

Limited availability of health risk communication related to community smoke exposure from prescribed burns in the United States: a review

Margaux Joe^A, Adrienne Cocci^B, Chioma Ihekweazu^B, Olorunfemi Adetona^{A,*}, Anna Adetona^B, Tanya Maslak^B and Luke P. Naeher^C

For full list of author affiliations and declarations see end of paper

***Correspondence to:**

Olorunfemi Adetona
Department of Environmental Health
Sciences, College of Public Health, The
Ohio State University, 1841 Neil Avenue, 436
Cunz Hall, Columbus, OH 43210, USA
Email: adetona.1@osu.edu

Received: 27 September 2023

Accepted: 3 August 2024

Published: 29 August 2024

Cite this: Joe M *et al.* (2024) Limited availability of health risk communication related to community smoke exposure from prescribed burns in the United States: a review. *International Journal of Wildland Fire* **33**, WF23158. doi:[10.1071/WF23158](https://doi.org/10.1071/WF23158)

© 2024 The Author(s) (or their employer(s)). Published by CSIRO Publishing on behalf of IAWF.

This is an open access article distributed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License ([CC BY-NC-ND](https://creativecommons.org/licenses/by-nc-nd/4.0/))

OPEN ACCESS

ABSTRACT

Prescribed burns are used to maintain wildland ecosystems and decrease fuel loads and associated wildfire hazard. Prescribed burns may produce enough smoke to cause adverse health outcomes. The aim of this review is to understand what communication materials exist for disseminating health risk information related to prescribed burn smoke and challenges to developing such communication. We examined United States peer-reviewed literature from PubMed, Scopus, and Web of Science databases and conducted an environmental scan of grey literature including materials from federal, and several US state and local governments, organisations, and newspapers. While 63% of the included peer-reviewed literature focuses on wildfire health risk communication, the review suggests similar methods and messages can be adapted for prescribed burns. The environmental scan review indicates effective strategies use several communication modes, and reliable and timely messaging. There are state regulations for prescribed burn notification, but these do not require communication or education of health risks associated with smoke exposure. Smoke management guidelines often contain information about prescribed burn health risks, but these do not discuss health risk education. Opportunities to expand effective health risk communication include improving inconsistent messaging and inter-agency collaborations, and increasing public interactions, especially with vulnerable populations.

Keywords: communication efficacy, community exposure, health communication, health risk communication, prescribed burn, prescribed fire, risk communication, smoke exposure.

Introduction

In the past decade, wildfires burned an average of approximately 2.8 million ha (7 million acres) per year in the United States ([National Interagency Fire Center n.d.b](#)). The potential for exposure to wildfire smoke increased due to population growth and the ability of smoke to travel long distances ([Radeloff *et al.* 2018](#); [Ager *et al.* 2019](#)). Whereas fire suppression was a primary land management approach for several decades, tribal and indigenous communities used controlled burns for centuries to promote ecological diversity, clear land for crops, and reduce the risk of larger wildfires ([Bureau of Indian Affairs 2019](#); [National Park Service 2022a](#)). Prescribed burns are acknowledged as a beneficial and successful land management tool, especially in the south-eastern US ([USDA Forest Service n.d.](#); [Ryan *et al.* 2013](#); [Clark *et al.* 2022](#)). Approximately two-thirds of the estimated 4.5 million ha treated by prescribed burns in the US annually ([Melvin 2021](#); [Cummins *et al.* 2023](#)) are in the south-eastern U.S. ([Melvin 2021](#)). However, there are still areas across the US and globally that are slower to use prescribed burns, likely a result of public concerns about potential fire escape, carbon emissions, and smoke exposure ([Ryan *et al.* 2013](#); [USDA Forest Service 2022](#)).

Exposure to air pollutants in wildland fire smoke (WFS) arising from burning vegetation in wildlands either from wildfire or prescribed burn may adversely impact health.

The link between PM_{2.5} (particulate matter with median aerodynamic diameter of 2.5 µm or fine particles) and adverse respiratory and cardiovascular morbidity and mortality is of primary concern. Smoke from prescribed burns can contribute to ambient air pollution and possibly impact human health as indicated in studies performed in the south-eastern US (Odman *et al.* 2018; Afrin and Garcia-Menendez 2020). Permitted prescribed burning accounts for 50% of the variability of PM_{2.5} concentrations measured at monitoring sites in Florida and Georgia between 2013 and 2016 (Afrin and Garcia-Menendez 2020). While careful planning, active monitoring, and low intensity prescribed burning of understorey (i.e. herbaceous (e.g. grass and forb) and shrub fuels above the litter surface up to 3 m) can collectively result in reduced emissions compared to wildfires (Navarro *et al.* 2018), smoke exposure in communities adjacent and downwind to prescribed burns can still occur albeit at less intensity (Liu *et al.* 2009; Aдетona *et al.* 2016; Navarro *et al.* 2018). Another potential risk of smoke is reduced visibility while driving, which could contribute to injury or death (Finlay *et al.* 2012; National Wildlife Coordinating Group 2020). Although a single prescribed burn produces less smoke compared to wildfires, there is still a possibility of reduced visibility, especially during temperature inversions that hold smoke closer to the ground (Indiana Division of Fish and Wildlife 2005; Varner *et al.* 2021).

While there are interventions to reduce community smoke exposure, health risk communication is essential for risk management at the individual and community levels. Although there are differences between prescribed burns and wildfires, one study suggests there may be a lack of public understanding that prescribed burns can still produce enough smoke to influence potential health risks (Olsen *et al.* 2014). This may be due to a lack of effective communication to the public, which can lead to inaction, or misunderstanding, in implementing interventions to reduce smoke exposure resulting in increased health risk among the population. There is limited information available about the strategies used by land management and other relevant agencies for communicating to the public about health risks due to smoke exposure, especially from prescribed burns (Fish *et al.* 2017). There is also limited evaluation of messaging, including timing, reach, and comprehension, to reduce smoke exposure from prescribed burns among communities (Sugerman *et al.* 2012). Additionally, it is unclear if stakeholders participate in the development process for the current interventions. Further, there are limitations to the use of several communication materials due to their geographic scope and limited discussion specific to smoke exposure. These gaps are potential barriers to effective communication of health risks associated with smoke exposure from prescribed burns (Olsen *et al.* 2014; Fish *et al.* 2017). To understand these limitations, we conducted a review of peer-reviewed literature to evaluate the current knowledge of health risk communication associated with wildland fire smoke among communities, with a primary

focus on prescribed burns. Additionally, we performed an environmental scan (a review of unpublished literature or publicly available information from government and organisational websites, conference presentations, and outreach materials) to identify existing health risk communication and education materials about prescribed burn smoke that wildland management and public health officials and organisations across the US use to communicate with impacted communities. The objectives of this environmental scan were to: (1) determine the types of communication materials that exist; (2) identify sources of the materials and for whom developed; and (3) describe the information found in the materials. The intent of this paper is not to undermine the short-term or longer-term benefits of the use of prescribed burns to manage catastrophic fire events, but rather to provide the public and private stakeholders and researchers with the current state of the science to inform communication practices about the expanding use of prescribed and cultural burning. While this review is part of a larger research project to develop a prescribed burn health risk communication toolkit, our findings are applicable to broader research efforts for health and environmental risk communication.

Materials and methods

We included peer-reviewed and grey literature in this review. For our justification for the vulnerable populations we chose to include in this review, see Supplementary materials file S1. We developed the following questions to guide both the literature review and the environmental scan:

- (1) What health risk communication materials have already been developed?
- (2) What federal or state laws determine the information that is legally required to be communicated?
- (3) What groups are most vulnerable to health risks associated with prescribed burns?
- (4) What are the known preventive measures/actions to reduce health risks related to prescribed burns?
- (5) How is information about prescribed burn use communicated to the public?
- (6) What barriers and facilitators do agencies face while creating messages about prescribed burns?

Literature review

We included peer-reviewed literature regarding communication of health risks associated with wildfires and prescribed burns. All types of peer-reviewed studies investigating health risk communication related to prescribed burns and wildfires were eligible for inclusion, while excluding non-English materials. We excluded articles published prior to 2005 and if the study objectives did not focus on health risk communication associated with prescribed burns or wildfires

(e.g. entomology, plant biology, modelling, etc.). We used the following search string, in this order, as search criteria: (“Prescribed burn*” OR “Prescribed burning” OR “Controlled burn*” OR “Prescribed burn smoke” OR “Prescribed fire*” OR “Landscape fire*” OR Wildfire OR “Wildland fire*” OR “Wildfire smoke” OR “Wildland fire smoke” OR Bushfire OR Woodsmoke OR “Wood Smoke” OR “Fire smoke exposure” OR “Fire smoke”) AND (Communication OR Education OR Mitigation OR Intervention OR “Health risk communication” OR “Social acceptability” OR “Public awareness” OR Awareness OR “Risk communication” OR “Risk communication strategies” OR “Risk communication strategy” OR Messaging OR “Perceived risk” OR “Subjective norm*”).

The study team conducted the search process between March and July 2023. We collected articles from the PubMed, Scopus, and Web of Science databases. We used title and abstracts to initially assess if articles found in our search met the inclusion criteria. If the title and abstracts suggested the article satisfied the inclusion criteria, then the study team assessed the full text articles. We evaluated the full text of articles that satisfied the inclusion criteria to determine final relevance. A subject matter expert and the principal investigator of the study team evaluated any articles that needed further review. We extracted the following data from all relevant articles: article title; author (s); year of publication; journal, description of the study design; and description of the study results. The first author completed the literature search and data extraction. Three other members of the research team reviewed the extracted data.

Environmental scan

The research team searched sources that included public information available through government and organisational websites and reports, traditional and social media outlets, conference or meeting abstracts or presentations, and communication and outreach materials. A general search engine (i.e. Google) query identified prescribed burn announcements issued by national and state parks, forests, and refuges. We included documents if they contained information on health risks, health risk communication, and/or laws and regulations as it pertains to prescribed burns or wildfires. The included materials also had to answer at least one of the research questions (Appendix S1). We excluded materials and documents not published in English and if published prior to 2005. However, we excluded prescribed burn announcements if published prior to 2018. We further categorised any communication materials included into fact sheets/brochures, frequently asked questions (FAQ)/overview documents, prescribed burn protocols/guidelines/compliance information, resource hubs/toolkits, or graphics/infographics/videos.

The study team conducted the search process between April 2022 and July 2023. We electronically searched the

following federal agencies for eligible materials: US Department of Agriculture (USDA Forest Service; Bureau of Land Management (BLM); US Environmental Protection Agency (US EPA); Centers for Disease Control and Prevention (CDC); US National Park Service (US NPS); and Bureau of Indian Affairs (BIA). We also electronically searched for eligible materials from state agencies in Alabama, Arizona, California, Colorado, Florida, Georgia, Ohio, Oregon, South Carolina, Texas, Virginia, and Washington. We included these states because they were either among the states with the largest acreage burned from wildfires or prescribed burns or they are a study location for the project under which this investigation was conducted (i.e. Ohio, South Carolina, Virginia). Additionally, we searched for eligible materials from the Wildfire Magazine by International Association of Wildland Fire (IAWF) and National Geographic. The study team also searched the archives of four of the largest national newspapers (i.e. *New York Times*, *Washington Post*, *Wall Street Journal*, *LA Times*) and the archives of ten of the largest state newspapers, which we identified using the frequency of circulation within the state. We extracted the following data from the eligible materials: source; title; type; (e.g. legislative document, newspaper article, magazine article, infographic, etc.); and summary of material. Two members of the research team independently reviewed the data.

Results

The study team included a final total of 155 documents from the environmental scan and literature review. From the literature review, we initially excluded articles from PubMed ($n = 1781$), Scopus ($n = 2811$), and Web of Science ($n = 4111$) because we determined they were not related to health risk communication of prescribed burns or wildfires based on the title and abstract of the article (Fig. 1). We excluded 68 duplicate references from more than one publication database. Based on reading the full text, we further excluded 32 articles because the content was not related to health risk communication of prescribed burns or wildfires. We included a final total of 27 articles from the literature review, which focused on health risk communication of prescribed burns and wildfires. More than half of the peer-reviewed articles ($n = 17$; 63%) we found focused on health risk communication for wildfire smoke risk. The articles we found for prescribed burns mostly investigated health risks and did not include information on health risk communication.

The environmental scan included 128 grey literature documents (e.g. infographics, government reports, prescribed burn announcements, etc.) (Table 1). The study team provided additional details on the environmental scan materials and peer-reviewed literature included in this review (Appendix S2).

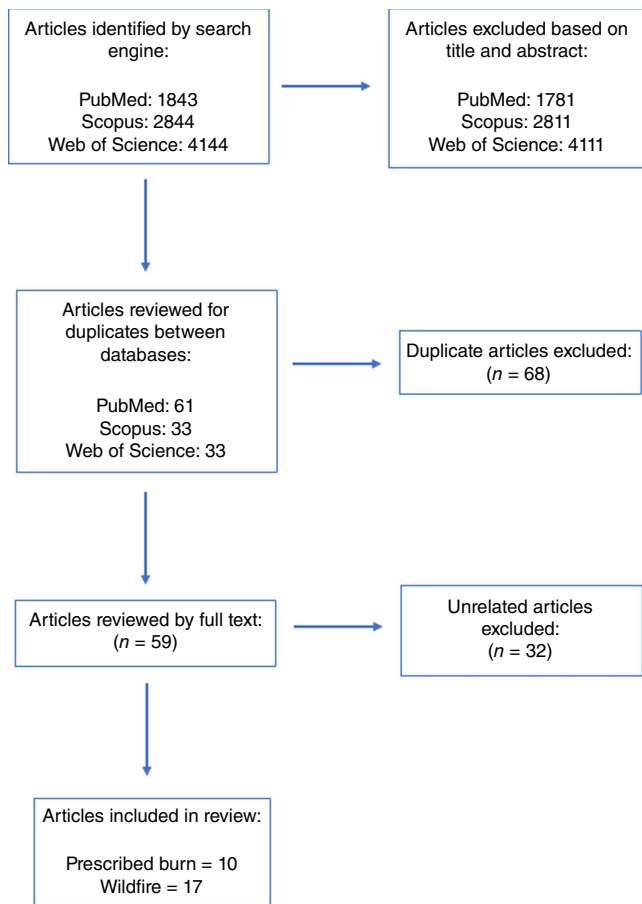


Fig. 1. A summary of the search and selection process for the peer-reviewed literature.

Sources and types of communication materials

From the environmental scan, we identified reports, communication materials (e.g. fact sheets, visuals, brochures, etc.), magazine articles, reviews, prescribed burn announcements, and featured news (Table S1). Federal and state agencies documents consisted of approximately 78% of the total documents identified. We found the remaining 22% on websites of non-governmental organisations and universities. These materials focus on prescribed burns, wildfires, or both types of fires (Table S2). The materials that are specific to prescribed burns ($n = 78$) included a definition of the term and why they are important to the environment. Of these 78 materials, we identified 17% ($n = 13$) that discussed prescribed burn health risks associated with smoke exposure and 13% ($n = 10$) that discussed safety precautions to reduce smoke exposure. Approximately 29% ($n = 37$) of all environmental scan materials ($n = 128$) included guidelines for notification of a prescribed burn event. Of those 37 materials, we found that 18% ($n = 23$) included guidance on health risk communication for prescribed burns and smoke exposure.

Table 1. Summary of materials found in the environmental scan.

Category	Count
Communication material	
Fact Sheets/Brochures	13
FAQ/Overview documents	18
Protocols, Guidance, and compliance documents	21
Resource Hubs/Toolkits	8
Graphics, Infographics, and Videos	8
Featured stories/Articles/News	2
Magazine articles	2
Prescribed Burn Announcements	32
Regulations	12
Reports	5
Reviews	3
Other	4
Total Count	128
Type of smoke event	Count
Prescribed burn	78
Wildfire	31
Prescribed burn and wildfire	19
Total count	128

Suggested guidance for effective communication

Of the environmental scan materials, we identified 17% ($n = 28$) that discussed tips or guidelines for effective communication of wildland fires, with only 17 of those 28 materials focusing on or including prescribed burns. These communication materials included protocols, reports, and toolkits. The protocol and report materials included guidance on general prescribed burn messaging, timing of communication distribution, and general smoke-related health risk messaging. The eight toolkits found in the environmental scan provided guidance on messages, as well as examples of communication materials for the public. Three of the toolkits (i.e. The Great Plains Fire Communication toolkit, Oakridge Air, and CAL FIRE) provided templates and examples of materials used to communicate with the public, such as example messaging for press releases, displays, social media posts, and email blasts (Oregon Prescribed Fire Council n.d.; Schwedler *et al.* 2013; CAL FIRE 2019). In the environmental scan, we also found a set of best practices, developed by professionals across the south-east, that private landowners can implement for prescribed fire communication (Table 2) (Kunkle *et al.* 2015).

We extracted all information on communication efficacy from the peer-reviewed literature articles related to wildfires ($n = 7$). These articles investigated how to tailor effective messages (Heaney *et al.* 2021), message compliance

Table 2. Seven best practices for prescribed fire communication from the Southern Fire Exchange (Kunkle *et al.* 2015).

Seven best practices for prescribed fire communication
1. Develop messages that are specific to the defined or targeted audience
2. Foster consensus among program partners on the use and efficacy of messaging strategies
3. Ensure the information comes from sources the audience is familiar with and trusts
4. Use language that is appropriate and understandable for the targeted audience
5. Encourage private landowners to build relationships with each other by: <ol style="list-style-type: none"> Developing prescribed burn mentoring programs Promoting interactions between landowners
6. Use multiple communication channels such as: <ol style="list-style-type: none"> Posting signs designating areas managed with prescribed fire Utilising demonstrations to attract new practitioners and to open discussion about prescribed burns
7. Maintain consistent contact, build relationships, and continue conversations with the target audience
Additional considerations for prescribed fire communication
1. Consider all communication outlets, including social media, as part of the communication plan
2. Partner with formal and informal educators to encourage inclusion of prescribed burn concepts into their curriculum
3. Designate well-managed landscapes that the public can visit to learn more about prescribed fire
4. Develop and/or use evaluation tools to identify needs, interests, and demographics of the target audience and collect feedback to assess the impact of communication plans
5. Use and support existing prescribed burn communication tools and education programs

(Sugerman *et al.* 2012; Keegan and Rahman 2021), community and inter-agency collaborations (Olsen *et al.* 2014; Reid and Maestas 2019), and communication channels (Chauhan and Hughes 2017; Humphreys *et al.* 2022). Two peer-reviewed articles also investigated the differences in efficacy for unidirectional versus multidirectional communication flow between communicators and their audience (Brenkert-Smith *et al.* 2013; Remenick 2018). Of the communication sources we included from the environmental scan, 68% used unidirectional or vertical messaging to communicate with the public about prescribed burns. The only communication sources that used multidirectional strategies were the prescribed burn announcements that provided the contact information for the agencies in charge of the burn.

Announcements, regulations, and smoke management guidelines for prescribed burns

The environmental scan search for prescribed burn announcements included those digitally (i.e. posted on the internet) released since 2018. Based on a Google search, we found 32 announcements from the USDA Forest Service, US National Park Service, US Fish and Wildlife, US Department of Defense, South Carolina Department of Natural Resources, The Sea Pines Forest Preserve, and the

Table 3. Percentage of the 32 prescribed burn announcements based on type of information.

Type of information	Percent of prescribed burn announcements (%)
Date of prescribed burn window	72
Geographic location of burn area	94
Preventative/protective behaviour suggestions	19
Personnel contact information	88

Bureau of Land Management that fit our inclusion criteria We identified 31 announcements published by state or federal agencies and one announcement published by a private organisation (a community homeowners' association). We found 19% ($n = 6$) of the announcements included additional links or information on air quality and smoke exposure (Table 3). However, only two of the six announcements, both from the BLM, provided information on health risks associated with WFS exposure and tips to reduce that exposure. As far as we are aware, there was no requirements for prescribed burn announcements to include health risk information. While 32 announcements are many, it is possibly a small count for the 5-year timeframe parameter we used for this search process. It is likely we missed announcements considering that there are thousands of prescribed burns conducted each year across the United States. Further, we acknowledge that several jurisdictions use traditional methods that sometimes do not include digital archiving of prescribed burn communication, and therefore we did not include these in this review.

In the environmental scan, we also found state regulations for prescribed burns, some of which included guidance on communication (Table S3). The states that provided communication guidance ($n = 8$) mainly instructed prescribed burn managers and landowners to notify the public or adjacent landowners or neighbours of the planned burn, but do not specify the type of communication (e.g. letter, phone call, etc.). In addition to state regulations, many states provided smoke management guidelines that included information on public notification of prescribed burns (Table S4). These guidelines typically included general information about prescribed burns, permit requirements, air quality monitoring, and public education. While these guidelines discussed prescribed burn public education, none discussed education of health risks or safety precautions associated with prescribed burn smoke exposure. We did not find smoke management guidelines for Ohio or South Carolina.

Safety precautions, preparedness, and interventions

We found that 56% ($n = 38$) of all 68 communication materials from the environmental scan for wildfires and prescribed burns (e.g. brochures, graphics, fact sheets)

included information on safety precautions. We identified most of these materials from state departments, with a few from federal organisations and other non-governmental organisations. Only 13 of the 38 communication materials that provided guidance on safety precautions included prescribed burns. These materials provided general information about prescribed burns, the burning process, general smoke-related health risks, and general guidance for smoke exposure mitigation. The National Park Service website provides information about potential risks to park visitors and neighbouring communities and how to reduce smoke exposure (National Park Service 2022c). Individual national parks also occasionally provide site specific information on their webpages. Prince William Forest Park in Virginia provides the goals and objectives for each burn, the general planning process, and a smoke management FAQ that includes health risks, vulnerable groups, and safety precautions (National Park Service 2022b). FAQ documents like those developed by the Southern Fire Exchange provided similar information but also outlined smoke management practices for reducing smoke impacts to surrounding areas (e.g. busy roads, airports, schools, nursing homes) (Kays *et al.* 2021). Of the articles we included from the literature review, we found that regional guidance often used to mitigate and prevent wildfire smoke-related health risks included the use of N95 respirators, indoor air filtration systems, and stay-at-home orders (Johnston 2017; Rice *et al.* 2021). We found that 19% ($n = 25$) of the environmental scan materials recommend wearing an N95 mask, if an individual is outdoors, to reduce smoke exposure. We also found that 28% ($n = 36$) of the environmental scan materials recommended indoor air filtration systems to reduce inhalation exposure to air contaminants, such as HVAC systems and portable air purifiers which operate with high-efficiency particulate air (HEPA) filters that can reduce residential $PM_{2.5}$ and exposure to wildfire smoke (Hill *et al.* 2022).

Barriers and opportunities

The study team found four peer-reviewed articles from the literature review that discussed barriers and opportunities for developing and disseminating health risk communication for smoke exposure from prescribed burns and wildfires. Olsen *et al.* (2014) summarised these barriers as inconsistent messages from different agencies and uncertainty of the efficacy of communication strategies (e.g. understanding of the message or audience reception). Another barrier we identified from the literature review is that researchers and government officials feel that health risks from smoke exposure are unknown or not well understood by the intended audiences of their messages since these messages come from several agencies and can be inconsistent (Olsen *et al.* 2014). We also found that lack of trust in the information source, as well as messages lacking information about interventions and vulnerable populations

can be barriers to effective prescribed burn communication (Keegan and Rahman 2021; Van Deventer *et al.* 2021). The opportunities we found for improved communication efficacy include inter-agency collaborations and public interactions and consistent and unified messaging across agencies to prevent miscommunication or mitigate the impact of misinformation from less credible sources (Olsen *et al.* 2014; Remenick 2018). We did not find any environmental scan materials that included barriers or opportunities for effective communication.

Discussion

Communication can be an important part for prevention and mitigation of smoke-related health risks. Prescribed burn health risk communication tends to use proactive communication unless the burn escapes (Schwedler *et al.* 2013). In such rare instances, reactive messaging is used. While some communication materials are specific to wildfires, some of the information can be adapted for prescribed burns with the use of less urgent and more precautionary messaging. Because prescribed burns are planned events, officials have a timeframe in which proactive health risk communication can be developed and released to the public prior to the burn. The grey and peer-reviewed literature suggest fire and health risk communication should utilise multiple media platforms to reach a wider audience and that messages should be transparent. Effective messages tend to be tailored to a specific area, clear, specific, consistent, and contain information that includes a timeframe, location, and hazards (Heaney *et al.* 2021). Additionally, short, non-technical messages have better compliance both before and during a fire event (Sugerman *et al.* 2012; Keegan and Rahman 2021). Messages should also be attentive to vulnerable populations (Reid and Maestas 2019). A critical point that the Great Plains toolkit emphasised is ensuring the first public message establishes the value of utilising prescribed burns so that surrounding communities understand its purpose and the risks involved (Schwedler *et al.* 2013). Subsequent messaging can entail any risks involved with the burns, necessary precautions, and solutions that prescribed burns can provide to natural or economic problems (Schwedler *et al.* 2013).

Our results further suggest that communication flow can also affect message compliance. Remenick (2018) found that integration of both unidirectional and multidirectional communication is most effective in relaying information concerning health risks associated with smoke exposure (Fig. S1). Brenkert-Smith *et al.* (2013) suggest that a combination of vertical and horizontal communication is most effective regarding fire safety and health risk communication (Fig. 2). There are many challenges, though, that public and environmental health professionals face in communicating health risks to their communities, one being the lack of

Integrative communication

Integration of both unidirectional and multidirectional communication is most effective in relaying information concerning health risks associated with smoke exposure. Vertical communication allows for information to the public in a top-down manner while horizontal communication is more interpersonal and relies on social interactions. A combination of vertical and horizontal communication is most effective regarding fire safety and health risk communication.

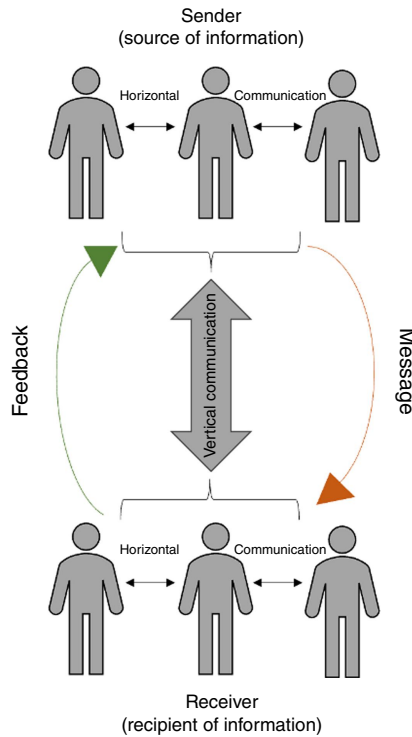


Fig. 2. Integration of unidirectional and multidirectional communication, and horizontal and vertical communication.

inter-agency communication and coordination (Olsen *et al.* 2014). Individuals developing and distributing communication materials should also be aware of these challenges when sharing information, such as changes or inconsistency in messaging when shared on several platforms and by multiple sources. For example, land management agencies are primarily concerned with planning and conducting the prescribed burns and may have limited resources to devote to health risk communication. This underscores the need for increased inter-agency collaborations with health agencies and social service agencies that can offer expertise in developing consistent, timely, and effective health risk communication and education, particularly to vulnerable individuals or harder to reach populations.

Our findings also suggest that communication channels, in addition to message content, is important for improved communication efficacy. Individual demographics can determine which communication sources people seek for information (Velez *et al.* 2017). Our results from the environmental scan and literature review suggest that a combination of traditional (radio, newspapers, TV, road signs, bulletins, etc.) and non-traditional (social media outlets, videos, blog posts, etc.) mechanisms should be used to communicate with the public about fires as well as health risks associated with smoke exposure from wildfires or prescribed burns. Local news media outlets can provide a high volume of timely information before and during smoke events (Chauhan and Hughes 2017). However, the recognition and use of existing social and communication networks is important for providing greater reach to remote

or rural areas (Olsen *et al.* 2014). Additionally, informational campaigns and community events are effective communication platforms because individuals can learn more about interpreting the air quality index and pick up resources on health information (Humphreys *et al.* 2022). Social media outlets are a good way to direct people to a central source (e.g. website or document) of information (Stone *et al.* 2019). For example, event-based resources, such as Facebook pages, can provide a high volume of relevant resources and information about prescribed burns prior to, during, and after the event (Chauhan and Hughes 2017). Because social media is a current major source of information, researchers also recommend using several social media outlets to reach as much of the community as possible (Stone *et al.* 2019). Local phone apps can provide push notifications for start and end times of prescribed burn events, notify communities that may experience smoke pollution, and inform users of harmful air quality levels (Humphreys *et al.* 2022). However, mobile phone applications may not reach all community members (e.g. the elderly, unhoused, etc.), highlighting the use of multiple types of communication methods (i.e. traditional and non-traditional) to communicate with the public.

Public health agencies are an important communication source and in recent years are becoming a key source of information for communities during times of public health crises, like prior to and during wildfires (Savoia *et al.* 2013). Because of this, many local and national public health professionals and environmental scientists, are collaborating to develop general guidelines to educate residents on smoke

exposure. Many of these collaborations resulted in the development of fact sheets, mainly for wildfires, such as the EPA's 'Smoke-Ready Toolbox for Wildfires', the CDC's 'Natural Disasters, and Severe Weather: Wildfires' website (Rice *et al.* 2021). These fact sheets, and many of the other environmental scan materials, pertain to wildfire smoke and not specifically to prescribed burn smoke. While there is a distinction between wildfire smoke and prescribed burn smoke, modifying portions of these fact sheets in relation to prescribed burn smoke exposure is possible. An example is the California Air Resources Board (CARB) infographic for wearing a correctly fitted N95 mask as protection against smoke because it fits over the nose and under the chin (California Air Resources Board n.d.). Medical masks are 20% effective while correctly fitted and worn N95 masks are 80% effective at decreasing exposure to smoke particles (WSPEHSU 2021). While masks can reduce smoke exposure, they should not be solely relied on for protection (U.S. EPA 2018b). HVAC systems are another common safety recommendation for wildfire smoke that can be adapted to prescribed burns. However, the caveat is that they typically only operate when there is need for heating or cooling because constant operations are costly (U.S. EPA 2018a). Therefore, these systems may not be the best option for indoor risk reduction. Portable air cleaners may be a better option because they can be selected based on room size and are effective at removing gases and particles (U.S. EPA 2018a). Although some wildfire communication resources can be adapted to prescribed burns, our review of these materials suggest that passive communication may have limited impact on individual behavioural change. Personal trusted sources, such as healthcare providers (e.g. doctors and nurses), tend to have a greater impact on individual behaviour change because they typically hold a high level of trust which is key for effective communication (Rice *et al.* 2021).

Economic and social barriers can affect whether the public follow fire preparation guidelines during a smoke episode highlighting the need for messaging that can be adapted for different groups (Mott *et al.* 2002). Public health and social service expertise, along with lessons learned from emergency management and preparedness, can assist with overcoming these barriers and positively affect behaviour change so that the public is more able to follow fire preparation guidelines. While many individuals may not take safety precautions during a smoke event, those with previous experience with fires or smoke episodes are more willing to prepare and follow guidelines during the next event (Spano *et al.* 2021). While Spano *et al.* (2021) did not discuss this directly, this propensity may also apply to individuals who are more susceptible to adverse health effects from exposure to smoke. Because the use of preparedness strategies and safety precautions vary among individuals, additional research is necessary to determine if the current prevention and intervention strategies are effective, determine if there are other strategies that may be more effective,

and determine whether tailoring messages to specific demographics based on their characteristics are effective.

Gaps, limitations, and research needs

Based on the literature review, we found several gaps and limitations in the current research on prescribed burn communication indicating the need for further research specifically to investigate the efficacy of current communication strategies for prescribed burns. The results of the literature review include very few health risk communication studies for prescribed burns compared to the studies for wildfires. Because of this gap in the literature, identifying effective approaches for communicating about prescribed burns will often depend on inference from research related to wildfire communication. To a certain extent the health hazards can be similar between wildfires and prescribed burns; however, the planning and scope of the two types of fires are different, specifically the burn time, smoke endurance and intensity, as well as the burn coverage. Literature materials on prescribed burns mostly report health risks and did not include any information on health risk communication.

The study team also found limited research on the importance of providing health risk communication, specifically for prescribed burns, to vulnerable populations exposed to wildfire smoke and its effectiveness. An exploratory spatial analysis of smoke dispersion and social vulnerability in the southern US suggests that higher socially vulnerable groups tend to be closer to the smoke plumes (Gaither *et al.* 2015). Another study investigating potential impacts of prescribed burn smoke on socially vulnerable populations in Georgia suggests that health impacts (e.g. asthma emergency room visits, respiratory hospital admissions, and mortality) from prescribed burn smoke were more concentrated in areas with higher populations of low socioeconomic status, elderly individuals, and disabled residents (Afrin and Garcia-Menendez 2021). These findings support the increased need to communicate with vulnerable populations during a smoke event and use of more consistent messaging across agencies (Keegan and Rahman 2021). Although these results are notable, there is still a need to further investigate smoke exposure, as well as effectiveness and outreach of health risk communication in vulnerable communities. Moreover, several of the articles and materials found in this review identified the need for more communications targeted toward vulnerable individuals but did not provide any existing examples of such materials. To close this gap in research, we suggest that best practices from other fields, such as health education or behaviour change science, be adapted, and applied to health risk communication about prescribed burn smoke for vulnerable individuals. These can include defining clear health goals and behavioural outcomes, addressing individual values and beliefs, addressing group norms and social influences, providing functional health knowledge, using audience-appropriate materials,

and using research-based and theory-driven methods (Centers for Disease Control and Prevention 2019). While a few toolkits already exist, they either are specific to a region, are specifically for wildfires, or are pre-emptive messaging for prescribed burn hazards that do not directly address smoke exposure. As part of the overarching research project, we plan to address these gaps and limitations outlined in this review, by developing a toolkit that is specifically aimed to facilitate improved communication planning and implementation for prescribed burns, applicable across different regions, directly addresses smoke exposure and health risk communication, and addresses the benefits of inter-agency collaboration, while providing guidelines and recommendations for effective prescribed burn health risk communication.

The challenges of health risk communication presented in this review also suggest a need for research on inter-agency coordination in communication efforts. Expanding inter-agency collaboration could increase the likelihood of prescribed burn and health risk communication messages reaching the intended audience. While synthesising the prescribed burn announcements, 81% ($n = 26$) provided no communication on health risks. Because of the planned nature of prescribed burns, there is an opportunity to provide effective communication. While many states have regulations for prescribed fire communication, most do not require the communication include health risk information. Rather, many states include this information as a recommendation in their smoke management guidelines. Federal agencies, state agencies, consultants, and private landowners conducted approximately 450,335 prescribed burns in the United States in 2018, with 445,953 of those burns conducted by state agencies and private landowners or consultants and the rest by federal agencies (National Interagency Fire Center n.d.a). In the environmental scan search, we found few guidelines for landowners who conduct or want to conduct prescribed burns. A few state regulations referenced landowners, but the Southern Fire Exchange was the only source we found to provide guidelines on communication from landowners. These guidelines suggested that private landowners respond better to interpersonal communication with peers and experts (e.g. prescribed burn associations and other informal social networks), as well as building trust with communities by helping and fostering a community where peers can be both learners and leaders (Kunkle *et al.* 2015). Perhaps one of the most important implications from the lack of guidance for landowners and consultants is that a large portion of communities exposed to prescribed burn smoke are not getting the communication they need about smoke-related health risks and safety precautions. The research team does acknowledge, however, that many of these professionals not only lack communication guidance, but also may not have the resources or skills to develop health risk messaging and materials. This gap supports our recommendation for

increased collaborations between land management agencies, public health and other social organisations, and private landowners or consultants to ensure timely and effective distribution of health risk communication.

Although there is need to address the described gaps and limitations, there are other research needs that were not directly highlighted in this review. The study team was not able to find communication research investigating prescribed burns and urban-rural gradients, economic status, regional differences, and various fire regimes. Additionally, we did not compare prescribed burn communication research to that from other countries as this review focused on the United States. It will be valuable to assess if similar themes of general lack of available information on health risk communication related to community smoke exposure from prescribed burns is apparent in other regions across the globe.

Conclusion

Prescribed burns are a critical land conservation practice that have clear ecological and cultural benefits. Despite widely used as an effective land management tool, it is important to understand how smoke from prescribed burns can increase the risk of adverse health outcomes among the public, especially in areas where prescribed burn smoke exposure exceeds that of wildfire smoke exposure. While communities near or downwind of the fire are at risk, individuals who are socially vulnerable, older adults, children, unhoused individuals, those with pre-existing conditions, and those with outdoor occupations are at higher risk of adverse health outcomes. Therefore, there is need for balance between communicating the benefits of prescribed burns and potential health risks and risk reduction behaviours. Government agencies and non-government entities developed some communication strategies and materials to inform the public about these health risks. However, materials may not be effective for every community or reach those at risk for exposure. While this review highlights several effective communication strategies, there is need for further research to better understand prevention and intervention approaches and the efficacy of communication strategies to minimise health risks of prescribed burns. This area of study would also benefit from additional research on regional differences in health risk communication since geographical differences (e.g. differences in fuel composition, topography, humidity levels, etc.) can affect smoke production and ultimately the communities exposed to smoke.

Supplementary material

Supplementary material is available [online](#).

References

- Adetona O, Reinhardt TE, Domitrovich J, Broyles G, Adetona AM, Kleinman MT, Ottmar RD, Naeher LP (2016) Review of the health effects of wildland fire smoke on wildland firefighters and the public. *Inhalation Toxicology* 28(3), 95–139. doi:10.3109/08958378.2016.1145771
- Afrin S, Garcia-Menendez F (2020) The influence of prescribed fire on fine particulate matter pollution in the southeastern United States. *Geophysical Research Letters* 47(15), e2020GL088988. doi:10.1029/2020GL088988
- Afrin S, Garcia-Menendez F (2021) Potential impacts of prescribed fire smoke on public health and socially vulnerable populations in a southeastern U.S. state. *Science of The Total Environment* 794(10), 148712. doi:10.1016/j.scitotenv.2021.148712
- Ager AA, Palaiologou P, Evers CR, Day MA, Ringo C, Short K (2019) Wildfire exposure to the wildland urban interface in the western US. *Applied Geography* 111, 102059. doi:10.1016/j.apgeog.2019.102059
- Brenkert-Smith H, Dickinson KL, Champ PA, Flores N (2013) Social amplification of wildfire risk: the role of social interactions and information sources. *Risk Analysis* 33(5), 800–817. doi:10.1111/j.1539-6924.2012.01917.x
- Bureau of Indian Affairs (2019) Native Fire. Available at <https://www.bia.gov/as-ia/opa/online-press-release/bureau-indian-affairs-releases-native-fire-educational-video-about> [verified 21 August 2024]
- CAL FIRE (2019) Prescribed Fires Campaign Toolkit. Available at <https://www.readyforwildfire.org/campaign-toolkits/prescribed-fires-toolkit/> [verified 19 July 2022]
- California Air Resources Board (n.d.) Protecting Yourself from Wildfire Smoke. Available at <https://ww2.arb.ca.gov/protecting-yourself-wildfire-smoke> [verified 3 May 2022]
- Centers for Disease Control and Prevention (2019) CDC Healthy Schools. Available at <https://www.cdc.gov/healthyschools/sher/characteristics/index.htm> [verified 12 April 2022]
- Chauhan A, Hughes AL (2017) Providing online crisis information: an analysis of official sources during the 2014 Carlton Complex wildfire. In 'Proceedings of the 2017 CHI conference on human factors in computing systems', Denver, CO, USA. doi:10.1145/3025453.3025627
- Clark AS, McGranahan DA, Geaumont BA, Wonkka CL, Ott JP, Kreuter UP (2022) Barriers to prescribed fire in the US great plains, part I: systematic review of socio-ecological research. *Land* 11(9), 1521. doi:10.3390/land11091521
- Cummins K, Noble J, Varner JM, Robertson KM, Hiers JK, Nowell HK, Simonson E (2023) The Southeastern U.S. prescribed fire permit database: hot spots and hot moments in prescribed fire across the Southeastern U.S.A. *Fire* 6(10), 372. doi:10.3390/fire6100372
- Finlay SE, Moffat A, Gazzard R, Baker D, Murray V (2012) Health impacts of wildfires. *PLoS Currents* 4, e4f959951cce2c. doi:10.1371/4f959951cce2c
- Fish JA, Peters M, Ramsey I, Sharplin G, Corsini N, Eckert M (2017) Effectiveness of public health messaging and communication channels during smoke events: a rapid systematic review. *Journal of Environmental Management* 193, 247–256. doi:10.1016/j.jenvman.2017.02.012
- Gaither C, Goodrick S, Murphy B, Poudyal N (2015) An exploratory spatial analysis of social vulnerability and smoke plume dispersion in the U.S. South. *Forests* 6(12), 1397–1421. doi:10.3390/f6051397
- Heaney E, Hunter L, Clulow A, Bowles D, Vardoulakis S (2021) Efficacy of communication techniques and health outcomes of bushfire smoke exposure: a scoping review. *International Journal of Environmental Research and Public Health* 18(20), 10889. doi:10.3390/ijerph182010889
- Hill LEL, Jaeger JM, Smith A (2022) Can Prescribed Fires Mitigate Health Harm? A Review of Health Quality and Public Health Implications of Wildfire and Prescribed Fire. Available at https://www.psehealthyenergy.org/wp-content/uploads/2022/07/PSE_Wildfire-and-Prescribed-Fire-Brief_FINAL_2022.pdf. [verified 3 June 2022]
- Humphreys A, Walker EG, Bratman GN, Errett NA (2022) What can we do when the smoke rolls in? An exploratory qualitative analysis of the impacts of rural wildfire smoke on mental health and wellbeing, and opportunities for adaptation. *BMC Public Health* 22(1), 41. doi:10.1186/s12889-021-12411-2
- Indiana Division of Fish and Wildlife (2005) Prescribed Burning. Available at <https://www.in.gov/dnr/fish-and-wildlife/files/HMFSPrescribedBurn.pdf> [verified 17 April 2022]
- Johnston FH (2017) Understanding and managing the health impacts of poor air quality from landscape fires. *Medical Journal of Australia* 207(6), 229–230. doi:10.5694/mja17.00072
- Kays L, Cammack S, Godwin D, Wharton M (2021) Prescribed Fire in Georgia: Frequent Asked Questions. Available at <https://eadn-wc02-7111601.nxedge.io/wp-content/uploads/2021-2.pdf> [verified 13 May 2022]
- Keegan SA, Rahman KM (2021) Health protection messaging for populations susceptible to air pollution during landscape fire smoke events: an integrative review. *Reviews on Environmental Health* 36(4), 599–609. doi:10.1515/revveh-2020-0134
- Kunkle K, Evans J, Godwin D, Dixon A (2015) Communication and Delivery of Prescribed Fire Messaging: Lessons from a Prescribed Fire Communications. Available at <https://eadn-wc02-7111601.nxedge.io/wp-content/uploads/2015-3.pdf> [verified 20 September 2022]
- Liu Y, Goodrick S, Achtemeier G, Jackson WA, Qu JJ, Wang W (2009) Smoke incursions into urban areas: simulation of a Georgia prescribed burn. *International Journal of Wildland Fire* 18(3), 336–348. doi:10.1071/WF08082
- Melvin MA (2021) 2021 National Prescribed Fire Use Survey Report. Available at https://www.stateforesters.org/wp-content/uploads/2023/01/2021-National-Rx-Fire-Use-Report_FINAL.pdf [verified 3 May 2022]
- Mott JA, Meyer P, Mannino D, Redd SC, Smith EM, Gotway-Crawford C, Chase E (2002) Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999. *Western Journal of Medicine* 176(3), 157–162. doi:10.1136/ejwim.176.3.157
- National Interagency Fire Center (n.d.a) Prescribed Fires and Acres by Agency. Available at <https://www.nifc.gov/fire-information/statistics/prescribed-fire> [verified 12 February 2023]
- National Interagency Fire Center (n.d.b) Total Wildland Fires and Acres (1926-2019). Available at <https://www.nifc.gov/fire-information/statistics/wildfires>
- National Park Service (2022a) Indigenous fire practices shape our land. Available at <https://www.nps.gov/subjects/fire/indigenous-fire-practices-shape-our-land.htm> [verified 3 April 2022]
- National Park Service (2022b) Prince William Forest Park Prescribed Fire Information. Available at <https://www.nps.gov/prwi/rxfire.htm> [verified 17 August 2022]
- National Park Service (2022c) Smoke Management and Air Quality. Available at <https://www.nps.gov/yose/learn/nature/smokemanagement.htm> [verified 14 June 2022]
- National Wildlife Coordinating Group (2020) Smoke and Roadway Safety Guide. Available at <https://www.nwgc.gov/sites/default/files/publications/pms477.pdf> [verified 12 October 2022]
- Navarro KM, Schweizer D, Balmes JR, Cisneros R (2018) A review of community smoke exposure from wildfire compared to prescribed fire in the United States. *Atmosphere* 9(5), 185. doi:10.3390/atmos9050185
- Odman MT, Huang R, Pophale AA, Sakhpara RD, Hu Y, Russell AG, Chang ME (2018) Forecasting the impacts of prescribed fires for dynamic air quality management. *Atmosphere* 9(6), 220. doi:10.3390/atmos9060220
- Olsen CS, Mazzotta DK, Toman E, Fischer AP (2014) Communicating about smoke from wildland fire: challenges and opportunities for managers. *Environmental Management* 54(3), 571–582. doi:10.1007/s00267-014-0312-0
- Oregon Prescribed Fire Council (n.d.) Smoke Management. Available at <https://www.oregonrxfire.org/smoke-management> [verified 12 August 2022]
- Radeloff VC, Helmers DP, Kramer HA, Mockrin MH, Alexandre PM, Bar-Massada A, Butsic V, Hawbaker TJ, Martinuzzi S, Syphard AD, Stewart SI (2018) Rapid growth of the US wildland-urban interface raises wildfire risk. *Proceedings of the National Academy of Sciences of the United States of America* 115(13), 3314–3319. doi:10.1073/pnas.1718850115
- Reid CE, Maestas MM (2019) Wildfire smoke exposure under climate change: impact on respiratory health of affected communities. *Current Opinion in Pulmonary Medicine* 25(2), 179–187. doi:10.1097/mcp.0000000000000552

- Remenick L (2018) The role of communication in preparation for wildland fire: a literature review. *Environmental Communication* 12(2), 164–176. doi:10.1080/17524032.2017.1346519
- Rice MB, Henderson SB, Lambert AA, Cromar KR, Hall JA, Cascio WE, Smith PG, Marsh BJ, Coefield S, Balmes JR, Kamal A, Gilmour MI, Carlsten C, Navarro KM, Collman GW, Rappold A, Miller MD, Stone SL, Costa DL (2021) Respiratory impacts of wildland fire smoke: future challenges and policy opportunities. *Annals of the American Thoracic Society* 18(6), 921–930. doi:10.1513/AnnalsATS.202102-148ST
- Ryan KC, Knapp EE, Varner JM (2013) Prescribed fire in North American forests and woodlands: history, current practice, and challenges. *Frontiers in Ecology and the Environment* 11(1), e15–e24. doi:10.1890/120329
- Savoia E, Lin L, Viswanath K (2013) Communications in public health emergency preparedness: a systematic review of the literature. *Biosecurity and Biodefense: Biodefense Strategy, Practice, and Science* 11(3), 170–184. doi:10.1089/bsp.2013.0038
- Schwedler J, Fulks W, Leis S (2013) Great Plains Fire Communication Kit. Available at <https://gpfirescience.org/wp-content/uploads/2022/05/GPECommKit20132-1.pdf> [verified 29 July 2022]
- Spano G, Elia M, Cappelluti O, Colangelo G, Giannico V, D'Este M, Laforteza R, Sanesi G (2021) Is experience the best teacher? Knowledge, perceptions, and awareness of wildfire risk. *International Journal of Environmental Research and Public Health* 18(16), 8385. doi:10.3390/ijerph18168385
- Stone S L, Anderko L, Berger M, Butler C, Cascio WE, Clune A, Damon S, Garbe P, Hauptman M, Haskell WE, Hoshiko S, Lahm P, Materna B, Mirabelli MC, Larkin N, O'Neill S, Peterson J, Riveles K, Sacks J, Wayland M, Williams JR (2019) 'Wildfire smoke: A guide for public health officials.' (U.S. EPA Office of Research and Development: Washington, DC)
- Sugerman DE, Keir JM, Dee DL, Lipman H, Waterman SH, Ginsberg M, Fishbein DB (2012) Emergency health risk communication during the 2007 San Diego wildfires: comprehension, compliance, and recall. *Journal of Health Communication* 17(6), 698–712. doi:10.1080/10810730.2011.635777
- U.S. EPA (2018a) Guide to Air Cleaners in the Home. Available at https://www.epa.gov/sites/default/files/2018-07/documents/guide_to_air_cleaners_in_the_home_2nd_edition.pdf [verified 19 August 2022]
- U.S. EPA (2018b) Protecting Children from Wildfire Smoke and Ash. Available at <https://www.epa.gov/sites/default/files/2018-11/documents/protecting-children-from-wildfire-smoke-and-ash.pdf> [verified 29 July 2022]
- USDA Forest Service (n.d.) Prescribed Fire. Available at <https://www.fs.usda.gov/managing-land/prescribed-fire> [verified 3 May 2022]
- USDA Forest Service (2022) Smoke and Air Quality. Available at <https://www.fs.usda.gov/research/fire/smoke> [verified 10 July 2022]
- Van Deventer D, Marecaux J, Doubleday A, Errett N, Isaksen TMB (2021) Wildfire smoke risk communication efficacy: a content analysis of Washington state's 2018 statewide smoke event public health messaging. *Journal of Public Health Management and Practice* 27(6), 607–614. doi:10.1097/phh.0000000000001151
- Varner JM, Hiers JK, Wheeler SB, McGuire J, Quinn-Davidson L, Palmer WE, Fowler L (2021) Increasing pace and scale of prescribed fire via catastrophe funds for liability relief. *Fire* 4(4), 77. doi:10.3390/fire4040077
- Velez ALK, Diaz JM, Wall TU (2017) Public information seeking, place-based risk messaging and wildfire preparedness in southern California. *International Journal of Wildland Fire* 26(6), 469–477. doi:10.1071/WF16219
- WSPEHSU (2021) Some masks protect you and your family from wildfire smoke more than others [Poster]. Available at https://wspehsu.ucsf.edu/wp-content/uploads/2021/07/wildfireinfogr_pg8_poster_0717.pdf

Data availability. Data sharing is not applicable as no new data were generated or analysed during this study.

Disclaimer. This publication 'Limited availability of health risk communication related to community smoke exposure from prescribed burns in the United States: A review' was developed under the Assistance Agreement No. RD84024101 awarded by the U.S. Environmental Protection Agency to The Ohio State University. No formal review came from EPA. The views expressed in this document are solely those of M. J., A. C., C. I., O. A., A. A., T. M., L. P. N. and do not necessarily reflect those of the Agency. EPA does not endorse any products or commercial services mentioned in this publication.

Conflicts of interest. The authors declare no conflicts of interest.

Declaration of funding. This study is funded by the U.S. Environmental Protection Agency under Assistance Agreement No. RD84024101.

Acknowledgements. The authors thank Dr. Roger Williams, Jack McGowan-Stinski, Dr. Scott Goodrick, and Dr. Sarah McCaffrey, the study's expert panel, for providing their expert knowledge and feedback on the review process and manuscript. We also thank Colin Wright, Erick Emmanuel Mollinedo, and Jack Morgan Podlesny for contributing to the environmental scan search process.

Author affiliations

^ADepartment of Environmental Health Sciences, College of Public Health, The Ohio State University, 1841 Neil Avenue, 436 Cunz Hall, Columbus, OH 43210, USA.

^BBattelle Memorial Institute, Columbus, OH 43201, USA.

^CDepartment of Environmental Health Science, College of Public Health, University of Georgia, Athens, GA 30602, USA.