

Assessing Protective Behaviors and Acceptability of Future Interventions for Reducing
Children's Wildfire Smoke Exposure

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Abstract

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Background: As wildfire activity in the U.S. increases, children are increasingly exposed to unhealthy levels of wildfire smoke. Public health interventions to reduce wildfire smoke impacts are needed, particularly in vulnerable communities who experience barriers to self-protection. More information is needed to understand families' current engagement in protective behaviors and the acceptability of potential future resources. This study aims to address these gaps in a rural community in Washington State.

Methods: We conducted a mixed-methods study using survey and focus group data collected from participants in an existing prospective cohort study. The survey was administered following a regional wildfire smoke event and collected information on protective actions taken, barriers to actions not taken, unmet needs, and interests in future resources. Descriptive summaries were reported. We conducted focus groups to gather information on the acceptability of a draft

intervention comprised of education, free durable goods, and wildfire smoke alerts. A thematic analysis guided by the Theoretical Framework of Acceptability revealed key takeaways.

Results: Of N=94 survey participants, most identified as Hispanic or Latino (74.5%), most were born in the United States (71.3%), and nearly half had attended some college or more (46.8%).

The protective action most frequently reported was closing windows and doors, with 88% reporting doing so “often.” Barriers to taking other protective actions included gaps in knowledge and economic limitations. Survey participants were interested in future resources including free durable goods and text alerts about wildfire smoke. Feedback from N=15 focus group participants indicated that the draft intervention is acceptable in this population, especially when suggested improvements are integrated.

Conclusions: This study provides novel insights into the experiences of families in vulnerable communities during wildfire smoke events. Participant perspectives on potential future resources to mitigate child health impacts should inform the design and implementation of public health interventions.

Introduction

As climate change continues to fuel an increase in wildfire frequency, severity, and size, the effect of wildfire smoke (WFS) exposure on U.S. communities intensifies [1, 2]. WFS contains a mixture of particulate matter, carbon monoxide, nitrogen oxides, and other pollutants [3].

Exposure to these particles and gases is linked to an array of adverse health effects, to which children are particularly vulnerable [3–5]. WFS often disproportionately affects those of minoritized racial and ethnic groups, lower educational attainment, and limited English proficiency, exacerbating existing health disparities [2, 6]. Additionally, families in low-income communities may have less capacity to cope and adapt to WFS exposure [6].

Public health agencies recommend parents take protective actions to reduce their children’s WFS exposure during WFS events [7, 8]. Protective actions often include staying indoors, checking the Air Quality Index (AQI) to inform decisions about outdoor activities, wearing masks or respirators if sized appropriately, and using indoor air cleaners [7–10]. There is some research describing how families are taking protective actions such as staying indoors, closing windows, and rescheduling outdoor activities in Washington, Oregon, and western Canada [11–13]. The ability to take many protective actions is limited by economic means and parent work schedules, which can reduce accessibility for low-income families [2]. Farmworker communities in rural, north-central Washington have also expressed concerns about lacking sufficient resources to keep themselves and their families safe from WFS exposure, including lack of accessible, culturally responsive messaging around wildfires and smoke translated in their primary language [14]. Several studies suggest the provision of free or low-cost air cleaners and respirators as a strategy for mitigating the effects of WFS [12, 15–17], and several studies investigate HEPA air cleaners as an intervention for general childhood air pollution exposure [18, 19], but it is

necessary to examine whether such strategies are acceptable and can be applied to WFS in rural communities.

This study aimed to address these gaps in a rural community impacted by WFS. The objectives were to 1) characterize the protective actions pregnant women and mothers of young children take, barriers to actions not taken, and unmet needs related to WFS, and 2) gather community feedback on the acceptability of a draft WFS intervention protocol, guided by the Theoretical Framework of Acceptability (TFA) [20]. The draft intervention, Reducing Infant Smoke Exposure (RISE), includes the provision of free supplies in a home-delivered package containing a HEPA air cleaner, N95 masks, and educational material as well as timely text alerts about serious smoke events, and access to a telephone or email accessible free query response service staffed by the Pediatric Environmental Health Specialty Unit (PEHSU) at the University of Washington. There is a planned intervention study to assess RISE's effect on health outcomes in young children (from infancy – 3 years of age during the WFS season of their involvement). This study contributes to the field of implementation science by guiding the development of the RISE intervention before additional planned research takes place. Qualitative data will provide richer insights into descriptive survey data that characterizes protective behaviors already taken, barriers, and interest in future resources. This work will inform culturally tailored and acceptable WFS interventions as wildfires and WFS exposure continue to worsen.

Methods

Study setting

This study was conducted in the Yakima Valley, a region in central Washington state that is known for its rural environment and agricultural economy [21]. Over 50% of Yakima County residents identify as Hispanic or Latino [22]. In September of 2025, regional wildfires caused

heavy WFS, dramatically elevated PM2.5 levels, and “Unhealthy” AQI levels in the Yakima Valley for about a week [23].

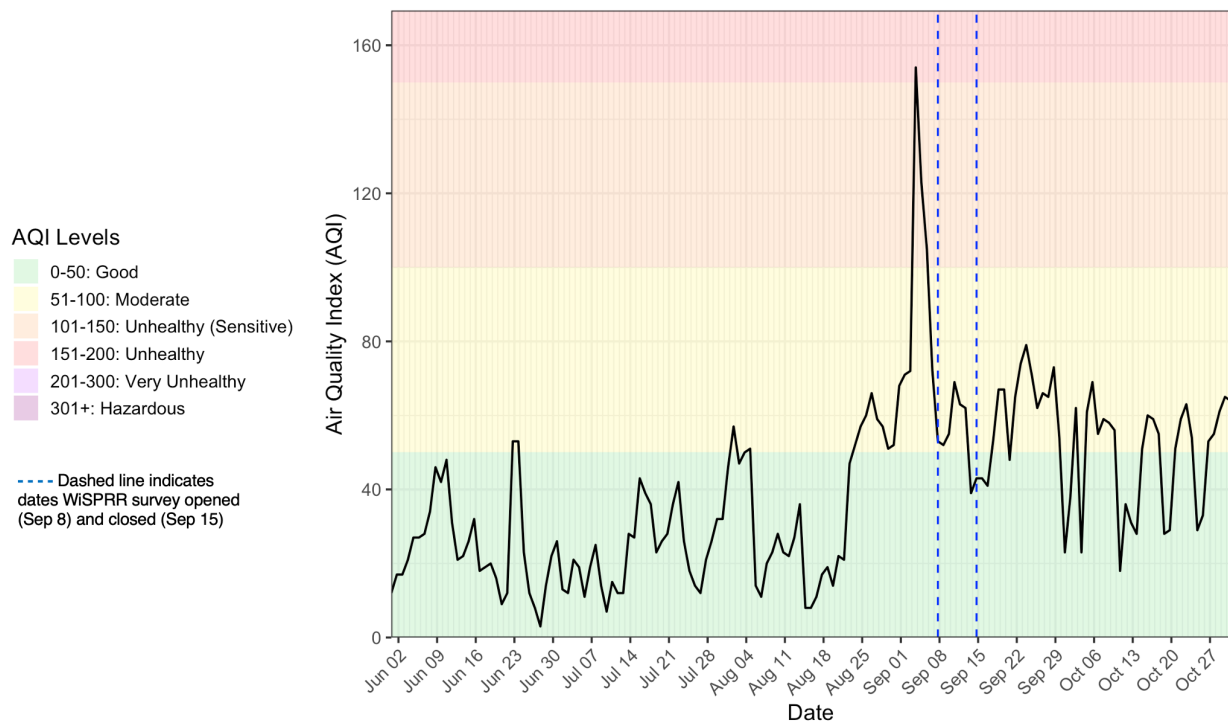
Study design and participants

This study used an explanatory sequential mixed-methods study design with quantitative survey and qualitative focus group data (Appendix A). All data came from the Environmental influences on Child Health Outcomes (ECHO) cohort in the Yakima Valley. This ongoing prospective cohort study recruits pregnant individuals with longitudinal follow-up of child growth and health. Eligibility criteria for ECHO Yakima Valley include women between 18-45 years old, pregnant and less than 20 weeks gestational age, and proficient in English and/or Spanish. Quantitative data came from the Wildfire Smoke Protocol for Rapid Response (WiSPRR) survey, which was developed to collect time-sensitive data from ECHO participants following acute WFS events. The survey was administered in September 2025, immediately following a significant WFS event in the Yakima Valley region (Figure 1). Survey responses provide information on protective actions taken during the WFS event, barriers to actions not taken, unmet needs, and interests in future resources. Demographic data to characterize the study population was derived from demographic surveys completed at the time of enrollment into the ECHO cohort. Qualitative data was collected via two focus groups conducted at the ECHO office in Yakima, Washington in March 2026. Some focus group participants completed the WiSPRR survey, but not all.

The study, Development of a Rapid Response Protocol for Acute Wildfire Smoke, has received approval from the University of Washington Institutional Review Board (PI: Dr. Christine Loftus; IRB Study # STUDY00022467). Study approval includes the WiSPRR survey analysis and focus group discussions. All participants provided written informed consent prior to their

enrollment in the ECHO cohort. Participants received a gift card incentive for participation in the focus groups.

Figure 1. Time Series Plot of AQI Levels in Yakima, WA, June – October 2025



Mixed-methods integration

This study included integration at the methods level. The quantitative and qualitative data shared the same sampling frame, and we collected new qualitative data to build upon existing quantitative data. Both focus group participants and WiSPRR survey respondents are derived from the ECHO Yakima Valley cohort. Both the results of the WiSPRR survey and the TFA informed the design of the focus group questions. At the reporting level, this project includes integration through narrative by presenting the results with a contiguous approach. We report the quantitative and qualitative results in separate sections and provide an analysis of shared themes and concepts in the discussion.

Survey

Data management

The WiSPRR survey was administered through REDCap electronic data capture tools hosted at the University of Washington's Institute of Translational Health Sciences [24, 25]. We cleaned and merged survey data with baseline demographic data from ECHO using R version 4.5.2 [26].

Data analysis

We performed all descriptive analyses in R version 4.5.2 using packages `table1` for Table 1 and `ggplot2` for figures [27, 28]. We summarized demographic information of the study populations (survey respondents and focus group participants), including age, race and ethnicity, and educational attainment. We conducted descriptive exploratory analyses to better understand how behaviors and interests in future resources vary by educational attainment. Educational attainment was dichotomized into groups representing “high school degree or less” and “greater than high school degree.”

Focus groups

Overview

The goals of the focus groups were to enhance our understanding of the information provided in the WiSPRR survey and collect feedback and perspectives from ECHO participants on the acceptability of specific components of the draft RISE intervention. We selected focus groups as a method to gather a range of opinions and generate discussion among participants.

Focus group guide development

We developed the focus group guide (Appendix B) with support of the ECHO site staff. We used the TFA to guide our understanding of the anticipated acceptability of the components and mode of delivery of the proposed RISE intervention among participants [20]. The TFA contains seven

constructs: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy (Table 2). We developed focus group questions to address each construct, although “ethicality” and “opportunity costs” were omitted due to lack of relevance to the RISE intervention.

Recruitment

In February 2026, we emailed N=69 ECHO cohort participants who had consented to being invited to ancillary research studies and who preferred English. They were informed about this new research opportunity and directed to an online screening and scheduling survey using REDCap [24, 25]. Of these, N=21 completed the survey. Email, text message, and/or phone calls were used to follow-up and confirm participants into one of two time slots.

Focus groups

We conducted two focus groups in person at the ECHO Yakima Valley office in Yakima, Washington, on March 4, 2026. Each session was conducted in English and lasted 1.5 hours in total, including time for check-in, refreshments, and check-out. We provided a live demonstration of the resources included in the draft RISE protocol (Appendix C) and led a discussion following the focus group guide. Each focus group was audio recorded using a portable voice recorder device equipped with a USB. At the end of each session, we administered a paper exit survey. The exit survey asked, “How likely would you be to use the following resource if available to you?” and included Likert scale response options of “very likely” to “very unlikely” for each separate component of the RISE intervention. The survey also included space for any other comments about WFS and child health in the Yakima Valley.

Data management

We uploaded the audio files to a secure Microsoft SharePoint site following each session.

Transcripts were generated using Word Online in Microsoft SharePoint. One researcher (JL) manually reviewed the transcripts while listening to the audio files to correct mistakes, add non-verbal cues, and de-identify the transcripts. Exit survey data collected on paper were entered into an Excel spreadsheet in SharePoint.

Thematic analysis

An initial codebook was created inductively based on the focus group guide, and new codes were deductively added to the codebook after reading through the transcripts (Appendix D). One researcher (JL) independently applied codes to each transcript using Dedoose version 10.0.59 [29]. The coded transcripts were then reviewed with a second researcher (CL), and several new codes were added to the transcripts. Three key themes emerged from the final coded transcripts, described in the results below.

Results: WiSPRR survey

Description of study population

N=94 women responded to the WiSPRR survey, a response rate of 68.6% (Table 1). The mean age of participants was 27 years (SD = 6.1 years). At the time of the survey, 37.2% of the participants were pregnant and 58.5% were the caregiver of an ECHO child under 12 months old. Participants primarily identified as Hispanic or Latino (74.5%). Most participants were born in the United States (71.3%), and a quarter of participants were born in Mexico (25.5%). Nearly half of participants had attended some college, or more (46.8%), while about a third of participants had attained a high school degree, GED, or equivalent (34.1%). When asked about WFS in the past 2 weeks, most participants (90.4%) reported a lot of outdoor smoke (i.e., enough smoke that they could smell, taste, and/or see it on at least one day).

Table 1. Characteristics of Study Participants, ECHO Yakima Valley, 2025-2026

Participant Characteristic	N (%) or Mean (SD)	
	Survey Participants N=94	Focus Group Participants N=15
Age (years)	27.0 (6.1)	29.5 (5.5)
Pregnancy Status		
Currently pregnant	35 (37.2%)	15 (100%)
Caregiver of an ECHO child under 12 months old	55 (58.5%)	0 (0%)
Currently pregnant and have an ECHO child under 12 months old	0 (0%)	0 (0%)
Missing	4 (4.3%)	0 (0%)
Asthma Status		
Yes	13 (13.8%)	2 (13.3%)
No	80 (85.1%)	13 (86.7%)
Missing	1 (1.1%)	0 (0%)
Race and Ethnicity (select all)		
Hispanic or Latino	70 (74.5%)	10 (66.7%)
White	34 (36.2%)	4 (26.7%)
American Indian or Alaska Native	6 (6.4%)	1 (6.7%)
Black or African American	2 (2.1%)	0 (0%)
Asian	1 (1.1%)	0 (0%)
Country of Birth		
United States	67 (71.3%)	15 (100%)
Mexico	24 (25.5%)	0 (0%)
Australia	1 (1.1%)	0 (0%)
Guatemala	1 (1.1%)	0 (0%)
Philippines	1 (1.1%)	0 (0%)
Highest Level of Education Completed		
No schooling/never attended	1 (1.1%)	0 (0%)
8th grade or less	4 (4.3%)	0 (0%)
Some high school, no degree	11 (11.7%)	2 (13.3%)
High school degree	26 (27.7%)	1 (6.7%)
GED or equivalent	6 (6.4%)	2 (13.3%)
Some college, no degree	20 (21.3%)	6 (40.0%)
Associate's degree / Technical School (AA, AS)	11 (11.7%)	1 (6.7%)
Bachelor's degree (BA, BS)	10 (10.6%)	2 (13.3%)
Master's degree (MA, MS, MEd, MSW, MBA, MPH)	3 (3.2%)	1 (6.7%)
Professorial or Doctorate Degree (PhD, EdD, MD, JD)	0 (0%)	0 (0%)
Missing	2 (2.1%)	0 (0%)

**Table 1. Characteristics of Study Participants, ECHO Yakima Valley, 2025-2026
(continued)**

Participant Characteristic	N (%) or Mean (SD)	
	Survey Participants N=94	Focus Group Participants N=15
Marital Status		
Married to a partner of the opposite sex	32 (34.0%)	6 (40.0%)
Married to a partner of the same sex	0 (0%)	0 (0%)
Not married but living with a partner of the opposite sex	27 (28.7%)	3 (20.0%)
Not married but living with a partner of the same sex	0 (0%)	0 (0%)
Widowed	0 (0%)	0 (0%)
Separated	4 (4.3%)	0 (0%)
Divorced	4 (4.3%)	0 (0%)
Single, never married	25 (26.6%)	6 (40.0%)
Missing	2 (2.1%)	0 (0%)
Annual Household Income (\$)		
Less than 4,999	5 (5.3%)	1 (6.7%)
5,000 - 9,999	6 (6.4%)	1 (6.7%)
10,000 - 19,999	9 (9.6%)	1 (6.7%)
20,000 - 29,999	9 (9.6%)	2 (13.3%)
30,000 - 39,999	13 (13.8%)	3 (20.0%)
40,000 - 49,999	3 (3.2%)	1 (6.7%)
50,000 - 74,999	8 (8.5%)	3 (20.0%)
75,000 - 99,999	4 (4.3%)	1 (6.7%)
100,000 - 199,999	7 (7.4%)	1 (6.7%)
200,000 or more	2 (2.1%)	0 (0%)
Missing	28 (29.8%)	1 (6.7%)
Number of Household Members	3.4 (1.6)	3.5 (1.1)
Missing	11 (11.7%)	0 (0%)

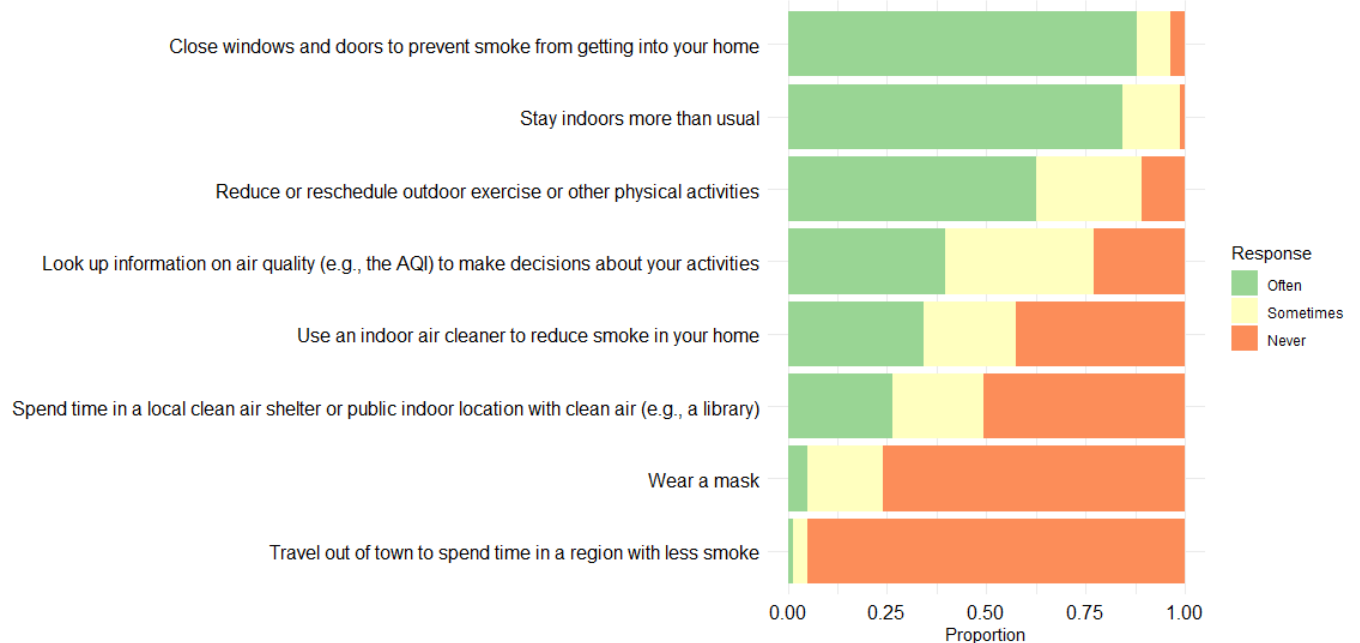
Protective behaviors and barriers to actions not taken

Participants (N=83) reported the protective actions they took when the air was smoky in the 2 weeks prior to the survey (Figure 2) and reason(s) for not acting if applicable. Most participants “often” closed windows and doors to prevent smoke from getting inside the home (88%) and stayed indoors (84.3%). Over half of participants “often” reduced or rescheduled their outdoor exercise or other physical activity (62.7%); many participants who did not reported thinking it

was unnecessary (66.7%). Most participants reported “often” or “sometimes” looking up information on the air quality, such as the Air Quality Index (AQI), to make decisions about activities (77.1%). Most participants who “never” looked up air quality information reported not knowing where to find the information (52.6%). About half of the participants reported “never” spending time in a local clean air shelter or other public indoor location with clean air (50.6%), due to reasons such as thinking it was unnecessary (54.8%), not knowing any places like that in the neighborhood (33.3%), and having to work (14.3%). Most participants “never” wore a mask when the air was smoky (75.9%), because they didn’t have any masks (46%), didn’t think wearing a mask was necessary (41.3%), thought wearing a mask was uncomfortable (11.1%), or didn’t like masks in general (9.5%). Of the 20 participants who did report wearing masks “often” or “sometimes,” most wore surgical masks (60%) or cloth masks (35%), with just 1 participant wearing a KN95 mask (5%) and none wearing an N95 mask. Many participants reported that they “never” used an indoor air cleaner (42.7%), and most of these participants reported not doing so because they did not have an air cleaner (80%). Participants also reported not using indoor air cleaners for reasons such as indoor air cleaners being too expensive (11.4%) or not knowing where to get an air cleaner or filters (11.4%). Nearly all participants reported that they “never” traveled out of town to spend time in a region with less smoke (95.2%), due to thinking it was unnecessary (43.6%), not being able to leave due to work and/or personal responsibilities (42.3%), it being too expensive (15.4%), not having anywhere to stay (14.1%), and not having transportation (10.3%).

Figure 2. Protective Actions Taken Among Survey Respondents

How often did you take this action when the air was smoky in the past two weeks?



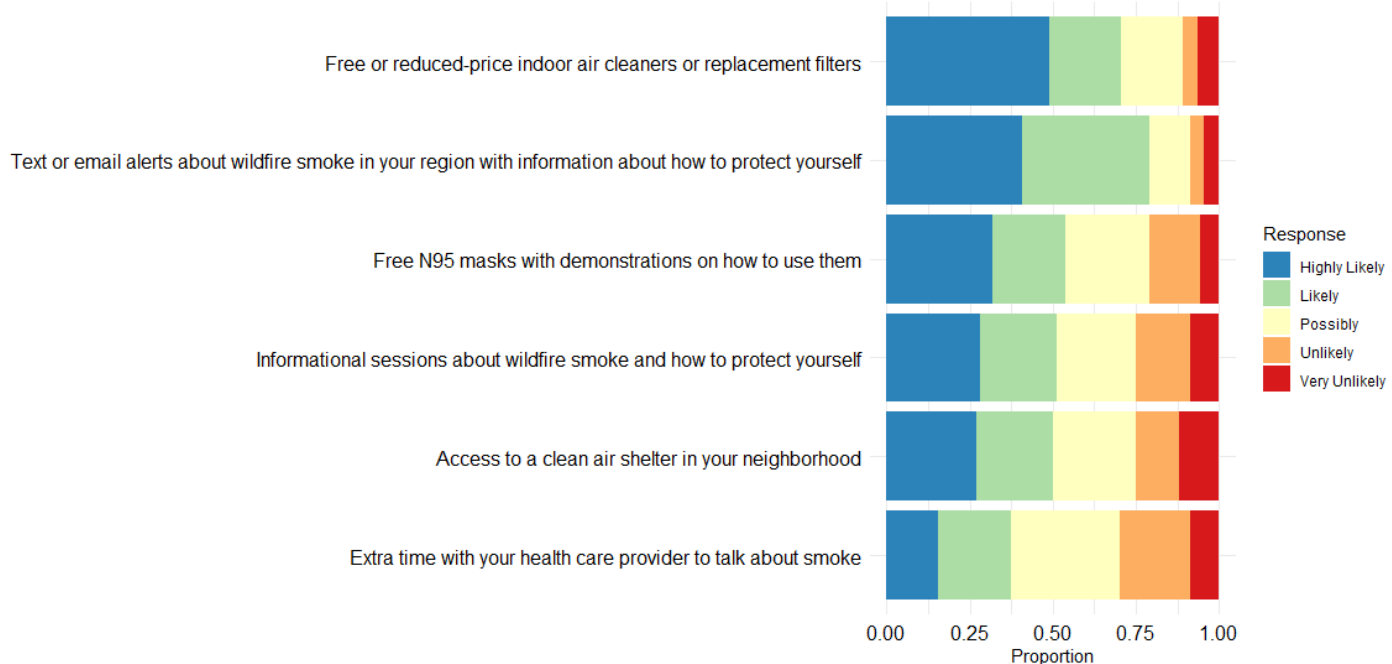
Interest in future resources

Participants (N=92) reported the likelihood they would use various types of WFS assistance if available (Figure 3). Receiving a free or reduced-price indoor air cleaner or replacement filters for the indoor air cleaner was popular: 48.9% of participants said they were “highly likely” to use this resource and 21.7% said “likely.” Participants were also highly interested in receiving text messages or email alerts about WFS in the region with information to protect themselves: most participants reported being “highly likely” or “likely” to use them (79.1%). Over half of participants were “highly likely” or “likely” to use free N95 masks with demonstrations on how to use them (53.8%), with 25.3% responding “possibly,” and the remaining 20.9% responding “unlikely” or “highly unlikely” to use these. About half of the participants responded they would be “highly likely” or “likely” to use informational sessions about WFS (51.1%), and half responded they would be “highly likely” or “likely” to use access to a clean air shelter in their neighborhood (50%). Participants were slightly less interested in extra time with their health care

provider to talk about smoke: 37.4% of participants said they were “highly likely” or “likely” to use this, with 33% responding “possibly,” and the remaining 29.7% responding “unlikely” or “highly unlikely.”

Figure 3. Interest in Future Resources Among Survey Respondents

How likely would you be to use the following types of assistance with wildfire smoke if available to you in the future?

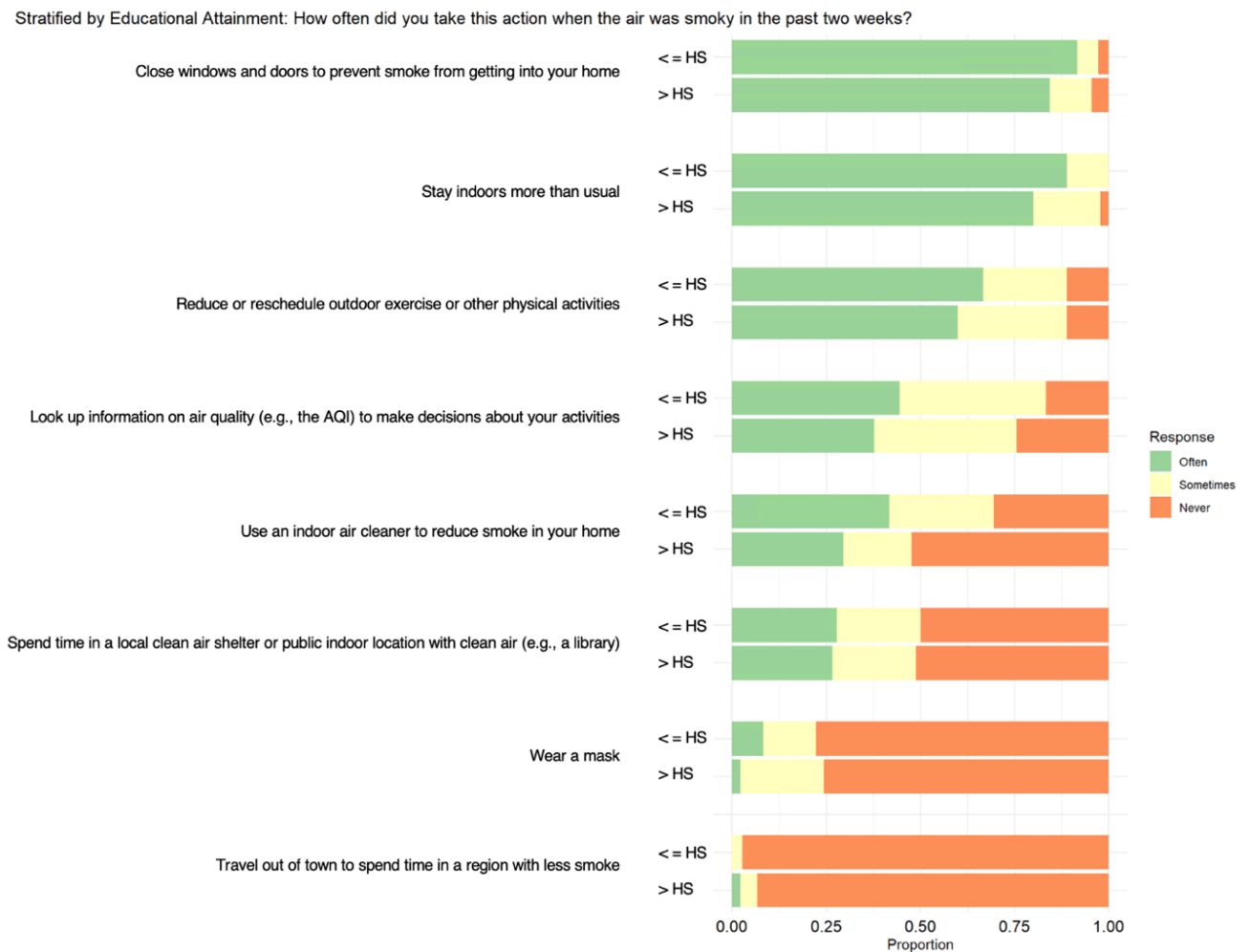


Variation by educational attainment

The distributions of protective behaviors taken and interest in future resources were explored by educational attainment, dichotomized into “high school degree or less” (N=42) and “greater than a high school degree” (N=50). Protective behaviors were generally similar across the two educational attainment groups (Figure 4), although the proportion of those reporting "often" or "sometimes" using an indoor air cleaner was higher in the lower educational attainment group (69.4%) compared to in the higher educational attainment group (47.7%). Interest in future WFS resources differed for some resources (Figure 5). Extra time with a health care provider to talk about smoke was less popular among those in the higher educational attainment group: A substantial number of this group said they would be “unlikely” or “very unlikely” to use that

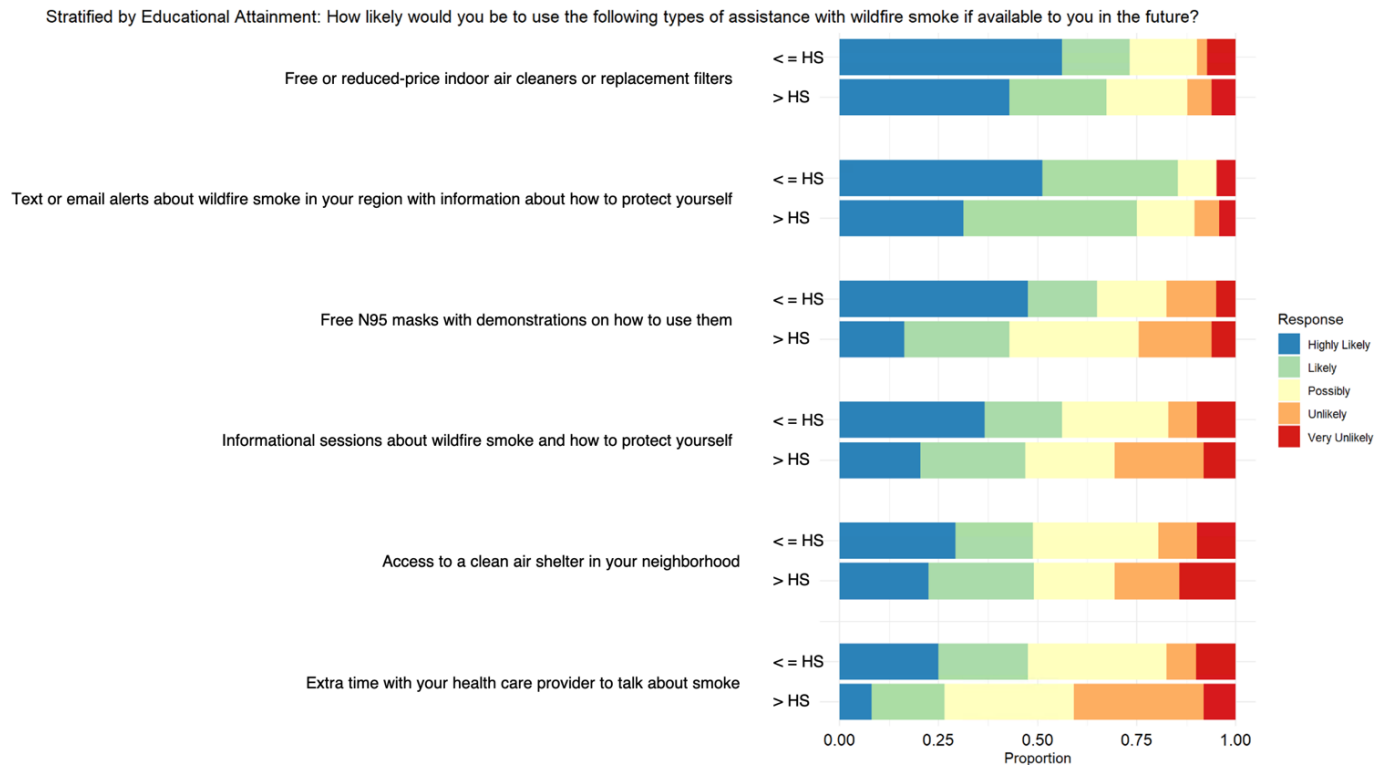
resource (40.8%), compared to just 17.5% of participants in the lower educational attainment group. Similarly, 30.6% of those in the higher educational attainment group said they were “unlikely” or “very unlikely” to use informational sessions about WFS and protective actions, compared to 17.1% of those in the lower educational attainment group. When asked about interest in free N95 masks with demonstrations on how to use them, a smaller proportion of participants in the higher educational attainment group reported being “highly likely” or “likely” to use them (42.9%) compared to participants in the lower educational attainment group (65%).

Figure 4. Protective Actions Taken Among Survey Respondents Stratified by Educational Attainment



≤ HS: High school degree or less, > HS: Greater than a high school degree

Figure 5. Interest in Future Resources Among Survey Respondents Stratified by Educational Attainment



<= HS: High school degree or less, > HS: Greater than a high school degree

Results: Focus groups

Description of study population

N=15 women participated in two focus groups, with sizes of N=8 and 7 (Table 1). The mean age of participants was 29.5 years (SD = 5.5 years). All focus group participants were pregnant (100%). Most identified as Hispanic or Latino (66.7%), and all participants were born in the United States (100%). Most participants had completed some college or more (66.7%). Participants described their experiences with WFS and provided their perspectives on the proposed RISE intervention.

Theme: Wildfire smoke is viewed as a public health issue, and there is a critical lack of community resources to help families

Participants and their family members experienced health impacts from WFS exposure, including respiratory symptoms (cough, asthma, lung irritation), itchy or burning eyes, headaches, and nausea. When asked on a scale of 1 – 5 how serious the health impacts of WFS were, with 1 being not serious at all and 5 being very serious, participants reported between a 1 and a 3. These personal health impacts contribute to the recognition of WFS as a public health issue in this community. There was a general sense of familiarity with protective resources and behaviors, such as staying inside, using indoor air cleaners, wearing masks, checking the AQI, and visiting a clean air shelter such as a library. None of these behaviors were widely used by the group; in fact, participants discussed several barriers and unmet needs related to WFS protective behaviors. Participants talked at length about their low, but growing, awareness about the negative health impacts of WFS. Participants who were not originally from the Yakima Valley said they did not learn about wildfires or WFS until relocating to the Yakima Valley. Other participants who grew up in the Yakima Valley said their community never knew or talked about the hazards of breathing in WFS. One participant shared,

“Growing up and stuff like that I know that my parents didn't know anything about this stuff. We were outside whether it was smoky or whatever it was and stuff and so like being able to have the resources to like air filter a room or like you know that kind of stuff and then like know like when it's not good to go outside and that kind of stuff would be helpful because like I said, growing up we were just out there anyway.”

Participants also described the challenges of living in a low-income community with gaps in knowledge about WFS protective resources and behaviors. When asked where Yakima Valley parents or pregnant women can go to receive help for WFS, including help with indoor air cleaning, participants replied, *“They direct you to Lowe’s”* and, *“They tell you to go buy it from a store or somewhere to try it out.”* Participants found this advice unhelpful, particularly due to

the high cost of purchasing an indoor air cleaner, and a lack of knowledge of what type of air cleaner to purchase. One participant shared,

“If you just go to your doctor and they tell you just get an air purifier you don't know what kind, you don't know what filter, and where do you get that information.”

Participants’ perspectives on the proposed RISE intervention will be discussed in greater detail in the following sections, but one participant’s reaction to the RISE intervention especially highlights the need for more WFS resources in the Yakima Valley:

“There's just no resources like that around here, and especially for how massive this is. We all said that this affects all of us and our kids and everything, so it's just like you guys are going to be probably one of the first in the area to even...think about doing something like this.”

Theme: The proposed RISE intervention is highly acceptable to Yakima Valley community members

The RISE intervention was highly acceptable to participants in both focus groups across the components of the TFA (Table 2). After we demonstrated the proposed RISE intervention components, which included a physical HEPA indoor air cleaner, N95 masks, and visual depictions of the educational and text message materials, participants agreed that the intervention made sense conceptually and had no questions about the goals of the intervention. All were interested in receiving the RISE box of resources, when asked for a show of hands. When asked to explain their interest, many participants focused on the HEPA air cleaner. One participant said,

“I like it just because, I mean, I've never actually used an air filter, so I would love to see like what the actual difference would be, like especially on really smoky days. Like, if it would make a difference inside the house. It would be good to know.”

Other participants agreed that they were interested in being able to have cleaner air inside when it was smoky outside. Participants also liked that the HEPA air cleaner would be a high-quality household appliance, as compared to lower quality indoor air cleaners that are more financially accessible. In terms of barriers to using the HEPA air cleaner provided in the RISE package, two participants expressed concern that their children would want to play with it and turn it off. One participant also noted that the HEPA air cleaner would not be accessible to all community members, specifically unhoused people who do not have an electricity source for the appliance. However, participants were generally under the impression that their friends, family, neighbors, and other community members would also be interested in receiving a HEPA air cleaner as part of the RISE intervention.

Table 2. Components of the Theoretical Framework of Acceptability and Corresponding Focus Group Discussion Questions

Component of TFA framework* [20]	Definition of TFA component	Corresponding question(s) in focus group guide
Affective Attitude	How an individual feels about the intervention	Can I see a show of hands if receiving this box sounds like something you would be interested in? Would anyone be willing to talk about why you'd be interested?
Burden	The perceived amount of effort that is required to participate in the intervention	What are some barriers you can think of that might make it hard for you to use these resources?
Intervention Coherence	The extent to which the participant understands the intervention and how it works	Does anybody have any questions about the box of supplies and what it is supposed to do? In general, does it make sense, as a concept? Please raise your hand if it does.

Table 2. Components of the Theoretical Framework of Acceptability and Corresponding Focus Group Discussion Questions (continued)

Component of TFA framework* [20]	Definition of TFA component	Corresponding question(s) in focus group guide
Perceived Effectiveness	The extent to which the intervention is perceived as likely to achieve its purpose	We would like to know how helpful do you think this entire program would be to you, for reducing your family's exposure to wildfire smoke? You can show your response on your fingers, 5 fingers for very helpful, and 1 finger for not helpful at all. Could someone talk about why you chose that number?
Self-efficacy	The participant's confidence that they can perform the behavior(s) required to participate in the intervention	With the information you have now, if you received these resources, how confident would you feel about using them? You can show your response on your fingers, 5 for very confident, and 1 for not confident at all. Would anyone like to explain why you chose that number?

*Two of the TFA components, ethicality and opportunity costs, were omitted due to lack of relevance to the proposed RISE intervention.

Participants were also interested in receiving text alerts on smoky days with information about WFS and how to protect yourself, with 86.7% of participants raising their hand to indicate their interest. Participants liked that the text alerts could help them plan their day (i.e., to consider canceling outdoor activities or staying inside to avoid smoke), that the alerts would ensure they would not have to remember to check the air quality themselves, that it would keep them informed about air quality issues if they were out of town or if conditions changed overnight, and that it could even serve as a reminder to change air filters at home. One participant appreciated that the text alerts could reinforce the seriousness of the WFS when combined with alerts from other sources:

“And then like we hear it right on the radio or from schools, you get a little message, but it's just like another form of, hey, yeah, this is pretty bad. Please keep everyone inside. That's just another, okay, conscious decision. I'm not going to keep, you know, I'm going to stay inside and do what I can to reduce.”

However, one other participant explained that she would not be interested in receiving the text alerts because her teaching and coaching jobs meant she was already very diligent in monitoring the air quality due to its potential effects on outdoor sports practices and other school activities.

Participants were also asked about their interest in the PEHSU service that would be advertised within the text alerts. Participants in the first focus group were less interested in using this service, explaining that they would prefer to search for information on the Internet, ask an AI assistant, or ask a family member. By contrast, participants in the second focus group were much more interested in the service, especially if modifications were made to how the service is described. These details will be discussed in the next section.

Other components of the RISE intervention included physical and digital educational resources, and N95 masks. Participants were less interested in the N95 masks compared to other components of the intervention, but some said they would use them if available. Most, if not all, participants indicated that they were interested in the educational components of the intervention. Both educational resources about why WFS is unhealthy as well as practical education about the types of resources available, were appealing to participants. Participants also felt that education could be helpful for other people in the community, who may not yet understand the health risks of exposure to WFS.

Participants indicated that their interests in the RISE intervention were related to their perceived effectiveness of the resources. When asked on a scale of 1 – 5 how helpful the RISE intervention

would be for reducing your family's exposure to WFS, 1 being not helpful at all and 5 being very helpful, 93.3% of participants said 4 or 5. Participants reiterated that the educational component would be helpful, especially for those who were not from the Yakima Valley area or did not grow up knowing about the health effects of WFS. Participants also explained that the HEPA air cleaner would benefit the health of their children and other people in their community, such as the elderly, people with other health conditions, and those who cannot afford to buy their own indoor air cleaner. One participant said their current air cleaner works well and creates a noticeable difference in air quality when used, so it would be nice to have another for a different part of the house. When describing the HEPA air cleaner, one participant said,

"It's not just some cheap thing off of Amazon that's not going to really benefit you. You know, this is a high-quality hygiene thing that's going to benefit you and the small particles that are affecting specifically asthma, nausea, all these things, you know."

Two participants mentioned some concerns about the effectiveness of the HEPA air cleaners in reducing WFS exposure, which were that the air cleaner only works inside the home, and that it can only clean one room or area in the home. Two participants also mentioned concerns about the effectiveness of the N95 masks, given that they are not suitable for children under seven years old, and that the RISE intervention might not include enough N95 masks for each family member to have one.

Regarding the overall RISE intervention, participants expressed high self-efficacy in using the resources, if provided to them. When asked on a scale of 1 – 5 how confident participants would feel in using the resources given the information they had at that point, with 1 being not confident at all and 5 being very confident, 93.3% of participants said 4 or 5. One participant explained,

“To me, it just seems self-explanatory. And I'm, I'm not old, but I'm not young either, you know what I mean? So it's like I've been there, done that, so it's pretty simple to figure out. Um, and then obviously if it's something that I don't know, the booklet or Google or you know, research myself type of thing, but it wouldn't be something where it's like, Hey, I need to call 1-800 and Hey, can you explain this to me? I think it would be pretty easy to figure out.”

Participants acknowledged the ways in which the RISE intervention may not be accessible for the elderly, people without smartphones, or those with limited literacy. However, another participant shared,

“But personally for me, I have the education, I understand, I have these resources that we're in right now. I have the phone, this is very accessible. This is very clear, this is very simple. And again, it's a want. You can give me all this stuff, if I don't want to use it, I'm not going to use it. Yeah. But it has to be like a desire to want to do it. But again, the education and the whys and the hows and all that stuff, that all comes into play as to I'm making the conscious health decision to put this in my home.”

Overall, findings indicate that the proposed RISE intervention protocol is highly acceptable in this study population. Participants expressed high perceived effectiveness, self-efficacy, intervention coherence and interest, and few barriers to implementation.

Theme: Modifications to the draft RISE intervention protocol will increase acceptability and interest

While most participants thought the RISE intervention was highly acceptable in its current iteration, many also had questions about the resources and suggestions for improvement that would increase acceptability if implemented. Questions and suggestions about certain components of the RISE intervention highlight interests and gaps in knowledge, and can guide the development of the educational booklet and videos (Table 3).

Table 3. Focus Group Participant Questions about RISE Intervention and Suggested Improvements

Component of RISE intervention	Question	Suggested improvement to RISE intervention
HEPA Air Cleaner	<i>How much does running the filter affect the electricity bill?</i> <i>Would the filter be replaced or cleaned?</i> <i>Where would you buy a replacement filter?</i> <i>How much do replacement filters cost?</i> <i>How often do you replace the filters?</i> <i>Will the air cleaner remind you when it's time to replace the filter?</i> <i>What power level is recommended?</i>	Include answers to these questions in educational booklet and/or step-by-step HEPA air cleaner instructions Include a sticker on the physical HEPA air cleaner unit with a phone number or QR code for help
N95 Masks	<i>How often would you change masks?</i> <i>What to do for aged 7 and under who can't use these?</i>	Include answers to these questions in educational booklet
Text Alerts	<i>Can the texts alert you to wildfires starting?</i> <i>What is the AQI?</i>	Include answer to this question in educational booklet Include a hyperlink to the AQI and spell out the acronym
Education	<i>Would the education come with updates on wildfire smoke research?</i> <i>How much time outdoors in smoky air has how much of a health impact?</i>	Include facts or other research findings in educational booklet
General RISE questions	<i>How many filters would come in the RISE box?</i> <i>Would we need to send the RISE box back or is it something to keep?</i> <i>Would there be some follow-up with families after the RISE box gets sent, like a questionnaire?</i>	Include answers to these questions in the educational booklet and/or introductory materials

Participants in the second focus group suggested several modifications to how the PEHSU service was described. Participants thought referring to the service as a consultation with an “environmental health expert” was intimidating and could mislead people to think they could get medical care using this service. The group agreed with the participant who explained,

“Maybe if it was phrased a little differently, if it was something like, you can call if you have further questions, and then like maybe some examples of what questions I would have. Because I probably would want to talk to somebody. But if it says environmental health care, like, what the hell does that mean?”

Participants also suggested examples like, “*call if you have questions regarding the air quality,*” or “*regarding the smoke in the area.*” Other suggestions included reiterating that the PEHSU service is not a replacement for medical care and advice and disclosing that the caller should hang up and dial 911 in case of an emergency. With these modifications, participants said they could see themselves using the PEHSU service.

Most of the other suggestions for improvement involve providing more information to potential RISE participants, so they better understand the benefit of the resources. For example, participants suggested stating the monetary value of the HEPA air cleaner, so people understand they are receiving a high-quality appliance. Similarly, participants also thought it was important to have more information about the benefits of HEPA air cleaners as compared to cheaper alternatives that may not adequately filter the air. Participants also wanted more information in the educational component quantifying the health impacts of time spent outdoors in smoky conditions. Participants stated that their interest in these resources would be higher after learning more details such as these.

Exit survey

Focus group participants filled out a brief exit survey following the conclusion of the discussion, and the results reiterate high interest in the RISE intervention (Table 4).

Table 4. Exit Survey: How likely would you be to use the following resource if available to you?

Resource	N (%)			
	Very Likely	Likely	Unlikely	Very Unlikely
The RISE pack (the box of free supplies delivered to your home)	15 (100%)	0 (0%)	0 (0%)	0 (0%)
Booklet and online videos about wildfire smoke	7 (46.7%)	7 (46.7%)	1 (6.7%)	0 (0%)
Text alerts when there is a lot of wildfire smoke in the Yakima Valley	13 (86.7%)	1 (6.7%)	1 (6.7%)	0 (0%)
Opportunity to get help by phone from an expert during wildfire smoke events	8 (53.3%)	6 (40%)	1 (6.7%)	0 (0%)

Discussion

This study used survey data to characterize the protective actions pregnant women and mothers of young children take, barriers to actions not taken, unmet needs, and interest in future resources related to WFS, while focus group data provided deeper insight into these experiences, as well as perspectives on the acceptability of a draft WFS intervention protocol. When the air is smoky, many pregnant women and mothers of young children take various protective actions, though several barriers hinder these actions. Participants expressed high interest in using future WFS resources. In focus groups, we elicited perceptions of the proposed multi-modal RISE intervention, and we found high perceived effectiveness, self-efficacy, intervention coherence and interest, and few barriers to implementation. Overall, findings indicate that the proposed RISE intervention protocol is highly acceptable in this study population. Modifications to better

tailor the RISE intervention to the community context will increase acceptability. This study provides novel and important insight into the experiences of families during WFS events and their perspectives on potential future resources that could help mitigate child health impacts. Many aspects of these findings can directly inform future public health interventions.

Our study found that pregnant women and mothers in the Yakima Valley take some action to protect themselves and their children from WFS, but face barriers to taking other actions.

Closing windows and doors, staying indoors, and rescheduling outdoor activities were commonly reported protective actions taken among survey participants. Research on protective actions during WFS events is limited, but several studies observed similar strategies among communities in Washington, Oregon, and western Canada [11, 13, 30]. D'Evelyn et al. describe participants needing to keep windows open to cool homes that lack air conditioning, which was not reported as a barrier in our survey results [11]. In our study, survey participants reported financial barriers and lack of knowledge when asked why they did not take certain actions.

Financial barriers to owning and maintaining indoor air cleaners contributed to limited implementation of indoor air cleaners in our study and in other low-income communities [16, 17, 30]. Additionally, gaps in knowledge about using WFS resources were observed in our study including not knowing what the AQI was or where to find it. Other studies similarly describe mixed use of the AQI as a resource among parents, particularly in rural, under-resourced communities [14, 31, 32]. Some research has reported that those with higher socioeconomic status were more likely to take protective actions [13, 32, 33]. We observed very few differences in protective actions taken when stratified by educational attainment, but our sample size may have been too small to detect differences.

Many of the barriers observed in this study are modifiable and could be addressed with interventions, such as observed gaps in knowledge regarding the health risks of WFS. Many survey respondents who “never” took protective actions on smoky days reported thinking it was unnecessary. Focus group participants who grew up in the Yakima Valley area discussed spending their childhoods outside regardless of smoke, because their parents did not know about the health impacts of WFS. Many participants reported learning about WFS impacts for the first time as adults who are trying to protect their own children. Focus group participants also believed that others in their communities would be motivated to protect themselves and their children from WFS if they were more knowledgeable about WFS and its impacts. This finding is consistent with other research [34, 35] and suggests that gaps in WFS knowledge could be addressed with targeted health communication and education. There were also observed gaps in knowledge about WFS resources and how to use them effectively. While WFS risk and resource communications via local, state, and federal governmental agencies have increased in the last decade, there remains a major gap in literature relating to communications created with and for vulnerable populations [36]. Research has also identified the urgent need for more culturally responsive and effective wildfire and WFS risk communications in Spanish-speaking communities [14, 37]. Our study echoes previous work calling for culturally tailored interventions to address gaps in knowledge about WFS health risks and available resources.

Economic barriers relating to accessibility of WFS resources like indoor air cleaners could also be addressed with interventions. Many study participants did not have an indoor air cleaner and described the expense as a barrier to acquiring one. Other research demonstrates that financial constraints limit the implementation of air cleaners [10, 12]. WFS communications consistently advise the use of an indoor air cleaner [7–10], and several studies suggest the provision or

subsidization of indoor air cleaners as a potential public health intervention for low-income communities [10, 15, 16, 30, 38]. There is an urgent need for interventions that increase the accessibility of indoor air cleaners.

This study provides insight into community interest in receiving material support to mitigate child health impacts from WFS. Our draft intervention protocol, the RISE intervention, is designed to target specific barriers to self-protection faced by families in vulnerable communities. After learning about the intervention, focus group participants expressed high perceived effectiveness, self-efficacy, intervention coherence and interest, and few barriers to implementation. Interpreted through the TFA, this indicates high anticipated acceptability [20]. Participants also believed that others in their community, including family, friends, and neighbors, would be interested in receiving this intervention, suggesting potential broader acceptability beyond the study population. Study participants were enthusiastic about receiving resources that address economic barriers and gaps in knowledge about WFS resources, including free supplies (HEPA air cleaner and N95 masks) and real-time air quality communications (text alerts). In the survey results, we observed some differences in interest between groups stratified on educational attainment. Participants in the higher educational attainment group were generally less interested in demonstration or education-based resources. However, the focus group participants were generally aligned on their interest in the RISE intervention resources, including resources with educational components. It is possible that the decreased interest among survey participants in the higher educational attainment group reflected higher baseline awareness. It is also possible that the live RISE intervention demonstration in the focus groups prompted more engagement and interest. Further examination of differences in interest in WFS resources

between higher and lower educational attainment groups would be useful for designing tailored WFS interventions.

Focus group participants provided additional insight into how the RISE intervention protocol could be adapted to increase effectiveness in their community. Many suggestions involved increasing the amount of information in the educational booklet to address common questions about WFS and explain the benefits of the included WFS resources (Table 3). Previous research has also observed a similar need for improved communications around which WFS resources provide the most protection, and better explanations of the technical details of HEPA filters and N95 masks [16, 36]. Participants also suggested changes to the description of the PEHSU service to make it more approachable. These suggestions for how to improve the proposed RISE intervention will directly guide the continued development of tailored WFS interventions.

Strengths and limitations

The mixed-methods design of this study provides multiple modes of understanding community experiences and perspectives on WFS protective actions, barriers, and interests in future resources. Findings also offer practical suggestions for improving tailored public health interventions to protect families from WFS. However, findings should be interpreted within the context of several limitations. Results from the survey, including those stratified by educational attainment groups, are descriptive and do not carry statistical significance. The survey results also may not be representative of the actions or attitudes of all pregnant women or women with young children vulnerable to WFS in the general community or other communities. However, the socioeconomic characteristics of the participants in this study are similar to those of the Yakima Valley and many other communities impacted by WFS in the U.S., so the findings likely have relevance for communities beyond the study population. While

most results between the two different focus groups were aligned, key differences in opinions and insights regarding the PEHSU service and improvements to the overall RISE intervention suggest that data saturation was not yet reached, and additional qualitative data collection could have benefited the study. Within the focus groups, it is possible that groupthink prevented all perspectives from being heard, although this was mitigated by having multiple focus groups, providing explicit reminders that there were no wrong answers, and specifically encouraging those with a diverging opinion to speak. The qualitative data analysis process was limited by time and researcher capacity, so a full intercoder reliability process was not conducted. However, any bias arising from the single researcher's perspective was mitigated by reviewing and revising codes and themes with the focus group research team.

Conclusion

This study finds that Yakima Valley community members are concerned about worsening wildfires and WFS as a public health problem. We identified ongoing needs for community member protection from WFS, especially in lower-resourced rural communities. Tailored interventions to address gaps in knowledge and lack of protective resources are urgently needed. Overall, the proposed RISE intervention, which comprises educational components, free durable goods (HEPA air cleaner and N95 masks) and timely WFS event direct messaging, was well-received by Yakima Valley community members. Participant suggestions to improve and tailor the RISE intervention will directly guide the continued development of the intervention and increase its acceptability among community members. These findings support implementation of an intervention package such as the RISE protocol to address modifiable barriers to protective action in the Yakima Valley community. Future research should continue to build an understanding of the acceptability and feasibility of direct WFS resource provision to inform

public health interventions in other WFS-impacted regions. In addition, future efforts to examine implementation and effectiveness outcomes of interventions on WFS exposure reduction and child health are needed.

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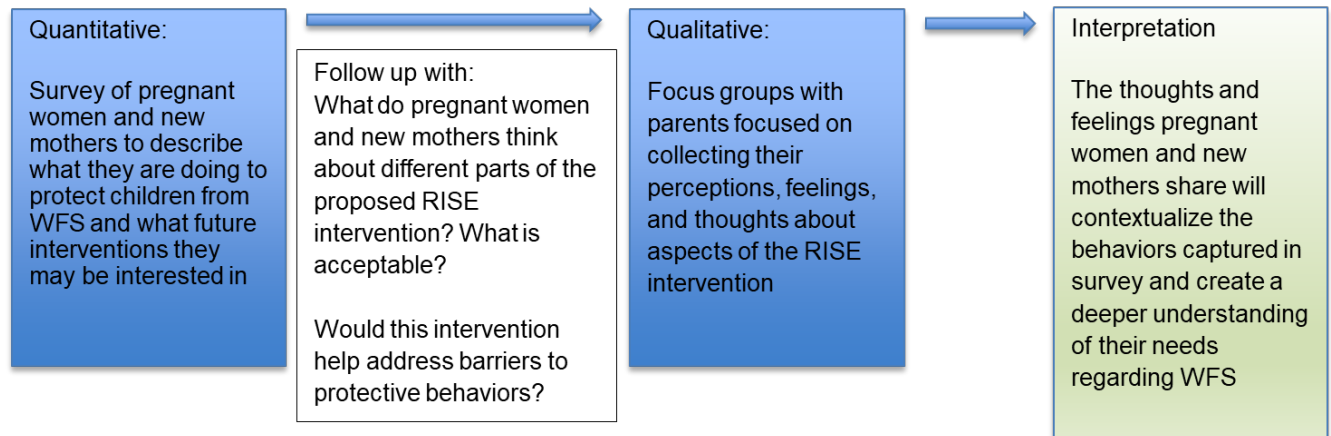
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Appendices

Appendix A – Explanatory Sequential Mixed Methods Study Design



Appendix B – Focus Group Questions

Topic	Script
Warmup	Great, thank you for those introductions! I'll ask a few questions about wildfire smoke to get us started. Could I see a show of hands if you noticed wildfire smoke in your area last year? • <i>I see everyone has raised their hands</i> • <i>I see 3 hands from ____ and ____</i> Great, thanks. Now I'm wondering whether wildfire smoke has ever caused health problems for you or your family members. On a scale of 1-5, can you hold up your answer on your fingers for how serious the problems have been for you? 1 means no health problems, and 5 means very serious problems • <i>I see a range of answers, ____ says 5, ____ said 2</i> • Thank you! Would anyone like to share more about why you chose that number? • [choose participant] I noticed you said the problems were pretty severe. Would you mind briefly describing some of the impacts you've seen on your family's health? • Would anyone else like to share? Thank you for sharing! Now I'll move into our demonstration.
RISE pack demonstration & questions	We'd like to get your thoughts on a specific resource we're developing for parents in the Yakima Valley. The main part of this program would be a box of supplies that would be mailed to your home. [Demonstration]
Intvn coherence	Does anybody have any questions about the box of supplies and what it is supposed to do? In general, does it make sense, as a concept? Please raise your hand if it does.
Affective attitude	Can I see a show of hands if receiving this box sounds like something you would be interested in? • Would anyone be willing to talk about why you'd be interested? • [pick participant] could you talk a little bit about why you'd be interested? • Does anyone else have anything to add?

Burden Perceived effectiveness	• [pick participant] could you talk a little bit about why you wouldn't be interested? • Does anyone else want to add anything? Could I hear from a few others about your first impressions of this box? What do you like about it and what do you not like? Some of you may have touched on this topic already, but I also want to ask about some challenges that might come up when using these supplies. For example, people receiving these boxes would need to learn how to use the air cleaner and masks if they weren't already familiar with them. People would need to set up the air cleaner in their home. So thinking about that, What are some barriers you can think of that might make it hard for you to use these resources? Thank you for giving your own opinions. Could you now think about other people you know in the Yakima Valley? Do you think this RISE Pack would help them? Are there community members who might not benefit? Why not? Thank you for sharing! Before we move on to the next section, does anyone have any suggestions about the box that would make it more helpful?
Text Messages & PEHSU Intvn coherence Affective attitude	So in addition to the box of supplies, we'd offer the opportunity to sign up for text alerts when there is smoke in the Yakima Valley, reminding you about how you can protect yourself and offering additional help. Here's an example of what the text might look like: This might happen 4 or 5 times a year depending on how bad smoke is that year. You'd receive just one text each time, so hopefully this wouldn't feel like a lot of spam. You could unsubscribe at any time. Does anybody have any questions about these texts and what they do? In general, does this concept make sense? Please raise your hand if it does. Can I see a show of hands if receiving these text alerts sounds like something you would be interested in?

Burden	• Could I get a few folks to share about why you might be interested in this? • [pick participant] could you talk a little bit about why you'd be interested? • Does anyone else have anything to add? • [pick participant] could you talk a little bit about why you wouldn't be interested? • Does anyone else want to add anything? Is there anything else you would like or dislike about receiving these text alerts? Can you think of anything that would make it difficult for you or others to receive these texts or use the information in them? Great, thank you!
Overall intervention	Okay, now we'd like to shift and talk a little more broadly about the entire program – the RISE Pack, educational materials, the text alerts and the opportunity to talk to an expert on wildfire smoke. We want to understand how confident you would feel using these resources. Self-efficacy With the information you have now, if you received these resources, how confident would you feel about using them? You can show your response on your fingers, 5 for very confident, and 1 for not confident at all. Thank you! Would anyone like to explain why you chose that number? • [choose participant] Could you share a bit about why you rated it that way? • Would anyone else like to share? Do you have any ideas about how we could improve the plan so that you and other people would have more confidence? Great! Perceived effectiveness Finally, we would like to know how helpful do you think this entire program would be to you, for reducing your family's exposure to wildfire smoke? You can show your response on your fingers, 5 fingers for very helpful, and 1 finger for not helpful at all.

	Thank you! Could someone talk about why you chose that number? • [choose participant] Could you share a bit about how you think these resources would be helpful to you? • Would anyone else like to share? Can you share any suggestions for how to make these resources more effective for Yakima Valley families in general?
Discussion Closing	Thank you for everything you have shared today. Is there anything else you would like to tell us that you haven't gotten a chance to say yet?

Appendix C – RISE Intervention Demonstration PowerPoint Slides Shared During Focus Groups

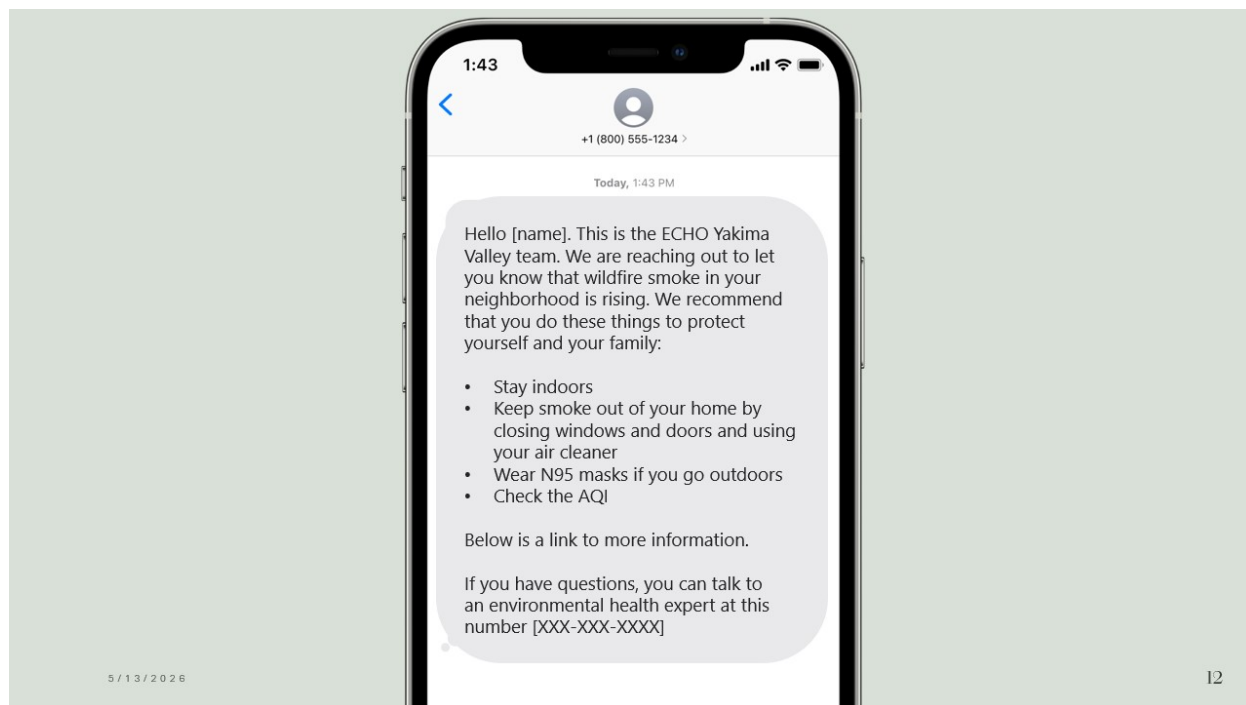
Slide 1 – RISE Pack box including HEPA air cleaner, extension cord, N95 masks, and educational booklet



Slide 2 – Example of educational video



Slide 3 – Example of text message alert during wildfire smoke event



Appendix D – Qualitative Codebook

Code	Definition	Notes or examples
WFS impact	Comments on how wildfire smoke has impacted them, their family members, or other people they know. Can include health impacts.	
Existing resource or behavior	Comments on protective behaviors already taken in the past or existing resources to help protect against wildfire smoke	
Current barriers	Comments on current barriers, unmet needs, lack of resources related to wildfire smoke	
Other people	Comments referring to what other people such as family, friends, neighbors, or general other groups of people, may think of the RISE intervention	For example, a comment that elderly people might benefit from RISE, or that farmworkers might want to protect themselves from wildfire smoke
Hands raised	Response to researchers asking for a show of hands	Example: Researcher 1: Can we get a show of hands for who would be interested in this air cleaner? Researcher 1: I'm seeing all hands raised
Scale of 1-5	Response to researchers asking for a response on a scale of 1 – 5	Example: Researcher 1: On a scale of 1 – 5, can you show on your hand how serious the health problems were? 5 being very serious, 1 being not serious at all Researcher 2: I'll call out the numbers. 2, 3, 3, 5, 1, 2.

Interest	Positive interest in the RISE resources, including own interest or perceptions on other people's interest	
Barriers	Challenges that may make it hard for them or others to use the resource	
Effectiveness	Comments on how well they think the resources will work to reduce wildfire smoke exposure or provide a benefit, for themselves or others	
Confidence	Comments on self-confidence in using the resources (high or low confidence)	
Improvements	Suggestions for improvements to the RISE pack, usually directly from participants but could also include researcher summarizing participant thoughts into potential improvements	This could include suggestions for accessibility, comprehension, clarity, etc
Questions	Questions to researchers that may inform RISE design	Example: Speaker 3: Will the box come with extra filters? Researcher 2: No, just one. (May inform RISE advertisement or booklet content)
Education	Interests in education related to wildfire smoke	
Air cleaner	Comments on HEPA air cleaners	Specifically HEPA – excluding mentions of other air purifiers
Masks	Comments on masks, including N95 masks	

Text alerts	Comments on the text alerts for heavy smoke days	
PEHSU	Comments on access to the phone consultation service	
Quotes	Comments that could be potential standout quotes to highlight in write-up	