WILDLAND FIRE SMOKE RISK COMMUNICATION RESEARCH:

AN OVERVIEW OF RECENT REVIEW ARTICLES

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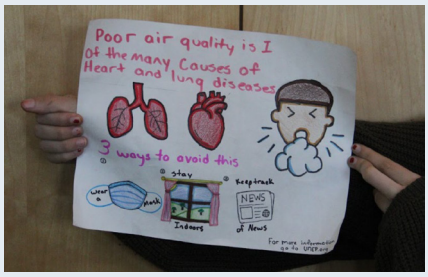
In recent years, smoke from wildland fire has increased in duration and frequency and is a recognized public health risk.[1,2] This has driven a corresponding need for more information on these topics and an increase in systematic reviews seeking to better understand the state of science and identify ongoing knowledge gaps.



The goal of this document is to summarize recent review articles that synthesize the state of wildland fire smoke communication research. We provide a summary of primary themes and then list key findings by article. Please note that each review article encompasses multiple studies, and here we focus on the themes shared across the articles. The review articles and the studies they cover offer abundant additional information, nuance, and detail for those seeking a deeper understanding of the available research.

SUMMARY

The six review articles provide insight into key aspects of the state of wildland fire smoke communication research, including:

1. **Providing clear, consistent, and actionable information.** Much existing research highlights the importance for communicators to craft messages that are clear, specific, accurate, consistent, and tailored to local contexts when possible. Recommendations include using simple, actionable advice and including specific guidance, timeframe, location, hazard, and information sources in messaging. In addition, some research highlights the importance of including both risk and efficacy information, and notes that promoting protective health behaviors is essential. Importantly, several different measures for what constitutes "effective" communication are used across the reviewed literature.
2. **Using diverse communication channels to increase reach.** Across the six review articles, studies advocate using multiple channels, including traditional and social media, along with nonelectronic channels such as in-person communication to communicate about wildland fire smoke risks. Authors note the strengths of different types of channels, and that channel preference may differ based on sociodemographic or community characteristics.
3. **Prioritizing coordination for credible and consistent communication.** Reviews highlight the key roles that trusted messengers and interagency coordination play in delivering consistent messages across diverse channels. Specifically, many articles highlight the need for agencies and organizations to proactively coordinate and plan communication strategies to ensure message consistency across sources and timeframes.
4. **Communicating effectively with at-risk populations[3].** Published research consistently notes the need to communicate with at-risk populations using approaches and messages that are targeted, relevant, and appropriate for different groups. Some reviews highlight the importance of sharing smoke or air quality information in advance of wildfire season or year-round to promote awareness, especially with at-risk populations.
5. **Addressing gaps in research and practice.** Across the review articles and the individual studies included, there is a consistent call for more research on communication effectiveness across channels, geographic areas, populations, and contexts. Specifically, authors highlight a need for more evaluations of communication efforts including both practice-based and rigorous research (both qualitative and quantitative) to determine the most effective communication strategies. One review highlights the lack of research on prescribed fire communication in particular.

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KEY FINDINGS

Study	Review process[4] (years included)	Purpose of Review	Key Findings	Research Gaps / Needs Identified
Fish et al. (2017) *Effectiveness of public health messaging and communication channels during smoke events: A rapid systematic review*	In review: n=10. Identified for screening: n=1775 (2009-2016)	Assess efficacy of public health messaging and communication outlets used for smoke events, for the public, especially at-risk[5] community members.	Public health messages about smoke exposure are delivered through multiple communication channels, but evidence is limited on what is considered the most effective channel for the public and for at-risk groups. Messages using simple language had higher recall, compliance and understanding based on four observational studies from 2002-2012. At-risk groups may be advised to take protective action before the general population.	More contemporary, experimental, and evaluative studies to assess the efficacy of communication channels and messaging used during smoke events.
Heaney et al. (2021) *Efficacy of communication techniques and health outcomes of bushfire smoke exposure: A scoping review*	In review: n=69. (Communication strategies in natural disaster: n=40. Health outcomes of wildfire smoke exposure: n=29). Identified for screening: n=852 (2000-2020)	Evaluate existing evidence regarding optimal communication strategies used in smoke-related disaster scenarios.	Utilized sources of information during disasters included traditional and non-traditional media sources, in addition to in- person communication. Age, rurality, and location may influence source preference. Preferred channels may be different at different points in a disaster (e.g., social media allows for real-time communication between the public and the authority providing the information, while newspapers become more relevant post-disaster for their ability to provide in-depth analytic coverage). Studies suggest that effective communication includes providing guidance, a timeframe, a location, a hazard, and information source, along with information that is clear, specific, accurate, certain, and consistent, and when possible, tailored to local contexts. Successful messaging also commonly had information for at-risk populations[6].	Quantitative comparison of communication methods in an effort to yield more specific messaging recommendations.
Keegan and Rahman (2021) *Health protection messaging for populations susceptible to air pollution during landscape fire smoke events: An integrative review*	In review: n=26. Identified for screening: n=245 (2010-2020)	Evaluate and summarize research on health protection messaging related to landscape fire, with a focus on susceptible populations[7].	Messages that were short and non-technical during smoke events were more likely to be recalled and followed. In emergency and non-emergency conditions, findings supported a need for more consistent and detailed information on air quality indices, health risks, and health protection strategies. Communication happens through a variety of channels. Lack of consistency in information is an issue, and several studies recommend creating greater consistency in messaging and delivery through interagency collaborations. Trust and timing are important elements to consider. Building trust is an essential aspect of risk communication and can be eroded by inconsistency, poor timing of messages, and perceived negligence. Studies found that messages for susceptible populations should be provided in advance of fire season.	How people interpret and respond to specific elements of messaging content and how to best deliver technical information. Preferences for communication channels under emergency and non-emergency conditions, particularly with susceptible populations. How to adapt health protective messaging for longer duration smoke events. Health impacts of landscape fire smoke, which will in turn inform consistent and effective health messaging.

Study	Review process[4] (years included)	Purpose of Review	Key Findings	Research Gaps / Needs Identified
Vien et al. (2024) *A scoping review of wildfire smoke risk communications: Issues, gaps, and recommendations*	In review: n=21. Identified for screening: n=384 (no limit on date range)	Identify relevant peer-reviewed literature and communication resources; summarize characteristics of effective communication strategies, dissemination strategies, and recommendations to improve research and practice.	Studies support using evidence-based messages in a variety of formats that includes clear and actionable information for reducing exposure and details about short- and long-term health effects. Studies suggest a need for explanations for technical information (e.g., N-95 or HEPA filters). Trusted intermediaries play an important role in communication. Specific to vulnerable populations[8], community-engaged design can be helpful to ensure communication is relevant.	Wildfire smoke risk communication generally, particularly studies that include qualitative depth and context and quantitative rigor, including evaluation of communication effectiveness across diverse populations.
Joe et al. (2024) *Limited availability of health risk communication related to community smoke exposure from prescribed burns in the United States: A review*	In review: n=155 (Peer-reviewed articles: n=27; grey literature documents: n=128). Identified for screening: n=187 (2005-2023)[9,10]	Assess the availability of health-related information for smoke from prescribed burning and wildfires, and to better define challenges for creating communication materials.	Little research exists on prescribed fire smoke communication specifically. However, some wildfire smoke health messages can be adapted for prescribed burns (e.g., how to properly wear a mask or use HVAC systems). A small percentage of prescribed fire communication materials included in the study contained health risk information. There is an opportunity for increased collaboration among agencies, organizations, and landowners to increase communication efforts. Studies supported tailoring messages to local contexts, making messages clear and consistent across agencies, using multiple outlets for communication that include traditional and non-traditional media sources, and engaging in community outreach via information campaigns and community events.	The effectiveness of prescribed burn communication strategies in general, as well as with vulnerable populations[11]. Evaluation of interagency coordination for communication of prescribed burning. Communication differences between urban-rural communities, by economic status, by region, or by fire regime.
Sandoval, Bui, and Hopfer (2025) *Wildfire and smoke risk communication: A systematic literature review from a health equity focus*	In review: n=23. Identified for screening: n=102 (2014-2024)	Identify gaps in wildfire and wildfire smoke communication research, identify qualities of effective communication for acute evacuation vs repeat smoke exposure, and identify communication strategies for marginalized communities[12].	Community characteristics can impact channel preferences, but most studies recommend using diverse communication channels to ensure greater reach. Trusted sources are important and may vary among groups. During an evacuation event, studies found it is important to not conflate evacuation and smoke information to reduce confusion. Some studies recommend including risk and efficacy information in communications. There is a need for greater collaboration across agencies and organizations to better reach and effectively communicate with marginalized groups.	Efficacy of messaging strategies on health-protective behavior changes and adequate identification of audience reach. Communication research in specific geographic regions and with marginalized communities to determine trusted and most used communication sources.

ARTICLE DETAILS

1 EFFECTIVENESS OF PUBLIC HEALTH MESSAGING AND COMMUNICATION CHANNELS DURING SMOKE EVENTS: A RAPID SYSTEMATIC REVIEW

Fish, J. A., Peters, M. D. J., Ramsey, I., Sharplin, G., Corsini, N., & Eckert, M. (2017). *Journal of Environmental Management*, *193*, 247-256. http://dx.doi.org/10.1016/j.jenvman.2017.02.012

Approach: *Rapid systematic review*
Timeframe: *2009–2016*
Focus: *Effectiveness of public health messaging during smoke events*
Geography: *US and Australia*

Results:

- **Public health messages about smoke exposure are delivered through multiple communication channels, but evidence is limited on what is considered the most effective strategy for the general public and for at-risk groups.** Based on this, the authors highlighted the importance of using a variety of communication channels during smoke events to optimize reach. While discussing media and non-media channels, the authors also note the emergence of mobile phone apps as a new source of information that can be used to enhance current efforts.
- **Although evidence was limited, the authors identified two studies that highlighted specific communication channels used to reach or were preferred by parents of children and people over 65** (Burns et al., 2010; Kolbe and Gilchrist, 2009). One study focusing on parents of children described communication via the usual channels and also through fact sheets distributed to child-care facilities and schools. A study focusing on people over 65 reported that smoke information was released through the news media and facts sheets that were distributed to aged-care facilities. Additionally, people over 75 were the least likely to be aware of public health messages. No studies in their review provided evidence for other social groups.
- **Observational studies from four studies published between 2002-2012 found that messages that used simple language—such as "stay indoors"—were the most commonly recalled, understood, and followed.** However, compliance varied across socio-demographic groups. Sugerman et al. (2012) found higher compliance among women, adults aged 18–64, English speakers, individuals with higher education, full-time employment, higher incomes, and those with certain medical conditions (e.g., asthma, COPD, depression). **However, it is important to note the authors commented on the limitation of these studies, which were cross-sectional and reliant on participant recall. Given this, the authors state, "it is difficult to determine if compliance with staying indoors was due to public health messages or if people would have stayed indoors regardless of advisories"** (p. 254).
- **There was no research investigating how the duration of a smoke event or the length of time people are advised to be indoors might influence message effectiveness.**
- **Studies use various definition for what constitutes "effective" communication,** which can make comparison difficult when trying to assess the 'best' methods for communication (e.g., effective communication could be defined by measures like awareness, recall, understanding, compliance, etc.) It is helpful to keep this detail in mind when trying to assess whether messages and channels have been effective and when interpreting results from studies.

Need more research to address:

i. **The overall effectiveness of messaging and channels, specifically using evaluations and experimental methods, because most research to date has been observational and descriptive.**
ii. **Effective use of modern platforms** (e.g., mobile apps, text alerts, social media, the internet).
iii. **Best communication strategies for reaching at-risk groups.**
iv. **An evaluation of key messages (e.g., "stay indoors") and the factors moderating their effectiveness or impact on health outcomes**. Particularly given that in this review, limited evidence was found regarding the effectiveness of the 'stay indoors' message to protect communities from negative health outcomes.

Management implications:

- *Use multiple channels to communicate in an effort to optimize reach to various groups.*
- *Leverage social media channels and apps to enhance—not replace—current communication efforts.*
- *Consider specific channels for reaching at-risk groups and learn more about communication preferences of at-risk communities in your local context.*

ARTICLE DETAILS

2 EFFICACY OF COMMUNICATION TECHNIQUES AND HEALTH OUTCOMES OF BUSHFIRE SMOKE EXPOSURE: A SCOPING REVIEW

Heaney, E., Hunter, L., Clulow, A., Bowles, D., & Vardoulakis, S. (2021). *International Journal of Environmental Research and Public Health, 18*(20), 10889. https://doi.org/10.3390/ijerph182010889

Approach: *Scoping review*
Timeframe: *2000–2020*
Focus: *Outcomes of smoke exposure (i.e., physical and mental health, psychosocial impacts), efficacy of communication techniques for reducing adverse health impacts, and health messaging recommendations in natural disasters*
Geography: *Australia, North America, global, SE Asia, UK, Portugal, Sri Lanka, Belgium, and China*

Results:

- **Communities access disaster information through traditional media (e.g., television, local radio, phone calls, newspapers), non-traditional media (e.g., social media), and in-person or interpersonal communication (e.g., word-of-mouth, community meetings)**. Preferences for information during a disaster can be influenced by factors such as age and location. For example, the authors cite three studies when noting rural households are more likely to get their disaster information from television and rely less on radio and newspapers.
- **Different media can play different roles at different stages of a disaster event**. For example, authors note that prior to a disaster, social media is not a site often used for discussing information. However, during disasters, social media is a primary channel for real-time information sharing, and after a disaster, some social media sites (e.g., Facebook and Twitter) can serve as the primary platform for organizing recovery and clean-up operations. Another study showed that newspapers tend to become more relevant and popular as disasters progress as they allow for more in-depth coverage.
- **Recommendations from several studies suggest the importance of providing information before a disaster occurs** in an effort to promote disaster literacy.
- **Effective communication includes providing guidance, a timeframe, a location, a hazard, and information source**. Messages need to have "clear, specific, accurate, certain, and consistent language" (p. 5), and if possible, tailored to the local context. Communication should be available in a variety of languages and format. In addition, communication should be timely, credible, and consistent across time and sources.
- **There are currently limited communication resources available for at-risk populations**. The authors note that these populations possibly require specific communication considerations (e.g., audio-visual, language proficiency) or additional supports (e.g., transportation, mobility assistance).

Need more research to address:

i. **Management of smoke exposure for at-risk groups,** including how to best prepare or notify them when events occur.
ii. **Quantitative comparison of communication methods** in an effort to yield more specific messaging recommendations.

Management implications:

- *Use multiple channels (including in-person) to communicate in an effort to optimize reach to various groups and consider how communication preferences might change during the disaster lifecycle.*
- *Try to ensure consistent, specific, accurate, and clear messaging across channels, sources and timeframes.*
- *Include guidance, a timeframe, location, hazard information, and information source in messaging.*

ARTICLE DETAILS

3 HEALTH PROTECTION MESSAGING FOR POPULATIONS SUSCEPTIBLE TO AIR POLLUTION DURING LANDSCAPE FIRE SMOKE EVENTS: AN INTEGRATIVE REVIEW

Keegan, S. A., & Rahman, K. M. (2021). *Reviews on Environmental Health, 36*(4), 599-609. https://doi.org/10.1515/reveh-2020-0134

Approach: *Integrative review*
Timeframe: *2010–2020*
Focus: *Health protective messaging for smoke from landscape fire related air pollution, while focusing on susceptible populations*
Geography: *Australia and North America, with one study being labeled as multi-national*

Results:

- **Similar to other reviews, the authors found that during acute phases of smoke, shorter messages with non-technical were more likely to be recalled and followed.** They also noted that "congruence of health risk message content with environmental cues (visual assessment of smoke) augmented compliance" (p. 602). Two qualitative studies from fire-prone communities reported participants wanted more detailed information on smoke emissions and its health impacts.
- **Similar to the other reviews included in this research brief, authors found multiple communication channels can all be useful.** In rural areas, some studies emphasized a preference for direct, personal communication methods given the issue of reception reliability in these areas.
- **Inconsistency in messaging is a key issue**. Specifically, it called for more consistency in both message content and distribution across public health, emergency services, care service providers, media, and others involved in smoke communication.
- **Trust is an essential aspect in emergency risk communication**. The authors note that "issues related to perceived or real negligence, inconsistent message content, poor timing and exaggerations in messaging were all found to erode community trust in health protective messaging during smoke events" (p. 605). They also note that despite issues identified, two studies (in Australia and Canada) suggest that there is a high degree of trust in information from government health authorities.
- **There is a need to share health protective information in advance of fire seasons, particularly for susceptible populations**. Additionally, some research recommended providing more frequent updates on air quality during the day to help people decide when it's safer to do outdoor activities. Authors also noted literature that called for a need to address compounding issues, which generally referenced conflicting health risks developing as a result of staying indoors, particularly for long periods of time.

Need more research to address:

i. **How people interpret and respond to specific elements of messaging content and how to deliver technical information** (e.g., how to use an air conditioner during a smoke event).
ii. **Preferences for and actual use of communication channels with different populations under emergency and non-emergency conditions**, particularly with susceptible populations. Specifically, how susceptible populations are engaging with smartphone apps, information provided through health and service providers, and radio.
iii. **How to adapt health protection content and delivery for longer duration events.**
iv. **Health impacts of landscape fire smoke, which will in turn inform health communication efforts.**

Management implications:

- *Coordinate and collaborate with other agencies for advanced to establish lines of communication, message templates, and information sources to ensure greater consistency and streamline coordination during smoke events.*
- *Aim to build community trust, as it is an essential element in emergency risk communication.*
- *Consider strategies in advance for messaging when compounding issues might arise.*
- *Share information in advance of wildfire season, particularly with susceptible populations.*

ARTICLE DETAILS

4 A SCOPING REVIEW OF WILDFIRE SMOKE RISK COMMUNICATIONS: ISSUES, GAPS, AND RECOMMENDATIONS

Vien, M. H., Ivey, S. L., Boyden, H., Holm, S. & Neuhauser, L. (2024). *BMC Public Health*, *24*(312). https://doi.org/10.1186/s12889-024-17681-09

Approach: *Scoping review*
Timeframe: *No limitations on publication date range*
Focus: *Wildfire smoke risk communication and public-facing communications and programs*
Geography: *Australia, North America, and Italy. Two more articles included multiple countries*

Results:

- **Wildfire smoke risk communication research remains limited**, though it has grown in the past decade as smoke exposure became a public health priority. Gaps exist across all communication areas, and there is a need for both qualitative depth and context in studies as well as quantitative rigor.
- **Other key results mirror findings outlined in the above reviews. Specifically, authors included recommendations across four thematic areas** (p. 32):
  - **Communication materials and messages**: Use evidence-based messaging and multi-media messaging (including maps, videos, PSAs, etc.) to provide clear, specific, and actionable recommendations for reducing exposure. In addition, provide short- and long-term health impacts. This review was the first to explicitly mention the use of videos or mapping studies. Authors highlighted two studies that showed maps can be an effective tool for sharing information and increasing knowledge, when designed appropriately using visuals and textual information (p. 28).
  - **Delivery strategies**: Use multiple local communication channels to share information simultaneously.
  - **Behavior change**: Provide information through trusted sources to increase knowledge and encourage behavior change. Ensure consistent messaging across agencies and build on existing communications from public officials to enhance trust and promote timely action.
  - **Vulnerable populations**: Prioritize targeted communications for at-risk groups and use community-engaged design to ensure messages are appropriate and relevant to the specific group.

Need more research to address:

i. **Evaluation of risk communication to assess effectiveness** of various messages and delivery channels.
ii. **Studying communications targeted to diverse US populations.**
iii. **Co-development of communications with vulnerable community members using health literacy principles.**

Management implications:

- *Communicate using multiple channels to deliver information simultaneously.*
- *Communicate through trusted intermediaries and ensure, again, that communication is consistent.*
- *Use community-engaged design with vulnerable populations to ensure materials are relevant and appropriate.*

ARTICLE DETAILS

5 LIMITED AVAILABILITY OF HEALTH RISK COMMUNICATION RELATED TO COMMUNITY SMOKE EXPOSURE FROM PRESCRIBED BURNS IN THE UNITED STATES: A REVIEW

Joe, M., Cocci, A., Ihekweazu, C., Adetona, O., Adetona, A., Maslak, T., & Naeher, L. P. (2024). *International Journal of Wildland Fire*, *33*(9), WF23158. https://doi.org/10.1071/wf23158

Approach: *Review of peer-reviewed literature and environmental scan of grey literature*
Timeframe: *2005–2023 (however, excluded prescribed burn announcements published before 2018)*
Focus: *Health risk communication for smoke from wildland fires, with a focus on prescribed burns, as well as environmental scan of public-facing health risk communication materials about wildland fire and prescribed burn smoke*
Geography: *US (national + specific states with large acreage burned from wildfire or prescribed burns)*

Results:

- **Health risk communications research on smoke from prescribed fire is limited**. This suggests that many communication recommendations rely on wildfire smoke risk research. Sixty-three percent of the peer-reviewed literature included in the study centered on wildfire smoke health communication. The studies that were included for prescribed fire did not include information on health risk communication. Because prescribed fire is a planned event with more known details ahead of time, it offers an opportunity to adapt some wildfire communication materials but approach communication differently than wildfire. The authors highlighted differences between the two, including planning and scope, burn time, smoke endurance and intensity, and burn coverage. The authors highlighted that some wildfire smoke messaging could be adapted for prescribed fires, including those about certain protective actions (e.g., wearing a mask or using an HVAC system).

- **Of the documents identified through the environmental scan focusing on prescribed fire, only a small number discussed smoke health risks or safety precautions to reduce smoke exposure** (17% and 13%, respectively; n=78). Seventeen percent of environmental scan documents discussed tips or guidelines for effective communication of wildland fires. The authors did identify three toolkits with templates and example materials (Oregon Prescribed Fire Council, n.d., Schwedler et al. 2013; CAL FIRE 2019), and one set of best practices for prescribed fire communication (Kunkle et al. 2015). The authors found that while many states have regulations about prescribed fire communication, most do not require the inclusion of health risk information. In addition, authors found that the Southern Fire Exchange (Kunkle et al. 2015) was the only resource to provide guidance to landowners who wanted to communicate about prescribed burns. As a result, the authors call for increased collaboration among agencies, organizations, and landowners to increase communication efforts.

- **Similar to the other reviews included in this research brief, the authors noted that effective communication approaches include**: tailoring messages to local context, making messages clear and consistent across agencies, using multiple outlets for communication that include traditional and non-traditional media sources, and engaging in community outreach via information campaigns and community events. Likewise, the authors noted the need for communications addressing vulnerable populations but noted a lack of real-world examples (p.8).

Need more research to address:

i. **Effectiveness of prescribed burn communication strategies**. While prescribed and wildfire smoke share some health risks, they differ in planning, burn time, and smoke intensity. The majority of existing toolkits are region-specific or wildfire-focused and don't directly address prescribed burn smoke exposure.

ii. **Inter-agency coordination in communication**. Most prescribed burn announcements omit health risk information. Although many states regulate burn notifications, few require health risk communication. The authors posit more coordination among groups and individuals may be helpful in increasing communication.

iii. **Communication differences between urban-rural communities, by economic status, by region, or by fire regime**. The review focused on the U.S., but similar information gaps may exist globally.

Management implications:

- *There is limited research on prescribed fire smoke communication. Consider what is appropriate messaging to adapt for prescribed fires from wildfire smoke health risk communication, including communication around protective actions.*
- *Consider coordinating with other agencies to share health risk information when prescribed burns are going to take place.*

ARTICLE DETAILS

6 WILDFIRE AND SMOKE RISK COMMUNICATION: A SYSTEMATIC LITERATURE REVIEW FROM A HEALTH EQUITY FOCUS

Sandoval, S., Bui, J., & Hopfer, S. (2025). *International Journal of Environmental Research and Public Health*, *22*(3), 368. https://doi.org/10.3390/ijerph22030368

Approach: *Systematic review*
Timeframe: *2014–2024*
Focus: *Identify research gaps in wildfire smoke risk communication research for and highlight effective communication strategies in different scenarios (evacuation vs. repeated smoke exposure), with an emphasis on marginalized groups.*
Geography: *Australia and North America*

Results:

- To bolster preparedness among marginalized communities, the authors found studies recommending **increasing outreach and communication between local government and "isolated (often unincorporated) and marginalized communities," and providing materials in people's languages** (p. 17).
- Studies demonstrated the importance of **communicating through trusted messengers, who are in many cases local leaders.**
- **Distinguishing evacuation from smoke communication can reduce confusion, particularly given their distinct goals**. Authors note that evacuation is time-sensitive with goals of providing life-saving information, while smoke communication can happen with longer or year-round messaging campaigns as a repeatable and essential strategy for sharing information on protective health behaviors. The authors also point to a need for more post-fire messaging on issues such as safe clean-up practices and mental health.
- **Multiple studies recommended risk messages include information about health impacts and actionable steps to protect health.** Studies in the review offered different strategies for communicating health risk, including using narrative framing; combining numeric information, verbal cues, and AQI risk labels; and including information about risk severity, likelihood of experiencing harm, effectiveness of mitigation measures, and self-efficacy (based in Protection Motivation Theory).
- **Interagency coordination is essential for messaging consistency, trust building, and for communicating wildfire risk effectively**. The research called for coordinated efforts and outreach partnerships between local government agencies (e.g., air quality districts, fire departments, county sheriff) and across local networks (e.g., schools, senior centers) and news media.
- **As in other reviews, the authors stressed the importance of using a variety of channels to share information, while also tailoring those channels to local knowledge and context**. Channel preferences depended on the population, location, and type of message being shared. Context and community factors should determine what channels to use when communicating with communities. The authors also note the importance of nonelectronic communication (e.g., sirens, radio, etc.), particularly during power outages.

Need more research to address:

i. **Efficacy of messaging strategies on health-protective behavior changes and adequate identification of audience reach**. Research needs to identify who receives which messages to determine whether these messages lead to behavior change. Studies need to evaluate how well messages convey threat and efficacy information, and assess their effectiveness, reach, and sufficiency. Lastly, more practice-based research is needed to improve government and media messaging.

ii. **Communication research in specific geographic regions and with marginalized communities to determine trust and used communication sources**, given that trusted sources are likely to differ based on community characteristics.

Management implications:

- *Engage in proactive communication during longer duration smoke events to promote understanding of smoke risks and health protection behaviors.*
- *Do not conflate evacuation information (time sensitive and emergency information) and smoke communication, given their different goals.*
- *Include both risk information and efficacy information in smoke communication efforts.*

ENDNOTES

[1] U.S. EPA (2024). Wildland Fire, Air Quality, and Public Health Considerations. [Fact Sheet]. https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-wildland-fire-air-quality-fact-sheet-final.pdf.

[2] Gould, C. F., Heft-Neal, S., Prunicki, M., Aguilera, J., Burke, M., & Nadeau, K. (2024). Health effects of wildfire smoke exposure. *Annual Review of Medicine, 75*(1), 277-292. https://doi.org/10.1146/annurev-med-052422-020909.

[3] We use this term in the summary section to encompass all the terms provided by the authors of each review, which are detailed in the footnotes. The term at-risk is inclusive of people with chronic diseases, people at specific life stages (e.g., children, the elderly, pregnant individuals), and people with higher exposure (U.S. EPA, 2024, https://document.airnow.gov/at-risk-groups-of-people-fact-sheet.pdf).

[4] For all scoping reviews, we defined this based on the number of articles the authors reported they identified after removing duplicates but before screening with inclusion criteria.

[5] "Based on previous literature that has identified groups who are particularly vulnerable to adverse effects from smoke or less likely to benefit from public advisories (Macnamara, 2014), at-risk groups for this review included people aged over 65 years, children, people with cardiovascular and respiratory conditions, culturally and linguistically diverse communities, and Indigenous/Aboriginal and/or Torres Strait Islander people. For the purposes of this review, effectiveness was defined as compliance with advisories that aim to reduce smoke exposure. Due to the challenge of retrospectively investigating compliance, proxy indicators of effectiveness such as recall or awareness of advisories, trust in communication channels, and source preferences were also examined." (p. 248 , original references left in).

[6] This finding refers to populations "such as elderly, pediatric, culturally, and linguistically diverse and those with pre-existing conditions such as asthma, chronic obstructive pulmonary disease (COPD), and cardiac conditions" (p. 5). In the abstract of their article, authors define at-risk populations as "those with underlying cardiorespiratory disease, elderly, pediatric, pregnant persons, and First Nations people" (p. 1).

[7] "Populations susceptible to the health impacts of smoke events include those who are more biologically sensitive and vulnerable populations who face socioeconomic adversity [5]. Biologically sensitive populations include those with chronic respiratory, cardiac or other inflammatory diseases, elderly, pregnant women and their fetuses and young children [6–10]. Biological sensitivity and vulnerability can often overlap, for example among older American persons hospitalised for health reasons related to a smoke event, proportionally more females and Black persons were admitted [11]. In the context of this review, the term 'susceptible populations' thus refers to all sub-populations, both sensitive and vulnerable groups, at increased risk of health impacts from smoke events." (p. 600, original references left in).

[8] "Wildfire smoke has especially impacted vulnerable at-risk populations [2], including Black, Indigenous, and People of Color (BIPOC) [1, 27, 28] as well as rural farming communities [18]. Vulnerable adult populations are more likely to have several chronic conditions, such as diabetes and cardiovascular disease, which already impact certain populations more than others, e.g., Black/African Americans have more hypertension and stroke, certain Latino populations and Native Americans have higher risks for Type 2 diabetes [29]. Vulnerable populations are at higher risk for exacerbations of those conditions, such as experiencing myocardial infarctions and/or strokes, during wildfire smoke events [6, 9, 10]." (p. 2, left with original citations). In addition to this definition, the authors also describe health impacts specifically on children, pregnant individuals, and more general health outcomes (p. 2, para 1-2).

[9] Of those, 128 came from the environmental scan and 59 from the literature. "The environmental scan included 128 grey literature documents (e.g. infographics, government reports, prescribed burn announcements, etc.)" (p.3).

[10] Excluded prescribed burn announcements published before 2018.

[11] "We referenced the American Journal of Managed Care (AJMC) to define vulnerable populations, which is defined as older adults, children, individuals with pre-existing medical conditions, immunocompromised individuals, racial and ethnic minority groups, and economically disadvantaged communities (AJMC 2006). Outdoor occupations are another potentially vulnerable population, however, occupational exposure related to firefighting and other emergency response activities was beyond the scope of this review (but see Navarro et al.2019) and therefore we did not include this group since the focus is on community exposure." (Supplementary materials, p. 3, original references left in).

[12] "Research on effective methods to communicate wildfire and wildfire smoke risks, both health and emergency related, is lacking. It is especially not well understood among marginalized communities, such as Indigenous, farm worker, low-income, rural, and older adult populations [17,18]. These groups are in some cases geographically isolated and reside in unincorporated communities (in the United States), which have little to no local governance structures to assist with wildfire and smoke mitigation. These communities may also exist in linguistic isolation (e.g., Spanish only), have low knowledge about what to do in the event of a wildfire and evacuation, and experience greater exposure to general air pollution as a consequence of environment and occupation [18,19]. Other marginalized communities include low-income, older, disabled, or low-education groups that are disadvantaged and may reside in urban–wildland interface or rural areas [20]." (p. 2, original references left in).

This research brief was written by Hollie Smith, Jess Downey, and Heidi Huber-Stearns with reviews by Autumn Ellison and Emily Jane Davis. We offered all authors of the articles we reviewed an opportunity to review the brief. The Northwest Fire Science Consortium is funded by the Joint Fire Science Program. Photo credits: Page 1 top left: Columbia River Gorge Smoke Response Plan, page 1 intro paragraph: Jess Downey

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