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Health research priorities for wildland firefighters: a modified Delphi study with stakeholder interviews

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ABSTRACT

Objectives: The increase in global wildland fire activity has accelerated the urgency to understand health risks associated with wildland fire suppression. The aim of this project was to identify occupational health research priorities for wildland firefighters and related personnel.

Design: In order to identify, rank, and rate health research priorities, we followed a modified Delphi approach. Data collection involved a two-stage online survey followed by semi-structured interviews.

Setting: British Columbia, Canada

Participants: Participants included any current or past wildland firefighter or individuals engaged in related roles. There were 132 respondents to the first survey. Responses to the first survey were analyzed to produce 10 research topics which were ranked by 75 participants in the second survey (response rate: 84%).

Primary and secondary outcome measures: The primary outcome was the identification, ranking, and level of agreement of research priorities through a two-round online survey. We contextualized these findings through deductive and inductive qualitative content analysis.

Results: The most important research priorities identified were (% consensus): effects of smoke inhalation on respiratory health (89%), fatigue & sleep (80%), mental health (78%), stress (76%), and long-term risk of disease (67%). Interviews were completed with 14 individuals. Two main themes were developed from an inductive content analysis of interview transcripts: 1) understand the dynamic risk environment; and 2) organizational fit of mitigation strategies.

Conclusions: Participants expressed a general concern with the unknown mental and physical health impacts of their jobs, including the long-term risk of morbidity and mortality. Future research must address knowledge gaps in our understanding of the health impacts of wildland

fire and work to develop appropriate mitigation strategies while considering the needs of workers and unpredictable environment.

Registration: Open Science Framework, osf.io/ugz4.

Keywords: wildfires, wildland fires, firefighters, Delphi technique, research priorities

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study has identified research priorities for wildland firefighters and related personnel (including people working in air support, office or managerial roles) based on direct stakeholder involvement
- Semi-structured interviews provide contextualization of ranked research priorities for worker health
- Although conducted to support the identification of provincial funding priorities, national and international participation indicates broad relevance
- Participants lacked a proportional representation of the seasonal and auxiliary staff because the first survey date was before the fire season
- After similar responses between wildland firefighters and personnel in the first survey, the second survey was collapsed to include both which may have resulted in priorities focused on more on wildland firefighters rather than related personnel

INTRODUCTION

Precipitated by climate change, accelerating wildland fire activity has extended fire seasons, increased demand for personnel, and amplified the need to understand health impacts of wildland fire smoke for the public and those engaged in suppression efforts [1-2]. Although there is variation across jurisdictions, wildland fire suppression typically includes a crew of frontline wildland firefighters working on a fire line, with support from related personnel including air support (e.g., water bombers), logistical coordination, and operational management (e.g, incident management teams). The role of a wildland firefighter is distinct from structural firefighting based on differences in smoke exposure, work structure and schedule, physical demands, and other occupational hazards [3]; a unique research focus, approach, and priorities are needed for wildland firefighters.

Health research priority setting is an important component of participatory research approaches and can maximize investments in research for funding organizations and governments [4-5]. Through research priority setting, people who stand to benefit the most from research, known as stakeholders or knowledge users, can contribute to the research process and direct research activities [5]. In relation to wildland fire, stakeholder voices include frontline firefighters, people working in roles related to or supporting direct fire suppression, occupational health and safety policy makers, and researchers. Health research priority setting must be well defined in scope, inclusive with broad representation, relevant to decision makers, and consider the specific research context [4-6].

Research priorities have been established to advance fire suppression knowledge [7] and for understanding general public health impacts of wildland fire smoke [8]. We are not aware of any stakeholder-identified health research priorities related to wildland firefighters or other

personnel involved in wildland fire suppression. Health research priorities are needed to ensure a coordinated and effective research plan, direct research funding by organizations and governments, support the development of appropriate mitigation strategies, and ultimately improve health and wellbeing for all workers engaged in wildland fire suppression. The purpose of this project was to identify health research priorities for wildland firefighters and related personnel.

METHODS

This study is part of a larger project to establish health research funding priorities for the British Columbia Wildfire Service (BCWS) based on gaps in literature and stakeholder priorities. The protocol for this project has been previously published [9] and registered (osf.io/ugz4). To align with public health guidelines on physical distancing during the COVID-19 pandemic, we did not conduct meetings with stakeholders as indicated in our original protocol. Instead, we conducted semi-structured individual interviews with a sample of survey respondents to contextualize research priorities identified in the two-round survey. Research ethics approval was provided by the University of Northern British Columbia Research Ethics Board and informed consent was obtained from all participants.

The Delphi method is a process to gather stakeholder knowledge and experience and is commonly used to identify occupational health research priorities [10-14]. The Delphi process allows for the collection of opinions from a variety of stakeholders followed by the presentation of ideas back to participants in iterative 'rounds' until consensus is reached [14]. For this study, we have followed a modified Delphi method involving a two-stage online survey (SurveyMonkey, California, USA) with follow-up semi-structured interviews. Based on similar work to establish research priorities using a modified Delphi approach, we established *a priori* to

conduct two survey rounds [11-12, 15] and determined consensus was achieved when at least 70% of respondents indicated the research priority was "*very important*" or "*extremely important*" during the second-round survey [16]. Participants were eligible to participate if they were current or past employees of BCWS (as frontline wildland firefighters or in officer/managerial roles), researchers or trainees with an interest in wildland fire, or employed in occupational health and safety. Both surveys included a basic demographic questionnaire querying age, gender, and role as it related to wildland fire. People employed by BCWS were also asked to identify the fire centre most recently worked, years working, and current or prior relevant roles.

Round 1: Identifying research priorities

An invitation to participate in the first survey was circulated via email to BCWS employees, occupational health policy makers, and researchers who had recently published in the field. Participants were asked to list up to 10 research priorities of concern for wildland firefighters and related personnel separately (see supplementary file 1). We conducted an inductive qualitative content analysis [17-19] of responses. Three members of the research team read and re-read open-field responses to identify codes and key concepts provided by participants. Codes were then grouped into categories sharing common features. Discussion was used to reach consensus on final research topics. The two job categories, wildland firefighters and related personnel, were collapsed for the second survey because the topics identified by participants were similar.

Round 2: Rating and ranking research priorities

The second survey was sent to participants who completed the first survey and expressed interest in continuing their participation. In the second survey, respondents were presented with

the research topics identified in survey 1 and asked to indicate the importance of each topic on a modified five-point Likert scale ranging from "*not at all important*" to "*extremely important*" (see supplementary file 2). To prevent a bias resulting from question order, the order of research topics was randomized for each survey respondent.

To determine the relative importance of each research topic, respondents were presented with all research topics and asked to rank them from most important to least important. To calculate the weighted average, each research topic in the data set was multiplied by the rank-weight assigned by each participant before the final means were calculated. For example, a weight of 10 would be given to the respondents' highest priority, 9 to the second highest priority and so on. This was repeated for each respondent's ranked research priorities. The mean weighted average was calculated for each research topic. Participant responses were also separated by job category (e.g., wildland firefighter, aviation crew) to determine if there was any difference in identified research priorities based on role.

Round 3: Semi-structured interviews

Semi-structured interviews allowed the opportunity for additional feedback, for participants to provide a more nuanced description of identified research topics, and to identify specific projects within each umbrella topic. Eligible interview participants were at least 18 years of age and had completed both surveys. We aimed for diversity in our sample based on length of time working in a wildland fire-related role and across different job categories (e.g., researchers, wildland firefighter).

Interviews were conducted by two research team members over Zoom videoconference or telephone. One researcher took detailed field notes. Interviews were between 22-49 minutes in length (average: 34 minutes). The interview schedule (see supplementary file 3) included open

ended questions about work-related health concerns, potential mitigation strategies, and research questions or specific projects for each of the top five ranked research priorities.

Interviews were transcribed verbatim by a study team member. Field notes were used during analysis to provide additional contextual information. Analysis was conducted in two phases using a qualitative content analysis [17-18] by two team members. First, we took a deductive approach to provide examples and nuanced description of each of the research topics identified in the survey. A structured categorization matrix was created for the top 5 research topics based on ranking and consensus. The interview transcripts were coded for correspondence with each research topic (category); only data aligning to the matrix (e.g., matched to a category or research topic) was chosen for the deductive phase of the analysis [18]. Data within each category was examined to determine if any sub-categories were necessary [19]. Items not explicitly aligned to one of the pre-identified research topics were analyzed using an inductive approach to identify additional themes [20]. Inductive open coding was completed to ensure we comprehensively represented content communicated by participants [17-18] and to understand issues discussed by participants not directly related to the pre-identified research topics.

Patient and Public Involvement

Patients were not involved in this study.

RESULTS

Participants

Survey 1 was completed by 132 participants (92 men, 40 women; Table 1). We are unable to calculate a response rate for the first survey because the invitation to participate was primarily circulated through a BCWS mailing list. Survey 2 was sent to 89 potential participants and completed by 75 respondents (response rate: 84%, 48 men, 27 women). Interviews were

conducted with 14 participants: six current or prior wildland firefighters, three researchers or trainees, and five people with administrative or officer roles.

[INSERT TABLE 1]

Research Priorities

More than 900 research areas were suggested from participants in survey 1 which were organized into 10 categories or research topics ranked by participants in survey 2. Consensus was achieved on five of the ten research topics (Figure 1). *Understanding & mitigating effects of smoke inhalation on respiratory health*, *fatigue & sleep*, and *mental health* were the research topics with the greatest consensus. While consensus was not reached across the entire cohort of respondents regarding the priority of *long-term risk & prevalence of disease other than respiratory,* within the subset of wildland firefighters and aviators, there was 81% consensus on the priority of the topic. Additionally, for the research topic *camp conditions*, there was consensus (74%) within the subset of zone and control staff.

[INSERT FIGURE 1]

When looking at the weighted rank of each research priority, the pattern was consistent with those research priorities achieving consensus, with two notable differences. *Work structure & organizational culture* was the fifth topic to satisfy the consensus requirement of a rating greater than 70%; however, it had the sixth highest weighted average. *Long-term risk & prevalence of disease other than respiratory* was ranked 4th by participants when considering the weighted average; however, it did not reach consensus (67%; Table 2). The role of a respondent did not appear to influence the ranking of research priorities. Four of the top five

areas of research as identified through the weighted average (*Understanding & mitigating effects of smoke inhalation on respiratory health*, *fatigue & sleep, mental health, and stress*) also have consensus ratings greater than 70%; therefore, any further research in these four areas would be addressing priority areas as identified by stakeholders.

[INSERT TABLE 2]

Interview Findings

In general, interview participants agreed with the ranked list of research priorities. Based on a deductive analysis of interviews, we generated areas of focus (sub-categories) for three of the top five-ranked research topics (Table 3). For some research topics, no sub-categories were developed.

[INSERT TABLE 3]

From the inductive interview analysis, we developed two overarching principles as themes relevant to every research topic:

1) Understanding the dynamic risk environment: Participants described the importance of understanding health risk and exposure across different roles. For example, people who work in office environments do not face the same exposures:

> *"the office stuff or the staff that are there, I don't think they have the same concerns around smoke exposure and physiological toxins"* (P8, researcher)

This different exposure may translate to different health research priorities. For instance, auxiliary staff who are typically students hired during the summer wildland fire season (typically May – August) may not be as concerned with long-term health risk, when compared to people who work in wildland fire related roles for their entire career:

> *"if we're looking at an older population of firefighters, whether that be more the career wildland firefighters, I think the health priorities, the health shifts a bit. Um, in that, I'd be more concerned about a mixture of cardio-respiratory factors. Um, whether or not long-term exposure to wildland smoke might be related to later in life – like, um, uh, like lung pathologies or you know, if there's any risk factors for cardiovascular disease"* (P6, researcher)

It is also important to understand and explore risks across multiple seasons because the unpredictability in fire activity may contribute to different health risks:

> *"We think of those big fire seasons, 2017, 2018, even 2015, and like the work component is very fatiguing, but um, it's also very engaging. And then we have slower seasons like this one [2020] and we may not think of it as harder on our mental health, because we're not doing as much. But I do think it actually creates different challenges for people. So, I think that's something that we need to be aware of – even though we're not on fires, there are stressors associated with the job and it might actually be harder for people because they [do not] have that active engagement in what we see as really fulfilling work"* (P4, wildland firefighter)

> *"It really depends on the year. Because some, uh, some seasons they're so busy, and some seasons they're so slow. There's going to be like different, there's different things*

people care about in each, kind of different, when things are busy" (P1, wildland firefighter)

Finally, the unpredictable work structure and schedule imposes barriers and challenges to conducting research:

"I mean our unpredictable work schedule could be tough for research, but the way you guys have been sending out like the surveys that we do on our own time has been awesome. Like, if we can just sit down and just take 20 minutes, then by all means. But if you need to like come into our workplace and try to organize that research is a bit tougher" (P3, wildland firefighter)

2) Organizational fit of mitigation strategies: Participants emphasized any mitigation strategy be worker-centred, reflect worker priorities and needs, and be developed with employees. This was reflected in participants discussing management may not always have a feel for what it is like to work on the front-line and any mitigation or management strategy not aligning with organizational realities would have minimal uptake.

*"people are so resistant to like any change, any, and I think it's a part of that whole disparity between management – like this is something else management's pushing down, oh they have no concept, like just ignore it...like that whole dynamic of like, just like, people sitting in office, and us like grinding out there" (*P5, wildland firefighter)

Relatedly, participants discussed how organizational culture and resistance to change could present a barrier to implementing mitigation strategies:

"the biggest challenge I come across is like the 'this is the way we do things' kind of attitude" (P8, researcher)

"And then the organizational culture about, sort of a can-do organization and you know, we can, we get a lot done – yes – we can take care of things, and this is the way we've always done it. And uh, yeah, it's certainly an organization, I think. The – yeah – so just sort of pushing through that organizational culture" (P13, administrative/office role)

DISCUSSION

The aim of this project was to identify health research priorities for wildland firefighters and related personnel. Despite the provincial focus of this work, national and international representation in surveys and our adherence to best practice guidelines for research priority setting [4-5] indicate broad relevance and applicability of our findings. Five research topics achieved consensus across the entire sample: *understanding & mitigating effects of smoke inhalation on respiratory health*, *fatigue & sleep*, *mental health, stress*, and *work structure & organizational culture*. A sixth research topic, *long-term risk & prevalence of disease other than respiratory*, nearly reached consensus (67% agreement) and was ranked highly by all participants. Based on interviews with relevant stakeholders, we have developed specific areas of study within each research topic. We identified two themes common to all research topics: 1) understand the dynamic risk environment across wildland fire seasons and roles; 2) organizational fit of mitigation strategies. Despite a different risk environment, the health concerns identified by participants in the current study parallel those by structural firefighters [21], although there is considerably less knowledge specific to health outcomes associated with wildland fire exposure.

The most important research topic identified by participants was related to smoke exposure and respiratory health, with 89% of participants indicating it was extremely or very important. During interviews, participants focused on the need for a better understanding of the

exposures and health risks associated with wildland fire smoke and the desire for feasible, effective personal protective equipment to protect against smoke inhalation. While many participants mentioned masks, they also noted the difficulties and practicality of wearing a mask in the field while fighting fire for long hours. Two recent papers have explored mask wearing to protect against wildland fire smoke, suggesting they may be effective at reducing particulate matter exposure even if used for only part of a shift; however, neither study reported any data on user experience [22-23]. Ultimately, participants expressed the desire to be engaged in the process of the development of any mitigation strategy and corresponding occupational health policy as essential to ensure uptake.

Participants indicated a need to understand the cumulative mental and physical health toll of both busy and quiet fire seasons, and recovery in the off-season. Of particular concern was the increasing length of fire seasons which can reduce downtime and opportunity to recover. Notably, while the research topic *long-term risk & prevalence of disease other than respiratory* did not reach consensus among the entire sample, it was ranked highly and reached consensus (81%) among people involved in direct fire suppression. Designing and conducting research to understand the cumulative impacts of multiple seasons of wildland fire exposure is a considerable challenge and critical gap in academic literature [24]. Many front-line wildland firefighters in BC are post-secondary students hired as auxiliary employees during the summer (May – August) wildland fire season. The transient and mobile workforce creates considerable challenges to evaluating risk related to morbidity and mortality outcomes over multiple seasons. Similarly, the unpredictability of a given fire season means generating consistent evidence or changes in health outcomes across any one season is challenging due to the variable exposure. For example, some participants mentioned unique challenges during less active fire seasons such

as a different mental health toll from not being able to engage in work they enjoy and find meaningful. Thus, while some fire seasons may be 'quieter' in terms of fire activity and respiratory health risk (e.g., lower smoke exposure), they may impose a different mental health risk. While our research priorities can be used to support researchers to make decisions on prioritizing collective research efforts, findings also suggest the need for sustainable, flexible research infrastructure to adapt and understand variable risk environments.

Limitations

The email invitation to participate was sent in March 2020. This was done to ensure data collection was not impacted by the busiest point in the fire season (typically June – August in BC). Because of this, many auxiliary/seasonal staff had not yet started work and may be underrepresented in our sample. Participants were asked to list their top 10 research priorities for wildland firefighters and related personnel separately in the first survey. Based on very similar research topics identified for both job categories and suggestions by participants in the open field question, we collapsed the two job categories for the stage 2 survey. This may have reduced our ability to tease out specific research topics for related personnel and identified research priorities are likely more applicable to wildland firefighters.

Conclusions

This project represents the first attempt to develop a comprehensive set of research priorities for wildland firefighters and related personnel. Our process included a broad range of stakeholders, from frontline staff to those working in occupational health and safety policy, with national and international representation. Stakeholders consistently identified the need for research to understand the physical and mental health risks of their job, and to work to understand how this risk may lead to long-term morbidity and mortality across multiple fire

seasons or an entire career. Appropriate, feasible mitigation, prevention, and/or management strategies are urgently needed to address health concerns for workers directly or indirectly engaged in wildland fire suppression.

Additional file 1. Survey 1: Identifying health research priorities for wildland firefighters and related personnel.

Additional file 2. Survey 2: Ranking health research priorities for wildland firefighters and related personnel.

Additional file 3. Interview Schedule

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Data sharing statement: No additional data are available.

Ethics approval: This study was approved by the University of Northern British Columbia Research Ethics Board (E2019.1220.076.00)**.**

Author contributions: CP lead study conception and design, data collection, analysis, and manuscript writing. CR was involved in the development, distribution, and analysis of online survey, and assisted in preparation of the manuscript. KB supported interview data collection, transcription, interview analysis, and preparation of the manuscript. TF, EK, and KC provided critical feedback on data collection, study design, assisted with survey and interview analysis. All authors participated in the interpretation of the results, provided critical revision of and approved the final manuscript.

Figure Legends

Figure 1. Consensus rating of research topics.

REFERENCES

1. Pechony O, Shindell DT. Driving forces of global wildfires over the past millennium and the forthcoming century. *Proc Matl Sci U S A* 2010;107(45):19167–70. doi:10.1073/pnas.1003669107
2. Westerling AL. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring. *Phil Trans R Soc B* 2016;371(1696):20150178. doi:10.1098/rstb.2015.0178
3. Booze TF, Reinhardt TE, Quiring SJ, et al. A screening-level assessment of the health risks of chronic smoke exposure for wildland firefighters. *J Occup Health Environ* 2004;1(5):296–305. doi:10.1080/15459620490442500
4. Sibbald SL, Singer PA, Upshur R, et al. Priority setting: what constitutes success? A conceptual framework for successful priority setting. *BMC Health Serv Res* 2009;9:43. doi:10.1186/1472-6963-9-43
5. Viergever RF, Olifson S, Ghaffar A et al. A checklist for health research priority setting: nine common themes of good practice. *Health Res Policy Sys* 2010; 8:36. doi:10.1186/1478-4505-8-36
6. Priority setting for health research: lessons from developing countries. The Working Group on Priority Setting. *Health Policy Plan* 2000;15(2):130–136. doi:10.1093/heapol/15.2.130
7. Sankey S. Blueprint for wildland fire science in Canada (2019-2029). *Natural Resources Canada* 2018. https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/blueprint-wildland-fire-science-canada-2019-2029/21614 (accessed 12 March 2021).

8. Errett NA, Roop HA, Pendergrast C, et al. Building a Practice-Based Research Agenda for Wildfire Smoke and Health: A Report of the 2018 Washington Wildfire Smoke Risk Communication Stakeholder Synthesis Symposium. *Int J Environ Res Public Health* 2019;16(13):2398.
9. Koopmans E, Fyfe T, Eadie M et al. Exploring prevention and mitigation strategies to reduce the health impacts of occupational exposure to wildfires for wildland firefighters and related personnel: protocol of a scoping study. *Syst Rev* 2020;9:119. doi:10.1186/s13643-020-01381-y
10. Okoli C, Pawlowski SD. The Delphi method as a research tool: an example, design considerations and applications. *Information & Management* 2004;42(1):15–29. doi:10.1016/j.im.2003.11.002
11. Iavicoli S, Rondinone B, Marinaccio A, et al. Identification of research priorities in occupational health. *Occup Environ Med* 2005;62:71-72. doi:10.1136/oem.2004.015487
12. Lalloo D, Demou E, Smedley J, et al. Current research priorities for UK occupational physicians and occupational health researchers: a modified Delphi study. *Occup Environ Med* 2018;75(11):830-836. doi: 10.1136/oemed-2018-105114.
13. Jones J, Hunter D. Qualitative Research: Consensus methods for medical and health services research. *BMJ* 1995;311(7001):376–80. doi:10.1136/bmj.311.7001.376
14. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. J *Adv Nurs* 2000;32(4):1008–1015. doi:10.1046/j.1365-2648.2000.t01-1-01567.x
15. Gagliardi D, Rondinone BM, Mirabile M, et al. The perspective of European researchers of national occupational safety and health institutes for contributing to a European

research agenda: a modified Delphi study. BMJ Open. 2017;7(6). doi:10.1136/bmjopen-2016-015336.

16. Kouyoumdjian FG, Schuler A, Mcisaac KE, et al. Using a Delphi process to define priorities for prison health research in Canada. BMJ Open. 2016;6:e010125. Doi: 10.1136/bmjopen-2015-010125.
17. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs* 2008;62(1):107–15. doi:10.1111/j.1365-2648.2007.04569.x
18. Hsieh H-F, Shannon SE. Three Approaches to Qualitative Content Analysis. *Qual Health Res* 2005 Nov;15(9):1277–88. doi:10.1177/1049732305276687
19. Bengtsson M. How to plan and perform a qualitative study using content analysis. *NursingPlus Open* 2016;2:8–14. doi:10.1016/j.npls.2016.01.001
20. Sandström B, Willman A, Svensson B, et al. Perceptions of national guidelines and their (non) implementation in mental healthcare: a deductive and inductive content analysis. *Implementation Sci* 2015;10(1):43. doi:10.1186/s13012-015-0234-0
21. Jahnke SA, Poston WS, Jitnarin N, et al. Health concerns of the U.S. fire service: perspectives from the firehouse. *Am J Health Promot* 2012;27(2):111-118. doi:10.4278/ajhp110311-QUAL-109
22. De Vos AJBM, Cook A, Devine B, Thompson PJ, et al. Effect of protective filters on fire fighter respiratory health during simulated bushfire smoke exposure. *Am J Ind Med* 2006;49(9):740–50. doi:10.1002/ajim.20369
23. Cherry N, Galarneau J-M, Kinniburgh D, et al. Exposure and Absorption of PAHs in Wildland Firefighters: A Field Study with Pilot Interventions. *Annals of Work Exposures and Health* 2020. doi:10.1093/annweh/wxaa064

24. Groot E, Caturay A, Khan Y, et al. A systematic review of the health impacts of occupational exposure to wildland fires. *Int J Occup Med Environ Health* 2019. doi:10.13075/ijomeh.1896.01326

Table 1. Participant demographics.

	Survey 1 (n = 132)	Survey 2 (n=75)	Interviews (n=14)
Gender (n, %)			
Woman	40, 30%	27, 36%	N/A
Man	92, 70%	48, 64%	N/A
Age (n, %)			
20-29	45, 34%	25, 33%	N/A
30-39	41, 31%	23, 31%	N/A
40-49	17, 13%	7, 9%	N/A
50-59	18, 14%	12, 16%	N/A
60+	7, 5%	4, 5%	N/A
No Response	4, 3%	4, 5%	N/A
Role in Last Firefighting Season			
Aviation (e.g., pilot, air attack officer)	2, 2%	1, 1%	0
BCWS PWCC/Fire Centre Staff	25, 19%	13, 17%	2
BCWS Zone Staff	23, 17%	14, 19%	1
Non-BCWS Role (e.g., researcher)	16, 12%	6, 8%	4
Other BCWS Role	18, 14%		0
Wildland firefighter	48, 36%	32, 43%	7
No Response		9, 12%	0
Specific to respondents with BCWS role	**Survey 1 (n=116)**	**Survey 2 (n=66)**	**Interviews (n=11)**
Years of Employment with BCWS			
1-5	48	29	2
6-10	28	13	4
11-15	15	9	4
16-20	11	5	0
21+	14	9	1
Years in Direct Fire Suppression			
0 (n/a)	21	7	3
1-3	14	10	1
4-6	22	13	4
7-9	29	15	1
10-12	14	11	4
13-15	9	4	0
16+	7	5	1
Fire Center Most Recently Working			
Cariboo	13, 10%	6, 8%	1
Coastal	14, 11%	8, 11%	1
Kamloops	26, 20%	18, 24%	3
Northwest	13, 10%	5, 7%	0
Headquarters (PWCC)	10, 8%	5, 7%	2
Prince George	26, 20%	16, 21%	3
Southeast	14, 11%	8, 11%	1
No Response	16, 12%	9, 12%	0

BCWS, British Columbia Wildfire Service; PWCC, Provincial Wildfire Coordination Centre

Table 2. Comparison of Consensus Rating vs. Weighted Average.

Research Priorities	Consensus Rating	Consensus Rank	Weighted Average	Rank
Understanding & mitigating effects of smoke inhalation on respiratory health	89%	1st	7.70	1st
Fatigue & Sleep	80%	2nd	6.49	3rd
Mental health	78%	3rd	6.68	2nd
Stress	76%	4th	6.18	5th
Work structure & organizational culture	71%	5th	5.03	6th
Long-term risk & prevalence of disease other than respiratory	67%	6th	6.41	4th
Nutrition, diet, & hydration	58%	7th	4.59	7th
Fire camp conditions	54%	8th	4.11	8th
Acute injuries & conditions	49%	9th	4.10	9th
Physical fitness & testing	49%	10th	3.68	10th

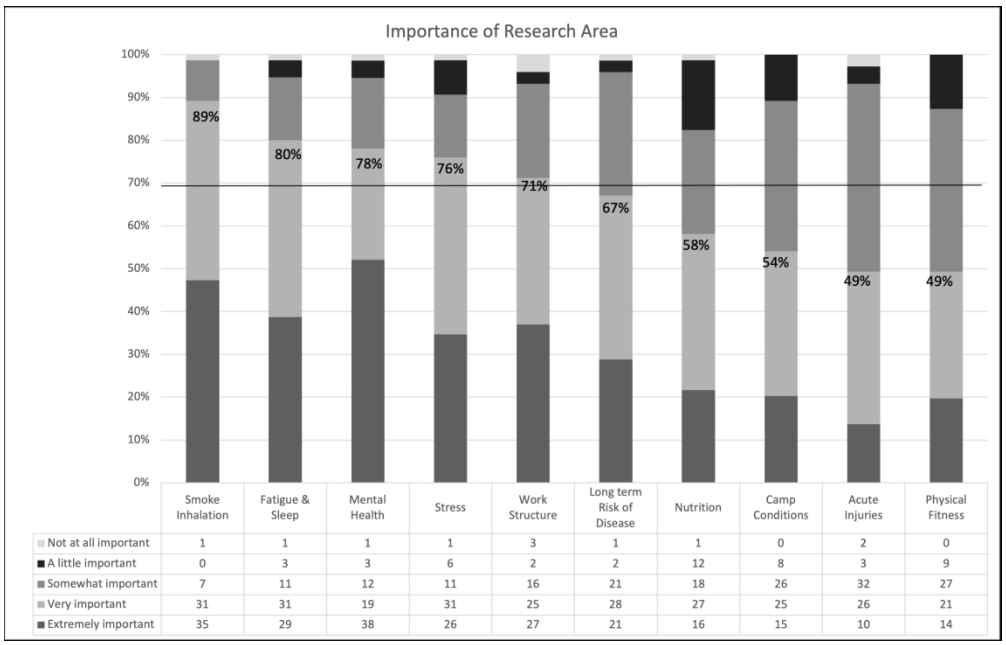
543 Table 3. Top five ranked research topics and areas of focus identified by interview participants through deductive
544 analysis.

Research topic (Category)	Areas of focus (Sub-category)	Examples of Meaning Unit (Quotes)
Understanding & mitigating effects of smoke inhalation on respiratory health	Development of appropriate mitigation strategies	"it's demoralizing sometimes being out there and not having a mask when you see, [like] … Police officers, or other agencies that are assisting us with different things, like not even really in the smoke, and wearing like large masks to protect their health, so. Um, I think it's definitely valuable to continue looking into that and to continue pushing to get us some, um, sort of lung protection. Cause, you, you [sic] definitely feel it., Like after fire season your lung capacity is, um, it's, it's [sic] not what it was at the beginning of the season" (P1, wildland firefighter) "I think most firefighters are pretty aware that it's not good to be breathing in what we're breathing in, but we're just at this standstill of what it seems like finding the right PPE that's appropriate for the job. So, I think research sort of on that more practical side on what, like what apparatus is going to work for us would be really important at this stage" (P4, wildland firefighter) "You know, actual things other than like bring a mask, like if wearing mask is the only way, great. But also, beyond wearing a mask, which I think would take a while to find the right mask and the right buy in, what are the real facts, don't do it? It's like if you're doing it, what's the distances, like a lot of information about, people will be around smoke[sic], probably not wearing masks at some point. What are ways to mitigate, or like mitigate some of those things in alternate ways?" (P5, wildland firefighter)
	Understand exposure	"like the smoke inhalation, like what does that look like? Like what particulates, how much, like exposure, which kind of smoke you're putting in, like how, what factors influence that, like what you're actually doing and how can you like minimize that" (P5, wildland firefighter) "the obvious one that stands out to me, that like, you know, I notice a lot more on the line, is that sort of long-term exposure piece to smoke. Um, it would probably be like fine particulate matter. Cause, there's a lot of times where, you know, in the later stages of a fire we are looking for smoke and looking for heat, and on our hand and knees in very, very [sic] fine ash with no PPE and um, and I think that probably proposes like a significant health risk. Um, I know it's been documented in other fields that kind of any really fine particulate matter like that is detrimental to your lungs, and we just go in with zero PPE and zero information about it" (P14, wildland firefighter)
Fatigue & sleep	Determine optimal amounts of sleep	"what is the optimal amount, amount of sleep that like a firefighter should be getting? Or what is the optimal amount of rest in order to fully, like, kind of reset our minds and reset our bodies, uh to get ready for that next fourteen-day deployment. I don't know, like fourteen to three just seems like it was pulled out of the air, so, um, I'd be curious to know like what, what is the proper amount of rest that we should be getting" (P1, wildland firefighter) "the quality of sleep, the length of shifts and whether or not they're able to achieve – or obtain – quality sleep while they're in the field,

		and whether or not that is, um, impacting on their safety while working" (P6, researcher)
	Understand impacts of long-term fatigue	"the short-term fatigue of like day-to-day, as opposed to the long-term fatigue of a season and how that affects you season to season kind of thing" (P3, wildland firefighter) "when you have, have eight hours off between shifts, including you know going home, cooking a meal, taking a shower, all things that you do at home, so that adds up over time. So yeah, I think it'd be interesting to see how that would affect um kind of like overall fatigue, long term fatigue" (P2, wildland firefighter)
Mental health	Understand mental health impacts during and after fire season	"people kind of just starting out, that you know, everything seems like super, super fun and exciting to start, and then you know, the season ends and the reality of what you went through kind of sinks in" (P1, wildland firefighter) "but you know, the day-to-day and how that effects morale at your base, or how that might affect behaviour dynamics between groups of people when you're stuck out there at a miserable fire for weeks at a time, that should be something that we talk about more" (P10, wildland firefighter/office role)
	Optimize supports and strategies to increase awareness	"Important to have information on what we're getting ourselves into and the long-term effects of this job" (P4, wildland firefighter) "The stigma and not really recognizing some of the effects of, you know, exposure and post-traumatic stress" (P6, researcher) "Some education in that area to people in the field would be good. Cause I think a lot of folks are not you know, aware of the mental toll that this job might have...it's certainly not something that's discussed as a standard as part of the training" (P10, wildland firefighter/office role)

Stress	"It would be interesting to know of the long-term effects of stress. People, people come and typically fight fire for anywhere between 3 and 5 years and they move on because we recruit really heavily from university students. Once they're done their degrees they leave. Um, but I do wonder, especially with the seasons of 2017 and 2018, how much is that taken out of people and like, what are the long-term effects of that?" (P10, wildland firefighter/office role) "Um, in terms of having an off-season and kind of being able to, um, recharge, I guess? And avoiding that burn out. So, it will be interesting to see like in the different roles, and in the different timing, um, how that plays into stress. And the other thing that's come up, is the other work priorities. So, it's not always just wildfire. And I think some of our additional priorities can contribute to stress, and contribute to chronic stress where, um, there's a little bit more push for prevention, and a little bit more push for like chainsaw work and training and stuff like that. Like, you know where we're just sitting waiting for fires, we're pushed to do work, um we're pushed to do other work like all the time. And sometimes even just busy work which might play into that kind of chronic stress, fatigue and not really getting to have a break" (P4, wildland firefighter)
Long-term risk & prevalence of disease other than respiratory	"I don't have a lot of understanding of how the body flushes its stuff out in the winters, but I hope it does. I don't know, I don't know [sic] what's really happening to the body" (P2, wildland firefighter) "But like, seeing the long-term effects of, like even lifespan. I know that's kind of dark but … But I mean, if someone's been doing this since they were eighteen kind of thing, it would be interesting to see how one's been affected… Yeah, their life overall and if they've had cancer pop up – not just lung cancer" (P3, wildland firefighter)

PPE, personal protective equipment



	Smoke Inhalation	Fatigue & Sleep	Mental Health	Stress	Work Structure	Long term Risk of Disease	Nutrition	Camp Conditions	Acute Injuries	Physical Fitness
Not at all important	1	1	1	1	3	1	1	0	2	0
A little important	0	3	3	6	2	2	12	8	3	9
Somewhat important	7	11	12	11	16	21	18	26	32	27
Very important	31	31	19	31	25	28	27	25	26	21
Extremely important	35	29	38	26	27	21	16	15	10	14

Figure 1

Who is conducting the study?

Principal Investigator:	Co-Investigator:
Chelsea Pelletier	Trina Fyfe
School of Health Sciences	Northern Medical Program
University of Northern British Columbia	University of Northern British Columbia
Prince George, BC V2N 4Z9	Prince George, BC V2N 4Z9
chelsea.pelletier@unbc.ca 250-960-5283	trina.fyfe@unbc.ca 250-960-5195

Who is funding this study?

This project is funded by the BC Wildfire Service (BCWS) through the Canadian Partnership for Wildfire Science (Canada Wildfire).

Why are we doing this study?

You are being invited to take part in this research study because you are a current or past wildland firefighter, someone who works in wildfire operations or management, or a researcher who has or is studying the health and wellbeing of wildland firefighters, or someone who works in occupational health and safety. We are doing this study to identify research priorities in the area of health and wellbeing of wildland firefighters. We are conducting this project in partnership with BCWS to develop a strategic 5-year research program based on identified priorities and gaps in current knowledge.

What will happen during the project?

If you decide you would like to participate in this study, we will ask you to complete two online surveys, each one should take approximately 10-15 minutes to complete.

The first (current survey) will ask you to list up to 10 research priorities related to the health and wellbeing of wildland firefighters and up to 10 research priorities for wildland fire related personnel. We will analyze the results from this survey and identify the most commonly identified research topics.

We will send you a second survey (approximately 1-2 months from now) that will ask you to rank the research topics identified in the first survey.

Is there any way that participating in this study could harm you?

We do not think there is anything in this study that could harm you. Thinking about health and wellbeing related to your job may upset you or make you think about past or current stresses or emotions. If, at any point in the study, you feel uncomfortable or upset and wish to end your participation, you are able to simply close the browser window and exit. If you would like to discuss any of these feelings, please reach out to the counsellors available to you through the Safe Reporting Line. This line is confidential and BCWS will not know if you called them or what you discussed. You may also access emotional support or other resources through the Crisis Line Association of BC at 310-6789 (toll free anywhere in BC, no area code needed). We will not send you the second survey unless you provide your contact information and submit the first survey.

How will your identity be protected?

Your anonymity will be respected. Although we will be asking for your personal email address, this will only be used to send you the second survey (ranking priorities) and will not be linked with your responses. BCWS will only receive aggregate group data and will not find out if you chose to participate in this study or not.

This online survey is be conducting using SurveyMonkey licensed through the University of Northern British Columbia. An American company owns the software, but data from our survey is stored on Canadian servers. If there are any technical problems during data collection, your data may be accessed by SurveyMonkey companies in the United States of America, Ireland, or Australia for the purpose of implementing, maintaining, repairing, troubleshooting or upgrading services provided by SurveyMonkey. All information stored on SurveyMonkey servers will be deleted 1-month after the survey closes and transferred into a spreadsheet that will be de-identified (your email address removed) and stored on a password-protected computer in a locked office on the UNBC campus. Only the investigators and study staff will have access to raw data. We will keep this data for a period of 5-years and then it will be destroyed. Electronic copies will be deleted and any paper copies will be shredded.

Will you be paid for taking part in this research study?

You will have the option of entering a draw to win one of five, $50 amazon gift cards.

How can you hear about the study findings?

The results of this study may be published in academic journal articles, books, and/or conference presentations. A report will also be prepared and shared with the BCWS, presented at BCWS meetings, and may be posted online.

Questions, Concerns or Complaints about the project

If you have any questions about what we are asking of you, please contact the Principal Investigator, Chelsea Pelletier at chelsea.pelletier@unbc.ca, 250-960-5283.

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the UNBC Office of Research at 250-960-6735 or by e-mail at reb@unbc.ca.

Participant Consent and Withdrawal

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. You are free to withdraw from this study at any time by closing your browser. The BCWS will not be aware if you decide to participate in this project or not and it will in no way impact your present or future employment with BCWS or a related agency.

If the questionnaire is completed, it will be assumed that you have given your consent to participate in this study.

* Do you agree to participate in the survey?

- ◯ Yes
- ◯ No

If you would like to receive an emailed copy of the summary, please provide your email address here:

What is your current age?

With which gender do you most identify?

- Female
- Male
- Gender non-conforming
- Prefer not to answer
- A gender not listed here:

* Are you a current BCWS employee, or auxiliary employee that worked in the 2019 wildfire season?

- Yes
- No

How would you best classify your current role?

- Researcher or research trainee
- Employed in occupational health and safety management or regulations
- Union (e.g., BCGEU) employee
- Other (please specify)

Out of which fire centre were/are you most recently working?

- ○ Cariboo
- ○ Coastal
- ○ Kamloops
- ○ Northwest
- ○ Prince George
- ○ Southeast
- ○ Other (please specify)

What was your primary role with BCWS this past wildfire season (2019)?

- ○ Wildland firefighter
- ○ BCWS PWCC/Fire Centre Staff
- ○ BCWS Zone Staff
- ○ Aviation (i.e. Pilot, Air Attack Officer, etc.)
- ○ Other (please specify)

What other roles, if any, have you participated in previous wildfire seasons, including 2019 (or will be doing in 2020) (select all that apply)?

- ☐ Wildland firefighter
- ☐ BCWS PWCC/Fire Centre Staff
- ☐ BCWS Zone Staff
- ☐ Aviation (i.e. Pilot, Air Attack Officer, etc.)
- ☐ Incident Command Team member
- ☐ Other (please specify)

How many years/seasons have you been an employee of BCWS (not counting 2020)?

How many of these years/seasons worked were spent participating in direct fire supression on the fireline (for example, as a crew member/leader)?

Please list up to 10 topics relating to health and wellbeing of **wildland firefighters** that you think should be the focus of (or priority for) research topics.

Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	

Please list up to 10 topics relating to health and wellbeing of wildland fire **related personnel** (i.e. members of Incident Command teams, Wildfire Officers/Assistants, PWCC/Fire Centre/Zone staff, dispatchers, etc) that you think should be the focus of (or priority for) research projects.

Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	

Please use this space to list more topic areas or make any additional comments.

Thank you for completing Phase 1 of the stakeholder consultation.
Phase 2 will involve ranking the most common answers regarding priority topics for research.
If you would like to participate in Phase 2 please provide your email address below (non-governmental email preferred).

Would you like to be entered into a draw for one of five $50 Amazon gift cards?

- [ ] Yes
- [ ] No

email address

If you would like to contact the research team please email us at: wildfirestudy@unbc.ca

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Who is conducting the study?

Principal Investigator:	Co-Investigator:
Chelsea Pelletier	Trina Fyfe
School of Health Sciences	Northern Medical Program
University of Northern British Columbia	University of Northern British Columbia
Prince George, BC V2N 4Z9	Prince George, BC V2N 4Z9
chelsea.pelletier@unbc.ca 250-960-5283	trina.fyfe@unbc.ca 250-960-5195

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Why are we doing this study?

You are being invited to take part in this research study because you are a current or past wildland firefighter, someone who works in wildfire operations or management, or a researcher who has or is studying the health and wellbeing of wildland firefighters, or someone who works in occupational health and safety. We are doing this study to identify research priorities in the area of health and wellbeing of wildland firefighters. We are conducting this project in partnership with BCWS to develop a strategic 5-year research program based on identified priorities and gaps in current knowledge.

What will happen during the project?

Approximately 2 months ago (March - April 2020), you completed a survey where we asked you to list up to 10 research priorities related to the health and wellbeing of wildland firefighters and up to 10 research priorities for wildland fire related personnel. We have analyzed the findings received from this survey.

In the current survey (Part 2 of this process), we will ask you to rank the research topics identified in the first survey. There were 134 responses received and we have narrowed the responses down to 10 topic areas plus associated subtopics. In this survey we will be asking you to rank the priority of each of these topics so we are able to determine what topic should be studied first.

Is there any way that participating in this study could harm you?

We do not think there is anything in this study that could harm you. Thinking about health and wellbeing related to your job may upset you or make you think about past or current stresses or emotions. If, at any point in the study, you feel uncomfortable or upset and wish to end your participation, you are able to simply close the browser window and exit. If you would like to discuss any of these feelings, please reach out to the counsellors available to you through the Safe Reporting Line. This line is confidential and BCWS will not know if you called them or what you discussed. You may also access emotional support or other resources through the Crisis Line Association of BC at 310-6789 (toll free anywhere in BC, no area code needed).

How will your identity be protected?

Your anonymity will be respected. In this survey, we will not be asking for any identifiable information (such as your email address). BCWS will only receive aggregate group data and will not find out if you chose to participate in this study or not.

This online survey is be conducting using SurveyMonkey licensed through the University of Northern British Columbia. An American company owns the software, but data from our survey is stored on Canadian servers. If there are any technical problems during data collection, your data may be accessed by SurveyMonkey companies in the United States of America, Ireland, or Australia for the purpose of implementing, maintaining, repairing, troubleshooting or upgrading services provided by SurveyMonkey. All information stored on SurveyMonkey servers will be deleted 1-month after the survey closes and transferred into a spreadsheet that will be stored on a password-protected computer in a locked office on the UNBC campus. Only the investigators and study staff will have access to raw data. We will keep this data for a period of 5-years and then it will be destroyed. Electronic copies will be deleted and any paper copies will be shredded.

Will you be paid for taking part in this research study?

You will have the option of entering a draw to win one of five, $50 amazon gift cards.

How can you hear about the study findings?

The results of this study may be published in academic journal articles, books, and/or conference presentations. A report will also be prepared and shared with the BCWS, presented at BCWS meetings, and may be posted online.

Questions, Concerns or Complaints about the project

If you have any questions about what we are asking of you, please contact the Principal Investigator, Chelsea Pelletier at chelsea.pelletier@unbc.ca, 250-960-5283.

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the UNBC Office of Research at 250-960-6735 or by e-mail at reb@unbc.ca.

Participant Consent and Withdrawal

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. You are free to withdraw from this study at any time by closing your browser. The BCWS will not be aware if you decide to participate in this project or not and it will in no way impact your present or future employment with BCWS or related agency.
If the questionnaire is completed, it will be assumed that you have given your consent to participate in this study.

* Do you agree to participate in the survey?

- ◯ Yes
- ◯ No

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

What is your current age?

With which gender do you most identify?

- Female
- Male
- Gender non-conforming
- Prefer not to answer
- A gender not listed here:

* Are you a current BCWS employee, or auxiliary employee that worked in the 2019 wildfire season?

- Yes
- No

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

How would you best classify your current role?

- ○ Researcher or research trainee
- ○ Employed in occupational health and safety management or regulations
- ○ Union (e.g., BCGEU) employee
- ○ Other (please specify)

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Out of which fire centre were/are you most recently working?

- Cariboo
- Coastal
- Kamloops
- Northwest
- Prince George
- Southeast
- Other (please specify)

What was your primary role with BCWS this past wildfire season (2019)?

- Wildland firefighter
- BCWS PWCC/Fire Centre Staff
- BCWS Zone Staff
- Aviation (i.e. Pilot, Air Attack Officer, etc.)
- Other (please specify)

What other roles, if any, have you participated in previous wildfire seasons, including 2019 (or currently are doing in 2020) (select all that apply)?

- [ ] Wildland firefighter
- [ ] BCWS PWCC/Fire Centre Staff
- [ ] BCWS Zone Staff
- [ ] Aviation (i.e. Pilot, Air Attack Officer, etc.)
- [ ] Incident Team Management
- [ ] Other (please specify)

How many years/seasons have you been an employee of BCWS (not counting 2020)?

How many of these years/seasons worked were spent participating in direct fire supression on the fireline (for example, as a crew member/leader)?

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

For the following questions focus the research topics, each with a list of subtopics or example research projects. Please indicate how important each topic is based on relevance to you personally and the BCWS, and urgency (eg, what topic should we give priority to?)

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Understanding and mitigating effects of smoke inhalation on respiratory/lung health
This may include as projects or sub-topics such as:

- Ability to estimate exposure in field (CO, PM)
- Exposure based on different fireline tasks
- Air quality at fire camp
- PPE/mask development and validation

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Long-term risk and prevalence of disease other than respiratory (cardiovascular, cancer)
This may include as projects or sub-topics such as:

- Understanding exposure through skin and clothing

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Physical fitness & testing

This may include as projects or sub-topics such as:

- Time for exercise during shift and maintaining fitness through season
- Effective fitness programs
- Testing fitness protocol development/optimization

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Fire camp conditions
This may include as projects or sub-topics such as:

- Hygiene and spread of disease
- Safety

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Nutrition, diet, & hydration
This may include as projects or sub-topics such as:

- Understanding optimal nutrition for performance
- Access to foods that meet personal preference and dietary needs

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Acute injuries & conditions
This may include as projects or sub-topics such as:

- Soft tissue injuries
- Musculoskeletal injuries
- Repetitive strain and ergonomics
- Heat stress

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Fatigue & Sleep
This may include as projects or sub-topics such as:

- Cognitive fatigue and decision making
- Fatigue management
- Cumulative fatigue
- Burnout
- Compassion fatigue
- Sleep hygiene

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Stress

This may include as projects or sub-topics such as:

- Elevated stress hormones
- Stress management
- Understanding impact of chronic stress

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Mental health
This may include as projects or sub-topics such as:

- Depression
- Social/emotional health
- PTSD
- Exposure to trauma
- Impact of public pressure and dealing with the public
- Supporting resilience

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Work structure & organizational culture
This may include as projects or sub-topics such as:

- Work/life balance
- Shift hours/length and on/off time
- Distance from families
- Gender bias
- Stigma
- Racial discrimination
- Harassment/discrimination
- Experiences of minority personnel (female, Indigenous peoples, non-cis, non-white)

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha
2

Please rank the research topics from most (1) to least important (10). Consider that while each of these topics are important, if you had to choose, where do you think we should start? What is the most relevant to you personally and the BCWS? And what is the most urgent?

≣

Understanding and mitigating effects of smoke inhalation on respiratory/lung health

≣

Long-term risk and prevalence of disease other than respiratory (cardiovascular, cancer)

≣

Physical fitness & testing

≣

Fire camp conditions

≣

Nutrition, diet, & hydration

≣

Acute injuries & conditions

≣

Fatigue & Sleep

≣

Stress

≣

Mental health & resilience

≣

Work structure & organizational culture

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Please use this space to list more topic areas or make any additional comments.

Would you like to be entered into a draw for one of five $50 Amazon gift cards?

- [ ] Yes
- [ ] No

email address

If you would like to contact the research team please email us at: wildfirestudy@unbc.ca

Semi-structured interview schedule

Thank you for taking the time to meet with us today. You previously completed two surveys where you were asked to list and then rank health research priorities for wildland firefighters (or wildfire fighters). Today, we would like to talk to you about these research priorities, to find out which ones are most relevant to you, most important to you, and to discuss some specific ideas you may have about a program of research. Although the ranking of priorities from the survey will not change based on our discussion, it will add a more nuanced description of the identified research topics. This interview will last approximately 20-30min. Have you reviewed the consent form? Do you have any questions?

Before we start, can you please confirm if you agree to be recorded?

1. What is your primary role as it relates to wildfire and what region of BC (or BCWS fire centre) do you work in (*if relevant*)? How long have you been in this role and have you done any other roles?
2. Can you tell me about your current understanding of research, if you think it is important for BCWS to support in general?
    a. Are you aware of any research or mitigation strategies in use that you think are particularly helpful or relevant?
3. Thinking about your role (or previous roles), what do you see as the most relevant health concerns or risks?
4. The top research priorities identified in our two round surveys were *1) understanding & mitigating effects of smoke inhalation on respiratory health; 2) fatigue & sleep; 3) mental health; 4) long-term risk & prevalence of disease other than respiratory (e.g., cardiovascular, cancer); 5) stress.*
    a. Do you agree with this ranking?
    b. Are there other topics that you think should be included that were not captured in this list?
    c. Under these broad categories, are there specific projects you would like to see accomplished?
    d. What research questions do you think we should focus on?
5. Do you perceive any specific barriers or challenges in doing this research?
    a. Do you anticipate there would be any barriers to implementing any of the mitigation strategies for these health risks?
6. Do you have anything to add specifically to research and health priorities for wildfire fighters?

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	#4	Present key elements of study design early in the paper	6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	6

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6-8
Bias	#9	Describe any efforts to address potential sources of bias	N/A
Study size	#10	Explain how the study size was arrived at	N/A
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	7/8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7/8
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A
Statistical methods	#12c	Explain how missing data were addressed	N/A
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	9/10
Participants	#13b	Give reasons for non-participation at each stage	N/A
Participants	#13c	Consider use of a flow diagram	N/A

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9/10
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9/10
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Generalisability	#21	Discuss the generalisability (external validity) of the study results	14-16
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

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Health research priorities for wildland firefighters: a modified Delphi study with stakeholder interviews

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Health research priorities for wildland firefighters: a modified Delphi study with stakeholder interviews

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ABSTRACT

Objectives: The increase in global wildland fire activity has accelerated the urgency to understand health risks associated with wildland fire suppression. The aim of this project was to identify occupational health research priorities for wildland firefighters and related personnel.

Design: In order to identify, rank, and rate health research priorities, we followed a modified Delphi approach. Data collection involved a two-stage online survey followed by semi-structured interviews.

Setting: British Columbia, Canada

Participants: Participants included any current or past wildland firefighter or individuals engaged in related roles. There were 132 respondents to the first survey. Responses to the first survey were analyzed to produce 10 research topics which were ranked by 75 participants in the second survey (response rate: 84%).

Primary and secondary outcome measures: The primary outcome was the identification, ranking, and level of agreement of research priorities through a two-round online survey. We contextualized these findings through deductive and inductive qualitative content analysis.

Results: The most important research priorities identified were (% consensus): effects of smoke inhalation on respiratory health (89%), fatigue & sleep (80%), mental health (78%), stress (76%), and long-term risk of disease (67%). Interviews were completed with 14 individuals. Two main themes were developed from an inductive content analysis of interview transcripts: 1) understand the dynamic risk environment; and 2) organizational fit of mitigation strategies.

Conclusions: Participants expressed a general concern with the unknown mental and physical health impacts of their jobs, including the long-term risk of morbidity and mortality. Future research must address knowledge gaps in our understanding of the health impacts of wildland

fire and work to develop appropriate mitigation strategies while considering the needs of workers and unpredictable environment.

Registration: Open Science Framework, osf.io/ugz4.

Keywords: wildfires, wildland fires, firefighters, Delphi technique, research priorities

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Semi-structured interviews provide contextualization of ranked research priorities for worker health
- Most participants were wildland firefighters, with a smaller number of people engaged in related roles
- Limited international and national participation; findings are primarily relevant to British Columbia
- Data collection during the fire season means participants were actively engaged in wildland fire-related tasks

INTRODUCTION

Precipitated by climate change, accelerating wildland fire activity has extended fire seasons, increased demand for personnel, and amplified the need to understand health impacts of wildland fire smoke for the public and those engaged in suppression efforts [1-2]. Although there is variation across jurisdictions, wildland fire suppression typically includes a crew of frontline wildland firefighters working on a fire line, with support from related personnel including air support (e.g., water bombers), logistical coordination, and operational management (e.g, incident management teams). The role of a wildland firefighter is distinct from structural firefighting based on differences in smoke exposure, work structure and schedule, physical demands, and other occupational hazards [3]. Despite accelerating global wildland fire activity, understanding of the health risks from occupational exposure to wildland fire is inconsistent and insufficient to draw conclusions on health outcomes [4,5]. Emerging areas of research focus include mental health, respiratory health (e.g., lung function), thermoregulation, cardiovascular health, and oxidative stress (for a recent comprehensive review of the literature see [5]). A unique research focus, approach, and priorities are needed for wildland firefighters.

Health research priority setting is an important component of participatory research approaches and can maximize investments in research for funding organizations and governments [6,7]. Through research priority setting, people who stand to benefit the most from research, known as stakeholders or knowledge users, can contribute to the research process and direct research activities [6]. In relation to wildland fire, stakeholder voices include frontline firefighters, people working in roles related to or supporting direct fire suppression, occupational health and safety policy makers, and researchers. Health research priority setting must be well

defined in scope, inclusive with broad representation, relevant to decision makers, and consider the specific research context [6-8].

Research priorities have been established to advance fire suppression knowledge [9] and for understanding general public health impacts of wildland fire smoke [10]. We are not aware of any stakeholder-identified health research priorities related to wildland firefighters or other personnel involved in wildland fire suppression. Health research priorities are needed to ensure a coordinated and effective research plan, direct research funding by organizations and governments, support the development of appropriate mitigation strategies, and ultimately improve health and wellbeing for all workers engaged in wildland fire suppression. The purpose of this project was to identify health research priorities for wildland firefighters and related personnel.

METHODS

This study is part of a larger project to establish health research funding priorities for the British Columbia Wildfire Service (BCWS) based on gaps in literature and stakeholder priorities. The protocol for this project has been previously published [11] and registered (osf.io/ugz4). To align with public health guidelines on physical distancing during the COVID-19 pandemic, we did not conduct meetings with stakeholders to discuss research priorities as indicated in our original protocol. Instead, we conducted virtual semi-structured individual interviews with a sample of survey respondents to contextualize identified research priorities, and enable broad representation given COVID-19 public health guidelines on travel and the realities of the wildland fire season. Research ethics approval was provided by the University of Northern British Columbia Research Ethics Board and informed consent was obtained from all participants.

The Delphi method is a process to gather stakeholder knowledge and experience and is commonly used to identify occupational health research priorities [12-16]. The Delphi process allows for the collection of opinions from a variety of stakeholders followed by the presentation of ideas back to participants in iterative 'rounds' until consensus is reached [16]. For this study, we have followed a modified Delphi method involving a two-stage online survey (SurveyMonkey, California, USA) with follow-up semi-structured interviews. We modified a traditional Delphi approach by combining qualitative and quantitative data and by not having an expert panel meeting to achieve consensus following the multiple round survey, instead opting to use this approach to obtain a ranked list of research priorities by inviting stakeholder (e.g., people with lived experience as experts). Based on similar work to establish research priorities using a modified Delphi approach, we established *a priori* to conduct two survey rounds [13,14, 17] and determined consensus was achieved when at least 70% of respondents indicated the research priority was "*very important*" or "*extremely important*" during the second-round survey [18]. Participants were eligible to participate if they were current or past employees of BCWS (as frontline wildland firefighters or in officer/managerial roles), researchers or trainees with an interest in wildland fire, or employed in occupational health and safety. Both surveys included a basic demographic questionnaire querying age, gender, and role as it related to wildland fire. People employed by BCWS were also asked to identify the fire centre most recently worked, years working, and current or prior relevant roles. At the end of each survey, participants could enter a draw to win one of five $50 Amazon gift cards. All interview participants were offered a $10 gift card to a food or retail vendor of their choice.

Round 1: Identifying research priorities

An invitation to participate in the first survey was circulated in March 2020 via email to BCWS employees, occupational health policy makers (identified through our BCWS partners), and researchers who had recently published in the field (e.g., contact information available on websites or as corresponding author). Participants were asked to list up to 10 research priorities of concern for wildland firefighters and up to 10 research priorities for related personnel in two separate lists (see supplementary file 1). We conducted an inductive qualitative content analysis [19-21] of responses. Three members of the research team read and re-read open-field responses to identify codes and key concepts provided by participants. Codes were then grouped into categories sharing common features. Discussion was used to reach consensus on final research topics. The two job categories, wildland firefighters and related personnel, were collapsed for the second survey because the topics identified by participants were similar.

Round 2: Rating and ranking research priorities

The second survey was sent in June 2020 to participants who completed the first survey and expressed interest in continuing their participation. In the second survey, respondents were presented with the research topics identified in survey 1 and asked to indicate the importance of each topic on a modified five-point Likert scale ranging from "*not at all important*" to "*extremely important*" (see supplementary file 2). To prevent a bias resulting from question order, the order of research topics was randomized for each survey respondent.

To determine the relative importance of each research topic, respondents were presented with all research topics and asked to rank them from most important to least important. To calculate the weighted average, each research topic in the data set was multiplied by the rank-weight assigned by each participant before the final means were calculated. For example, a

weight of 10 would be given to the respondents' highest priority, 9 to the second highest priority and so on. This was repeated for each respondent's ranked research priorities. The mean weighted average was calculated for each research topic. Participant responses were separated by job category (e.g., wildland firefighter, aviation crew) to determine if there was any difference in identified research priorities based on role.

Round 3: Semi-structured interviews

Semi-structured interviews allowed the opportunity for participants to provide a nuanced description of identified research topics and to identify specific projects within each umbrella topic. Eligible interview participants were at least 18 years of age and had completed both surveys. We aimed for diversity in our sample based on length of time working in a wildland fire-related role and across different job categories (e.g., researchers, wildland firefighter).

Interviews were conducted by two research team members over Zoom videoconference or telephone. One researcher took detailed field notes and the other facilitated the interview using a semi-structured interview schedule. Interviews were between 22-49 minutes in length (average: 34 minutes). The interview schedule (see supplementary file 3) included open ended questions about work-related health concerns, potential mitigation strategies, and research questions or specific projects for each of the top five ranked research priorities.

Interviews were transcribed verbatim by a study team member. Field notes were used during analysis to provide additional contextual information. Analysis was conducted in two phases using a qualitative content analysis [19-20] by two team members. First, we took a deductive approach to provide examples and nuanced description of each of the research topics identified in the survey. A structured categorization matrix was created for the top 5 research topics based on ranking and consensus. The interview transcripts were coded for correspondence

with each research topic (category); only data aligning to the matrix (e.g., matched to a category or research topic) was chosen for the deductive phase of the analysis [20]. Data within each category was examined to determine if any sub-categories were necessary [21]. Items not explicitly aligned to one of the pre-identified research topics were analyzed using an inductive approach to identify additional themes [22]. Inductive open coding was completed to ensure we comprehensively represented content communicated by participants and to understand issues discussed by participants not directly related to the pre-identified research topics [19,20].

Patient and Public Involvement

Patients were not involved in this study.

RESULTS

Participants

Survey 1 was completed by 132 participants (92 males, 40 females; Table 1). We are unable to calculate a response rate for the first survey because the invitation to participate was primarily circulated through a BCWS mailing list. Survey 2 was sent to 89 potential participants and completed by 75 respondents (response rate: 84%, 48 males, 27 females). Interviews were conducted with 14 participants: six current or prior wildland firefighters, three researchers or trainees, and five people with administrative or officer roles.

[INSERT TABLE 1]

Research Priorities

More than 900 research areas were suggested from participants in survey 1 which were organized into 10 categories or research topics ranked by participants in survey 2. Consensus was achieved on five of the ten research topics (Figure 1). *Understanding & mitigating effects of smoke inhalation on respiratory health (89% consensus)*, *fatigue & sleep (80% consensus)*, and

mental health (78% consensus) were the research topics with the greatest consensus. While consensus was not reached across the entire cohort of respondents regarding the priority of *long-term risk & prevalence of disease other than respiratory (67% consensus across entire sample),* within the subset of wildland firefighters and aviators, there was 81% consensus on the priority of the topic. Additionally, for the research topic *camp conditions*, there was consensus (74%) within the subset of zone and control staff.

[INSERT FIGURE 1]

When looking at the weighted rank of each research priority, the pattern was consistent with those research priorities achieving consensus, with two notable differences. *Work structure & organizational culture* was the fifth topic to satisfy the consensus requirement of a rating greater than 70%; however, it had the sixth highest weighted average. *Long-term risk & prevalence of disease other than respiratory* was ranked 4th by participants when considering the weighted average; however, it did not reach consensus (67%; Table 2). The role of a respondent did not appear to influence the ranking of research priorities. Four of the top five areas of research as identified through the weighted average (*Understanding & mitigating effects of smoke inhalation on respiratory health*, *fatigue & sleep, mental health, and stress*) also have consensus ratings greater than 70%; therefore, any further research in these four areas would be addressing priority areas as identified by stakeholders.

[INSERT TABLE 2]

Interview Findings

In general, interview participants agreed with the ranked list of research priorities. Based on a deductive analysis of interviews, we generated areas of focus (sub-categories) for three of the top five-ranked research topics (Table 3). For some research topics, no sub-categories were developed.

[INSERT TABLE 3]

From the inductive interview analysis, we developed two overarching principles as themes relevant to every research topic:

1) Understanding the dynamic risk environment: Participants described the importance of understanding health risk and exposure across different roles. For example, people who work in office environments do not face the same exposures:

> *"the office stuff or the staff that are there, I don't think they have the same concerns around smoke exposure and physiological toxins"* (P8, researcher)

This different exposure may translate to different health research priorities. For instance, auxiliary staff who are typically students hired during the summer wildland fire season (typically May – August) may not be as concerned with long-term health risk when compared to people who work in wildland fire related roles for their entire career:

> *"if we're looking at an older population of firefighters, whether that be more the career wildland firefighters, I think the health priorities, the health shifts a bit. Um, in that, I'd be more concerned about a mixture of cardio-respiratory factors. Um, whether or not long-term exposure to wildland smoke might be related to later in life – like, um, uh, like*

lung pathologies or you know, if there's any risk factors for cardiovascular disease" (P6, researcher)

It is also important to understand and explore risks across multiple seasons because the unpredictability in fire activity may contribute to different health risks:

"We think of those big fire seasons, 2017, 2018, even 2015, and like the work component is very fatiguing, but um, it's also very engaging. And then we have slower seasons like this one [2020] and we may not think of it as harder on our mental health, because we're not doing as much. But I do think it actually creates different challenges for people. So, I think that's something that we need to be aware of – even though we're not on fires, there are stressors associated with the job and it might actually be harder for people because they [do not] have that active engagement in what we see as really fulfilling work" (P4, wildland firefighter)

"It really depends on the year. Because some, uh, some seasons they're so busy, and some seasons they're so slow. There's going to be like different, there's different things people care about in each, kind of different, when things are busy" (P1, wildland firefighter)

Finally, the unpredictable work structure and schedule imposes barriers and challenges to conducting research:

"I mean our unpredictable work schedule could be tough for research, but the way you guys have been sending out like the surveys that we do on our own time has been awesome. Like, if we can just sit down and just take 20 minutes, then by all means. But if you need to like come into our workplace and try to organize that research is a bit tougher" (P3, wildland firefighter)

2) Organizational fit of mitigation strategies: Participants emphasized any mitigation strategy be worker-centred, reflect worker priorities and needs, and be developed with employees. This was reflected in participants discussing management may not always have a feel for what it is like to work on the front-line and any mitigation or management strategy not aligning with organizational realities would have minimal uptake.

> *"people are so resistant to like any change, any, and I think it's a part of that whole disparity between management – like this is something else management's pushing down, oh they have no concept, like just ignore it...like that whole dynamic of like, just like, people sitting in office, and us like grinding out there" (*P5, wildland firefighter)

Relatedly, participants discussed how organizational culture and resistance to change could present a barrier to implementing mitigation strategies:

> *"the biggest challenge I come across is like the 'this is the way we do things' kind of attitude"* (P8, researcher)

> *"And then the organizational culture about, sort of a can-do organization and you know, we can, we get a lot done – yes – we can take care of things, and this is the way we've always done it. And uh, yeah, it's certainly an organization, I think. The – yeah – so just sort of pushing through that organizational culture"* (P13, administrative/office role)

DISCUSSION

Following best practice guidelines for research priority setting [6,7], the aim of this project was to identify health research priorities for wildland firefighters and related personnel. Five research topics achieved consensus across the entire sample: *understanding & mitigating effects of smoke inhalation on respiratory health*, *fatigue & sleep*, *mental health, stress*, and *work structure & organizational culture*. A sixth research topic, *long-term risk & prevalence of*

disease other than respiratory, nearly reached consensus (67% agreement) and was ranked highly by all participants. Based on interviews with relevant stakeholders, we have developed specific areas of study within each research topic. We identified two themes common to all research topics: 1) understand the dynamic risk environment across wildland fire seasons and roles; 2) organizational fit of mitigation strategies. Despite a different risk environment, the health concerns identified by participants in the current study parallel those by structural firefighters [23], although there is considerably less knowledge specific to health outcomes associated with wildland fire exposure and substantial gaps in knowledge on the long-term health impacts [5].

The most important research topic identified by participants was related to smoke exposure and respiratory health, with 89% of participants indicating it was extremely or very important. During interviews, participants focused on the need for a better understanding of the exposures and health risks associated with wildland fire smoke and the desire for feasible, effective personal protective equipment to protect against smoke inhalation. While many participants mentioned masks, they also noted the difficulties and practicality of wearing a mask in the field while fighting fire for long hours. Two recent papers have explored mask wearing to protect against wildland fire smoke, suggesting they may be effective at reducing particulate matter exposure even if used for only part of a shift; however, neither study reported any data on user experience [24,25]. Ultimately, participants expressed the desire to be engaged in the development of any mitigation strategy and corresponding occupational health policy as essential to ensure uptake.

Participants indicated a need to understand the cumulative mental and physical health toll of both busy and quiet fire seasons, and recovery in the off-season. Of particular concern was the

need to understand the risk of chronic fatigue resulting from an increasing length of fire seasons and reduced opportunity to recover. The nature of the occupation typically necessitates sleeping at a fire camp, where wildland firefighters do not typically achieve appropriate quality of quantity of sleep [26-28]. While research has documented poor sleep conditions and reduced cognitive function in-field [26-28], research questions remain about the optimal work to rest schedule for wildland firefighting, strategies for recovery in the off-season, and how to balance sleep hygiene with the realities of wildland fire operations and crew management.

Notably, while the research topic *long-term risk & prevalence of disease other than respiratory* did not reach consensus among the entire sample, it was ranked highly and reached consensus (81%) among people involved in direct fire suppression. Designing and conducting research to understand the cumulative impacts of multiple seasons of wildland fire exposure is a considerable challenge and the long-term health impacts of wildland firefighting are poorly understood [4,5], although we do note ongoing work by the United States National Institute for Occupational Safety and Health [29]. In BC, many front-line wildland firefighters are post-secondary students hired as auxiliary employees during the summer (May – August) wildland fire season. The transient and mobile workforce creates considerable challenges to evaluating risk related to morbidity and mortality outcomes over multiple seasons. Similarly, the unpredictability of a given fire season means generating consistent evidence or changes in health outcomes across any one season is challenging due to the variable exposure. For example, some participants mentioned unique challenges during less active fire seasons such as a different mental health toll from not being able to engage in work they enjoy and find meaningful. Thus, while some fire seasons may be 'quieter' in terms of fire activity and respiratory health risk (e.g., lower smoke exposure), they may impose a different mental health risk. While our research

priorities can be used to support researchers to make decisions on prioritizing collective research efforts, findings also suggest the need for sustainable, flexible research infrastructure to adapt and understand variable risk environments.

Limitations

The email invitation to participate was sent in March 2020. This was done to ensure data collection was not impacted by the busiest point in the fire season (typically June – August in BC). Because of this, many auxiliary/seasonal staff had not yet started work and may be underrepresented in our sample. Participants were asked to list their top 10 research priorities for wildland firefighters and related personnel separately in the first survey. Based on very similar research topics identified for both job categories and suggestions by participants in the open field question, we collapsed the two job categories for the stage 2 survey. This may have reduced our ability to tease out specific research topics for related personnel and identified research priorities are likely more applicable to wildland firefighters. Occupational health policy makers and researchers were identified by convenience sampling through our partnership with BCWS and by extracting contact information from recently published papers in the field, which may have limited the breadth of stakeholder participant perspectives.

Conclusions

This project represents the first attempt to develop a comprehensive set of research priorities for wildland firefighters and related personnel. Our process included a broad range of stakeholders, from frontline staff to those working in occupational health and safety policy, with national and international representation. Stakeholders consistently identified the need for research to understand the physical and mental health risks of their job, and to work to understand how this risk may lead to long-term morbidity and mortality across multiple fire

seasons or an entire career. Appropriate, feasible mitigation, prevention, and/or management strategies are urgently needed to address health concerns for workers directly or indirectly engaged in wildland fire suppression.

Additional file 1. Survey 1: Identifying health research priorities for wildland firefighters and related personnel.

Additional file 2. Survey 2: Ranking health research priorities for wildland firefighters and related personnel.

Additional file 3. Interview Schedule

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Competing interests: The authors declare they have no competing interests.

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Ethics approval: This study was approved by the University of Northern British Columbia Research Ethics Board (E2019.1220.076.00)**.**

Author contributions: CP lead study conception and design, data collection, analysis, and manuscript writing. CR was involved in the development, distribution, and analysis of online survey, and assisted in preparation of the manuscript. KB supported interview data collection,

transcription, interview analysis, and preparation of the manuscript. TF, EK, and KC provided critical feedback on data collection, study design, assisted with survey and interview analysis. All authors participated in the interpretation of the results, provided critical revision of and approved the final manuscript.

Figure Legends

Figure 1. Consensus rating of research topics.

REFERENCES

1. Pechony O, Shindell DT. Driving forces of global wildfires over the past millennium and the forthcoming century. *Proc Matl Sci U S A* 2010;107(45):19167–70. doi:10.1073/pnas.1003669107
2. Westerling AL. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring. *Phil Trans R Soc B* 2016;371(1696):20150178. doi:10.1098/rstb.2015.0178
3. Booze TF, Reinhardt TE, Quiring SJ, et al. A screening-level assessment of the health risks of chronic smoke exposure for wildland firefighters. *J Occup Health Environ* 2004;1(5):296–305. doi:10.1080/15459620490442500
4. Groot E, Caturay A, Khan Y, et al. A systematic review of the health impacts of occupational exposure to wildland fires. *Int J Occup Med Environ Health* 2019;32(2):121-140. doi:10.13075/ijomeh.1896.01326

5. Koopmans E, Cornish K, Fyfe TM, et al. Health risks and mitigation strategies from occupational exposure to wildland fire: a scoping review. *J Occ Med Toxicol* 2021. doi:10.1186/s12995-021-00328-w
6. Sibbald SL, Singer PA, Upshur R, et al. Priority setting: what constitutes success? A conceptual framework for successful priority setting. *BMC Health Serv Res* 2009;9:43. doi:10.1186/1472-6963-9-43
7. Viergever RF, Olifson S, Ghaffar A et al. A checklist for health research priority setting: nine common themes of good practice. *Health Res Policy Sys* 2010; 8:36. doi:10.1186/1478-4505-8-36
8. Priority setting for health research: lessons from developing countries. The Working Group on Priority Setting. *Health Policy Plan* 2000;15(2):130–136. doi:10.1093/heapol/15.2.130
9. Sankey S. Blueprint for wildland fire science in Canada (2019-2029). *Natural Resources Canada* 2018. https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/blueprint-wildland-fire-science-canada-2019-2029/21614 (accessed 12 March 2021).
10. Errett NA, Roop HA, Pendergrast C, et al. Building a Practice-Based Research Agenda for Wildfire Smoke and Health: A Report of the 2018 Washington Wildfire Smoke Risk Communication Stakeholder Synthesis Symposium. *Int J Environ Res Public Health* 2019;16(13):2398.
11. Koopmans E, Fyfe T, Eadie M et al. Exploring prevention and mitigation strategies to reduce the health impacts of occupational exposure to wildfires for wildland firefighters

and related personnel: protocol of a scoping study. *Syst Rev* 2020;9:119. doi:10.1186/s13643-020-01381-y

12. Okoli C, Pawlowski SD. The Delphi method as a research tool: an example, design considerations and applications. *Information & Management* 2004;42(1):15–29. doi:10.1016/j.im.2003.11.002
13. Iavicoli S, Rondinone B, Marinaccio A, et al. Identification of research priorities in occupational health. *Occup Environ Med* 2005;62:71-72. doi:10.1136/oem.2004.015487
14. Lalloo D, Demou E, Smedley J, et al. Current research priorities for UK occupational physicians and occupational health researchers: a modified Delphi study. *Occup Environ Med* 2018;75(11):830-836. doi: 10.1136/oemed-2018-105114.
15. Jones J, Hunter D. Qualitative Research: Consensus methods for medical and health services research. *BMJ* 1995;311(7001):376–80. doi:10.1136/bmj.311.7001.376
16. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. J *Adv Nurs* 2000;32(4):1008–1015. doi:10.1046/j.1365-2648.2000.t01-1-01567.x
17. Gagliardi D, Rondinone BM, Mirabile M, et al. The perspective of European researchers of national occupational safety and health institutes for contributing to a European research agenda: a modified Delphi study. BMJ Open. 2017;7(6). doi:10.1136/bmjopen-2016-015336.
18. Kouyoumdjian FG, Schuler A, Mcisaac KE, et al. Using a Delphi process to define priorities for prison health research in Canada. BMJ Open. 2016;6:e010125. Doi: 10.1136/bmjopen-2015-010125.
19. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs* 2008;62(1):107–15. doi:10.1111/j.1365-2648.2007.04569.x

20. Hsieh H-F, Shannon SE. Three Approaches to Qualitative Content Analysis. *Qual Health Res* 2005 Nov;15(9):1277–88. doi:10.1177/1049732305276687

21. Bengtsson M. How to plan and perform a qualitative study using content analysis. *NursingPlus Open* 2016;2:8–14. doi:10.1016/j.npls.2016.01.001

22. Sandström B, Willman A, Svensson B, et al. Perceptions of national guidelines and their (non) implementation in mental healthcare: a deductive and inductive content analysis. *Implementation Sci* 2015;10(1):43. doi:10.1186/s13012-015-0234-0

23. Jahnke SA, Poston WS, Jitnarin N, et al. Health concerns of the U.S. fire service: perspectives from the firehouse. *Am J Health Promot* 2012;27(2):111-118. doi:10.4278/ajhp110311-QUAL-109

24. De Vos AJBM, Cook A, Devine B, et al. Effect of protective filters on fire fighter respiratory health during simulated bushfire smoke exposure. *Am J Ind Med* 2006;49(9):740–50. doi:10.1002/ajim.20369

25. Cherry N, Galarneau J-M, Kinniburgh D, et al. Exposure and absorption of PAHs in wildland firefighters: a field study with pilot interventions. *Annals of Work Exposures and Health* 2020. doi:10.1093/annweh/wxaa064

26. Jeklin AT, Davies HW, Bredin SSD, et al. Fatigue and sleep patterns among Canadian wildland firefighters during a 17-day fire line deployment. *J Occup Environ Hyg* 2020;17(7–8):364–71.

27. Vincent GE, Aisbett B, Hall SJ, et al. Fighting fire and fatigue: sleep quantity and quality during multi-day wildfire suppression. *Ergonomics* 2016;59(7):932–40.

28. McGillis Z, Dorman SC, Robertson A, et al. Sleep quantity and quality of Ontario wildland firefighters across a low-hazard fire season. *J Occup Environ Med* 2017;59(12):1188–96.

29. The National Institute for Occupational Safety and Health (NIOSH). Wildland firefighter exposure and health effects study, October 15, 2020 [date accessed: October 21, 2021]. https://www.cdc.gov/niosh/topics/firefighting/wffhealthstudy.html

Table 1. Participant demographics.

	Survey 1 (n = 132)	Survey 2 (n=75)	Interviews (n=14)
Gender (n, %)			
Female	40, 30%	27, 36%	N/A
Male	92, 70%	48, 64%	N/A
Age (n, %)			
20-29	45, 34%	25, 33%	N/A
30-39	41, 31%	23, 31%	N/A
40-49	17, 13%	7, 9%	N/A
50-59	18, 14%	12, 16%	N/A
60+	7, 5%	4, 5%	N/A
No Response	4, 3%	4, 5%	N/A
Role in Last Firefighting Season			
Aviation (e.g., pilot, air attack officer)	2, 2%	1, 1%	0
BCWS PWCC/Fire Centre Staff	25, 19%	13, 17%	2
BCWS Zone Staff	23, 17%	14, 19%	1
Non-BCWS Role (e.g., researcher)	16, 12%	6, 8%	4
Other BCWS Role	18, 14%		0
Wildland firefighter	48, 36%	32, 43%	7
No Response		9, 12%	0
Specific to respondents with BCWS role	**Survey 1 (n=116)**	**Survey 2 (n=66)**	**Interviews (n=11)**
Years of Employment with BCWS			
1-5	48	29	2
6-10	28	13	4
11-15	15	9	4
16-20	11	5	0
21+	14	9	1
Years in Direct Fire Suppression			
0 (n/a)	21	7	3
1-3	14	10	1
4-6	22	13	4
7-9	29	15	1
10-12	14	11	4
13-15	9	4	0
16+	7	5	1
Fire Center Most Recently Working			
Cariboo	13, 10%	6, 8%	1
Coastal	14, 11%	8, 11%	1
Kamloops	26, 20%	18, 24%	3
Northwest	13, 10%	5, 7%	0
Headquarters (PWCC)	10, 8%	5, 7%	2
Prince George	26, 20%	16, 21%	3
Southeast	14, 11%	8, 11%	1
No Response	16, 12%	9, 12%	0

BCWS, British Columbia Wildfire Service; PWCC, Provincial Wildfire Coordination Centre

Table 2. Comparison of Consensus Rating vs. Weighted Average.

Research Priorities	Consensus Rating	Consensus Rank	Weighted Average	Rank
Understanding & mitigating effects of smoke inhalation on respiratory health	89%	1st	7.70	1st
Fatigue & Sleep	80%	2nd	6.49	3rd
Mental health	78%	3rd	6.68	2nd
Stress	76%	4th	6.18	5th
Work structure & organizational culture	71%	5th	5.03	6th
Long-term risk & prevalence of disease other than respiratory	67%	6th	6.41	4th
Nutrition, diet, & hydration	58%	7th	4.59	7th
Fire camp conditions	54%	8th	4.11	8th
Acute injuries & conditions	49%	9th	4.10	9th
Physical fitness & testing	49%	10th	3.68	10th

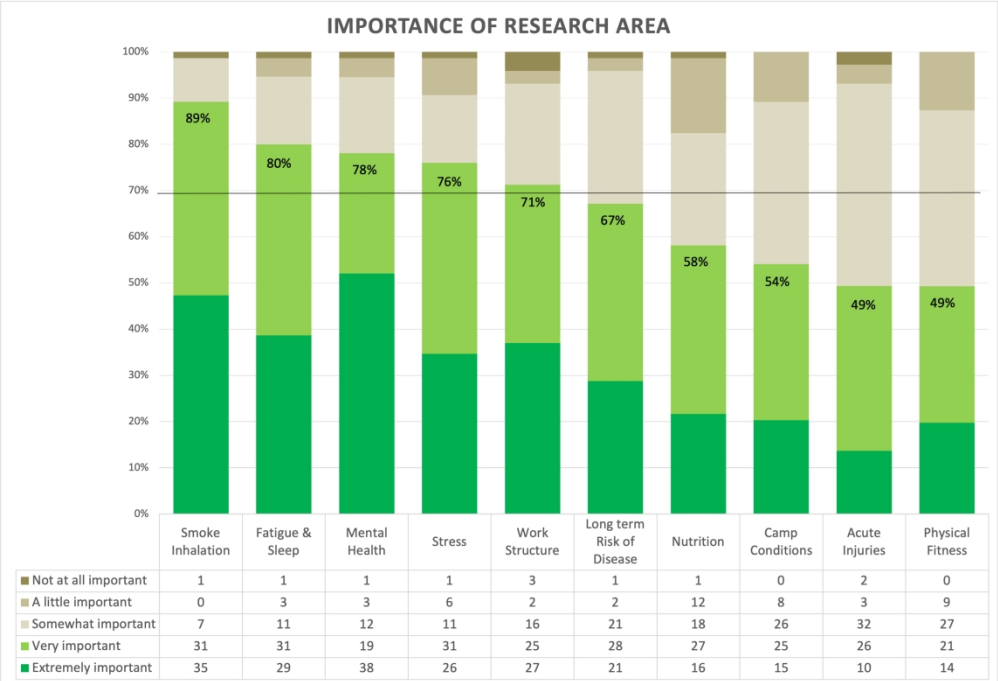
Table 3. Top five ranked research topics and areas of focus identified by interview participants through deductive analysis.

Research topic (Category)	Areas of focus (Sub-category)	Examples of Meaning Unit (Quotes)
Understanding & mitigating effects of smoke inhalation on respiratory health	Development of appropriate mitigation strategies	"it's demoralizing sometimes being out there and not having a mask when you see, [like] … Police officers, or other agencies that are assisting us with different things, like not even really in the smoke, and wearing like large masks to protect their health, so. Um, I think it's definitely valuable to continue looking into that and to continue pushing to get us some, um, sort of lung protection. Cause, you, you [sic] definitely feel it., Like after fire season your lung capacity is, um, it's, it's [sic] not what it was at the beginning of the season" (P1, wildland firefighter)
		"I think most firefighters are pretty aware that it's not good to be breathing in what we're breathing in, but we're just at this standstill of what it seems like finding the right PPE that's appropriate for the job. So, I think research sort of on that more practical side on what, like what apparatus is going to work for us would be really important at this stage" (P4, wildland firefighter)
		"You know, actual things other than like bring a mask, like if wearing mask is the only way, great. But also, beyond wearing a mask, which I think would take a while to find the right mask and the right buy in, what are the real facts, don't do it? It's like if you're doing it, what's the distances, like a lot of information about, people will be around smoke[sic], probably not wearing masks at some point. What are ways to mitigate, or like mitigate some of those things in alternate ways?" (P5, wildland firefighter)
	Understand exposure	"like the smoke inhalation, like what does that look like? Like what particulates, how much, like exposure, which kind of smoke you're putting in, like how, what factors influence that, like what you're actually doing and how can you like minimize that" (P5, wildland firefighter)
		"the obvious one that stands out to me, that like, you know, I notice a lot more on the line, is that sort of long-term exposure piece to smoke. Um, it would probably be like fine particulate matter. Cause, there's a lot of times where, you know, in the later stages of a fire we are looking for smoke and looking for heat, and on our hand and knees in very, very [sic] fine ash with no PPE and um, and I think that probably proposes like a significant health risk. Um, I know it's been documented in other fields that kind of any really fine particulate matter like that is detrimental to your lungs, and we just go in with zero PPE and zero information about it" (P14, wildland firefighter)
Fatigue & sleep	Determine optimal amounts of sleep	"what is the optimal amount, amount of sleep that like a firefighter should be getting? Or what is the optimal amount of rest in order to fully, like, kind of reset our minds and reset our bodies, uh to get ready for that next fourteen-day deployment. I don't know, like fourteen to three just seems like it was pulled out of the air, so, um, I'd be curious to know like what, what is the proper amount of rest that we should be getting" (P1, wildland firefighter)
		"the quality of sleep, the length of shifts and whether or not they're able to achieve – or obtain – quality sleep while they're in the field,

		and whether or not that is, um, impacting on their safety while working" (P6, researcher)
	Understand impacts of long-term fatigue	"the short-term fatigue of like day-to-day, as opposed to the long-term fatigue of a season and how that affects you season to season kind of thing" (P3, wildland firefighter) "when you have, have eight hours off between shifts, including you know going home, cooking a meal, taking a shower, all things that you do at home, so that adds up over time. So yeah, I think it'd be interesting to see how that would affect um kind of like overall fatigue, long term fatigue" (P2, wildland firefighter)
Mental health	Understand mental health impacts during and after fire season	"people kind of just starting out, that you know, everything seems like super, super fun and exciting to start, and then you know, the season ends and the reality of what you went through kind of sinks in" (P1, wildland firefighter) "but you know, the day-to-day and how that effects morale at your base, or how that might affect behaviour dynamics between groups of people when you're stuck out there at a miserable fire for weeks at a time, that should be something that we talk about more" (P10, wildland firefighter/office role)
	Optimize supports and strategies to increase awareness	"Important to have information on what we're getting ourselves into and the long-term effects of this job" (P4, wildland firefighter) "The stigma and not really recognizing some of the effects of, you know, exposure and post-traumatic stress" (P6, researcher) "Some education in that area to people in the field would be good. Cause I think a lot of folks are not you know, aware of the mental toll that this job might have...it's certainly not something that's discussed as a standard as part of the training" (P10, wildland firefighter/office role)

Stress	"It would be interesting to know of the long-term effects of stress. People, people come and typically fight fire for anywhere between 3 and 5 years and they move on because we recruit really heavily from university students. Once they're done their degrees they leave. Um, but I do wonder, especially with the seasons of 2017 and 2018, how much is that taken out of people and like, what are the long-term effects of that?" (P10, wildland firefighter/office role) "Um, in terms of having an off-season and kind of being able to, um, recharge, I guess? And avoiding that burn out. So, it will be interesting to see like in the different roles, and in the different timing, um, how that plays into stress. And the other thing that's come up, is the other work priorities. So, it's not always just wildfire. And I think some of our additional priorities can contribute to stress, and contribute to chronic stress where, um, there's a little bit more push for prevention, and a little bit more push for like chainsaw work and training and stuff like that. Like, you know where we're just sitting waiting for fires, we're pushed to do work, um we're pushed to do other work like all the time. And sometimes even just busy work which might play into that kind of chronic stress, fatigue and not really getting to have a break" (P4, wildland firefighter)
Long-term risk & prevalence of disease other than respiratory	"I don't have a lot of understanding of how the body flushes its stuff out in the winters, but I hope it does. I don't know, I don't know [sic] what's really happening to the body" (P2, wildland firefighter) "But like, seeing the long-term effects of, like even lifespan. I know that's kind of dark but … But I mean, if someone's been doing this since they were eighteen kind of thing, it would be interesting to see how one's been affected… Yeah, their life overall and if they've had cancer pop up – not just lung cancer" (P3, wildland firefighter)

PPE, personal protective equipment



	Smoke Inhalation	Fatigue & Sleep	Mental Health	Stress	Work Structure	Long term Risk of Disease	Nutrition	Camp Conditions	Acute Injuries	Physical Fitness
Not at all important	1	1	1	1	3	1	1	0	2	0
A little important	0	3	3	6	2	2	12	8	3	9
Somewhat important	7	11	12	11	16	21	18	26	32	27
Very important	31	31	19	31	25	28	27	25	26	21
Extremely important	35	29	38	26	27	21	16	15	10	14

Figure 1

271x185mm (300 x 300 DPI)

Who is conducting the study?

Principal Investigator:	Co-Investigator:
Chelsea Pelletier	Trina Fyfe
School of Health Sciences	Northern Medical Program
University of Northern British Columbia	University of Northern British Columbia
Prince George, BC V2N 4Z9	Prince George, BC V2N 4Z9
chelsea.pelletier@unbc.ca 250-960-5283	trina.fyfe@unbc.ca 250-960-5195

Who is funding this study?

This project is funded by the BC Wildfire Service (BCWS) through the Canadian Partnership for Wildfire Science (Canada Wildfire).

Why are we doing this study?

You are being invited to take part in this research study because you are a current or past wildland firefighter, someone who works in wildfire operations or management, or a researcher who has or is studying the health and wellbeing of wildland firefighters, or someone who works in occupational health and safety. We are doing this study to identify research priorities in the area of health and wellbeing of wildland firefighters. We are conducting this project in partnership with BCWS to develop a strategic 5-year research program based on identified priorities and gaps in current knowledge.

What will happen during the project?

If you decide you would like to participate in this study, we will ask you to complete two online surveys, each one should take approximately 10-15 minutes to complete.

The first (current survey) will ask you to list up to 10 research priorities related to the health and wellbeing of wildland firefighters and up to 10 research priorities for wildland fire related personnel. We will analyze the results from this survey and identify the most commonly identified research topics.

We will send you a second survey (approximately 1-2 months from now) that will ask you to rank the research topics identified in the first survey.

Is there any way that participating in this study could harm you?

We do not think there is anything in this study that could harm you. Thinking about health and wellbeing related to your job may upset you or make you think about past or current stresses or emotions. If, at any point in the study, you feel uncomfortable or upset and wish to end your participation, you are able to simply close the browser window and exit. If you would like to discuss any of these feelings, please reach out to the counsellors available to you through the Safe Reporting Line. This line is confidential and BCWS will not know if you called them or what you discussed. You may also access emotional support or other resources through the Crisis Line Association of BC at 310-6789 (toll free anywhere in BC, no area code needed). We will not send you the second survey unless you provide your contact information and submit the first survey.

How will your identity be protected?

Your anonymity will be respected. Although we will be asking for your personal email address, this will only be used to send you the second survey (ranking priorities) and will not be linked with your responses. BCWS will only receive aggregate group data and will not find out if you chose to participate in this study or not.

This online survey is be conducting using SurveyMonkey licensed through the University of Northern British Columbia. An American company owns the software, but data from our survey is stored on Canadian servers. If there are any technical problems during data collection, your data may be accessed by SurveyMonkey companies in the United States of America, Ireland, or Australia for the purpose of implementing, maintaining, repairing, troubleshooting or upgrading services provided by SurveyMonkey. All information stored on SurveyMonkey servers will be deleted 1-month after the survey closes and transferred into a spreadsheet that will be de-identified (your email address removed) and stored on a password-protected computer in a locked office on the UNBC campus. Only the investigators and study staff will have access to raw data. We will keep this data for a period of 5-years and then it will be destroyed. Electronic copies will be deleted and any paper copies will be shredded.

Will you be paid for taking part in this research study?

You will have the option of entering a draw to win one of five, $50 amazon gift cards.

How can you hear about the study findings?

The results of this study may be published in academic journal articles, books, and/or conference presentations. A report will also be prepared and shared with the BCWS, presented at BCWS meetings, and may be posted online.

Questions, Concerns or Complaints about the project

If you have any questions about what we are asking of you, please contact the Principal Investigator, Chelsea Pelletier at chelsea.pelletier@unbc.ca, 250-960-5283.

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the UNBC Office of Research at 250-960-6735 or by e-mail at reb@unbc.ca.

Participant Consent and Withdrawal

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. You are free to withdraw from this study at any time by closing your browser. The BCWS will not be aware if you decide to participate in this project or not and it will in no way impact your present or future employment with BCWS or a related agency.

If the questionnaire is completed, it will be assumed that you have given your consent to participate in this study.

* Do you agree to participate in the survey?

- ◯ Yes
- ◯ No

If you would like to receive an emailed copy of the summary, please provide your email address here:

What is your current age?

With which gender do you most identify?

- Female
- Male
- Gender non-conforming
- Prefer not to answer
- A gender not listed here:

* Are you a current BCWS employee, or auxiliary employee that worked in the 2019 wildfire season?

- Yes
- No

How would you best classify your current role?

- Researcher or research trainee
- Employed in occupational health and safety management or regulations
- Union (e.g., BCGEU) employee
- Other (please specify)

Out of which fire centre were/are you most recently working?

- ○ Cariboo
- ○ Coastal
- ○ Kamloops
- ○ Northwest
- ○ Prince George
- ○ Southeast
- ○ Other (please specify)

What was your primary role with BCWS this past wildfire season (2019)?

- ○ Wildland firefighter
- ○ BCWS PWCC/Fire Centre Staff
- ○ BCWS Zone Staff
- ○ Aviation (i.e. Pilot, Air Attack Officer, etc.)
- ○ Other (please specify)

What other roles, if any, have you participated in previous wildfire seasons, including 2019 (or will be doing in 2020) (select all that apply)?

- ☐ Wildland firefighter
- ☐ BCWS PWCC/Fire Centre Staff
- ☐ BCWS Zone Staff
- ☐ Aviation (i.e. Pilot, Air Attack Officer, etc.)
- ☐ Incident Command Team member
- ☐ Other (please specify)

How many years/seasons have you been an employee of BCWS (not counting 2020)?

How many of these years/seasons worked were spent participating in direct fire supression on the fireline (for example, as a crew member/leader)?

Please list up to 10 topics relating to health and wellbeing of **wildland firefighters** that you think should be the focus of (or priority for) research topics.

Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	

Please list up to 10 topics relating to health and wellbeing of wildland fire **related personnel** (i.e. members of Incident Command teams, Wildfire Officers/Assistants, PWCC/Fire Centre/Zone staff, dispatchers, etc) that you think should be the focus of (or priority for) research projects.

Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	

Please use this space to list more topic areas or make any additional comments.

Thank you for completing Phase 1 of the stakeholder consultation.
Phase 2 will involve ranking the most common answers regarding priority topics for research.
If you would like to participate in Phase 2 please provide your email address below (non-governmental email preferred).

Would you like to be entered into a draw for one of five $50 Amazon gift cards?

- [ ] Yes
- [ ] No

email address

If you would like to contact the research team please email us at: wildfirestudy@unbc.ca

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Who is conducting the study?

Principal Investigator:	Co-Investigator:
Chelsea Pelletier	Trina Fyfe
School of Health Sciences	Northern Medical Program
University of Northern British Columbia	University of Northern British Columbia
Prince George, BC V2N 4Z9	Prince George, BC V2N 4Z9
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What will happen during the project?

Approximately 2 months ago (March - April 2020), you completed a survey where we asked you to list up to 10 research priorities related to the health and wellbeing of wildland firefighters and up to 10 research priorities for wildland fire related personnel. We have analyzed the findings received from this survey.

In the current survey (Part 2 of this process), we will ask you to rank the research topics identified in the first survey. There were 134 responses received and we have narrowed the responses down to 10 topic areas plus associated subtopics. In this survey we will be asking you to rank the priority of each of these topics so we are able to determine what topic should be studied first.

Is there any way that participating in this study could harm you?

We do not think there is anything in this study that could harm you. Thinking about health and wellbeing related to your job may upset you or make you think about past or current stresses or emotions. If, at any point in the study, you feel uncomfortable or upset and wish to end your participation, you are able to simply close the browser window and exit. If you would like to discuss any of these feelings, please reach out to the counsellors available to you through the Safe Reporting Line. This line is confidential and BCWS will not know if you called them or what you discussed. You may also access emotional support or other resources through the Crisis Line Association of BC at 310-6789 (toll free anywhere in BC, no area code needed).

How will your identity be protected?

Your anonymity will be respected. In this survey, we will not be asking for any identifiable information (such as your email address). BCWS will only receive aggregate group data and will not find out if you chose to participate in this study or not.

This online survey is be conducting using SurveyMonkey licensed through the University of Northern British Columbia. An American company owns the software, but data from our survey is stored on Canadian servers. If there are any technical problems during data collection, your data may be accessed by SurveyMonkey companies in the United States of America, Ireland, or Australia for the purpose of implementing, maintaining, repairing, troubleshooting or upgrading services provided by SurveyMonkey. All information stored on SurveyMonkey servers will be deleted 1-month after the survey closes and transferred into a spreadsheet that will be stored on a password-protected computer in a locked office on the UNBC campus. Only the investigators and study staff will have access to raw data. We will keep this data for a period of 5-years and then it will be destroyed. Electronic copies will be deleted and any paper copies will be shredded.

Will you be paid for taking part in this research study?

You will have the option of entering a draw to win one of five, $50 amazon gift cards.

How can you hear about the study findings?

The results of this study may be published in academic journal articles, books, and/or conference presentations. A report will also be prepared and shared with the BCWS, presented at BCWS meetings, and may be posted online.

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If the questionnaire is completed, it will be assumed that you have given your consent to participate in this study.

* Do you agree to participate in the survey?

- ◯ Yes
- ◯ No

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

What is your current age?

With which gender do you most identify?

- Female
- Male
- Gender non-conforming
- Prefer not to answer
- A gender not listed here:

* Are you a current BCWS employee, or auxiliary employee that worked in the 2019 wildfire season?

- Yes
- No

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

How would you best classify your current role?

- ○ Researcher or research trainee
- ○ Employed in occupational health and safety management or regulations
- ○ Union (e.g., BCGEU) employee
- ○ Other (please specify)

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Out of which fire centre were/are you most recently working?

- Cariboo
- Coastal
- Kamloops
- Northwest
- Prince George
- Southeast
- Other (please specify)

What was your primary role with BCWS this past wildfire season (2019)?

- Wildland firefighter
- BCWS PWCC/Fire Centre Staff
- BCWS Zone Staff
- Aviation (i.e. Pilot, Air Attack Officer, etc.)
- Other (please specify)

What other roles, if any, have you participated in previous wildfire seasons, including 2019 (or currently are doing in 2020) (select all that apply)?

- [ ] Wildland firefighter
- [ ] BCWS PWCC/Fire Centre Staff
- [ ] BCWS Zone Staff
- [ ] Aviation (i.e. Pilot, Air Attack Officer, etc.)
- [ ] Incident Team Management
- [ ] Other (please specify)

How many years/seasons have you been an employee of BCWS (not counting 2020)?

How many of these years/seasons worked were spent participating in direct fire supression on the fireline (for example, as a crew member/leader)?

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

For the following questions focus the research topics, each with a list of subtopics or example research projects. Please indicate how important each topic is based on relevance to you personally and the BCWS, and urgency (eg, what topic should we give priority to?)

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Understanding and mitigating effects of smoke inhalation on respiratory/lung health
This may include as projects or sub-topics such as:

- Ability to estimate exposure in field (CO, PM)
- Exposure based on different fireline tasks
- Air quality at fire camp
- PPE/mask development and validation

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Long-term risk and prevalence of disease other than respiratory (cardiovascular, cancer)
This may include as projects or sub-topics such as:

- Understanding exposure through skin and clothing

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Physical fitness & testing
This may include as projects or sub-topics such as:

- Time for exercise during shift and maintaining fitness through season
- Effective fitness programs
- Testing fitness protocol development/optimization

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Fire camp conditions
This may include as projects or sub-topics such as:

- Hygiene and spread of disease
- Safety

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Nutrition, diet, & hydration
This may include as projects or sub-topics such as:

- Understanding optimal nutrition for performance
- Access to foods that meet personal preference and dietary needs

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Acute injuries & conditions
This may include as projects or sub-topics such as:

- Soft tissue injuries
- Musculoskeletal injuries
- Repetitive strain and ergonomics
- Heat stress

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Fatigue & Sleep
This may include as projects or sub-topics such as:

- Cognitive fatigue and decision making
- Fatigue management
- Cumulative fatigue
- Burnout
- Compassion fatigue
- Sleep hygiene

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Stress

This may include as projects or sub-topics such as:

- Elevated stress hormones
- Stress management
- Understanding impact of chronic stress

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Mental health
This may include as projects or sub-topics such as:

- Depression
- Social/emotional health
- PTSD
- Exposure to trauma
- Impact of public pressure and dealing with the public
- Supporting resilience

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Work structure & organizational culture
This may include as projects or sub-topics such as:

- Work/life balance
- Shift hours/length and on/off time
- Distance from families
- Gender bias
- Stigma
- Racial discrimination
- Harassment/discrimination
- Experiences of minority personnel (female, Indigenous peoples, non-cis, non-white)

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha
2

Please rank the research topics from most (1) to least important (10). Consider that while each of these topics are important, if you had to choose, where do you think we should start? What is the most relevant to you personally and the BCWS? And what is the most urgent?

Understanding and mitigating effects of smoke inhalation on respiratory/lung health

Long-term risk and prevalence of disease other than respiratory (cardiovascular, cancer)

Physical fitness & testing

Fire camp conditions

Nutrition, diet, & hydration

Acute injuries & conditions

Fatigue & Sleep

Stress

Mental health & resilience

Work structure & organizational culture

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Please use this space to list more topic areas or make any additional comments.

Would you like to be entered into a draw for one of five $50 Amazon gift cards?

- [ ] Yes
- [ ] No

email address

If you would like to contact the research team please email us at: wildfirestudy@unbc.ca

Semi-structured interview schedule

Thank you for taking the time to meet with us today. You previously completed two surveys where you were asked to list and then rank health research priorities for wildland firefighters (or wildfire fighters). Today, we would like to talk to you about these research priorities, to find out which ones are most relevant to you, most important to you, and to discuss some specific ideas you may have about a program of research. Although the ranking of priorities from the survey will not change based on our discussion, it will add a more nuanced description of the identified research topics. This interview will last approximately 20-30min. Have you reviewed the consent form? Do you have any questions?

Before we start, can you please confirm if you agree to be recorded?

1. What is your primary role as it relates to wildfire and what region of BC (or BCWS fire centre) do you work in (*if relevant*)? How long have you been in this role and have you done any other roles?
2. Can you tell me about your current understanding of research, if you think it is important for BCWS to support in general?
    a. Are you aware of any research or mitigation strategies in use that you think are particularly helpful or relevant?
3. Thinking about your role (or previous roles), what do you see as the most relevant health concerns or risks?
4. The top research priorities identified in our two round surveys were *1) understanding & mitigating effects of smoke inhalation on respiratory health; 2) fatigue & sleep; 3) mental health; 4) long-term risk & prevalence of disease other than respiratory (e.g., cardiovascular, cancer); 5) stress.*
    a. Do you agree with this ranking?
    b. Are there other topics that you think should be included that were not captured in this list?
    c. Under these broad categories, are there specific projects you would like to see accomplished?
    d. What research questions do you think we should focus on?
5. Do you perceive any specific barriers or challenges in doing this research?
    a. Do you anticipate there would be any barriers to implementing any of the mitigation strategies for these health risks?
6. Do you have anything to add specifically to research and health priorities for wildfire fighters?

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	#4	Present key elements of study design early in the paper	6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	6

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6-8
Bias	#9	Describe any efforts to address potential sources of bias	N/A
Study size	#10	Explain how the study size was arrived at	N/A
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	7/8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7/8
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A
Statistical methods	#12c	Explain how missing data were addressed	N/A
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	9/10
Participants	#13b	Give reasons for non-participation at each stage	N/A
Participants	#13c	Consider use of a flow diagram	N/A

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9/10
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9/10
Discussion			
Key results	#18	Summarise key results with reference to study objectives	14/15
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	16
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14-16
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

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Health research priorities for wildland firefighters: a modified Delphi study with stakeholder interviews

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Health research priorities for wildland firefighters: a modified Delphi study with stakeholder interviews

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ABSTRACT

Objectives: The increase in global wildland fire activity has accelerated the urgency to understand health risks associated with wildland fire suppression. The aim of this project was to identify occupational health research priorities for wildland firefighters and related personnel.

Design: In order to identify, rank and rate health research priorities, we followed a modified Delphi approach. Data collection involved a two-stage online survey followed by semi-structured interviews.

Setting: British Columbia, Canada

Participants: Participants included any current or past wildland firefighter or individuals engaged in related roles. There were 132 respondents to the first survey. Responses to the first survey were analyzed to produce 10 research topics which were ranked by 75 participants in the second survey (response rate: 84%).

Primary and secondary outcome measures: The primary outcome was the identification, ranking and level of agreement of research priorities through a two-round online survey. We contextualized these findings through deductive and inductive qualitative content analysis of semi-structured interviews.

Results: The most important research priorities identified were (% consensus): effects of smoke inhalation on respiratory health (89%), fatigue & sleep (80%), mental health (78%), stress (76%) and long-term risk of disease (67%). Interviews were completed with 14 individuals. Two main themes were developed from an inductive content analysis of interview transcripts: 1) understand the dynamic risk environment; and 2) organizational fit of mitigation strategies.

Conclusions: Participants expressed a general concern with the unknown mental and physical health impacts of their jobs, including the long-term risk of morbidity and mortality. Future

research must address knowledge gaps in our understanding of the health impacts of wildland fire and work to develop appropriate mitigation strategies while considering the needs of workers and unpredictable workplace environment.

Registration: Open Science Framework, osf.io/ugz4.

Keywords: wildfires, wildland fires, firefighters, Delphi technique, research priorities

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Semi-structured interviews provide contextualization of ranked research priorities for worker health
- Most participants were wildland firefighters, with a smaller number of people engaged in related roles
- Limited international and national participation; findings are primarily relevant to British Columbia
- Data collection during the fire season means participants were actively engaged in wildland fire-related tasks

INTRODUCTION

Precipitated by climate change, accelerating wildland fire activity has extended fire seasons, increased demand for personnel, and amplified the need to understand health impacts of wildland fire smoke for the public and those engaged in suppression efforts [1-2]. Although there is variation across jurisdictions, wildland fire suppression typically includes a crew of frontline wildland firefighters working on a fireline, with support from related personnel such as air support (e.g., water bombers), logistical coordination, and operational management (e.g, incident management teams). The role of a wildland firefighter is distinct from structural firefighting based on differences in smoke exposure, work structure and schedule, physical demands, and other occupational hazards [3]. A unique research focus, approach, and priorities are needed for wildland firefighters.

Wildland firefighters are exposed to health hazards from inhalation of known air pollutants (e.g., particular matter, carbon monoxide, and polycyclic hydrocarbons) at levels near or above occupational exposure limits [4,5,6]. Despite accelerating global wildland fire activity, knowledge on the health risks from occupational exposure to wildland fire is broad, inconsistent, and insufficient to draw conclusions on health outcomes [7,8]. To date, the majority of research on the health of wildland firefighters is focused on exploring acute effects of smoke exposure across a single shift or season, with most studies finding a reduction in lung function [9-12] and increased systemic inflammation [13,14]. Modelling exposure data, Navarro et al [15] estimated an increased lung cancer and cardiovascular disease risk among wildland firefighters, although this finding has yet to be confirmed in a prospective or longitudinal trial. Cross-sectional studies have identified associations between career length and occurrence of cardiovascular disease [16] and between wildland fire smoke exposure, oxidative stress, and vascular function [17]. Outside

of the hazards from exposure to wildland fire smoke, wildland firefighters are exposed to occupational stressors due to the nature of the profession (e.g., unpredictable extended deployments, trauma from seeing homes or communities burned) and workplace culture (e.g., masculine dominance). Studies focusing on mental health have identified an increased risk of post-traumatic stress among wildland firefighters and increased suicide risk [18,19]. Fireline deployments have been associated with fatigue resulting from poor sleep quality and quantity [20]. Injuries are also commonly reported following work as a wildland firefighter, related to fire complexity and seasonal timing [21,22]. Few studies have been published evaluating strategies to reduce health risk. The broad focus of these intervention strategies include prescribed drinking interventions to support better thermal regulation [23,24], mask wearing to reduce exposure to particular matter [25,26], and enhanced skin hygiene (e.g., showering, laundering clothing) to reduce polycyclic aromatic hydrocarbon exposure [26].

Health research priority setting is an important component of participatory research approaches, can maximize investments in research for funding organizations and governments and help focus research efforts across broad fields of study [27,28]. Through research priority setting, people who stand to benefit the most from research, known as stakeholders or knowledge users, can contribute to the research process and direct research activities [27]. In relation to wildland fire, stakeholder voices include frontline firefighters, people working in roles related to or supporting direct fire suppression, occupational health and safety policy makers, and researchers. Health research priority setting must be well defined in scope, inclusive with broad representation, relevant to decision makers, and consider the specific research context [27-29].

Research priorities have been established to advance fire suppression knowledge [30] and for understanding general public health impacts of wildland fire smoke [31]. We are not aware of

any stakeholder-identified health research priorities related to wildland firefighters or other personnel involved in wildland fire suppression. Health research priorities are needed to ensure a coordinated and effective research plan, direct research funding by organizations and governments, support the development of appropriate mitigation strategies, and ultimately improve health and wellbeing for all workers engaged in wildland fire suppression. The purpose of this project was to identify health research priorities for wildland firefighters and related personnel.

METHODS

This study is part of a larger project to establish health research funding priorities for the British Columbia Wildfire Service (BCWS) based on gaps in literature and stakeholder priorities. The protocol for this project has been previously published [32] and registered (osf.io/ugz4). To align with public health guidelines on physical distancing during the COVID-19 pandemic, we did not conduct meetings with stakeholders to discuss research priorities as indicated in our original protocol. Instead, we conducted virtual semi-structured individual interviews with a sample of survey respondents to contextualize identified research priorities, and enable broad representation given COVID-19 public health guidelines on travel and the realities of the wildland fire season. Research ethics approval was provided by the University of Northern British Columbia Research Ethics Board and informed consent was obtained from all participants.

The Delphi method is a process to gather stakeholder knowledge and experience and is commonly used to identify occupational health research priorities [33-36]. The Delphi process allows for the collection of opinions from a variety of stakeholders followed by the presentation of ideas back to participants in iterative ‘rounds’ until consensus is reached [37]. For this study,

we have followed a modified Delphi method involving a two-stage online survey (SurveyMonkey, California, USA) with follow-up semi-structured interviews. We modified a traditional Delphi approach by combining qualitative and quantitative data and by not having an expert panel meeting to achieve consensus following the multiple round survey. Instead, we used a modified Delphi approach to obtain a ranked list of research priorities by inviting a broad range of stakeholder (e.g., people with lived experience as experts) participants. Based on similar work to establish research priorities using a modified Delphi approach, we established *a priori* to conduct two survey rounds [33,34,38] and determined consensus was achieved when at least 70% of respondents indicated the research priority was "*very important*" or "*extremely important*" during the second-round survey [39].

Participants were eligible to participate if they were current or past employees of BCWS (as frontline wildland firefighters or in officer/managerial roles), researchers or trainees with an interest in wildland fire, or employed in occupational health and safety. Both surveys included a basic demographic questionnaire querying age, gender, and role as it related to wildland fire. People employed by BCWS were also asked to identify the fire centre most recently worked, years working, and current or prior relevant roles. Interview participants were asked to identify their job role, but we did not collect further demographic information (e.g., age, gender) to protect participant confidentiality. Given the relatively small sample pool, limited number of women working for the BCWS, and sensitive nature of the project in relation to the participants' workplace, the identity of some participants may be easy to deduce based on their fire zone and role and was thus not collected or reported. At the end of each survey, participants could enter a draw to win one of five $50 Amazon gift cards. All interview participants were offered a $10 gift card to a food or retail vendor of their choice.

Round 1: Identifying research priorities

An invitation to participate in the first survey was circulated in March 2020 via email to BCWS employees, occupational health policy makers (identified through our BCWS partners), and researchers who had recently published in the field (e.g., contact information available on websites or as corresponding author). Participants were asked to list up to 10 research priorities of concern for wildland firefighters and up to 10 research priorities for related personnel in two separate lists (see supplementary file 1). We conducted an inductive qualitative content analysis of responses [40-42]. Three members of the research team read and re-read open-field responses to identify codes and key concepts provided by participants. Codes were then grouped into categories sharing common features. Discussion was used to reach consensus on final research topics. The two job categories, wildland firefighters and related personnel, were collapsed for the second survey because the topics identified by participants were similar.

Round 2: Rating and ranking research priorities

The second survey was sent in June 2020 to participants who completed the first survey and expressed interest in continuing their participation. In the second survey, respondents were presented with the research topics identified in survey 1 and asked to indicate the importance of each topic on a modified five-point Likert scale ranging from "*not at all important*" to "*extremely important*" (see supplementary file 2). To prevent a bias resulting from question order, the order of research topics was randomized for each survey respondent.

To determine the relative importance of each research topic, respondents were presented with all research topics and asked to rank them from most important to least important. To calculate the weighted average, each research topic in the data set was multiplied by the rank-weight assigned by each participant before the final means were calculated. For example, a

weight of 10 would be given to the respondents' highest priority, 9 to the second highest priority and so on. This was repeated for each respondent's ranked research priorities. The mean weighted average was calculated for each research topic. Participant responses were separated by job category (e.g., wildland firefighter, aviation crew) to determine if there was any difference in identified research priorities based on role.

Round 3: Semi-structured interviews

Semi-structured interviews allowed the opportunity for participants to provide a nuanced description of identified research topics and to identify specific projects within each umbrella topic. Eligible interview participants were at least 18 years of age and had completed both surveys. We aimed for diversity in our sample based on length of time working in a wildland fire-related role and across different job categories (e.g., researchers, wildland firefighter).

Interviews were conducted by two research team members over Zoom videoconference or telephone. One researcher took detailed field notes and the other facilitated the interview using a semi-structured interview schedule. Interviews were between 22-49 minutes in length (average: 34 minutes). The interview schedule (see supplementary file 3) included open ended questions about work-related health concerns, potential mitigation strategies, and research questions or specific projects for each of the top five ranked research priorities.

Interviews were transcribed verbatim by a study team member. Field notes were used during analysis to provide additional contextual information. Analysis was conducted in two phases using a qualitative content analysis [40,41] by two team members. First, we took a deductive approach to provide examples and nuanced description of each of the research topics identified in the survey. A structured categorization matrix was created for the top 5 research topics based on ranking and consensus. The interview transcripts were coded for correspondence

with each research topic (category); only data aligning to the matrix (e.g., matched to a category or research topic) was chosen for the deductive phase of the analysis [41]. Data within each category was examined to determine if any sub-categories were necessary [42]. Items not explicitly aligned to one of the pre-identified research topics were analyzed using an inductive approach to identify additional themes [43]. Inductive open coding was completed to ensure we comprehensively represented content communicated by participants and to understand issues discussed by participants not directly related to the pre-identified research topics [40,41].

Patient and Public Involvement

Patients were not involved in this study.

RESULTS

Participants

Survey 1 was completed by 132 participants (92 males, 40 females; Table 1). We are unable to calculate a response rate for the first survey because the invitation to participate was primarily circulated through a BCWS mailing list. Survey 2 was sent to 89 potential participants and completed by 75 respondents (response rate: 84%, 48 males, 27 females). Interviews were conducted with 14 participants: six current or prior wildland firefighters, three researchers or trainees, and five people with administrative or officer roles.

[INSERT TABLE 1]

Research Priorities

More than 900 research areas were suggested from participants in survey 1 which were organized into 10 categories or research topics ranked by participants in survey 2. Consensus

was achieved on five of the ten research topics (Figure 1). *Understanding & mitigating effects of smoke inhalation on respiratory health (89% consensus)*, *fatigue & sleep (80% consensus)*, and *mental health (78% consensus)* were the research topics with the greatest consensus. While consensus was not reached across the entire cohort of respondents regarding the priority of *long-term risk & prevalence of disease other than respiratory (67% consensus across entire sample),* within the subset of wildland firefighters and aviators, there was 81% consensus on the priority of the topic. Additionally, for the research topic *camp conditions*, there was consensus (74%) within the subset of zone and control staff.

[INSERT FIGURE 1]

When looking at the weighted rank of each research priority, the pattern was consistent with those research priorities achieving consensus, with two notable differences. *Work structure & organizational culture* was the fifth topic to satisfy the consensus requirement of a rating greater than 70%; however, it had the sixth highest weighted average. *Long-term risk & prevalence of disease other than respiratory* was ranked 4th by participants when considering the weighted average; however, it did not reach consensus (67%; Table 2). The role of a respondent did not appear to influence the ranking of research priorities. Four of the top five areas of research as identified through the weighted average (*Understanding & mitigating effects of smoke inhalation on respiratory health*, *fatigue & sleep, mental health, and stress*) also have consensus ratings greater than 70%; therefore, any further research in these four areas would be addressing priority areas as identified by stakeholders.

[INSERT TABLE 2]

Interview Findings

In general, interview participants agreed with the ranked list of research priorities. Based on a deductive analysis of interviews, we generated areas of focus (sub-categories) for three of the top five-ranked research topics (Table 3). For some research topics, no sub-categories were developed.

[INSERT TABLE 3]

From the inductive interview analysis, we developed two overarching principles as themes relevant to every research topic:

1) Understanding the dynamic risk environment: Participants described the importance of understanding health risk and exposure across different roles. For example, people who work in office environments do not face the same exposures:

> *"the office stuff or the staff that are there, I don't think they have the same concerns around smoke exposure and physiological toxins"* (P8, researcher)

This different exposure may translate to different health research priorities. For instance, auxiliary staff who are typically students hired during the summer wildland fire season (typically May – August) may not be as concerned with long-term health risk when compared to people who work in wildland fire related roles for their entire career:

> *"if we're looking at an older population of firefighters, whether that be more the career wildland firefighters, I think the health priorities, the health shifts a bit. Um, in that, I'd*

be more concerned about a mixture of cardio-respiratory factors. Um, whether or not long-term exposure to wildland smoke might be related to later in life – like, um, uh, like lung pathologies or you know, if there's any risk factors for cardiovascular disease" (P6, researcher)

It is also important to understand and explore risks across multiple seasons because the unpredictability in fire activity may contribute to different health risks:

"We think of those big fire seasons, 2017, 2018, even 2015, and like the work component is very fatiguing, but um, it's also very engaging. And then we have slower seasons like this one [2020] and we may not think of it as harder on our mental health, because we're not doing as much. But I do think it actually creates different challenges for people. So, I think that's something that we need to be aware of – even though we're not on fires, there are stressors associated with the job and it might actually be harder for people because they [do not] have that active engagement in what we see as really fulfilling work" (P4, wildland firefighter)

"It really depends on the year. Because some, uh, some seasons they're so busy, and some seasons they're so slow. There's going to be like different, there's different things people care about in each, kind of different, when things are busy" (P1, wildland firefighter)

Finally, the unpredictable work structure and schedule imposes barriers and challenges to conducting research:

"I mean our unpredictable work schedule could be tough for research, but the way you guys have been sending out like the surveys that we do on our own time has been awesome. Like, if we can just sit down and just take 20 minutes, then by all means. But if

you need to like come into our workplace and try to organize that research is a bit tougher" (P3, wildland firefighter)

2) Organizational fit of mitigation strategies: Participants emphasized any mitigation strategy be worker-centred, reflect worker priorities and needs, and be developed with employees. This was reflected in participants discussing management may not always have a feel for what it is like to work on the front-line and any mitigation or management strategy not aligning with organizational realities would have minimal uptake.

*"people are so resistant to like any change, any, and I think it's a part of that whole disparity between management – like this is something else management's pushing down, oh they have no concept, like just ignore it...like that whole dynamic of like, just like, people sitting in office, and us like grinding out there" (*P5, wildland firefighter)

Relatedly, participants discussed how organizational culture and resistance to change could present a barrier to implementing mitigation strategies:

"the biggest challenge I come across is like the 'this is the way we do things' kind of attitude" (P8, researcher)

"And then the organizational culture about, sort of a can-do organization and you know, we can, we get a lot done – yes – we can take care of things, and this is the way we've always done it. And uh, yeah, it's certainly an organization, I think. The – yeah – so just sort of pushing through that organizational culture" (P13, administrative/office role)

DISCUSSION

Following best practice guidelines for research priority setting [27,28], the aim of this project was to identify health research priorities for wildland firefighters and related personnel. Five research topics achieved consensus across the entire sample: *understanding & mitigating*

effects of smoke inhalation on respiratory health, *fatigue & sleep*, *mental health, stress*, and *work structure & organizational culture*. A sixth research topic, *long-term risk & prevalence of disease other than respiratory*, nearly reached consensus (67% agreement) and was ranked highly by all participants. Based on interviews with relevant stakeholders, we have developed specific areas of study within each research topic. We identified two themes common to all research topics: 1) understand the dynamic risk environment across wildland fire seasons and roles; 2) organizational fit of mitigation strategies. Despite a different risk environment, the health concerns identified by participants in the current study parallel those by structural firefighters [44], although there is considerably less knowledge specific to health outcomes associated with wildland fire exposure and substantial gaps in knowledge on the long-term health impacts [8].

The most important research topic identified by participants was related to smoke exposure and respiratory health, with 89% of participants indicating it was extremely or very important. During interviews, participants focused on the need for a better understanding of the exposures and health risks associated with wildland fire smoke and the desire for feasible, effective personal protective equipment to protect against smoke inhalation. While many participants mentioned masks, they also noted the difficulties and practicality of wearing a mask in the field while fighting fire for long hours. Two recent papers have explored mask wearing to protect against wildland fire smoke, suggesting they may be effective at reducing particulate matter exposure even if used for only part of a shift; however, neither study reported any data on user experience [25,26]. Ultimately, participants expressed the desire to be engaged in the development of any mitigation strategy and corresponding occupational health policy as essential to ensure uptake. Collaborative intervention development can help researchers better understand

the wildland fire occupational context, ensure alignment with organization policy and support effective implementation - a process recently used to develop interventions to address psychosocial health and physical fitness of wildland firefighters in Ontario, Canada [45].

Participants indicated a need to understand the cumulative mental and physical health toll of both busy and quiet fire seasons, and recovery in the off-season. Of particular concern was the need to understand the risk of chronic fatigue resulting from an increasing length of fire seasons and reduced opportunity to recover. The nature of the occupation typically necessitates sleeping at a fire camp, where wildland firefighters do not typically achieve appropriate quality and quantity of sleep [20,46,47]. While research has documented poor sleep conditions and reduced cognitive function in-field [20,46,47], research questions remain about the optimal work to rest schedule for wildland firefighting, strategies for recovery in the off-season, and how to balance sleep hygiene with the realities of wildland fire operations and crew management.

Notably, while the research topic *long-term risk & prevalence of disease other than respiratory* did not reach consensus among the entire sample, it was ranked highly and reached consensus (81%) among people involved in direct fire suppression. Designing and conducting research to understand the cumulative impacts of multiple seasons of wildland fire exposure is a considerable challenge and the long-term health impacts of wildland firefighting are poorly understood [7,8], although we do note ongoing work by the United States National Institute for Occupational Safety and Health [48]. In BC, many front-line wildland firefighters are post-secondary students hired as auxiliary employees during the summer (May – August) wildland fire season. The transient and mobile workforce creates considerable challenges to evaluating risk related to morbidity and mortality outcomes over multiple seasons. Similarly, the unpredictability of a given fire season means generating consistent evidence or changes in health

outcomes across any one season is challenging due to the variable exposure. For example, some participants mentioned unique challenges during less active fire seasons such as a different mental health toll from not being able to engage in work they enjoy and find meaningful. Thus, while some fire seasons may be 'quieter' in terms of fire activity and respiratory health risk (e.g., lower smoke exposure), they may impose a different mental health risk. While our research priorities can be used to support researchers to make decisions on prioritizing collective research efforts, findings also suggest the need for sustainable, flexible research infrastructure to adapt and understand variable risk environments.

Limitations

The email invitation to participate was sent in March 2020. This was done to ensure data collection was not impacted by the busiest point in the fire season (typically June – August in BC). Because of this, many auxiliary/seasonal staff had not yet started work and may be underrepresented in our sample. Participants were asked to list their top 10 research priorities for wildland firefighters and related personnel separately in the first survey. Based on very similar research topics identified for both job categories and suggestions by participants in the open field question, we collapsed the two job categories for the stage 2 survey. This may have reduced our ability to tease out specific research topics for related personnel and identified research priorities are likely more applicable to wildland firefighters. Occupational health policy makers and researchers were identified by convenience sampling through our partnership with BCWS and by extracting contact information from recently published papers in the field, which may have limited the breadth of stakeholder participant perspectives.

Conclusions

This project represents the first attempt to develop a comprehensive set of research priorities for wildland firefighters and related personnel. Our process included a broad range of stakeholders, from frontline staff to those working in occupational health and safety policy, with national and international representation. Stakeholders consistently identified the need for research to understand the physical and mental health risks of their job, and to work to understand how this risk may lead to long-term morbidity and mortality across multiple fire seasons or an entire career. Appropriate, feasible mitigation, prevention, and/or management strategies are urgently needed to address health concerns for workers directly or indirectly engaged in wildland fire suppression.

Additional file 1. Survey 1: Identifying health research priorities for wildland firefighters and related personnel.

Additional file 2. Survey 2: Ranking health research priorities for wildland firefighters and related personnel.

Additional file 3. Interview Schedule

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Data sharing statement: No additional data are available.

Ethics approval: This study was approved by the University of Northern British Columbia Research Ethics Board (E2019.1220.076.00)**.**

Author contributions: CP lead study conception and design, data collection, analysis, and manuscript writing. CR was involved in the development, distribution, and analysis of online survey, and assisted in preparation of the manuscript. KB supported interview data collection, transcription, interview analysis, and preparation of the manuscript. TF, EK, and KC provided critical feedback on data collection, study design, assisted with survey and interview analysis. All authors participated in the interpretation of the results, provided critical revision of and approved the final manuscript.

Figure Legends

Figure 1. Consensus rating of research topics.

REFERENCES

1. Pechony O, Shindell DT. Driving forces of global wildfires over the past millennium and the forthcoming century. *Proc Matl Sci U S A* 2010;107(45):19167–70. doi:10.1073/pnas.1003669107
2. Westerling AL. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring. *Phil Trans R Soc B* 2016;371(1696):20150178. doi:10.1098/rstb.2015.0178
3. Booze TF, Reinhardt TE, Quiring SJ, et al. A screening-level assessment of the health risks of chronic smoke exposure for wildland firefighters. *J Occup Health Environ* 2004;1(5):296–305. doi:10.1080/15459620490442500
4. Navarro KM, Cisneros R, Noth EM, et al. Occupational exposure to polycyclic aromatic hydrocarbon of wildland firefighters at prescribed and wildland fires. *Environ Sci Technol* 2017;51(11):6461-6469. doi: 10.1021/acs.est.7b00950.
5. Miranda AI, Martins V, Cascão P, et al. Wildland smoke exposure values and exhaled breath indicators in firefighters. *J Toxicol Environ Health A* 2012;75(13-15):831-43. doi: 10.1080/15287394.2012.690686
6. Materna BL, Jones JR, Sutton PM, et al. Occupational exposures in California wildland firefighting. *Am Ind Hyg Assoc J* 1992,53:69-76. doi: 10.1080/15298669291359311.
7. Groot E, Caturay A, Khan Y, et al. A systematic review of the health impacts of occupational exposure to wildland fires. *Int J Occup Med Environ Health* 2019;32(2):121-140. doi:10.13075/ijomeh.1896.01326
8. Koopmans E, Cornish K, Fyfe TM, et al. Health risks and mitigation strategies from occupational exposure to wildland fire: a scoping review. *J Occ Med Toxicol* 2021. doi:10.1186/s12995-021-00328-w
9. Gaughan DM, Cox-Ganser JM, Enright PL, et al. Acute upper and lower respiratory effects

in wildland firefighters. *J Occup Environ Med* 2008;50(9):1019.

10. Jacquin L, Michelet P, Brocq FX, et al. Short-term spirometric changes in wildland firefighters. *Am J Ind Med* 2011;54(11):819.
11. Rothman N, Ford DP, Baser ME, et al. Pulmonary function and respiratory symptoms in wildland firefighters. *J Occup Med* 1991;33(11):1163–7.
12. Liu D, Tager IB, Balmes JR, et al. The effect of smoke inhalation on lung function and airway responsiveness in wildland fire fighters. *Am Rev Respir Dis* 1992;146(6):1469.
13. Gianniou N, Giannakopoulou C, Dima E, et al. Acute effects of smoke exposure on airway and systemic inflammation in forest firefighters. *J Asthma Allergy* 2018;11:81–8.
14. Main LC, Wolkow AP, Tait JL, et al. Firefighter's acute inflammatory response to wildfire suppression. *J Occup Environ Med* 2019;18:18.
15. Navarro KM, Kleinman MT, Mackay CE, et al. Wildland firefighter smoke exposure and risk of lung cancer and cardiovascular disease mortality. *Environ Res* 2019;173:462–8.
16. Semmens EO, Domitrovich J, Conway K, et al. A cross-sectional survey of occupational history as a wildland firefighter and health. *Am J Ind Med* 2016;59(4):330.
17. Gaughan DM, Siegel PD, Hughes MD, et al. Arterial stiffness, oxidative stress, and smoke exposure in wildland firefighters. *Am J Ind Med* 2014;57(7):748.
18. McFarlane AC. Relationship between psychiatric impairment and a natural disaster: the role of distress. *Psychol Med* 1988;18(1):129–39.
19. Stanley IH, Hom MA, Gai AR, et al. Wildland firefighters and suicide risk: Examining the role of social disconnectedness. *Psychiatry Res* 2018;266:269–74.

20. Jeklin AT, Davies HW, Bredin SSD, et al. Fatigue and sleep patterns among Canadian wildland firefighters during a 17-day fire line deployment. *J Occup Environ Hyg* 2020;17(7–8):364–71.

21. Britton C, Lynch CF, Ramirez M, et al. Epidemiology of injuries to wildland firefighters. *Am J Emerg Med* 2013;31(2):339–45.

22. Moody VJ, Purchio TJ, Palmer CG. Descriptive analysis of injuries and illnesses self-reported by wildland firefighters. *Int J Wildl Fire* 2019;28(6):412–9.

23. Raines J, Snow R, Petersen A, et al. Pre-shift fluid intake: Effect on physiology, work and drinking during emergency wildfire fighting. *Appl Ergon* 2012;43(3):532.

24. Raines J, Snow R, Petersen A, et al. The effect of prescribed fluid consumption on physiology and work behavior of wildfire fighters. *Appl Ergon* 2013;44(3):404.

25. De Vos AJBM, Cook A, Devine B, et al. Effect of protective filters on fire fighter respiratory health during simulated bushfire smoke exposure. *Am J Ind Med* 2006;49(9):740–50. doi:10.1002/ajim.20369

26. Cherry N, Galarneau J-M, Kinniburgh D, et al. Exposure and absorption of PAHs in wildland firefighters: a field study with pilot interventions. *Annals of Work Exposures and Health* 2020. doi:10.1093/annweh/wxaa064

27. Sibbald SL, Singer PA, Upshur R, et al. Priority setting: what constitutes success? A conceptual framework for successful priority setting. *BMC Health Serv Res* 2009;9:43. doi:10.1186/1472-6963-9-43

28. Viergever RF, Olifson S, Ghaffar A et al. A checklist for health research priority setting: nine common themes of good practice. *Health Res Policy Sys* 2010; 8:36. doi:10.1186/1478-4505-8-36

29. Priority setting for health research: lessons from developing countries. The Working Group on Priority Setting. *Health Policy Plan* 2000;15(2):130–136. doi:10.1093/heapol/15.2.130

30. Sankey S. Blueprint for wildland fire science in Canada (2019-2029). *Natural Resources Canada* 2018. https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/blueprint-wildland-fire-science-canada-2019-2029/21614 (accessed 12 March 2021).

31. Errett NA, Roop HA, Pendergrast C, et al. Building a Practice-Based Research Agenda for Wildfire Smoke and Health: A Report of the 2018 Washington Wildfire Smoke Risk Communication Stakeholder Synthesis Symposium. *Int J Environ Res Public Health* 2019;16(13):2398.

32. Koopmans E, Fyfe T, Eadie M et al. Exploring prevention and mitigation strategies to reduce the health impacts of occupational exposure to wildfires for wildland firefighters and related personnel: protocol of a scoping study. *Syst Rev* 2020;9:119. doi:10.1186/s13643-020-01381-y

33. Okoli C, Pawlowski SD. The Delphi method as a research tool: an example, design considerations and applications. *Information & Management* 2004;42(1):15–29. doi:10.1016/j.im.2003.11.002

34. Iavicoli S, Rondinone B, Marinaccio A, et al. Identification of research priorities in occupational health. *Occup Environ Med* 2005;62:71-72. doi:10.1136/oem.2004.015487

35. Lalloo D, Demou E, Smedley J, et al. Current research priorities for UK occupational physicians and occupational health researchers: a modified Delphi study. *Occup Environ Med* 2018;75(11):830-836. doi: 10.1136/oemed-2018-105114.

36. Jones J, Hunter D. Qualitative Research: Consensus methods for medical and health services research. *BMJ* 1995;311(7001):376–80. doi:10.1136/bmj.311.7001.376

37. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. J *Adv Nurs* 2000;32(4):1008–1015. doi:10.1046/j.1365-2648.2000.t01-1-01567.x

38. Gagliardi D, Rondinone BM, Mirabile M, et al. The perspective of European researchers of national occupational safety and health institutes for contributing to a European research agenda: a modified Delphi study. BMJ Open. 2017;7(6). doi:10.1136/bmjopen-2016-015336.

39. Kouyoumdjian FG, Schuler A, Mcisaac KE, et al. Using a Delphi process to define priorities for prison health research in Canada. BMJ Open. 2016;6:e010125. Doi: 10.1136/bmjopen-2015-010125.

40. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs* 2008;62(1):107–15. doi:10.1111/j.1365-2648.2007.04569.x

41. Hsieh H-F, Shannon SE. Three Approaches to Qualitative Content Analysis. *Qual Health Res* 2005 Nov;15(9):1277–88. doi:10.1177/1049732305276687

42. Bengtsson M. How to plan and perform a qualitative study using content analysis. *NursingPlus Open* 2016;2:8–14. doi:10.1016/j.npls.2016.01.001

43. Sandström B, Willman A, Svensson B, et al. Perceptions of national guidelines and their (non) implementation in mental healthcare: a deductive and inductive content analysis. *Implementation Sci* 2015;10(1):43. doi:10.1186/s13012-015-0234-0

44. Jahnke SA, Poston WS, Jitnarin N, et al. Health concerns of the U.S. fire service: perspectives from the firehouse. *Am J Health Promot* 2012;27(2):111-118. doi:10.4278/ajhp110311-QUAL-109

45. Leduc C, Giga SI, Fletcher IJ, et al. Participatory development process of two human dimension intervention programs to foster physical fitness and psychological health and well-being in wildland firefighting. *Int J Environ Res Public Health*. 2021;18(13):7118. doi:10.3390/ijerph18137118

46. Vincent GE, Aisbett B, Hall SJ, et al. Fighting fire and fatigue: sleep quantity and quality during multi-day wildfire suppression. *Ergonomics* 2016;59(7):932–40.

47. McGillis Z, Dorman SC, Robertson A, et al. Sleep quantity and quality of Ontario wildland firefighters across a low-hazard fire season. *J Occup Environ Med* 2017;59(12):1188–96.

48. The National Institute for Occupational Safety and Health (NIOSH). Wildland firefighter exposure and health effects study, October 15, 2020 [date accessed: October 21, 2021]. https://www.cdc.gov/niosh/topics/firefighting/wffhealthstudy.html

Table 1. Participant demographics.

	Survey 1 (n = 132)	Survey 2 (n=75)	Interviews (n=14)
Gender (n, %)			
Female	40, 30%	27, 36%	N/A
Male	92, 70%	48, 64%	N/A
Age (n, %)			
20-29	45, 34%	25, 33%	N/A
30-39	41, 31%	23, 31%	N/A
40-49	17, 13%	7, 9%	N/A
50-59	18, 14%	12, 16%	N/A
60+	7, 5%	4, 5%	N/A
No Response	4, 3%	4, 5%	N/A
Role in Last Firefighting Season			
Aviation (e.g., pilot, air attack officer)	2, 2%	1, 1%	0
BCWS PWCC/Fire Centre Staff	25, 19%	13, 17%	2
BCWS Zone Staff	23, 17%	14, 19%	1
Non-BCWS Role (e.g., researcher)	16, 12%	6, 8%	4
Other BCWS Role	18, 14%		0
Wildland firefighter	48, 36%	32, 43%	7
No Response		9, 12%	0
Specific to respondents with BCWS role	**Survey 1 (n=116)**	**Survey 2 (n=66)**	**Interviews (n=11)**
Years of Employment with BCWS			
1-5	48	29	2
6-10	28	13	4
11-15	15	9	4
16-20	11	5	0
21+	14	9	1
Years in Direct Fire Suppression			
0 (n/a)	21	7	3
1-3	14	10	1
4-6	22	13	4
7-9	29	15	1
10-12	14	11	4
13-15	9	4	0
16+	7	5	1
Fire Center Most Recently Working			
Cariboo	13, 10%	6, 8%	1
Coastal	14, 11%	8, 11%	1
Kamloops	26, 20%	18, 24%	3
Northwest	13, 10%	5, 7%	0
Headquarters (PWCC)	10, 8%	5, 7%	2
Prince George	26, 20%	16, 21%	3
Southeast	14, 11%	8, 11%	1
No Response	16, 12%	9, 12%	0

BCWS, British Columbia Wildfire Service; PWCC, Provincial Wildfire Coordination Centre

Table 2. Comparison of Consensus Rating vs. Weighted Average.

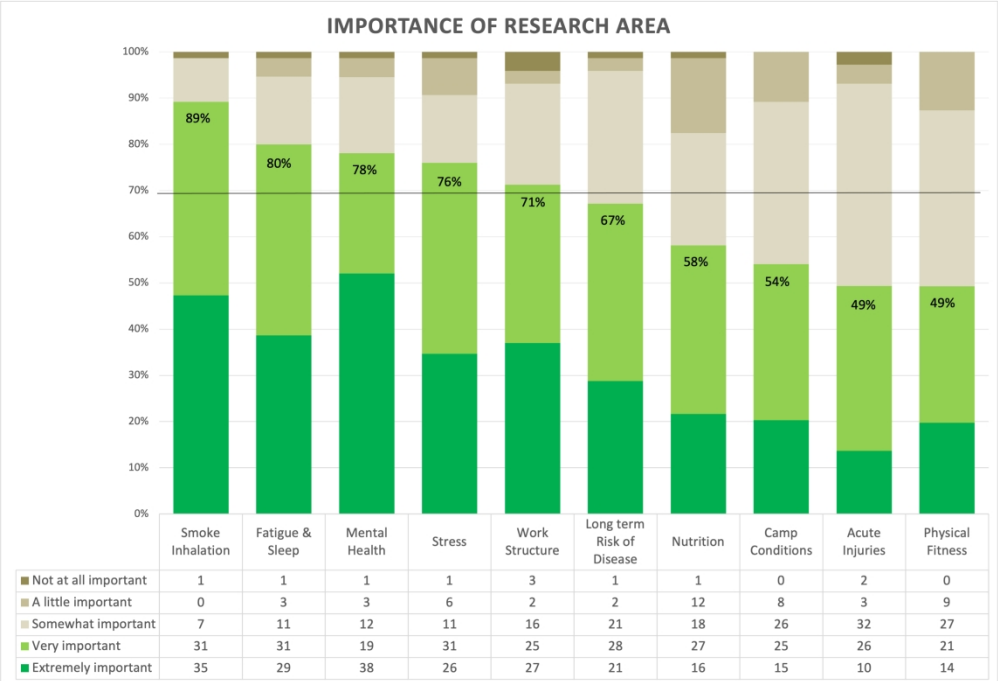
Research Priorities	Consensus Rating	Consensus Rank	Weighted Average	Rank
Understanding & mitigating effects of smoke inhalation on respiratory health	89%	1st	7.70	1st
Fatigue & Sleep	80%	2nd	6.49	3rd
Mental health	78%	3rd	6.68	2nd
Stress	76%	4th	6.18	5th
Work structure & organizational culture	71%	5th	5.03	6th
Long-term risk & prevalence of disease other than respiratory	67%	6th	6.41	4th
Nutrition, diet, & hydration	58%	7th	4.59	7th
Fire camp conditions	54%	8th	4.11	8th
Acute injuries & conditions	49%	9th	4.10	9th
Physical fitness & testing	49%	10th	3.68	10th

633 Table 3. Top five ranked research topics and areas of focus identified by interview participants through deductive
634 analysis.

Research topic (Category)	Areas of focus (Sub-category)	Examples of Meaning Unit (Quotes)
Understanding & mitigating effects of smoke inhalation on respiratory health	Development of appropriate mitigation strategies	"it's demoralizing sometimes being out there and not having a mask when you see, [like] … Police officers, or other agencies that are assisting us with different things, like not even really in the smoke, and wearing like large masks to protect their health, so. Um, I think it's definitely valuable to continue looking into that and to continue pushing to get us some, um, sort of lung protection. Cause, you, you [sic] definitely feel it., Like after fire season your lung capacity is, um, it's, it's [sic] not what it was at the beginning of the season" (P1, wildland firefighter)
		"I think most firefighters are pretty aware that it's not good to be breathing in what we're breathing in, but we're just at this standstill of what it seems like finding the right PPE that's appropriate for the job. So, I think research sort of on that more practical side on what, like what apparatus is going to work for us would be really important at this stage" (P4, wildland firefighter)
		"You know, actual things other than like bring a mask, like if wearing mask is the only way, great. But also, beyond wearing a mask, which I think would take a while to find the right mask and the right buy in, what are the real facts, don't do it? It's like if you're doing it, what's the distances, like a lot of information about, people will be around smoke[sic], probably not wearing masks at some point. What are ways to mitigate, or like mitigate some of those things in alternate ways?" (P5, wildland firefighter)
	Understand exposure	"like the smoke inhalation, like what does that look like? Like what particulates, how much, like exposure, which kind of smoke you're putting in, like how, what factors influence that, like what you're actually doing and how can you like minimize that" (P5, wildland firefighter)
		"the obvious one that stands out to me, that like, you know, I notice a lot more on the line, is that sort of long-term exposure piece to smoke. Um, it would probably be like fine particulate matter. Cause, there's a lot of times where, you know, in the later stages of a fire we are looking for smoke and looking for heat, and on our hand and knees in very, very [sic] fine ash with no PPE and um, and I think that probably proposes like a significant health risk. Um, I know it's been documented in other fields that kind of any really fine particulate matter like that is detrimental to your lungs, and we just go in with zero PPE and zero information about it" (P14, wildland firefighter)
Fatigue & sleep	Determine optimal amounts of sleep	"what is the optimal amount, amount of sleep that like a firefighter should be getting? Or what is the optimal amount of rest in order to fully, like, kind of reset our minds and reset our bodies, uh to get ready for that next fourteen-day deployment. I don't know, like fourteen to three just seems like it was pulled out of the air, so, um, I'd be curious to know like what, what is the proper amount of rest that we should be getting" (P1, wildland firefighter)
		"the quality of sleep, the length of shifts and whether or not they're able to achieve – or obtain – quality sleep while they're in the field, and whether or not that is, um, impacting on their safety while working" (P6, researcher)
	Understand impacts of long-term fatigue	"the short-term fatigue of like day-to-day, as opposed to the long-term fatigue of a season and how that affects you season to season kind of thing" (P3, wildland firefighter)
		"when you have, have eight hours off between shifts, including you know going home, cooking a meal, taking a shower, all things that you do at home, so that adds up over time. So yeah, I think it'd be interesting to see how that would affect um kind of like overall fatigue, long term fatigue" (P2, wildland firefighter)

Mental health	Understand mental health impacts during and after fire season	"people kind of just starting out, that you know, everything seems like super, super fun and exciting to start, and then you know, the season ends and the reality of what you went through kind of sinks in" (P1, wildland firefighter) "but you know, the day-to-day and how that effects morale at your base, or how that might affect behaviour dynamics between groups of people when you're stuck out there at a miserable fire for weeks at a time, that should be something that we talk about more" (P10, wildland firefighter/office role)
	Optimize supports and strategies to increase awareness	"Important to have information on what we're getting ourselves into and the long-term effects of this job" (P4, wildland firefighter) "The stigma and not really recognizing some of the effects of, you know, exposure and post-traumatic stress" (P6, researcher) "Some education in that area to people in the field would be good. Cause I think a lot of folks are not you know, aware of the mental toll that this job might have...it's certainly not something that's discussed as a standard as part of the training" (P10, wildland firefighter/office role)
Stress		"It would be interesting to know of the long-term effects of stress. People, people come and typically fight fire for anywhere between 3 and 5 years and they move on because we recruit really heavily from university students. Once they're done their degrees they leave. Um, but I do wonder, especially with the seasons of 2017 and 2018, how much is that taken out of people and like, what are the long-term effects of that?" (P10, wildland firefighter/office role) "Um, in terms of having an off-season and kind of being able to, um, recharge, I guess? And avoiding that burn out. So, it will be interesting to see like in the different roles, and in the different timing, um, how that plays into stress. And the other thing that's come up, is the other work priorities. So, it's not always just wildfire. And I think some of our additional priorities can contribute to stress, and contribute to chronic stress where, um, there's a little bit more push for prevention, and a little bit more push for like chainsaw work and training and stuff like that. Like, you know where we're just sitting waiting for fires, we're pushed to do work, um we're pushed to do other work like all the time. And sometimes even just busy work which might play into that kind of chronic stress, fatigue and not really getting to have a break" (P4, wildland firefighter)
Long-term risk & prevalence of disease other than respiratory		"I don't have a lot of understanding of how the body flushes its stuff out in the winters, but I hope it does. I don't know, I don't know [sic] what's really happening to the body" (P2, wildland firefighter) "But like, seeing the long-term effects of, like even lifespan. I know that's kind of dark but … But I mean, if someone's been doing this since they were eighteen kind of thing, it would be interesting to see how one's been affected… Yeah, their life overall and if they've had cancer pop up – not just lung cancer" (P3, wildland firefighter)

PPE, personal protective equipment



	Smoke Inhalation	Fatigue & Sleep	Mental Health	Stress	Work Structure	Long term Risk of Disease	Nutrition	Camp Conditions	Acute Injuries	Physical Fitness
Not at all important	1	1	1	1	3	1	1	0	2	0
A little important	0	3	3	6	2	2	12	8	3	9
Somewhat important	7	11	12	11	16	21	18	26	32	27
Very important	31	31	19	31	25	28	27	25	26	21
Extremely important	35	29	38	26	27	21	16	15	10	14

Figure 1

271x185mm (330 x 330 DPI)

Who is conducting the study?

Principal Investigator:	Co-Investigator:
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Who is funding this study?

This project is funded by the BC Wildfire Service (BCWS) through the Canadian Partnership for Wildfire Science (Canada Wildfire).

Why are we doing this study?

You are being invited to take part in this research study because you are a current or past wildland firefighter, someone who works in wildfire operations or management, or a researcher who has or is studying the health and wellbeing of wildland firefighters, or someone who works in occupational health and safety. We are doing this study to identify research priorities in the area of health and wellbeing of wildland firefighters. We are conducting this project in partnership with BCWS to develop a strategic 5-year research program based on identified priorities and gaps in current knowledge.

What will happen during the project?

If you decide you would like to participate in this study, we will ask you to complete two online surveys, each one should take approximately 10-15 minutes to complete.

The first (current survey) will ask you to list up to 10 research priorities related to the health and wellbeing of wildland firefighters and up to 10 research priorities for wildland fire related personnel. We will analyze the results from this survey and identify the most commonly identified research topics.

We will send you a second survey (approximately 1-2 months from now) that will ask you to rank the research topics identified in the first survey.

Is there any way that participating in this study could harm you?

We do not think there is anything in this study that could harm you. Thinking about health and wellbeing related to your job may upset you or make you think about past or current stresses or emotions. If, at any point in the study, you feel uncomfortable or upset and wish to end your participation, you are able to simply close the browser window and exit. If you would like to discuss any of these feelings, please reach out to the counsellors available to you through the Safe Reporting Line. This line is confidential and BCWS will not know if you called them or what you discussed. You may also access emotional support or other resources through the Crisis Line Association of BC at 310-6789 (toll free anywhere in BC, no area code needed). We will not send you the second survey unless you provide your contact information and submit the first survey.

How will your identity be protected?

Your anonymity will be respected. Although we will be asking for your personal email address, this will only be used to send you the second survey (ranking priorities) and will not be linked with your responses. BCWS will only receive aggregate group data and will not find out if you chose to participate in this study or not.

This online survey is be conducting using SurveyMonkey licensed through the University of Northern British Columbia. An American company owns the software, but data from our survey is stored on Canadian servers. If there are any technical problems during data collection, your data may be accessed by SurveyMonkey companies in the United States of America, Ireland, or Australia for the purpose of implementing, maintaining, repairing, troubleshooting or upgrading services provided by SurveyMonkey. All information stored on SurveyMonkey servers will be deleted 1-month after the survey closes and transferred into a spreadsheet that will be de-identified (your email address removed) and stored on a password-protected computer in a locked office on the UNBC campus. Only the investigators and study staff will have access to raw data. We will keep this data for a period of 5-years and then it will be destroyed. Electronic copies will be deleted and any paper copies will be shredded.

Will you be paid for taking part in this research study?

You will have the option of entering a draw to win one of five, $50 amazon gift cards.

How can you hear about the study findings?

The results of this study may be published in academic journal articles, books, and/or conference presentations. A report will also be prepared and shared with the BCWS, presented at BCWS meetings, and may be posted online.

Questions, Concerns or Complaints about the project

If you have any questions about what we are asking of you, please contact the Principal Investigator, Chelsea Pelletier at chelsea.pelletier@unbc.ca, 250-960-5283.

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the UNBC Office of Research at 250-960-6735 or by e-mail at reb@unbc.ca.

Participant Consent and Withdrawal

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. You are free to withdraw from this study at any time by closing your browser. The BCWS will not be aware if you decide to participate in this project or not and it will in no way impact your present or future employment with BCWS or a related agency.

If the questionnaire is completed, it will be assumed that you have given your consent to participate in this study.

* Do you agree to participate in the survey?

- ◯ Yes
- ◯ No

If you would like to receive an emailed copy of the summary, please provide your email address here:

What is your current age?

With which gender do you most identify?

- Female
- Male
- Gender non-conforming
- Prefer not to answer
- A gender not listed here:

* Are you a current BCWS employee, or auxiliary employee that worked in the 2019 wildfire season?

- Yes
- No

How would you best classify your current role?

- Researcher or research trainee
- Employed in occupational health and safety management or regulations
- Union (e.g., BCGEU) employee
- Other (please specify)

Out of which fire centre were/are you most recently working?

- Cariboo
- Coastal
- Kamloops
- Northwest
- Prince George
- Southeast
- Other (please specify)

What was your primary role with BCWS this past wildfire season (2019)?

- Wildland firefighter
- BCWS PWCC/Fire Centre Staff
- BCWS Zone Staff
- Aviation (i.e. Pilot, Air Attack Officer, etc.)
- Other (please specify)

What other roles, if any, have you participated in previous wildfire seasons, including 2019 (or will be doing in 2020) (select all that apply)?

- [ ] Wildland firefighter
- [ ] BCWS PWCC/Fire Centre Staff
- [ ] BCWS Zone Staff
- [ ] Aviation (i.e. Pilot, Air Attack Officer, etc.)
- [ ] Incident Command Team member
- [ ] Other (please specify)

How many years/seasons have you been an employee of BCWS (not counting 2020)?

How many of these years/seasons worked were spent participating in direct fire supression on the fireline (for example, as a crew member/leader)?

Please list up to 10 topics relating to health and wellbeing of **wildland firefighters** that you think should be the focus of (or priority for) research topics.

Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	

Please list up to 10 topics relating to health and wellbeing of wildland fire **related personnel** (i.e. members of Incident Command teams, Wildfire Officers/Assistants, PWCC/Fire Centre/Zone staff, dispatchers, etc) that you think should be the focus of (or priority for) research projects.

Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	
Research Topic	

Please use this space to list more topic areas or make any additional comments.

Thank you for completing Phase 1 of the stakeholder consultation.
Phase 2 will involve ranking the most common answers regarding priority topics for research.
If you would like to participate in Phase 2 please provide your email address below (non-governmental email preferred).

Would you like to be entered into a draw for one of five $50 Amazon gift cards?

- [ ] Yes
- [ ] No

email address

If you would like to contact the research team please email us at: wildfirestudy@unbc.ca

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Who is conducting the study?

Principal Investigator:	Co-Investigator:
Chelsea Pelletier	Trina Fyfe
School of Health Sciences	Northern Medical Program
University of Northern British Columbia	University of Northern British Columbia
Prince George, BC V2N 4Z9	Prince George, BC V2N 4Z9
chelsea.pelletier@unbc.ca 250-960-5283	trina.fyfe@unbc.ca 250-960-5195

Who is funding this study?

This project is funded by the BC Wildfire Service (BCWS) through the Canadian Partnership for Wildfire Science (Canada Wildfire).

Why are we doing this study?

You are being invited to take part in this research study because you are a current or past wildland firefighter, someone who works in wildfire operations or management, or a researcher who has or is studying the health and wellbeing of wildland firefighters, or someone who works in occupational health and safety. We are doing this study to identify research priorities in the area of health and wellbeing of wildland firefighters. We are conducting this project in partnership with BCWS to develop a strategic 5-year research program based on identified priorities and gaps in current knowledge.

What will happen during the project?

Approximately 2 months ago (March - April 2020), you completed a survey where we asked you to list up to 10 research priorities related to the health and wellbeing of wildland firefighters and up to 10 research priorities for wildland fire related personnel. We have analyzed the findings received from this survey.

In the current survey (Part 2 of this process), we will ask you to rank the research topics identified in the first survey. There were 134 responses received and we have narrowed the responses down to 10 topic areas plus associated subtopics. In this survey we will be asking you to rank the priority of each of these topics so we are able to determine what topic should be studied first.

Is there any way that participating in this study could harm you?

We do not think there is anything in this study that could harm you. Thinking about health and wellbeing related to your job may upset you or make you think about past or current stresses or emotions. If, at any point in the study, you feel uncomfortable or upset and wish to end your participation, you are able to simply close the browser window and exit. If you would like to discuss any of these feelings, please reach out to the counsellors available to you through the Safe Reporting Line. This line is confidential and BCWS will not know if you called them or what you discussed. You may also access emotional support or other resources through the Crisis Line Association of BC at 310-6789 (toll free anywhere in BC, no area code needed).

How will your identity be protected?

Your anonymity will be respected. In this survey, we will not be asking for any identifiable information (such as your email address). BCWS will only receive aggregate group data and will not find out if you chose to participate in this study or not.

This online survey is be conducting using SurveyMonkey licensed through the University of Northern British Columbia. An American company owns the software, but data from our survey is stored on Canadian servers. If there are any technical problems during data collection, your data may be accessed by SurveyMonkey companies in the United States of America, Ireland, or Australia for the purpose of implementing, maintaining, repairing, troubleshooting or upgrading services provided by SurveyMonkey. All information stored on SurveyMonkey servers will be deleted 1-month after the survey closes and transferred into a spreadsheet that will be stored on a password-protected computer in a locked office on the UNBC campus. Only the investigators and study staff will have access to raw data. We will keep this data for a period of 5-years and then it will be destroyed. Electronic copies will be deleted and any paper copies will be shredded.

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The results of this study may be published in academic journal articles, books, and/or conference presentations. A report will also be prepared and shared with the BCWS, presented at BCWS meetings, and may be posted online.

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If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the UNBC Office of Research at 250-960-6735 or by e-mail at reb@unbc.ca.

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If the questionnaire is completed, it will be assumed that you have given your consent to participate in this study.

* Do you agree to participate in the survey?

- ◯ Yes
- ◯ No

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

What is your current age?

With which gender do you most identify?

- Female
- Male
- Gender non-conforming
- Prefer not to answer
- A gender not listed here:

* Are you a current BCWS employee, or auxiliary employee that worked in the 2019 wildfire season?

- Yes
- No

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

How would you best classify your current role?

- ○ Researcher or research trainee
- ○ Employed in occupational health and safety management or regulations
- ○ Union (e.g., BCGEU) employee
- ○ Other (please specify)

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Out of which fire centre were/are you most recently working?

- Cariboo
- Coastal
- Kamloops
- Northwest
- Prince George
- Southeast
- Other (please specify)

What was your primary role with BCWS this past wildfire season (2019)?

- Wildland firefighter
- BCWS PWCC/Fire Centre Staff
- BCWS Zone Staff
- Aviation (i.e. Pilot, Air Attack Officer, etc.)
- Other (please specify)

What other roles, if any, have you participated in previous wildfire seasons, including 2019 (or currently are doing in 2020) (select all that apply)?

- [ ] Wildland firefighter
- [ ] BCWS PWCC/Fire Centre Staff
- [ ] BCWS Zone Staff
- [ ] Aviation (i.e. Pilot, Air Attack Officer, etc.)
- [ ] Incident Team Management
- [ ] Other (please specify)

How many years/seasons have you been an employee of BCWS (not counting 2020)?

How many of these years/seasons worked were spent participating in direct fire supression on the fireline (for example, as a crew member/leader)?

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

For the following questions focus the research topics, each with a list of subtopics or example research projects. Please indicate how important each topic is based on relevance to you personally and the BCWS, and urgency (eg, what topic should we give priority to?)

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Understanding and mitigating effects of smoke inhalation on respiratory/lung health
This may include as projects or sub-topics such as:

- Ability to estimate exposure in field (CO, PM)
- Exposure based on different fireline tasks
- Air quality at fire camp
- PPE/mask development and validation

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Long-term risk and prevalence of disease other than respiratory (cardiovascular, cancer)
This may include as projects or sub-topics such as:

- Understanding exposure through skin and clothing

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Physical fitness & testing
This may include as projects or sub-topics such as:

- Time for exercise during shift and maintaining fitness through season
- Effective fitness programs
- Testing fitness protocol development/optimization

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Fire camp conditions
This may include as projects or sub-topics such as:

- Hygiene and spread of disease
- Safety

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Nutrition, diet, & hydration
This may include as projects or sub-topics such as:

- Understanding optimal nutrition for performance
- Access to foods that meet personal preference and dietary needs

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Acute injuries & conditions
This may include as projects or sub-topics such as:

- Soft tissue injuries
- Musculoskeletal injuries
- Repetitive strain and ergonomics
- Heat stress

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Fatigue & Sleep
This may include as projects or sub-topics such as:

- Cognitive fatigue and decision making
- Fatigue management
- Cumulative fatigue
- Burnout
- Compassion fatigue
- Sleep hygiene

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Stress

This may include as projects or sub-topics such as:

- Elevated stress hormones
- Stress management
- Understanding impact of chronic stress

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Mental health
This may include as projects or sub-topics such as:

- Depression
- Social/emotional health
- PTSD
- Exposure to trauma
- Impact of public pressure and dealing with the public
- Supporting resilience

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Topic: Work structure & organizational culture
This may include as projects or sub-topics such as:

- Work/life balance
- Shift hours/length and on/off time
- Distance from families
- Gender bias
- Stigma
- Racial discrimination
- Harassment/discrimination
- Experiences of minority personnel (female, Indigenous peoples, non-cis, non-white)

- [ ] Extremely important
- [ ] Very important
- [ ] Somewhat important
- [ ] A little important
- [ ] Not at all important

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha
2

Please rank the research topics from most (1) to least important (10). Consider that while each of these topics are important, if you had to choose, where do you think we should start? What is the most relevant to you personally and the BCWS? And what is the most urgent?

Understanding and mitigating effects of smoke inhalation on respiratory/lung health

Long-term risk and prevalence of disease other than respiratory (cardiovascular, cancer)

Physical fitness & testing

Fire camp conditions

Nutrition, diet, & hydration

Acute injuries & conditions

Fatigue & Sleep

Stress

Mental health & resilience

Work structure & organizational culture

Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Pha 2

Please use this space to list more topic areas or make any additional comments.

Would you like to be entered into a draw for one of five $50 Amazon gift cards?

- [ ] Yes
- [ ] No

email address

If you would like to contact the research team please email us at: wildfirestudy@unbc.ca

Semi-structured interview schedule

Thank you for taking the time to meet with us today. You previously completed two surveys where you were asked to list and then rank health research priorities for wildland firefighters (or wildfire fighters). Today, we would like to talk to you about these research priorities, to find out which ones are most relevant to you, most important to you, and to discuss some specific ideas you may have about a program of research. Although the ranking of priorities from the survey will not change based on our discussion, it will add a more nuanced description of the identified research topics. This interview will last approximately 20-30min. Have you reviewed the consent form? Do you have any questions?

Before we start, can you please confirm if you agree to be recorded?

1. What is your primary role as it relates to wildfire and what region of BC (or BCWS fire centre) do you work in (*if relevant*)? How long have you been in this role and have you done any other roles?
2. Can you tell me about your current understanding of research, if you think it is important for BCWS to support in general?
    a. Are you aware of any research or mitigation strategies in use that you think are particularly helpful or relevant?
3. Thinking about your role (or previous roles), what do you see as the most relevant health concerns or risks?
4. The top research priorities identified in our two round surveys were *1) understanding & mitigating effects of smoke inhalation on respiratory health; 2) fatigue & sleep; 3) mental health; 4) long-term risk & prevalence of disease other than respiratory (e.g., cardiovascular, cancer); 5) stress.*
    a. Do you agree with this ranking?
    b. Are there other topics that you think should be included that were not captured in this list?
    c. Under these broad categories, are there specific projects you would like to see accomplished?
    d. What research questions do you think we should focus on?
5. Do you perceive any specific barriers or challenges in doing this research?
    a. Do you anticipate there would be any barriers to implementing any of the mitigation strategies for these health risks?
6. Do you have anything to add specifically to research and health priorities for wildfire fighters?

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	#4	Present key elements of study design early in the paper	6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	6

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6-8
Bias	#9	Describe any efforts to address potential sources of bias	N/A
Study size	#10	Explain how the study size was arrived at	N/A
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	7/8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7/8
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A
Statistical methods	#12c	Explain how missing data were addressed	N/A
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	9/10
Participants	#13b	Give reasons for non-participation at each stage	N/A
Participants	#13c	Consider use of a flow diagram	N/A

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9/10
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9/10
Discussion			
Key results	#18	Summarise key results with reference to study objectives	14/15
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	16
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14-16
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17