A qualitative content analysis of wildfire smoke preparedness and response plans in the United States and Canada

Wildfire smoke preparedness and response plans

Andrew Philips[1¶], Uthaylah Al-Arab[1¶], Tania Busch Isaksen[1,&], Anna Reed[1&*]

[1] Department of Environmental and Occupational Health Sciences, School of Public Health, University of Washington, Seattle, Washington, United States of America.

[¶] These authors contributed equally to this work.

[&] These authors also contributed equally to this work.

* Corresponding author

E-mail: areed5@uw.edu

Abstract

Wildfires in North America have become more frequent and intense in recent years. This increase can be attributed to climate change, which has led to higher temperatures and altered precipitation patterns, creating conditions that favor wildfires. In addition, human activities, such as land development, forest management practices, and the ignition of fires, further contribute to the rising incidence of wildfires, as they increase the likelihood of fire outbreaks in certain areas. Wildfire smoke can cause adverse health impacts, creating an urgent public health concern. Some strategies to reduce wildfire smoke exposure include indoor air filtration, clean air centers, and cancellations of outdoor events when necessary. Wildfire smoke preparedness and response plans (wildfire smoke plans) play a crucial role in coordinating and implementing these strategies across jurisdictions during wildfire smoke events. This study compares wildfire smoke plans developed by jurisdictions and institutions in the United States and Canada, including counties, cities, states, provinces, and universities. We used qualitative content analysis methods to assess the characteristics of 20 wildfire smoke plans. The majority of plans utilize risk reduction strategies such as air quality monitoring, risk communication, and guidance for household-level exposure reduction. Wildfire smoke plans are a relatively new emergency response strategy; as such, a “gold standard” set of plan components has yet to be established. As a result, there were significant variations in the plan components we reviewed. Future research should evaluate the efficacy of existing wildfire smoke plans to identify best practices and gaps. The findings from such evaluations can inform the development of a

standardized framework for preparedness and targeted outreach programs for susceptible populations. By grounding future frameworks in evidence from existing plans, jurisdictions can strengthen their wildfire smoke preparedness and response efforts, ultimately protecting public health more effectively.

Background

Wildfires in North America have become more frequent and intense in recent years [1]. This is in part due to greenhouse gas emissions driving anthropogenic climate change, as hotter temperatures create more arid environments, making vegetation drier and more susceptible to burning [2,3]. This pattern is likely to continue as greenhouse gas emissions increase, and the ramifications of already front-loaded emissions are realized, leading to persistent drought conditions, longer fire seasons, and an overall increase in fire severity [4]. Another contributor to increased wildfires is human activity; land management practices such as fire suppression can lead to fuel accumulation [5]. In addition, human-caused fires account for the majority of wildfires in the United States and have expanded the seasonal extent of wildfire events [6].

Wildfire smoke contains harmful components such as fine particulate matter ($PM_{2.5}$), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), gases (e.g., CO, SO2, NO, NO2), and metals, which degrade outdoor and indoor air quality [7]. Fine particulate matter is of greatest concern to human health because it can be inhaled deep into the lungs due to its small size, where it can irritate and corrode the alveolar wall, consequently impairing lung function [8,9]. Wildfire smoke exposure can lead to significant physical and mental health outcomes by exacerbating cardiovascular and respiratory conditions, reducing sleep quality, and heightening anxiety [7-8, 10-11]. For example, emergency department visits in California were collected from 2006-2017 for asthma, chronic obstructive pulmonary disease, and cough, indicating an increase from 30% to 110% following wildfire smoke exposure [12].

Certain populations, such as children, older adults, and pregnant people, as well as people with cardiovascular and respiratory diseases such as asthma and chronic obstructive pulmonary disease, face greater risk from wildfire smoke exposure [13-15]. Additionally, certain populations, such as people of color, people with lower incomes, and Indigenous communities, experience disproportionate wildfire smoke exposure and face structural barriers that limit access to resources to reduce exposure and mitigate health impacts [16-18]. This disparity is further demonstrated in a recent air quality modeling study which found that Black and Indigenous populations face greater exposure to wildfire-related $PM_{2.5}$ than other racial groups [19]. Renters also face elevated risk since they may not be able to invest in ventilation or filtration measures, and landlords may neglect such investments [20].

In the United States (U.S.), jurisdictions prepare for natural hazard-related emergencies through hazard mitigation and emergency response planning processes guided by the Federal Emergency Management Agency (FEMA). To guide risk-informed hazard mitigation, FEMA primarily publishes guidance related to hazards that affect infrastructure, with limited wildfire smoke-specific guidance for public health preparedness and response [21-22]. Similarly, in Canada, emergency management is coordinated through federal, provincial, and territorial emergency management frameworks led by Public Safety Canada [23]. Similar to extreme heat, wildfire smoke is largely not a threat to infrastructure and therefore not consistently incorporated into emergency operation and response plans. As jurisdictions across North America experience more frequent and widespread wildfire smoke events affecting large populations, many have recognized the need to develop wildfire smoke-specific preparedness and response plans to coordinate public health actions and reduce smoke-related health impacts. Therefore, wildfire smoke preparedness and response plans (wildfire smoke plans) are a relatively new and non-standardized emergency response strategy. This study aimed to characterize this variation by assessing the content of publicly available wildfire smoke plans developed by jurisdictions (counties, cities, states, territories, provinces) and academic institutions in the U.S. and Canada.

Methods

We conducted a qualitative content analysis of wildfire smoke plans using methods previously developed to systematically assess and analyze extreme heat plans [24].

Plan Identification

Two study team members identified search terms (S1 Table) and used Google to identify publicly available wildfire smoke plans. Additional plans were identified using the Environmental Law Institute's State Policies for Reducing Indoor Exposure report, which summarizes state-level policies and strategies related to wildfire smoke exposure reduction and indoor air quality protection [25].

Plans were selected for review based on the inclusion and exclusion criteria in Fig 1.

Fig 1. Exclusion and Inclusion Criteria for Wildfire Smoke Plans.

We included plans that were created or updated between 2014 and 2026, based in the U.S. or Canada, publicly available, and implemented by government agencies or universities. We excluded plans that did not meet the above criteria or were not specific to wildfire smoke, were written for prescribed fire management, or were written for a specific company, organization, or building.

Codebook Development

We developed a survey in REDCap to collect plan characteristic data, with each entry representing one plan and each question representing a plan component or strategy (S1 Appendix). We developed the survey using both deductive and inductive methods. The Environmental Protection Agency (EPA)'s Wildfire Smoke: A Guide for Public Health Officials and Environmental Law Institute's Wildfire Smoke Report were used to identify evidence-based wildfire smoke exposure reduction strategies, while FEMA's Local Mitigation Planning Policy Guide, and A Content Analysis of Heat Action Plans in Local United States Jurisdictions informed the organization and structure of the survey [21, 24-26]. The survey was inductively edited after reviewing three sample plans to identify commonly implemented components and strategies for inclusion. Three team members co-coded the three sample plans independently to ensure clarity of codebook definitions. After reviewing discrepancies and making revisions for clarity, the survey was finalized for data collection.

Plan Review and Analysis

At least two team members reviewed and coded each plan using the REDCap survey. We then quantified the survey responses in Excel and analyzed the data to understand common strategies and gaps.

Results

Plan Characteristics

We collected and analyzed 20 wildfire smoke plans that met our inclusion criteria (S2 Table). The plans represented jurisdictions and one university throughout the Western U.S. and Canada. The population size of the U.S. plans' jurisdictions ranged from 7,500 to 39 million, with a median of 800,00 [27]. In Canada, the population sizes of provinces and territories ranged from 40,000 to 14 million, with a median of 5 million people [28]. Of the analyzed plans, 15 (75%) were standalone wildfire smoke plans. Three plans (15%) were all-hazards plans or wildfire plans with a chapter or annex specific to wildfire smoke. Two plans (10%) were combined wildfire smoke and heat plans.

Fig 2A and B illustrate the geographical distribution of the wildfire smoke plans analyzed. Fig 2A (left) illustrates the geographical distribution of analyzed wildfire smoke plans at the city and county levels across the United States. Fig 2B (right) highlights the states, territories, and provincial-level plans included in our study, illustrating the concentration of plans in the Western United States and Canada.

Fig 2. Geographical Distribution of Analyzed Wildfire Smoke Plans.

A) U.S. City and County-level plans (2014-2026). B) States, Territories, and Provincial-level plans (2014-2026).

Table 1 summarizes key plan components identified across the 20 analyzed plans. The table presents the frequency and percentage of plans that included specific strategies related to plan activation, coordination, risk communication, and exposure reduction strategies at both the household and community levels.

Table 1. Wildfire Smoke Plans that Included Wildfire Smoke Strategies: U.S. and Canada (2014-2026).

Plan Components	No. (%)
Plan activation	14 (70%)
Interagency and/or inter-organizational coordination	
Procedures for Calls/Meetings	14 (70%)
Advisory Group	4 (20%)
Air quality monitoring	
Forecasting	18 (90%)
Increasing Infrastructure	11 (55%)
Risk communication	
Any Strategies (Y/N)	20 (100%)
Communication Methods	20 (100%)
Information to be Communicated	10 (95%)
Household-level exposure reduction	
General Strategies	18 (90%)
Ventilation and/or filtration	16 (80%)
Respiratory protection	13 (65%)

Pets/livestock	2 (10%)
Community-level exposure reduction	
Closures	14 (70%)
Clean air centers	15 (75%)
Targeted outreach to at-risk populations	13 (65%)
Plan update	13 (65%)
Plan review/evaluation	12 (60%)
Long-term planning	7 (35%)

Plan Activation

Fourteen plans (70%) described plan activation procedures, nine of which (45%) identified an air quality index (AQI) or air quality health index (AQHI) threshold for activation (e.g., the plan is activated when the local AQI exceeds 150). The AQI is a tool used in the United States to communicate to the public how polluted the air is, ranging from 0 to 500 while the AQHI is used in Canada for the same purpose but it ranges from 1 to 10+ [29-30].

Of the other five plans, one indicated activation upon request from a regional health officer in the plan's province; one plan's activation was determined when the local office of the emergency management director convened a planning meeting; and three plans were activated based on prescribed burn activity. Plans commonly assigned responsibility for activation to agencies such as local or state public health agencies, local offices of emergency management, as well as specialized committees with a focus on health and smoke exposure coordination. Activation decisions were generally made by health officials and Tribal or local governments, with consultations involving agencies such as environmental quality departments and emergency management organizations. Eight plans (40%) discussed the importance of monitoring respiratory illness in hospitals, asthma-related emergency department visits, and emergency medical service calls to inform agency actions.

Interagency and/or Interorganizational Coordination

Most plans (90%) identified a lead agency and supporting government agencies or non-governmental organizations for plan implementation. To coordinate among agencies and jurisdictions, seven plans (35%) outlined procedures for annual pre-wildfire season calls or meetings; the majority of these plans included meeting procedures. Five plans (25%) included procedures for convening a wildfire smoke advisory group. Other plans assigned coordination roles to local public health agencies, air quality management districts, environmental quality departments, or provincial/territorial health authorities.

Seven plans (35%) listed the Office of Emergency Management (OEM) as the lead or co-lead of plan administration among other authoring agencies. Although public health agencies had a role in implementing all plans, only four (20%) plans listed public health as the lead or co-lead. The remaining plans (50%) included various organizations that contributed to plan development, such as: the air quality agencies, environmental health agencies, housing corporations, health departments, school districts, aging and disability services, forestry agencies, fire services, land management agencies, and transportation agencies.

Air Quality Monitoring

Seventeen plans (85%) provided detailed guidance for air quality surveillance or monitoring. Nine plans directed government agencies to conduct air quality monitoring, while seven plans directed the public to air quality resources. Only one plan provided air quality monitoring guidance for government agencies and the public.

Nine plans (45%) suggested using the EPA AirNow Fire and Smoke Map as a guide for government agencies to identify areas affected by wildfires. Nine plans (45%) directed the public to the EPA AirNow Fire and Smoke Map to learn about the air quality in their area, which groups of people may be affected, and steps to take to reduce exposure to air pollution. The EPA AirNow Fire and Smoke Map differs from the EPA AirNow mobile app, which was provided as a resource by four plans (20%). The app utilizes GPS for localized air quality information, whereas the desktop typically requires manual entry of location [31]. Only one plan listed the National Interagency Fire Center (NIFC) as an air quality monitoring resource for the public. Five plans (25%) included provisions for deployment of mobile smoke monitors during wildfire events to increase regional air quality monitoring capacity.

Fig 3 presents the distribution of plan components across 20 wildfire smoke plans. The table displays the relative percentage of specific strategies within each plan; the variation across plans highlights the difference in how these strategies are implemented and prioritized across jurisdictions.

Fig 3. Distribution of Wildfire Smoke Strategies Across Individual Plans in U.S. and Canada (2014-2026). The right color scale represents the percentage of each individual strategy present in each plan. The left color scale represents the total percentage across all strategies in each plan.

Risk Communication

All plans included strategies for communicating the risks of wildfire smoke exposure to the public. Thirteen plans (65%) included a communications plan, and six plans (30%) included guidance for creating a communications plan. Many communications plans were structured with different actions corresponding to different AQI levels. For example, Garfield County's communications plan designates actions for AQI 101-150, including issuing a press release and designating further actions for AQI 151-500 such as releasing emergency notifications. Twelve plans (60%) included prepared messaging templates. The most common templates were messaging toolkits and press releases focused on health risks and strategies to reduce smoke exposure.

Sixteen plans (80%) provided suggested modes of communication. Common modes included radio, social media, text alerts, and press releases. Nineteen plans (95%) documented the agency or agencies responsible for coordinating public risk communication, and twelve plans (60%) listed suggested partners to help disseminate the information. Agencies responsible for coordination were often public health agencies, while suggested partners included community-based organizations, schools, nursing homes, and a variety of government agencies. Ten plans (50%) included instructions or guidance for disseminating messages in languages other than English. Common strategies included translated messaging templates and targeted outreach to populations with a primary language other than English.

Household-Level Exposure Reduction

Most plans (90%) included household-level strategies to reduce smoke exposure during wildfire events.

General Strategies: Eighteen plans (80%) included guidance for the public to stay indoors (75%), close windows and doors (75%), reduce other sources of indoor air pollution (75%), and reduce outdoor physical activity or exertion (75%).

Ventilation and/or filtration: Sixteen plans (80%) included household-level ventilation and filtration recommendations, such as using a portable air cleaner (75%), making a DIY box fan filter (50%), installing a filter with a Maximum Efficiency Reporting Value (MERV) of 13 or higher in a home's central air system (45%), and setting air conditioning to recirculate (25%).

Respiratory protection: Thirteen plans (65%) included guidance for mask use. Thirteen plans (65%) recommended the use of National Institute of Occupational Safety and Health (NIOSH)-approved N95 or P100 respirators for individuals who must be outdoors. Eleven plans (55%) included guidance for wearing a mask with proper fit. Ten plans (50%) recommended that the public prioritize more effective measures to limit their smoke exposure before resorting to a mask, with the most common recommendation being to stay indoors.

Pets/livestock: Two plans (10%) included household-level guidance for taking care of pets and livestock, which included reducing the animal's time spent in smoky areas, keeping indoor air clean, limiting their physical activity levels, and reducing their exposure to dust and other air pollutants.

Community-Level Exposure Reduction

Most plans (85%) included community-level strategies to reduce smoke exposure during wildfire events.

Closures: Fourteen plans (70%) included closure guidance for schools and businesses, and cancellation guidance for events. Seven plans (35%) included guidance for schools, including limiting outdoor activities and closures. Most plans recommended similar actions at corresponding AQI levels. For example, several plans recommended moving recess indoors when the AQI reached 151-200. Five plans (25%) included guidance for business activities and closures. Of those that recommended closures, some specified an unhealthy AQI level (151-200) or AQHI level exceeding 7. Some plans that included guidance for businesses and events tasked their lead agency to work with local partners and organizers of events to cancel outdoor events. For example, two plans specified that public health agencies should communicate air quality advisories and coordinate the cancellation of outdoor events and work activities when the AQI reaches 151. Finally, thirteen plans (65%) included guidance for public event closures. Some plans had specific AQI levels with recommended actions, while others required cancellation during all wildfire smoke events with no provided definition. Several plans included guidance for communicating to the public about closures through public service announcements or event coordinators, in consultation with local public health and air district officials.

Clean Air Centers: Fifteen plans (75%) included guidance for establishing clean air centers - public spaces equipped with high-efficiency air filtration systems to allow members of the public to access clean air. When detailing physical building requirements and necessary upkeep for these centers, eight plans (40%) recommended evaluating HVAC systems and fresh-air intakes; seven plans (35%) recommended acquiring portable air cleaning units; five plans (25%) recommended installing high-efficiency filters with MERV-13 or higher; four plans (20%) recommended monitoring indoor air quality during center operation; and two plans (10%) recommended weatherizing the building. Three plans (15%) included guidance to evaluate agency staffing levels before opening centers. Four plans (20%) addressed transportation to and from clean air centers, collaborating with local transit agencies to establish free public transit routes, and ensuring accessibility for individuals with impairments. Finally, nine plans (45%) sought to increase public awareness about clean air centers through community outreach and announcements on social media platforms.

Targeted Outreach

Most plans (65%) identified specific populations as being at elevated risk from wildfire smoke. Some populations were included due to increased risk of exposure to wildfire smoke, including outdoor workers (70%) and renters (10%). Other populations were included due to increased risk of negative health outcomes from wildfire smoke exposure, including older adults (90%), people with underlying health conditions (e.g., asthma and/or other respiratory diseases, cardiovascular disease) (90%), children (85%), and pregnant people (80%). Certain populations may be at increased risk of both exposure and negative health outcomes, including homeless people (65%), people with low-income (50%), people of color (30%), and Indigenous people (25%).

Many plans included specific outreach strategies for at-risk populations (Fig 4). Six plans (30%) included targeted outreach for older adults, with strategies including communication with senior living facilities. Five plans (25%) recommended that people with asthma have a written asthma action plan. Five plans (25%) recommended that people with heart or lung disease check with their health care providers about precautions to take during smoke events. Although the plans generally provided recommendations for these at-risk populations, they rarely specified how this information would be communicated to the intended populations. Six plans (30%) included guidance for people with underlying conditions to contact a health care provider if conditions worsen. Eleven plans (55%) included targeted outreach for children, including disseminating information to childcare providers, school administrators, teachers, and after-school programs. One plan (5%) included targeted outreach for pregnant people by communicating with local women’s health organizations.

Fig 4. Percentage of Wildfire Smoke Plans with Identification of and Targeted Outreach Strategies for At-Risk Populations.

Nine plans (45%) included targeted outreach for outdoor workers. Most of these plans included guidance for employers to protect employee health. Commonly recommended actions included ensuring access to N95 respirators and encouraging employees to use them when needed (35%), relocating workers to less smoky areas or rescheduling tasks to less smoky times of day (30%), postponing or shortening time spent outdoors (20%), providing frequent breaks in cleaner air spaces (20%), and reducing workers' physical activity and exertion levels (15%). Ten plans (50%) included targeted outreach for people experiencing homelessness, including disseminating information to local homeless organizations and shelters, as well as visiting encampments to distribute materials such as masks and educational materials. One plan (5%) included targeted outreach for people of color, and no plans included targeted outreach for Indigenous people or renters.

Plan Update, Plan Review/Evaluation, and Long-term Planning

Of the plans reviewed, fifteen were in their first version (75%), while the remaining five had been updated (25%). Twelve plans (60%) described procedures for their evaluation and/or review. The most common evaluation strategies included reaching out to local partners, conducting community surveys, and holding workshops to receive feedback. Thirteen plans (65%) described processes for updating the plans. Common elements included collecting feedback from partner agencies/organizations and the general public, and using it to revise the plan. Eight plans (40%) described the intervals at which the plans should be updated, and thirteen plans (65%) indicated which parties were responsible for updating them. Seven plans (35%) included long-term planning goals to reduce their jurisdiction's risk from wildfire smoke, and each of these plans included equity as either a consideration or a focus of long-term planning.

Discussion

Overall Aim of this Research

Our review of 20 wildfire smoke plans identified variation in preparedness and response strategies used for wildfire smoke exposure reduction. Although plans used both response and preparedness strategies, response strategies were more commonly included. Interdisciplinary leadership and coordination was common, with responsibilities distributed to diverse sets of agencies. Common community-level exposure reduction strategies included risk communication, guidance for opening clean air centers, and facilitating closures of schools and public events. Common household-level exposure reduction strategies included guidance for staying indoors and improving indoor air quality. Most plans were activated based on AQI thresholds tied to specific actions, and responsibility was largely designated to local and state government agencies like public health and emergency management. Many plans identified at-risk populations and included targeted outreach strategies, with some notable gaps in populations represented.

Common Exposure Reduction Strategies

The most common exposure reduction strategy was risk communication, used for both preparedness and response. All plans featured strategies for risk communication, and nearly all identified the responsible agency or agencies involved. Prior research has identified significant limitations in wildfire smoke risk communication, including a lack of clarity in exposure reduction guidance and targeted communication adapted to at-risk groups' preferred communication modes, languages, and health literacy levels [32]. Ineffective or incomplete communication may limit individuals' ability to take appropriate action, particularly among at-risk populations [33]. Our findings suggest that risk communication is widely prioritized, however more standardized and evidence-based guidance may improve public health messaging during wildfire smoke events by helping people understand the information and take appropriate actions.

Among plans with household-level guidance, most recommended staying indoors and improving indoor air quality through ventilation and filtration. These strategies are critical for reducing individual exposure to wildfire smoke, however plans often lacked detailed guidance on how to implement these measures [34]. For example, many plans did not account for barriers related to cost, access to resources, or housing conditions such as homelessness or housing insecurity, which may limit feasibility for certain populations. Similar gaps have been identified in heat action plans, where guidance may fail to account for the accessibility of interventions for low-income populations [24]. Prior research has found that families in low-resourced communities face barriers to protecting themselves from wildfire smoke, including limited access to resources, information, and programs supporting protective behaviors [35]. These findings highlight the need for more actionable and equitable guidance to ensure that household-level strategies are effective and accessible to diverse populations.

Many plans' community-level exposure reduction strategies contain guidance for opening clean air centers, including identifying spaces to serve as clean air centers and planning to install high-efficiency filters. However, few plans addressed considerations such as: transportation accessibility, staffing capacities, monitoring the indoor air quality, and promoting public awareness. These gaps suggest that while clean air centers are widely utilized as a community-level exposure reduction intervention, their effectiveness may be limited by implementation and accessibility challenges. Prior research has identified barriers to clean air center implementation, including staffing, facility availability, transportation access, and outreach [36]. In terms of access, Treves et al. [36] suggested that individuals may be reluctant to leave their homes or belongings to access clean air centers after conducting community-based interviews. Similarly, Teigen et al. found that respondents to a community survey expressed reluctance to leave their homes and pets to access clean indoor air at a hypothetical community resilience hub [37]. Similar barriers have been observed for public cooling centers. Lau et al. [38] found that distance from home and transportation difficulties were barriers to use. Clean air centers might be made more impactful by ensuring equitable access and clearly communicating their availability, but more research is needed to understand if they are an effective intervention.

Another widely utilized community-level exposure reduction strategy was facilitating closures of schools and events. However, plans provided limited guidance on how these decisions should be implemented or balanced with potential social and economic impacts. While closures may reduce immediate exposure to wildfire smoke, they may also disrupt access to essential services and education [39]. In addition, environmental hazards including wildfire smoke have been shown to negatively impact labor market outcomes, including reductions in earnings and productivity [40]. Strengthening guidance on when and how to implement closures, including consideration of potential trade-offs, may improve the effectiveness and feasibility of this strategy during wildfire smoke events.

Response vs. Preparedness Strategies

Our analysis demonstrated that jurisdictions utilize both response and preparedness strategies, although response strategies (e.g., risk communication and guidance for reducing exposure during wildfires) were more common. This lower emphasis on proactive preparedness strategies may constrain the effectiveness of existing wildfire smoke planning. Wildfire smoke preparedness strategies such as pre-wildfire season risk communication, interagency coordination and resource allocation, may reduce the burden on response systems when events occur, particularly when access to services may be limited. Although evidence of these strategies' effectiveness is limited, prior research has supported the value of pre-event interventions. He et al. [41] found that providing asthma patients with action plans prior to extreme heat events led to improved outcomes in a survey measuring their knowledge and preparedness related to actions to take to minimize exposure. This indicates the action plans increased the patients' likelihood to take protective actions during an event, which could decrease negative health outcomes. Additionally, Slavik et al. found that parents' adherence to AQI-based health messaging was dependent on their existing wildfire smoke risk perceptions and their use of internet/mobile applications for smoke information, both of which are factors that may be addressed by preparedness strategies such as pre-wildfire season risk communication [42]. By strengthening preparedness strategies in future wildfire smoke planning, jurisdictions have the opportunity to educate their communities in advance which may better promote exposure reduction measures, potentially reducing health impacts.

Public Health Leadership in Wildfire Smoke Response Planning

Traditional emergency management frameworks for environmental hazards such as floods, hurricanes, and severe storms typically rely on formal incident management and multiagency coordination structures such as Incident Command Systems and Emergency Operations Centers to coordinate preparedness and response activities [43]. Consistent with this approach, Randazza et al. [24] found that 76.2% of heat action plans incorporated National Incident Management System or Emergency Operations Centers structures to support interagency coordination. In contrast, wildfire smoke plans in our study distributed leadership and coordination across a diverse set of organizations, including emergency management, public health, environmental quality, forestry and transportation. This cross-sector nature of wildfire smoke planning may indicate that wildfire smoke remains less standardized than planning frameworks used for other hazards. This could be because wildfire smoke is a newer hazard that jurisdictions have less experience with, or because wildfire smoke doesn't impact infrastructure the way floods, hurricanes or other hazards do.

Gaps in Inclusion of At-Risk Populations

Inclusion of targeted outreach for at-risk populations was common but inconsistent across plans. Eighteen plans (90%) acknowledged that certain populations were at greater risk. Thirteen plans (65%) included targeted outreach strategies for at-risk populations, although there were notable gaps in these populations' representation. Only one plan incorporated targeted outreach for pregnant individuals and people of color. No plans specifically addressed the communication preferences of Indigenous people or renters. Targeted engagement with at-risk populations has been identified as a best practice for risk communication for extreme weather and climate change [44]. MacIntyre et al. [44] performed a scoping review on evaluations of risk communication strategies, and found that engaging with at-risk populations was a key theme among more successful strategies. The gaps in targeted outreach from our findings are reflected by prior extreme event research, which has found relatively low levels of public awareness and personal interventions among at-risk populations during extreme heat events, especially among older adults [45].

Study Limitations

Our analysis only included plans that were accessible online, and excluded plans that were not specific to wildfire smoke, such as comprehensive emergency response plans or prescribed burn procedures. This limits the generalizability of our findings since our study may not represent all relevant wildfire smoke plans. Additionally, our study did not assess the extent to which these plans, or their components, have been implemented, nor has there been a published evaluation of any plan's implementation. As such, this remains an important area for future exploration, especially concerning their effects on public health.

Implications for Policy, Practice, and Future Research

Our analysis signals opportunities for further research on standardization and expansion of plan development guidance. In particular, standardization of plan activation criteria across different jurisdictions requires further examination, as does collaboration with air quality monitoring agencies to establish clear AQI and AQHI thresholds. Additional research is needed to develop guidelines for early activation based on forecasted conditions. Strengthening partnerships among local governments, environmental agencies, and health organizations will also be critical to enhancing air quality monitoring capacities through the deployment of additional sensors/monitors and the utilization of comprehensive data-sharing platforms, such as the EPA AirNow Fire and Smoke Map.

Our findings indicate several opportunities for further research to explore the effectiveness and outcomes of both community and household-level wildfire smoke risk reduction strategies. Risk communication strategies are well-established and supported by evidence showing improvements in public education and protective behavior during disasters [46]. However, a systematic review of disaster risk communication noted the general lack of randomized controlled trials to thoroughly assess these outcomes, especially in the context of wildfire smoke and vulnerable populations [46].

Research supports the guidance to stay indoors and close windows and doors during wildfire smoke events [47-48]. Indoor $PM_{2.5}$ levels have been found to be lower than outdoor levels, and buildings with low air-exchange rates have better air quality than those with high air-exchange rates [47-48]. Likewise, strong evidence demonstrates that active ventilation and filtration strategies, particularly with portable air cleaners, reduce indoor $PM_{2.5}$ concentrations during wildfire smoke events [49-50]. However, there is a gap in the literature that characterizes indoor air pollutant constituents and average concentrations typically present during wildfire smoke events - especially those fires that include structures. These data would help elucidate event-based and cumulative exposures used for health outcome studies.

Further research is also needed on the uptake of various exposure reduction strategies. Although experimental studies demonstrate that properly fitted N95 respirators effectively reduce particulate exposure, few studies have evaluated real-world uptake of respiratory protection during wildfire smoke events [51-53]. Additionally, disaster research has shown that concern for pets and limited animal sheltering options can discourage evacuation during emergencies [54-55]. Only two plans included risk-reduction strategies for pets and livestock during wildfire smoke events; additional research is needed to assess whether expanding preparedness planning for pets and livestock may improve evacuation behavior. Finally, while research on the utilization of clean air centers is still limited, identified barriers include limited transportation options, operational hours and the inability to bring your pets along [36-37]. Additional research is needed to identify strategies for improving utilization of clean air centers or alternative models for accessing clean air. Surveying community members after wildfire smoke events will provide valuable insight into the perception and uptake of different exposure reduction strategies.

Conclusion

Wildfire smoke preparedness and response plans can help guide public health responses to wildfire smoke events with strategies including coordinating actions across agencies and organizations, communicating risks and household-level guidance with the public, closing public events and establishing clean air centers. This study highlights the elements and strategies currently used in plans throughout the U.S. and Canada providing insight into which ones are more and less commonly used. Further research is needed to evaluate the effectiveness of wildfire smoke plans and specific strategies.

Acknowledgements

The authors would like to acknowledge Dr. Brian Henning and Dante Jester of the Gonzaga Institute for Climate, Water, and the Environment for their ongoing partnership. We would also like to thank Charlotte Crocco for her assistance coding the wildfire smoke preparedness and response plans.

References

1. Cunningham CX, Williamson GJ, Bowman DMJS. Increasing frequency and intensity of the most extreme wildfires on Earth. Nat Ecol Evol. 2024 Jun 24;8(8):1420–5. doi:10.1038/s41559-024-02452-2
2. Abatzoglou JT, Williams AP. Impact of anthropogenic climate change on wildfire across western US forests. Proc Natl Acad Sci USA. 2016 Oct 18;113(42):11770–5. doi:10.1073/pnas.1607171113
3. Kweku D, Bismark O, Maxwell A, Desmond K, Danso K, Oti-Mensah E, et al. Greenhouse Effect: Greenhouse Gases and Their Impact on Global Warming. JSRR. 2018 Feb 15;17(6):1–9. doi:10.9734/JSRR/2017/39630
4. Romanello M, Walawender M, Hsu SC, Moskeland A, Palmeiro-Silva Y, Scamman D, et al. The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action. The Lancet. 2024 Nov;404(10465):1847–96. doi:10.1016/S0140-6736(24)01822-1
5. Hessburg PF, Prichard SJ, Hagmann RK, Povak NA, Lake FK. Wildfire and climate change adaptation of western North American forests: a case for intentional management. Ecological Applications. 2021;31(8):e02432. doi:10.1002/eap.2432
6. Balch JK, Bradley BA, Abatzoglou JT, Nagy RC, Fusco EJ, Mahood AL. Human-started wildfires expand the fire niche across the United States. Proceedings of the National Academy of Sciences. 2017 Mar 14;114(11):2946–51. doi:10.1073/pnas.1617394114
7. Chen H, Samet JM, Bromberg PA, Tong H. Cardiovascular health impacts of wildfire smoke exposure. Part Fibre Toxicol. 2021 Jan 7;18(1):2. doi:10.1186/s12989-020-00394-8
8. US EPA O. Health and Environmental Effects of Particulate Matter (PM) [Overviews and Factsheets] [Internet]. 2016 [cited 2026 Jul 22]. Available from: https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm
9. Xing YF, Xu YH, Shi MH, Lian YX. The impact of $PM_{2.5}$ on the human respiratory system. 胸部疾病杂志. 2016;8(1):E69. doi:10.3978/j.issn.2072-1439.2016.01.19
10. Doubleday A, Sheppard L, Austin E, Busch Isaksen T. Wildfire smoke exposure and emergency department visits in Washington State. Environ Res: Health. 2023 Jun 1;1(2):025006. doi:10.1088/2752-5309/acd3a1

11. Gould CF, Heft-Neal S, Johnson M, Aguilera J, Burke M, Nadeau K. Health Effects of Wildfire Smoke Exposure. Annu Rev Med. 2024 Jan 29;75(1):277–92. doi:10.1146/annurev-med-052422-020909
12. Heft-Neal S, Gould CF, Childs ML, Kiang MV, Nadeau KC, Duggan M, et al. Emergency department visits respond nonlinearly to wildfire smoke. Proc Natl Acad Sci U S A. 2023 Sep 18;120(39):e2302409120. doi:10.1073/pnas.2302409120 PubMed PMID: 37722035; PubMed Central PMCID: PMC10523589.
13. 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. Thomson M, editor. PLoS Med. 2018 Jul 10;15(7):e1002601. doi:10.1371/journal.pmed.1002601
14. Iyaz D, Perkins A, Cogen JD, Doubleday A, Sack C, Busch Isaksen T. Association between wildfire smoke exposure and Seattle, Washington Pediatric Hospital services, 2006–2020. Environ Res: Health. 2023 Jun 1;1(2):025010. doi:10.1088/2752-5309/acd2f6
15. Basilio E, Chen R, Fernandez AC, Padula AM, Robinson JF, Gaw SL. Wildfire Smoke Exposure during Pregnancy: A Review of Potential Mechanisms of Placental Toxicity, Impact on Obstetric Outcomes, and Strategies to Reduce Exposure. Int J Environ Res Public Health. 2022 Oct 22;19(21):13727. doi:10.3390/ijerph192113727 PubMed PMID: 36360613; PubMed Central PMCID: PMC9657128.
16. Casey JA, Kioumourtzoglou MA, Padula A, González DJX, Elser H, Aguilera R, et al. Measuring long-term exposure to wildfire $PM_{2.5}$ in California: Time-varying inequities in environmental burden. Proceedings of the National Academy of Sciences. 2024 Feb 20;121(8):e2306729121. doi:10.1073/pnas.2306729121
17. Kramer AL, Liu J, Li L, Connolly R, Barbato M, Zhu Y. Environmental justice analysis of wildfire-related $PM_{2.5}$ exposure using low-cost sensors in California. Science of The Total Environment. 2023 Jan;856:159218. doi:10.1016/j.scitotenv.2022.159218
18. Winker R, Payton A, Brown E, McDermott E, Freedman JH, Lenhardt C, et al. Wildfires and climate justice: future wildfire events predicted to disproportionally impact socioeconomically vulnerable communities in North Carolina. Front Public Health. 2024 Apr 29;12. doi:10.3389/fpubh.2024.1339700
19. Rice RB, Sacks JD, Baker KR, LeDuc SD, West JJ. Wildland fire smoke adds to disproportionate $PM_{2.5}$ exposure in the United States. ACS EST Air. 2025 Feb 14;2(2):215–25. doi:10.1021/acsestair.4c00173 PubMed PMID: 40256491; PubMed Central PMCID: PMC12004501.

20. 1. Melvin J. The split incentives energy efficiency problem: Evidence of underinvestment by landlords. Energy Policy. 2018 Apr 1;115:342–52. doi:10.1016/j.enpol.2017.11.069
21. Federal Emergency Management Agency. Developing and Maintaining Emergency Operations Plans Comprehensive Preparedness Guide. 2025 May.
22. Federal Emergency Management Agency. Local Mitigation Planning Policy Guide. 2025 Apr 11.
23. Canada Public Safety. An Emergency Management Framework for Canada - Third Edition [Internet]. 2018 [cited 2026 May 20]. Available from: https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/2017-mrgnc-mngmnt-frmwrk/index-en.aspx
24. Randazza JM, Hess JJ, Bostrom A, Hartwell C, Adams QH, Nori-Sarma A, et al. Planning to Reduce the Health Impacts of Extreme Heat: A Content Analysis of Heat Action Plans in Local United States Jurisdictions. Am J Public Health. 2023 May;113(5):559–67. doi:10.2105/AJPH.2022.307217
25. Bernstein T. Wildfire Smoke: State Policies for Reducing Indoor Exposure | Environmental Law Institute [Internet]. 2024 [cited 2026 Jul 22]. Available from: https://www.eli.org/research-report/wildfire-smoke-state-policies-reducing-indoor-exposure
26. US EPA O. Wildfire Smoke: A Guide for Public Health Officials [Overviews and Factsheets] [Internet]. 2026. Available from: https://www.epa.gov/wildfires/wildfire-smoke-guide-public-health-officials
27. U.S. Census Bureau QuickFacts. Available from: https://www.census.gov/quickfacts/fact/table//PST045225
28. Government of Canada SC. Population estimates, July 1, by census metropolitan area and census agglomeration, 2021 boundaries [Internet]. 2024 . Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710014801&pickMembers%5B0%5D=2.1&pickMembers%5B1%5D=3.1&cubeTimeFrame.startYear=2025&cubeTimeFrame.endYear=2025&referencePeriods=20250101%2C20250101
29. AQI Basics | AirNow.gov [Internet]. AirNow.gov, U.S. EPA; [cited 2026 Jul 30]. Available from: https://www.airnow.gov/aqi/aqi-basics/
30. Canada E and CC. About the Air Quality Health Index [service description] [Internet]. 2007 [cited 2026 Jul 30]. Available from: https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index/about.html
31. US EPA. AirNow Mobile App | AirNow.gov [Internet]. AirNow.gov, U.S. EPA. Available from: https://www.airnow.gov/airnow-mobile-app/

32. Vien MH, Ivey SL, Boyden H, Holm S, Neuhauser L. A scoping review of wildfire smoke risk communications: issues, gaps, and recommendations. BMC Public Health. 2024 Jan 27;24(1):312. doi:10.1186/s12889-024-17681-0
33. Neuhauser L, Rothschild B, Graham C, Ivey SL, Konishi S. Participatory Design of Mass Health Communication in Three Languages for Seniors and People With Disabilities on Medicaid. Am J Public Health. 2009 Dec;99(12):2188–95. doi:10.2105/AJPH.2008.155648
34. Singer BC, Delp WW, Black DR, Destaillats H, Walker IS. Reducing In-Home Exposure to Air Pollution. 2016 May 21.
35. Silva J, Andrade-Torres A, Schuster C, Black J, Tavira J, Yelechin V, et al. Barriers and Facilitators to Early-life Wildfire Smoke Protection in a Rural Population: The Role of Community in Research and Public Health Practice. Res Sq. 2025 Sep 22;rs.3.rs-7359173. doi:10.21203/rs.3.rs-7359173/v1 PubMed PMID: 41041563; PubMed Central PMCID: PMC12486116.
36. Treves RJ, Liu E, Fischer SL, Rodriguez E, Wong-Parodi G. Wildfire Smoke Clean Air Centers: Identifying Barriers and Opportunities for Improvement from California Practitioner and Community Perspectives. Society & Natural Resources. 2023 Sep 2;36(9):1078–97. doi:10.1080/08941920.2022.2113487
37. Teigen, Katharine A.; Reed, Anna; Jester, Dante; Costa, Lauren; ten Berge, Lola; Pham, Kim; Henning, Brian G.; Busch Isaksen, Tania. Household Perceptions and Preparedness for Wildfire Smoke: Findings from a Community Assessment for Public Health Emergency Response in Spokane, Washington. Disaster Medicine and Public Health Preparedness journal. Forthcoming.
38. Lau JJ, Henning B, Tokareva K, Ducken K, Malik FS. Beat the Heat: Community Perspectives Around Extreme Heat in Spokane, WA, Post-2021 Northwest Heat Dome. J Community Med Public Health. 2024 Aug 5;8(3). doi:10.29011/2577-2228.100456
39. Wen J, Burke M. Wildfire smoke exposure worsens students' learning outcomes. Nat Sustain. 2022 Sep 29;5(11):920–1. doi:10.1038/s41893-022-00958-w
40. Roth Tran B, Wilson DJ. The Local Economic Impact of Natural Disasters. Journal of the Association of Environmental and Resource Economists. 2025 Nov;12(6):1667–704. doi:10.1086/735533
41. He R, Shellington E, Barn P, Rideout K, Bueso A, Joshi I, et al. Development and pilot of the BC Wildfire Smoke and Extreme Heat Action Plan: empowering patients with climate health readiness. BMJ Open Qual. 2025 Oct;14(4):e003407. doi:10.1136/bmjoq-2025-003407
42. Slavik CE, Chapman DA, Cleland SE, Peters E. What drives parents' use of air quality indexes during wildfire smoke events: predictors of index knowledge, frequent checking, and following health guidance. Popul Environ. 2025 Jun;47(2):20. doi:10.1007/s11111-025-00491-w

43. Federal Emergency Management Agency. National Incident Management System. 2017 Oct.
44. MacIntyre E, Khanna S, Darychuk A, Copes R, Schwartz B. Evidence synthesis - Evaluating risk communication during extreme weather and climate change: a scoping review. Health Promot Chronic Dis Prev Can. 2019 Apr;39(4):142–56. doi:10.24095/hpcdp.39.4.06
45. Bassil KL, Cole DC. Effectiveness of Public Health Interventions in Reducing Morbidity and Mortality during Heat Episodes: a Structured Review. IJERPH. 2010 Mar 10;7(3):991–1001. doi:10.3390/ijerph7030991
46. Bradley DT, McFarland M, Clarke M. The Effectiveness of Disaster Risk Communication: A Systematic Review of Intervention Studies. PLoS Curr. 2014 Aug 22;6. doi:10.1371/currents.dis.349062e0db1048bb9fc3a3fa67d8a4f8 PubMed PMID: 25642365; PubMed Central PMCID: PMC4172473.
47. O'Dell K, Ford B, Burkhardt J, Magzamen S, Anenberg SC, Bayham J, et al. Outside in: the relationship between indoor and outdoor particulate air quality during wildfire smoke events in western US cities. Environ Res: Health. 2022 Nov;1(1):015003. doi:10.1088/2752-5309/ac7d69
48. May NW, Dixon C, Jaffe DA. Impact of Wildfire Smoke Events on Indoor Air Quality and Evaluation of a Low-cost Filtration Method. Aerosol Air Qual Res. 2021 May 12;21(7):210046. doi:10.4209/aaqr.210046
49. Fisk WJ, Chan WR. Health benefits and costs of filtration interventions that reduce indoor exposure to PM2.5 during wildfires. Indoor Air. 2016 Feb 4;27(1):191–204. doi:10.1111/ina.12285
50. Tran VV, Park D, Lee YC. Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality. International Journal of Environmental Research and Public Health. 2020 Jan;17(8):2927. doi:10.3390/ijerph17082927
51. Hoshiko S, Buckman JR, Jones CG, Yeomans KR, Mello A, Thilakaratne R, et al. Responses to Wildfire and Prescribed Fire Smoke: A Survey of a Medically Vulnerable Adult Population in the Wildland-Urban Interface, Mariposa County, California. Int J Environ Res Public Health. 2023 Jan 10;20(2):1210. doi:10.3390/ijerph20021210 PubMed PMID: 36673971; PubMed Central PMCID: PMC9858942.
52. Kodros JK, O'Dell K, Samet JM, L'Orange C, Pierce JR, Volckens J. Quantifying the Health Benefits of Face Masks and Respirators to Mitigate Exposure to Severe Air Pollution. GeoHealth. 2021;5(9):e2021GH000482. doi:10.1029/2021GH000482
53. Laumbach RJ. Clearing the Air on Personal Interventions to Reduce Exposure to Wildfire Smoke. Ann Am Thorac Soc. 2019 Jul;16(7):815–8.

doi:10.1513/AnnalsATS.201812-894PS PubMed PMID: 31145636; PubMed Central PMCID: PMC6600837.

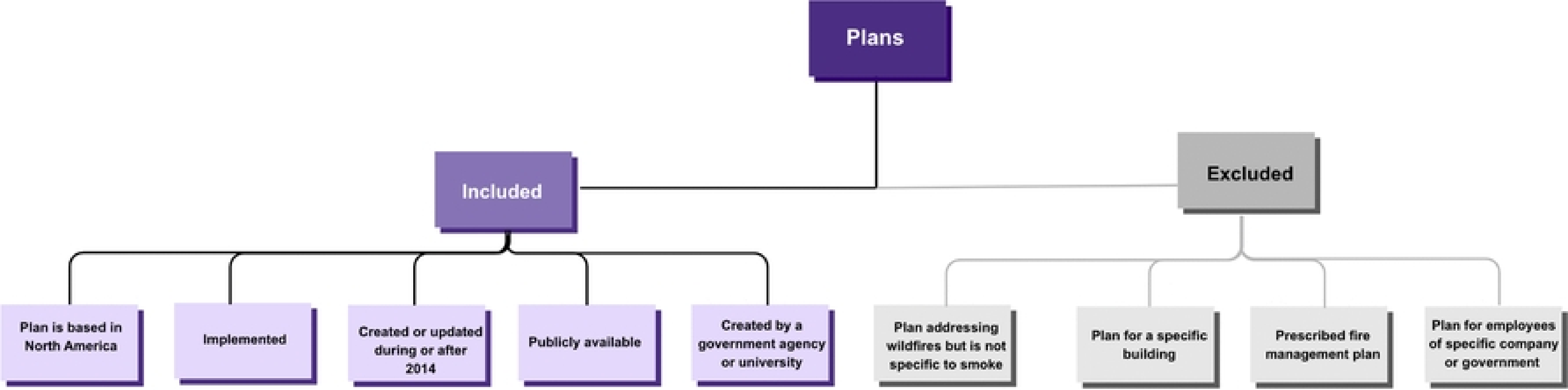
54. Bansal P, Parzniewski S, Ru S, Chen S, Wu H. The Roles of Companion Animals in the Relationship Between Disaster Risk Perception and Willingness to Evacuate. International Journal of Disaster Risk Science. 2025 Jun 13;16(3):333–45. doi:10.1007/s13753-025-00648-z
55. Chadwin R. Evacuation of Pets During Disasters: A Public Health Intervention to Increase Resilience. Am J Public Health. 2017 Sep;107(9):1413–7. doi:10.2105/AJPH.2017.303877 PubMed PMID: 28727532; PubMed Central PMCID: PMC5551593.

Supporting Information

S1 Table. Search Terms Used in Google Searches to Collect Wildfire Smoke Plans.

S2 Table. Wildfire Smoke Plans Included in the Analysis.

S1 Appendix. Wildfire Smoke Plan Content Analysis Survey.



Plans
Included
Excluded
Plan is based in North America
Implemented
Created or updated during or after 2014
Publicly available
Created by a government agency or university
Plan addressing wildfires but is not specific to smoke
Plan for a specific building
Prescribed fire management plan
Plan for employees of specific company or government

Figure 1

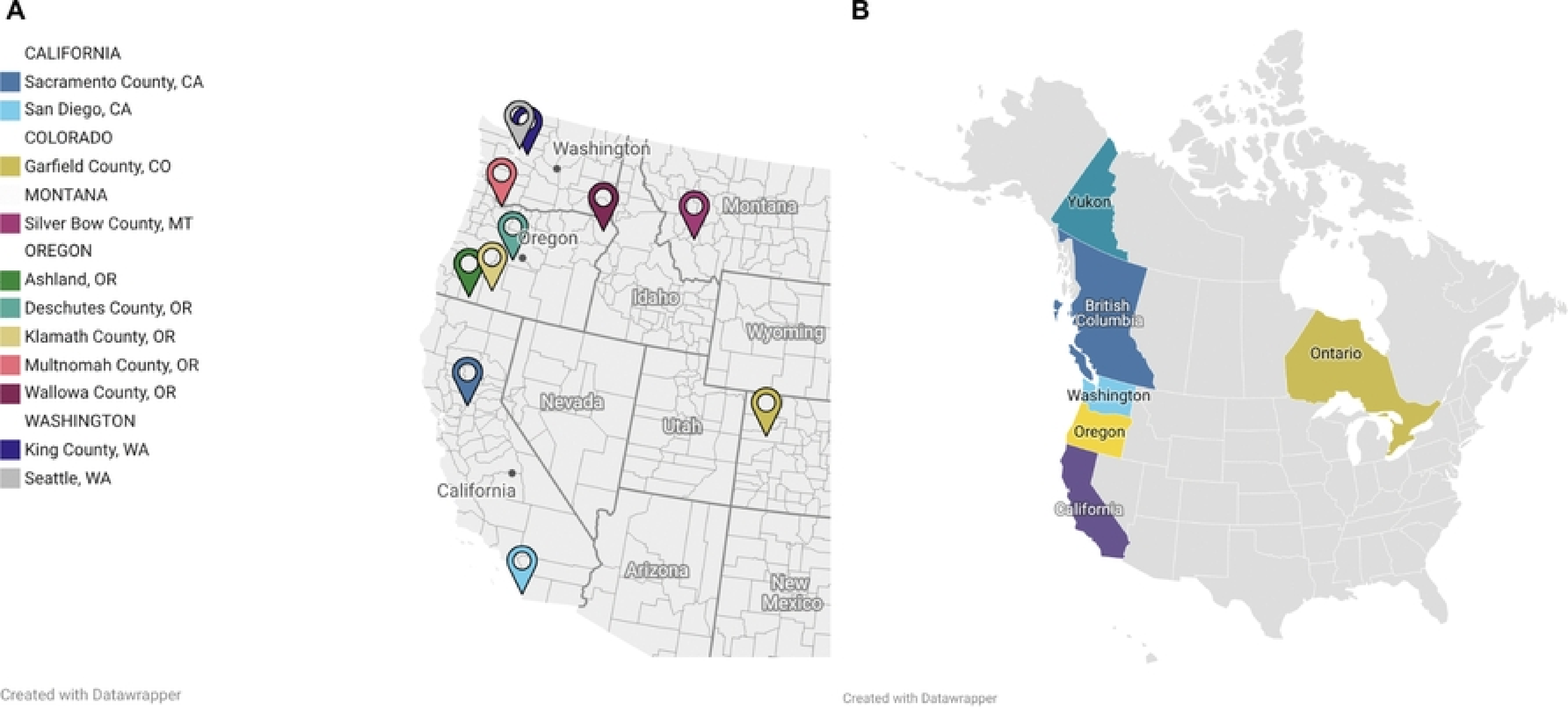

A
CALIFORNIA
Sacramento County, CA
San Diego, CA
COLORADO
Garfield County, CO
MONTANA
Silver Bow County, MT
OREGON
Ashland, OR
Deschutes County, OR
Klamath County, OR
Multnomah County, OR
Wallowa County, OR
WASHINGTON
King County, WA
Seattle, WA
Washington
Oregon
Montana
Idaho
Wyoming
Nevada
Utah
California
Arizona
New Mexico
Created with Datawrapper
B
Yukon
British Columbia
Washington
Oregon
California
Ontario
Created with Datawrapper

Figure 2

Strategies	British Columbia (HASE)	British Columbia (Housing)	British Columbia (Sample)	British Columbia	Ontario	Yukon	Oregon	Deschutes County	Ashland	Multnomah County	Wallowa County	Klamath County	California	San Diego State University	Sacramento County	Butte-Silver Bow County	Garfield County	Washington	Seattle	King County
Plan Activation	1/1	0/1	1/1	0/1	1/1	0/1	1/1	1/1	1/1	0/1	0/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
Air Quality Monitoring																				
Forecasting	3/7	0/7	0/7	2/7	3/7	3/7	7/7	2/7	1/7	2/7	2/7	2/7	3/7	3/7	5/7	6/7	2/7	6/7	2/7	3/7
Increasing Infrastructure	2/2	0/2	0/2	2/2	0/2	2/2	1/2	1/2	0/2	1/2	0/2	1/2	0/2	0/2	0/2	2/2	1/2	1/2	0/2	1/2
Interagency and/or Interorganizational Coordination																				
Procedures for Calls/Meetings	2/3	2/3	1/3	0/3	0/3	0/3	2/3	2/3	1/3	2/3	1/3	0/3	0/3	0/3	1/3	1/3	1/3	2/3	1/3	1/3
Advisory Group	1/1	0/1	0/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1	1/1
Risk Communication																				
Any Strategies (Y/N)	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
Communication Methods	6/7	3/7	3/7	3/7	4/7	4/7	6/7	6/7	5/7	1/7	4/7	5/7	7/7	2/7	5/7	5/7	5/7	3/7	5/7	6/7
Information to be Communicated	5/9	0/9	1/9	5/9	6/9	3/9	5/9	6/9	5/9	3/9	4/9	2/9	7/9	2/9	5/9	6/9	6/9	5/9	1/9	5/9
Household-level Exposure Reduction																				
General Strategies	5/6	0/6	1/6	4/6	5/6	6/6	6/6	5/6	5/6	6/6	0/6	4/6	6/6	3/6	4/6	6/6	5/6	6/6	6/6	1/6
Ventilation and/or Filtration	5/9	1/9	2/9	5/9	4/9	7/9	6/9	4/9	6/9	9/9	0/9	4/9	8/9	1/9	7/9	6/9	3/9	2/9	4/9	0/9
Respiratory Protection	2/3	0/3	0/3	3/3	3/3	0/3	2/3	0/3	3/3	3/3	0/3	0/3	3/3	3/3	2/3	3/3	2/3	1/3	3/3	2/3
Pets/Livestock	0/6	0/6	0/6	0/6	0/6	0/6	0/6	0/6	0/6	5/6	0/6	0/6	2/6	0/6	0/6	0/6	0/6	0/6	0/6	0/6
Community-level Exposure Reduction																				
Closures	1/3	0/3	0/3	2/3	2/3	2/3	3/3	0/3	2/3	2/3	0/3	1/3	3/3	0/3	3/3	1/3	1/3	2/3	0/3	1/3
Clean air centers	2/10	0/10	3/10	3/10	2/10	6/10	8/10	3/10	2/10	6/10	0/10	2/10	6/10	0/10	10/10	0/10	0/10	1/10	2/10	6/10
Targeted Outreach to At-Risk Populations	0/16	0/16	0/16	1/16	5/16	3/16	7/16	4/16	4/16	2/16	0/16	4/16	10/16	5/16	12/16	3/16	4/16	0/16	7/16	4/16
Plan Update	1/3	3/3	0/3	0/3	0/3	0/3	1/3	3/3	3/3	3/3	3/3	0/3	0/3	1/3	2/3	2/3	1/3	0/3	2/3	3/3
Plan Review/ Evaluation	0/1	1/1	0/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	0/1	0/1	0/1	1/1	1/1	0/1	1/1	0/1	1/1
Long-term Planning	0/1	1/1	0/1	0/1	1/1	0/1	0/1	1/1	1/1	1/1	0/1	0/1	1/1	0/1	0/1	0/1	0/1	1/1	0/1	0/1
Total	37/88	12/88	13/88	31/88	38/88	38/88	58/88	40/88	41/88	48/88	26/88	27/88	57/88	22/88	59/88	45/88	33/88	33/88	35/88	37/88
Percentage	42.05%	13.64%	14.77%	35.23%	43.18%	43.18%	65.91%	45.45%	46.59%	54.55%	29.55%	30.68%	64.77%	25.00%	67.05%	51.14%	37.50%	37.50%	39.77%	42.05%

Individual strategy inclusion

0-25%	26-50%	51-75%	76-100%

Total strategy inclusion

0.00-34.09%	34.10%-42.05%	42.06%-50.00%	50.00%-67.05%

Figure 3

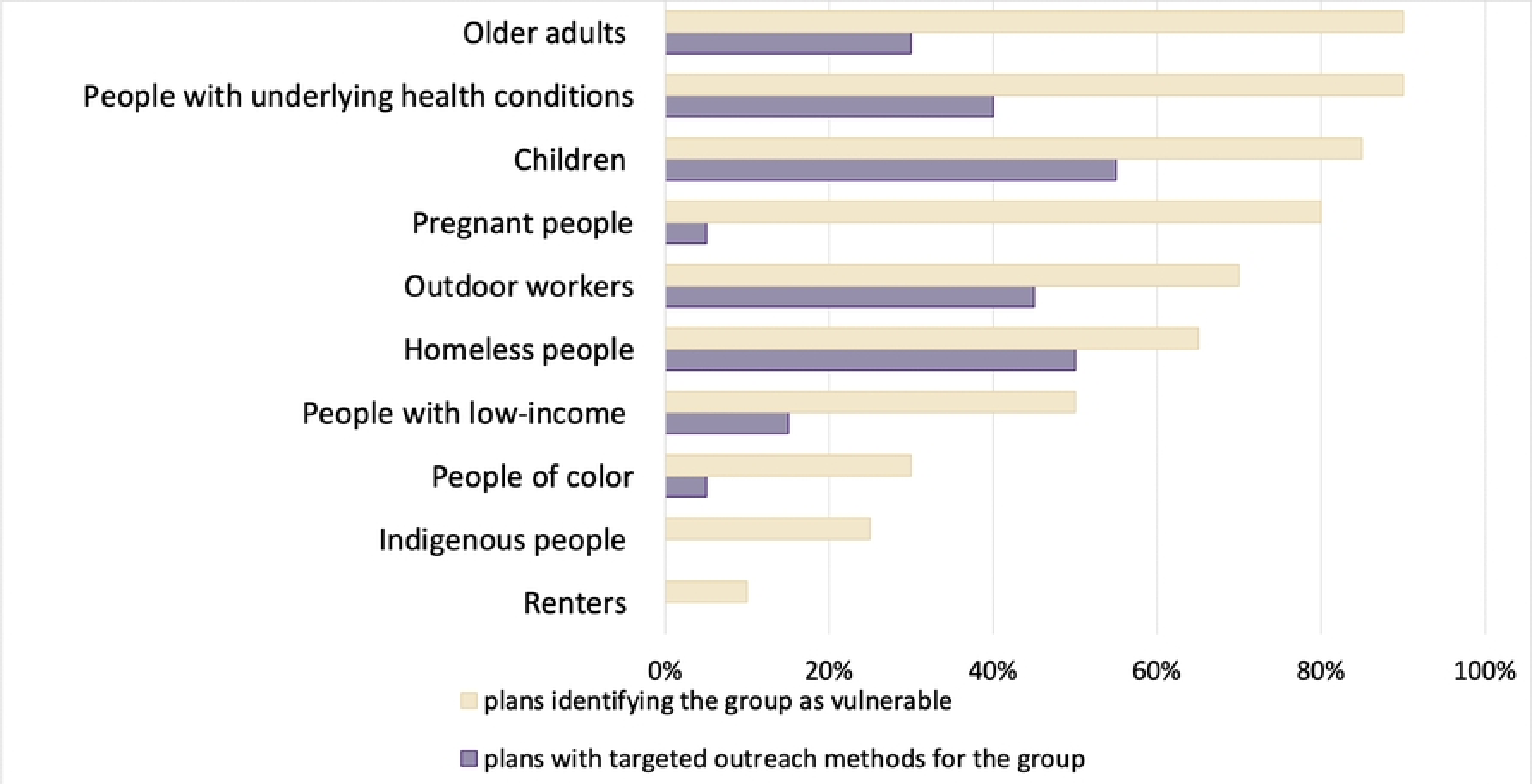

Older adults
People with underlying health conditions
Children
Pregnant people
Outdoor workers
Homeless people
People with low-income
People of color
Indigenous people
Renters
0%
20%
40%
60%
80%
100%
plans identifying the group as vulnerable
plans with targeted outreach methods for the group

Figure 4