

Review

Wildfire Smoke and Protective Actions in Canadian Indigenous Communities

Brieanna Batdorf and Tara K. McGee *

Department of Earth and Atmospheric Sciences, Faculty of Science, University of Alberta,
Edmonton, AB T6G 0N6, Canada

* Correspondence: tmcgee@ualberta.ca

Abstract: In Canada, Indigenous populations are disproportionately threatened by wildfire smoke and the associated adverse health impacts. This paper presents the results of a narrative review of 51 academic and related resources which explored protective action decision making during wildfire smoke events within Indigenous communities in Canada. A search of scholarly articles and other relevant sources yielded resources which were subject to thematic analysis and described in order to present a narrative review of current knowledge and gaps in research. A small and growing literature provides insights into protective actions taken by the general population during wildfire smoke events, but very little is known about protective actions taken by Indigenous peoples in Canada during wildfire smoke events. This lack of understanding hinders the capacity of decision makers to improve emergency management and minimize community health impacts of wildfire smoke.

Keywords: wildfire; smoke; air quality; protective actions; public health; Indigenous



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1. Introduction

In 2022, 5726 wildfires occurred across Canada consuming 1,656,504 hectares [1]. It is predicted that the global frequency of catastrophic wildfires will increase concurrently with anthropogenic climate change throughout Canada [2] and the rest of the world [3]. An important impact of wildfires is due to the emissions generated by the biomass burning. While the composition of wildfire smoke tends to be dominated by water vapor and CO₂, there are also multiple health-damaging pollutants present within emissions including respirable particulate matter, polycyclic aromatic hydrocarbons, benzene, aldehydes, carbon monoxide, nitrogen oxides and other carcinogenic compounds [4,5]. Wildfires can often burn erratically and change direction unpredictably, resulting in smoke pollutants that affect communities a long distance away from the original source. Studies have found that not only is a significantly higher portion of the population affected by wildfire smoke in comparison to being directly exposed to the wildfire [6], but wildfire smoke can also be responsible for considerably more fatalities in comparison to fatalities from the fire itself [7]. There is a growing body of literature linking wildfire smoke to adverse health outcomes. Exposure to wildfire smoke PM_{2.5} has been associated with psychological stress, adverse birth outcomes, respiratory and cardiovascular disease, and mortality [8–11]. On a global scale, the estimated average mortality due to landscape fire smoke (including wild and prescribed forest fires, deforestation fires, peat fires, agricultural burning and grass fires) is 339,000 annually [12]. Matz et al. [10] analyzed the health impacts of wildfire smoke in Canada between 2013–2015 and 2017–2018 and found that PM_{2.5} attributable to wildfire smoke caused 54–240 acute premature mortalities per year due to short-term exposure and 570–2500 mortalities from long-term exposure, as well as many cardio-respiratory morbidity outcomes. Specific groups of people have been identified as being more susceptible to the impacts of wildfire smoke including children, the elderly, pregnant women, individuals with cardio-respiratory disease, and First Nations people [13–15].

As of 2021, 1.8 million Canadians identified as Indigenous peoples, accounting for 5.0% of Canada's total population [16]. The Indigenous population is relatively young and growing faster than the non-Indigenous population, with an increase of 8.0% between 2016 and 2021 [16]. Indigenous peoples in Canada are grouped into three distinct groups: First Nations, Métis and Inuit, with considerable diversity between and within these three groups. First Nations make up the largest group, with more than 630 First Nation communities in Canada, representing more than 50 Nations. The 2021 Canadian census identified that there were 1,048,405 First Nations peoples, 624,220 Métis and 70,545 Inuit living in Canada [17]. People living in Indigenous communities in Canada are disproportionately threatened by wildfires and exposed to wildfire smoke. Only 19% of evacuation events in Canada between 1980–2007 were attributed to wildfire smoke; however, 75% of these events involved First Nation communities [18]. When examining 41 smoke-related evacuations in Canada between 2000–2007, Krstic and Henderson [19] found that First Nations communities accounted for 87% of evacuees. In addition to high exposure to wildfire smoke, research in Canada shows that asthma is more prevalent amongst Indigenous communities, and it is more than twice as likely that First Nations people would be hospitalized because of asthma [20]. The disproportionate burden of wildfire smoke health impacts on global Indigenous populations in comparison to non-Indigenous populations has been found in multiple studies observing associations between wildfire smoke and hospital admissions [21–23]. There is therefore a clear need to examine wildfire smoke experiences and protective actions in Indigenous communities in Canada.

Reducing exposure to wildfire smoke rests almost exclusively with individuals and their use of protective actions [24,25]. The Protective Action Decision Model (PADM) has been widely used to understand protective actions related to environmental hazards [26]. Within this model, environmental cues, social cues and warnings start a process that leads to perceptions of the threat, and protective actions. Situational factors can facilitate or impede protective actions. Protective actions included in the model include searching for information, protective response and emotion-focused coping. Perceptions of environmental threats can be influenced by a variety of factors including a person's previous experience with the environmental hazard [26,27]. This paper presents the results of a narrative review of the scholarly literature and other relevant sources that aimed to explore wildfire smoke experiences, information and communications, risk perceptions, protective actions during wildfire smoke events, and impediments to protective actions with a focus on Indigenous peoples in Canada. This review identifies the literature that exists and where knowledge gaps exist.

2. Materials and Methods

To achieve the aims of this study, we reviewed the existing academic and non-academic literature using a narrative approach [28]. Due to the interdisciplinary and exploratory nature of this project, a number of strategies were used to increase our chances of locating relevant materials [29]. First, a primary search of the University of Alberta Library and Google Scholar was conducted to collect relevant articles and reports. Search parameters included terms such as "First Nation", "Indigenous", "wildfire", "bushfire", "wildland fire", "forest fire", "smoke", "haze", "emissions", "experience", "perception", "preparedness", "attitude", "behavior" and "communication". Articles which included information related to wildfire smoke experiences, perceptions of wildfire smoke as a hazard, preparedness for wildfire smoke, protective actions taken during wildfire smoke events and public safety advisories or communications about wildfire smoke were identified and included in the database. Additional articles describing Indigenous peoples' experiences with both wildfires and wildfire smoke were then identified and added to the database. The references cited in these articles were then reviewed to identify additional articles and resources. Finally, in addition to the academic articles, relevant government reports and books were also identified and included. These searches yielded 51 resources including articles, books and reports available in English that were included in the narrative review.

The literature was synthesized using a narrative approach [28] where the literature was grouped into five themes based on the aims of this study, and then an integrative approach was taken allowing for sub-categories to naturally emerge [30]. This allowed for better organization of themes within the evidence that was then used to narrate and interpret recurring themes identified within the literature and produce an account of currently existing research and identify gaps in knowledge [30].

3. Results

3.1. Wildfire Smoke Experiences

A small number of studies in Canada have examined how Indigenous communities experience wildfire smoke. During wildfire smoke events in First Nation communities in the NWT, itchy eyes, headaches and sore throats were commonly reported mild physical symptoms experienced [31]. This research team and two others found that difficulty breathing, coughing, chest pain and worsening of existing respiratory conditions (i.e., asthma) were more severe physical symptoms experienced by some people, significantly hindering activity levels and functioning [31–33]. In addition to these physical health symptoms, anxiety, fear and stress were reported as mental health impacts as a result of persistent smoke [31]. The uncertainty experienced when having to change daily routines to avoid the smoke was also found to result in depression and difficulties coping [33]. Being sequestered inside one's home or motel room during a wildfire smoke event and the associated isolation resulted in further emotional hardships with the lack of space to engage in physical activities were of particular concern for the guardians of children [31,33]. In D'Nilo, events were organized at the community hall to encourage physical activity to try to overcome this problem [31]. These emotional impacts are not restricted to the period of time that smoke is present in the community. Even once the smoke had passed, community members still struggled with the memories of dealing with that smoke event and felt an ongoing sense of uncertainty that another wildfire and associated smoke could occur at any time [31].

High levels of smoke in First Nation communities during the 2014 NWT fires resulted in separation from traditional activities such as harvesting, fishing, hunting and trapping [31]. The feelings of separation from the land that arose due to the inability to spend time outside the same way took a deep toll on individuals mentally, emotionally and spiritually [31]. The loss of these activities can also cause economic impacts. Northern populations, where many Indigenous communities are located, can rely on traditional activities such as hunting and fishing as key forms of subsistence [34]. The cost of food and other essentials in northern communities is extremely high, so being able to harvest, hunt, fish and trap are essential for food security of families [31].

In addition to the individual impacts of living through an active wildfire season, research in non-Indigenous populations has found that wildfire smoke is disruptive to a community's social fabric. The diminished air quality from wildfire smoke has been found to result in less community cohesion, gatherings and opportunities to interact; however, in some cases the common experience of dealing with wildfire smoke can also result in the temporary reconfiguration of social ties, with shared hardships presenting the opportunity for meaningful interactions and the need to work together helping to strengthen community connections [35,36]. Mirroring these findings, when the D'Nilo First Nation and Yellowknife communities experienced prolonged smoke events, community-based initiatives emerged to help community members socialize [31]. Residents recalled a positive outcome of the experience being how everyone was concerned about others and chipped in to help, demonstrating similar findings to the other hazard literature regarding how shared adversity can bring people together [31].

Studies of the general population also demonstrate that individuals who experience physical symptoms from smoke are more likely to perceive a risk from wildfire smoke to themselves and take protective actions [36,37]. Direct experience with a hazard has the potential to increase risk perceptions and reinforce participating in protective behaviors [27],

but there are mixed findings in the literature with non-Indigenous populations. Two studies found that the sensory experience of wildfire smoke and previous exposure directly increases the perceived risk of smoke exposure [37,38]. Prior exposure to wildfire smoke resulting in individuals adapting their behavior and beliefs has also been observed [25]. In contrast, Del Ponte et al. [39] found that attitude, perceptions and practices remained stable after an active wildfire season, with only participants' knowledge about air quality increasing significantly. However, this increase in understanding about risks associated with poor air quality may eventually lead to changed attitudes as studies have also found that individuals with higher knowledge about the risk of wildfire smoke are also more concerned about its effects [40]. After experiencing the "summer of smoke" in the NWT, residents from Yellowknife, N'Dilo, Detah and Kakisa took action by advocating for increased planning and adaptation in order to prepare for future wildfires, suggesting that improved education and dialogue about climate change and its impacts was needed [31]. It is unclear whether wildfire smoke exposure would encourage Indigenous peoples to adopt recommended protective actions.

3.2. Wildfire Smoke Information and Communications

Public health and safety messaging not only informs people about the potential threat of the hazard, but also helps to disseminate the information and resources about what steps individuals should take to protect themselves. Engaging with wildfire smoke information can be instrumental in shaping threat perceptions and influencing decisions to reduce exposure such as changing behavior [38,41]. While research within the general population indicates that the most commonly used source for wildfire smoke information is television [41–43], other findings indicate that both television and radio play vital roles in disseminating safety messaging for the general rural population and First Nation communities [14,15]. This may be a result of radio being able to reach areas with limited cellular coverage or internet connection [15]. Social media such as private Facebook groups are another commonly reported source of wildfire smoke hazard and safety information for those who have internet access in both Indigenous and non-Indigenous populations since details can be both timely and locally relevant [13,44,45]. However, there can be a level of mistrust with information shared on social platforms since people feel the need to discern what is accurate or misinformation [13,44,46]. An example of this occurring is when the Lac La Ronge Indian Band ordered a wildfire evacuation, but misinformation circulated on Facebook which left people unsure of where they were supposed to go [46].

The general wildfire smoke literature demonstrates that despite many people being exposed to wildfire smoke and experiencing symptoms they can be left unsure of how to protect themselves due in part to a lack of adequate information [24,35]. A content analysis of public health messaging in Washington revealed that of the messaging distributed during a major wildfire smoke event, only 46% of government messages and 33% of media messages included information about personal interventions (i.e., staying indoors, using air filtration systems, closing doors and windows, wearing a mask and evacuating) that one could take [47]. Missing information about how to protect oneself is highly problematic when considering that greater knowledge about the smoke is associated with people being more likely to engage in protective actions [40] and knowledge about the air quality index and understanding what it means results in higher safety adherence rates [48]. Straight forward messages are key because ambiguous messaging makes it more likely that a cycle of information seeking and processing will initiate and can continue until it is too late for recipients to respond to the impending hazard [26]. Maintaining consistency in messaging across sources is important for promoting trust and increasing the uptake of content; competing messaging from various agencies decreases source credibility and increases confusion [14,49]. Effective communications include straightforward messages that are free of jargon, consistent and containing information informing people of the risk and what actions they can take to avoid it [14]. Research on the general population has also found that timeliness of messages can help to maximize the reduction in negative

outcomes [40,47,50], likely because receiving information about wildfire smoke ahead of the event allows communities adequate time to prepare and respond effectively [51]. A study completed amongst residents of the Hoopa Valley Nation Indian Reservation found that timely communication was associated with a reduction in reported respiratory symptoms [32].

The literature about wildfire smoke response in the general population has shown that individuals receive information and social cues from those around them to help fill their gaps in knowledge, which can be essential to how they interpret wildfire smoke [38]. The informational social support and psychosocial factors (i.e., descriptive, subjective and injunctive social norms) that individuals are exposed to can be unique to each community and have the ability to influence perception of threat severity, interest in protective supplies such as masks, seeking out information and taking protective actions [38,52]. One explanation for why people will place higher value on information received from a familiar source is that in unfamiliar situations where there is a higher reliance on outside information, individuals do not only evaluate information based on content but also based on their trust in the social institutions providing information [49]. Understanding and considering these social processes can be particularly important when communicating with Indigenous people who may have a higher level of trust for information received from their own social network in comparison to outside sources such as government agencies [43]. For example, a study that examined trusted sources of wildfire smoke risk information in the Okanogan River Airshed Emphasis Area of north central Washington found that First Nation participants deemed information shared directly through the Confederated Tribes of the Colville Reservation (CTCR), or correspondence containing the CTCR logo, to be the most trustworthy [44].

It is important to ensure that wildfire smoke communications are tailored to populations at high risk as well as the broader population [13,14]. Despite studies finding that First Nations would benefit from tailored health messaging, it can still be difficult for them to access community specific information which may exacerbate confusion around how to properly respond to a smoke event [14]. Even when communities do receive information about recommended actions to cope with wildfire smoke, it can be difficult for them to determine if they are implementing it correctly and if it is helping to reduce their risk. A survey completed in British Columbia examining public messaging for wildfire smoke found that more than 18% of Indigenous participants felt unsure if their exposure was reduced after applying recommendations in comparison to 11% of non-indigenous participants [15].

3.3. Wildfire Smoke Risk Perceptions

Risk perceptions of a hazard can motivate individuals to take avoidance or mitigating actions, or even ignore risks altogether [27]. In Lindell and Perry's Protective Action Decision Model, a person's core perceptions of a hazard provide the basis for their decision making; therefore, understanding individual and community risk perceptions of wildfire smoke can be key in informing what motivates participation in protective actions that can reduce severe health outcomes [26].

The existing literature with general populations indicates that while people often recognize wildfire smoke as a hazard and health risk, on average many do not recognize the risk to themselves and focus on the risk for those they deem more susceptible such as children, pregnant women or individuals with preexisting health issues [37,38,42,53]. In studies of the general population, respondents expressed that their interest in seeking more wildfire information was driven by concern for loved ones and that they felt more acutely aware of the smoke in comparison to if they were only concerned about themselves [54]. Researchers have found that families with young children are the most likely to comply with safety recommendations and make some of the largest modifications to their routines, with parents citing children's smoke exposure as a significant source of stress and anxiety [35,36,41,55,56].

Studies of the general population also demonstrate that there is likely a link between risk perception and protective actions in response to wildfire smoke. Risk perception has been found to be positively associated with behavioral intentions and greater perceived harm from wildfire smoke is associated with greater frequency of using protective actions [52,57]. Protective actions can also be affected by perception of potential health impacts, with individuals who believe that smoke will affect their health being more likely to minimize smoke exposure [58]. Increased worry about being impacted by smoke has also been linked to increased information seeking behaviors [52,59]. The perceived threat of wildfire smoke and knowledge about its impacts affecting behavioral response in the aforementioned studies proposes individuals engage in protective behaviors as a preventative response. However, Rappold et al. [53] also found that individuals with a higher number of symptomatic days due to wildfire smoke were more likely to participate in exposure reducing behaviors. These findings show that in some cases protective actions occur when people are experiencing health impacts from wildfire smoke [53]. We are not aware of any studies that examine wildfire smoke risk perceptions in an Indigenous community context. However, a study completed in California about wildfire risk perceptions found that participants identifying as First Nations reported a 26% and 28% lower perceived threat from wildfire to health and the environment, respectively, in comparison to participants identifying as Caucasian [60]. One potential explanation for this is the long history of use of fire by Indigenous peoples across North America with cultural burning practices being used to manage the landscape [61]. The observed lower perception of risk from wildfires may be due to this important role of fire in Indigenous culture and knowledge that has been passed down [60]. Whether or not this decreased risk perception amongst First Nations communities extends to wildfire smoke is currently unknown.

3.4. Protective Actions during Wildfire Smoke Events

Studies examining protective actions undertaken during wildfire smoke events have found that the most popular actions, which are free to complete, include closing doors and windows to avoid smoke entering buildings, staying inside and avoiding outdoor recreation or exercise [37,43,53,58,62]. Less popular protective actions included wearing masks, avoiding going to work, running home air conditioning, using high-efficiency particulate air (HEPA) filters to clean the indoor air and evacuating the community [14,43,53,58]. These less popular actions included those which are more costly, demonstrating that more accessible behaviors are arguably the most likely to be taken [58].

Few studies have examined protective actions taken by Indigenous residents during wildfire smoke events. Dodd et al. [31] conducted interviews with residents from Yellowknife and three First Nation communities (N'Dilo, Detah and Ka'a'gee Tu First nation) in the Northwest Territories (NWT) in Canada to examine their experiences living with wildfire smoke and protective actions taken during the summer of 2014. Protective actions carried out by their research participants included keeping windows closed, staying indoors, reducing physical activity and in some cases leaving the community or the NWT due to the smoke [31]. Mott et al., [32] examined the use of protective actions taken by members of the Hoopa Valley Reservation in northern California, USA. The researchers provided participants with free masks, vouchers for hotel services in nearby towns, and portable HEPA cleaners and then studied the extent to which these were used. They found that 48.8% of participants evacuated, 35.0% of participants wore a mask and 34.1% ran a portable high-efficiency particulate air (HEPA) cleaner to protect themselves from wildfire smoke when these were provided at no cost as part of the study. It is clear that additional factors influence the use of these protective measures, even when there is no cost associated with them. Further study is needed to examine the use of wildfire smoke protective actions by Indigenous peoples in Canada. A study in British Columbia provides an example of how community leadership reduced wildfire smoke exposure for vulnerable community members. When members of Nadleh Whut'en First Nation experienced thick smoke from the 2018 Shovel Lake fire, the chief and council arranged for air purifiers to be

put into homes of more vulnerable individuals including the elderly, children and those with preexisting lung conditions [63].

3.5. Impediments to Wildfire Smoke Protective Actions

Even when people have the intention of participating in a protective behavior this does not always correspond to carrying out the behavioral response due to situational impediments [26]. The effects of colonization continue to be apparent in First Nation communities across Canada, with individual and community wide challenges making it difficult to be prepared for wildfire related hazards [33]. In 2015 the median income of First Nations people living on reserves across Canada was less than half of the non-indigenous population [64]. Financial constraints have been found to be a significant limiting factor in studies of the general population when it comes to individuals reducing their smoke exposure, with certain protective measures such as air filters and air conditioning being unaffordable and therefore unrealistic for some households [24,25,36]. This barrier was demonstrated in First Nation communities, such as in Hoopa Valley when 12% of participants cited economic restraints as the reason for not evacuating during a heavy wildfire smoke event [32]. In addition to financial constraints, evacuation away from high levels of wildfire smoke has also been found to be inaccessible for people who have mobility challenges, when people do not have anywhere to go or if they have concerns about separation from family members [26,65]. Living in a fly-in community or not owning a vehicle also affects the ability to evacuate due to wildfire smoke [65].

One of the most commonly promoted protective behaviors against wildfire smoke is staying indoors while keeping windows and doors shut with the purpose of keeping the smoke “out” and healthier air “in”. General studies on wildfire smoke have revealed that older, not airtight buildings allow a greater ingress of outside air providing less protection [24] and even if people are aware of this vulnerability, factors such as lack of access to transportation can limit their ability to utilize clean air spaces [66]. Therefore, the assumption that one’s home can be made into an airtight space or that they have the inherent ability to retreat to a safe space underscores inequities for populations dealing with homelessness or poor-quality housing [55]. Inadequate housing is a prevalent issue amongst Indigenous peoples in Canada, with 16.4% of the Indigenous population living in a home that requires major repairs in comparison to 5.7% of the non-indigenous population [67]. Indigenous people are more likely to live in northern or remote communities where high costs and limited access to building supplies further contribute to the issue [67]. Transportation barriers have also been documented in First Nations communities during previous responses to wildfire smoke, meaning that even in cases where a clean air space is set up community members may not be able to use it to its full potential [65].

The nature of a person’s employment can impact their ability to respond to wildfire smoke, with general population studies finding outdoor workers being especially vulnerable to PM_{2.5} exposure and not having the option to retreat indoors and miss work [68,69]. For low-income households with no safety nets to fall back on, people are willing to continue working in unsafe conditions because they depend on the income to maintain their livelihood and provide for their family [68,70]. In addition, forest fires can bring economic opportunities for those with firefighting experience, making individuals less likely to participate in averting behaviors such as evacuation [71]. This is especially true in locales with high unemployment rates such as Indigenous communities [32]. For example, the unemployment rate of the Canadian Indigenous population is continuously higher than that of the non-Indigenous population [72] and the desire to gain employment firefighting was documented as a reason for a community member resisting to leave during the wildfire evacuation of Mishkeegogamang Ojibway Nation in Ontario [71].

Sometimes a lack of protective actions during wildfire smoke events can be due to a feeling that one’s effort to avoid the smoke would be futile. General studies about air quality have found this to be attributed to perceived lack of self-efficacy or a lack of locus of control, with situational factors such as insufficient time to check and follow through

with advisories further amplifying feelings of having no power over the situation [48]. It is not clear if this is a factor influencing protective actions due to wildfire smoke for Indigenous peoples.

4. Conclusions

This analysis of the wildfire smoke literature shows that a small but growing literature exists about how people in the general public respond by taking protective actions during wildfire smoke events, and factors that influence these actions. Limited research has examined Indigenous peoples' experiences of wildfire smoke events in Canada, despite the high level of exposure. Further research is needed to examine wildfire smoke experiences in different contexts. For example, it will be useful to compare experiences in communities where wildfire smoke is a regular occurrence and those with little past wildfire smoke exposure. It would also be valuable to examine the influence of wildfire smoke experience on protective action decision making.

It is clear that wildfire smoke information should be disseminated through appropriate channels (local radio, social media) using trusted sources, that it should be tailored to the audience and should highlight the effectiveness of recommended actions. Indigenous communities in Canada often do not have local air quality monitoring stations. It would be valuable to explore air quality monitoring by Indigenous communities and barriers to the use of monitoring stations and the resulting data. Further study of the credibility of wildfire smoke information sources would be valuable. It would also be useful to examine how wildfire smoke information influences the use of protective actions during wildfire smoke events.

We are not aware of any research examining wildfire smoke risk perceptions in an Indigenous community context. This research is important since risk perception may influence protective actions during wildfire smoke events. As part of this line of research, it would be useful to examine who is perceived to be at risk from the wildfire smoke, and the link between cultural burning and wildfire risk perceptions.

Existing research provides insights into which wildfire smoke protective actions are being completed in Indigenous communities. It would be useful to build on this existing research by examining which protective actions are less popular, and identify barriers to their use. It would also be valuable to examine if protective actions are perceived to be effective. Research should also be completed on the use of clean air spaces during wildfire smoke events in Indigenous communities. In particular, their value for protecting those community members most vulnerable to impacts of wildfire smoke should be examined. It would also be useful to examine low-cost ways to reduce wildfire smoke intrusion in homes that are not airtight.

Changes to policies and practices can help reduce exposure to wildfire smoke in the Indigenous communities context. Strong support is needed for wildfire prevention and mitigation programs across Canada which will help prevent and reduce wildfire smoke events and their considerable impacts on Indigenous peoples. Air quality monitoring should be offered at no cost to all Indigenous communities in Canada, and assistance provided to use and interpret the air quality information. There is a need to establish clean air spaces within Indigenous communities to protect people at high risk from wildfire smoke impacts. If these places already exist within communities, they should be promoted, and transportation and other assistance provided so they will be used. Wildfire smoke information and protective actions need to be developed in collaboration with Indigenous communities, communicated by appropriate channels and provided by trusted information sources (e.g., local health nurses). Information provided to residents should emphasize the effectiveness of protective actions. Communities should reduce barriers to adoption of recommended protective actions; for example, by providing free air masks and air filters for those people at high risk from wildfire smoke impacts.

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