are high efficiency particulate air (HEPA) and electronic precipitators (EPs). Most central air systems are equipped with conventional filters that can help to lower PM concentrations somewhat. High efficiency filters can further reduce particle concentrations, particularly smaller particles found in wildfire smoke.

A lesser degree of filtration is achieved using existing in-duct filtration, for example in central air conditioners. Use of conventional air conditioners on recirculation mode will decrease PM compared with no air conditioner use. In addition, those using air conditioners are more likely to keep windows and doors closed, thereby reducing air exchange and infiltration of wildfire smoke from outdoors. Increasing the efficiency of filters in central air should also increase the PM reduction. Both EPs and higher efficiency filters are available for some residential central air systems. Companies these systems can provide advice about how best to augment filtration for a specific system.

Portable HEPA filters will also effectively reduce indoor PM, provided that they are used properly. A portable filter is designed to clean air in the room in which it is located, but their use has been shown to lead to PM reductions in other areas of the home in some cases. Overall effectiveness of portable filters in reducing PM concentrations in a home depends on several factors, including volume of the home, number of portable air cleaners used, and air exchange within the room and home. Electrostatic

precipitators (EPs) are another type of portable filter that has been shown to be effective at reducing indoor PM. There are concerns around the use of EPs because some models may produce ozone, a respiratory irritant, as a by-product.

Home-CAS use for long durations (i.e. weeks to months) has not been adequately evaluated.

Is home-CAS use effective at reducing adverse health effects?

Only a few studies have evaluated the efficacy of home-CAS at reducing adverse health effects. A single study of portable HEPA filtration use during a wildfire provided evidence that is suggestive of reduced respiratory symptoms with portable HEPA filtration. Studies of HEPA filtration use to reduce health effects from other sources of pollution (i.e., wood smoke, cigarette smoke, and urban air pollution) are suggestive of improved markers of cardiac health in adults and reduced asthma symptoms among children. Although there is little research, the results of existing research are in line with what we would expect based on exposure reduction achieved by filtration.

What should be considered when advising people to use a home clean air shelter?

Home clean air shelters require set up and maintenance. For in-duct filtration, people need to ensure that their system has the capacity for high efficiency filters, and that they are equipped use them during a smoke event. For portable filtration, the filter must be well-maintained and used in an appropriately sized room, according to the manufacturer's instructions.

People are most likely to use an home-CAS if it is set up in advance of a wildfire smoke event. Research in California and New South Wales, Australia, has demonstrated that during wildfires people are less likely to follow technical advice than non-technical advice. Other research has found that it is difficult to follow technical advice in stressful situations, such as wildfire smoke events. In places where wildfire smoke events are anticipated, home-CAS should be part of preparedness.

Home-CASs work best in a tightly sealed home, however sealing homes in the absence of air conditioning can increase indoor temperature. The benefits of filtration should be weighed against the risk of heat. During concurrent wildfire smoke and heat events, people should be advised to seek clean and cool air.

Advice to use home-CAS should include:

- How best to minimize indoor air pollutants such as nitrogen oxides and carbon monoxide
- How to size and use a portable HEPA filter
- How to set up and use in-duct filtration
- How to seal air leaks, particularly in older and lower quality homes where air exchange rates, and therefore infiltration of smoke, may be high

Home-CAS set up and use requires an investment of time and resources. Therefore their use may be limited to areas prone to frequent wildfire smoke events and/or to susceptible populations. Certain segments of the population are more able to set up and run an home-CAS due to financial, physical or other assets. Other groups may require additional support.

How can authorities prepare for wildfire season?

Authorities may choose to:

- Produce clear simple instructions on setting up a home-CAS
- Determine trigger points for releasing advice to use home-CASs (e.g. PM concentration/duration, health effects)
- Set up mechanisms to obtain portable HEPA filters rapidly such as agreements with retailers or stockpiling
- Determine how to support groups who may have difficultly setting up an home-CAS due to financial, physical or other limitations

For more information, please see the evidence review: *Clean Air Shelters* available from: http://www.bccdc.ca/healthenv/AirQuality/default.htm.

This information has been produced by Environmental Health Services, BC Centre for Disease Control.