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# BMJ Open

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

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3 1 **Health research priorities for wildland firefighters: a modified Delphi study with**  
4 2 **stakeholder interviews**  
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3 39 **ABSTRACT**  
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5 40 **Objectives:** The increase in global wildland fire activity has accelerated the urgency to  
6  
7 41 understand health risks associated with wildland fire suppression. The aim of this project was to  
8  
9 42 identify occupational health research priorities for wildland firefighters and related personnel.  
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11

12 43 **Design:** In order to identify, rank, and rate health research priorities, we followed a modified  
13  
14 44 Delphi approach. Data collection involved a two-stage online survey followed by semi-structured  
15  
16 45 interviews.  
17  
18

19 46 **Setting:** British Columbia, Canada  
20

21 47 **Participants:** Participants included any current or past wildland firefighter or individuals  
22  
23 48 engaged in related roles. There were 132 respondents to the first survey. Responses to the first  
24  
25 49 survey were analyzed to produce 10 research topics which were ranked by 75 participants in the  
26  
27 50 second survey (response rate: 84%).  
28  
29

30 51 **Primary and secondary outcome measures:** The primary outcome was the identification,  
31  
32 52 ranking, and level of agreement of research priorities through a two-round online survey. We  
33  
34 53 contextualized these findings through deductive and inductive qualitative content analysis.  
35  
36

37 54 **Results:** The most important research priorities identified were (% consensus): effects of smoke  
38  
39 55 inhalation on respiratory health (89%), fatigue & sleep (80%), mental health (78%), stress  
40  
41 56 (76%), and long-term risk of disease (67%). Interviews were completed with 14 individuals. Two  
42  
43 57 main themes were developed from an inductive content analysis of interview transcripts: 1)  
44  
45 58 understand the dynamic risk environment; and 2) organizational fit of mitigation strategies.  
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49 59 **Conclusions:** Participants expressed a general concern with the unknown mental and physical  
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51 60 health impacts of their jobs, including the long-term risk of morbidity and mortality. Future  
52  
53 61 research must address knowledge gaps in our understanding of the health impacts of wildland  
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3 62 fire and work to develop appropriate mitigation strategies while considering the needs of workers  
4  
5 63 and unpredictable environment.  
6

7  
8 64 **Registration:** Open Science Framework, [osf.io/ugz4](https://osf.io/ugz4).  
9

10 65 **Keywords:** wildfires, wildland fires, firefighters, Delphi technique, research priorities  
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## 80 STRENGTHS AND LIMITATIONS OF THIS STUDY

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

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## 103 INTRODUCTION

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

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

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



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3 126 personnel involved in wildland fire suppression. Health research priorities are needed to ensure a  
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5 127 coordinated and effective research plan, direct research funding by organizations and  
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8 128 governments, support the development of appropriate mitigation strategies, and ultimately  
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10 129 improve health and wellbeing for all workers engaged in wildland fire suppression. The purpose  
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12 130 of this project was to identify health research priorities for wildland firefighters and related  
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15 131 personnel.

## 16 17 132 **METHODS**

18  
19 133 This study is part of a larger project to establish health research funding priorities for the  
20  
21 134 British Columbia Wildfire Service (BCWS) based on gaps in literature and stakeholder priorities.  
22  
23 135 The protocol for this project has been previously published [9] and registered ([osf.io/ugz4](https://osf.io/ugz4)). To  
24  
25  
26 136 align with public health guidelines on physical distancing during the COVID-19 pandemic, we  
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28 137 did not conduct meetings with stakeholders as indicated in our original protocol. Instead, we  
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30 138 conducted semi-structured individual interviews with a sample of survey respondents to  
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32 139 contextualize research priorities identified in the two-round survey. Research ethics approval was  
33  
34 140 provided by the University of Northern British Columbia Research Ethics Board and informed  
35  
36 141 consent was obtained from all participants.

37  
38 142 The Delphi method is a process to gather stakeholder knowledge and experience and is  
39  
40 143 commonly used to identify occupational health research priorities [10-14]. The Delphi process  
41  
42 144 allows for the collection of opinions from a variety of stakeholders followed by the presentation  
43  
44 145 of ideas back to participants in iterative ‘rounds’ until consensus is reached [14]. For this study,  
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46 146 we have followed a modified Delphi method involving a two-stage online survey  
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48 147 (SurveyMonkey, California, USA) with follow-up semi-structured interviews. Based on similar  
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50 148 work to establish research priorities using a modified Delphi approach, we established *a priori* to  
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3 149 conduct two survey rounds [11-12, 15] and determined consensus was achieved when at least  
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5 150 70% of respondents indicated the research priority was “*very important*” or “*extremely*  
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7 151 *important*” during the second-round survey [16]. Participants were eligible to participate if they  
8  
9 152 were current or past employees of BCWS (as frontline wildland firefighters or in  
10  
11 153 officer/managerial roles), researchers or trainees with an interest in wildland fire, or employed in  
12  
13 154 occupational health and safety. Both surveys included a basic demographic questionnaire  
14  
15 155 querying age, gender, and role as it related to wildland fire. People employed by BCWS were  
16  
17 156 also asked to identify the fire centre most recently worked, years working, and current or prior  
18  
19 157 relevant roles.

#### 23 24 158 *Round 1: Identifying research priorities*

25  
26 159 An invitation to participate in the first survey was circulated via email to BCWS  
27  
28 160 employees, occupational health policy makers, and researchers who had recently published in the  
29  
30 161 field. Participants were asked to list up to 10 research priorities of concern for wildland  
31  
32 162 firefighters and related personnel separately (see supplementary file 1). We conducted an  
33  
34 163 inductive qualitative content analysis [17-19] of responses. Three members of the research team  
35  
36 164 read and re-read open-field responses to identify codes and key concepts provided by  
37  
38 165 participants. Codes were then grouped into categories sharing common features. Discussion was  
39  
40 166 used to reach consensus on final research topics. The two job categories, wildland firefighters  
41  
42 167 and related personnel, were collapsed for the second survey because the topics identified by  
43  
44 168 participants were similar.

#### 45 46 47 48 49 169 *Round 2: Rating and ranking research priorities*

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51 170 The second survey was sent to participants who completed the first survey and expressed  
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53 171 interest in continuing their participation. In the second survey, respondents were presented with  
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3 172 the research topics identified in survey 1 and asked to indicate the importance of each topic on a  
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5 173 modified five-point Likert scale ranging from “*not at all important*” to “*extremely important*”  
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8 174 (see supplementary file 2). To prevent a bias resulting from question order, the order of research  
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10 175 topics was randomized for each survey respondent.

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12 176 To determine the relative importance of each research topic, respondents were presented  
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14 177 with all research topics and asked to rank them from most important to least important. To  
15  
16 178 calculate the weighted average, each research topic in the data set was multiplied by the rank-  
17  
18 179 weight assigned by each participant before the final means were calculated. For example, a  
19  
20 180 weight of 10 would be given to the respondents’ highest priority, 9 to the second highest priority  
21  
22 181 and so on. This was repeated for each respondent’s ranked research priorities. The mean  
23  
24 182 weighted average was calculated for each research topic. Participant responses were also  
25  
26 183 separated by job category (e.g., wildland firefighter, aviation crew) to determine if there was any  
27  
28 184 difference in identified research priorities based on role.

### 29 185 *Round 3: Semi-structured interviews*

30  
31 186 Semi-structured interviews allowed the opportunity for additional feedback, for  
32  
33 187 participants to provide a more nuanced description of identified research topics, and to identify  
34  
35 188 specific projects within each umbrella topic. Eligible interview participants were at least 18 years  
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37 189 of age and had completed both surveys. We aimed for diversity in our sample based on length of  
38  
39 190 time working in a wildland fire-related role and across different job categories (e.g., researchers,  
40  
41 191 wildland firefighter).

42  
43 192 Interviews were conducted by two research team members over Zoom videoconference  
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45 193 or telephone. One researcher took detailed field notes. Interviews were between 22-49 minutes in  
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47 194 length (average: 34 minutes). The interview schedule (see supplementary file 3) included open  
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3 195 ended questions about work-related health concerns, potential mitigation strategies, and research  
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5 196 questions or specific projects for each of the top five ranked research priorities.  
6

7  
8 197 Interviews were transcribed verbatim by a study team member. Field notes were used  
9  
10 198 during analysis to provide additional contextual information. Analysis was conducted in two  
11  
12 199 phases using a qualitative content analysis [17-18] by two team members. First, we took a  
13  
14 200 deductive approach to provide examples and nuanced description of each of the research topics  
15  
16 201 identified in the survey. A structured categorization matrix was created for the top 5 research  
17  
18 202 topics based on ranking and consensus. The interview transcripts were coded for correspondence  
19  
20 203 with each research topic (category); only data aligning to the matrix (e.g., matched to a category  
21  
22 204 or research topic) was chosen for the deductive phase of the analysis [18]. Data within each  
23  
24 205 category was examined to determine if any sub-categories were necessary [19]. Items not  
25  
26 206 explicitly aligned to one of the pre-identified research topics were analyzed using an inductive  
27  
28 207 approach to identify additional themes [20]. Inductive open coding was completed to ensure we  
29  
30 208 comprehensively represented content communicated by participants [17-18] and to understand  
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32 209 issues discussed by participants not directly related to the pre-identified research topics.  
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### 37 210 *Patient and Public Involvement*

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40 211 Patients were not involved in this study.  
41

## 42 212 **RESULTS**

### 43 213 *Participants*

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45  
46 214 Survey 1 was completed by 132 participants (92 men, 40 women; Table 1). We are  
47  
48 215 unable to calculate a response rate for the first survey because the invitation to participate was  
49  
50 216 primarily circulated through a BCWS mailing list. Survey 2 was sent to 89 potential participants  
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53 217 and completed by 75 respondents (response rate: 84%, 48 men, 27 women). Interviews were  
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3 218 conducted with 14 participants: six current or prior wildland firefighters, three researchers or  
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5 219 trainees, and five people with administrative or officer roles.

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8 220 [INSERT TABLE 1]

9  
10 221 *Research Priorities*

11  
12 222 More than 900 research areas were suggested from participants in survey 1 which were  
13  
14 223 organized into 10 categories or research topics ranked by participants in survey 2. Consensus  
15  
16 224 was achieved on five of the ten research topics (Figure 1). *Understanding & mitigating effects of*  
17  
18 225 *smoke inhalation on respiratory health, fatigue & sleep, and mental health* were the research  
19  
20 226 topics with the greatest consensus. While consensus was not reached across the entire cohort of  
21  
22 227 respondents regarding the priority of *long-term risk & prevalence of disease other than*  
23  
24 228 *respiratory*, within the subset of wildland firefighters and aviators, there was 81% consensus on  
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26 229 the priority of the topic. Additionally, for the research topic *camp conditions*, there was  
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28 230 consensus (74%) within the subset of zone and control staff.

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35 232 [INSERT FIGURE 1]

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40 234 When looking at the weighted rank of each research priority, the pattern was consistent  
41  
42 235 with those research priorities achieving consensus, with two notable differences. *Work structure*  
43  
44 236 *& organizational culture* was the fifth topic to satisfy the consensus requirement of a rating  
45  
46 237 greater than 70%; however, it had the sixth highest weighted average. *Long-term risk &*  
47  
48 238 *prevalence of disease other than respiratory* was ranked 4th by participants when considering  
49  
50 239 the weighted average; however, it did not reach consensus (67%; Table 2). The role of a  
51  
52 240 respondent did not appear to influence the ranking of research priorities. Four of the top five  
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241 areas of research as identified through the weighted average (*Understanding & mitigating effects*  
242 *of smoke inhalation on respiratory health, fatigue & sleep, mental health, and stress*) also have  
243 consensus ratings greater than 70%; therefore, any further research in these four areas would be  
244 addressing priority areas as identified by stakeholders.

245

246 [INSERT TABLE 2]

247

248 *Interview Findings*

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

253

254 [INSERT TABLE 3]

255

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

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

261 *“the office stuff or the staff that are there, I don’t think they have the same concerns*  
262 *around smoke exposure and physiological toxins”* (P8, researcher)

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3 263 This different exposure may translate to different health research priorities. For instance,  
4  
5 264 auxiliary staff who are typically students hired during the summer wildland fire season (typically  
6  
7  
8 265 May – August) may not be as concerned with long-term health risk, when compared to people  
9  
10 266 who work in wildland fire related roles for their entire career:

11  
12 267 *“if we’re looking at an older population of firefighters, whether that be more the career*  
13  
14 268 *wildland firefighters, I think the health priorities, the health shifts a bit. Um, in that, I’d*  
15  
16 269 *be more concerned about a mixture of cardio-respiratory factors. Um, whether or not*  
17  
18 270 *long-term exposure to wildland smoke might be related to later in life – like, um, uh, like*  
19  
20 271 *lung pathologies or you know, if there’s any risk factors for cardiovascular disease”* (P6,  
21  
22  
23  
24 272 researcher)

25  
26 273 It is also important to understand and explore risks across multiple seasons because the  
27  
28 274 unpredictability in fire activity may contribute to different health risks:

29  
30 275 *“We think of those big fire seasons, 2017, 2018, even 2015, and like the work component*  
31  
32 276 *is very fatiguing, but um, it’s also very engaging. And then we have slower seasons like*  
33  
34 277 *this one [2020] and we may not think of it as harder on our mental health, because we’re*  
35  
36 278 *not doing as much. But I do think it actually creates different challenges for people. So, I*  
37  
38 279 *think that’s something that we need to be aware of – even though we’re not on fires, there*  
39  
40 280 *are stressors associated with the job and it might actually be harder for people because*  
41  
42 281 *they [do not] have that active engagement in what we see as really fulfilling work”* (P4,  
43  
44 282 wildland firefighter)

45  
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48  
49 283 *“It really depends on the year. Because some, uh, some seasons they’re so busy, and*  
50  
51 284 *some seasons they’re so slow. There’s going to be like different, there’s different things*

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3 285 *people care about in each, kind of different, when things are busy” (P1, wildland*  
4  
5 286 *firefighter)*

7  
8 287 Finally, the unpredictable work structure and schedule imposes barriers and challenges to  
9  
10 288 conducting research:

11  
12 289 *“I mean our unpredictable work schedule could be tough for research, but the way you*  
13  
14 290 *guys have been sending out like the surveys that we do on our own time has been*  
15  
16 291 *awesome. Like, if we can just sit down and just take 20 minutes, then by all means. But if*  
17  
18 292 *you need to like come into our workplace and try to organize that research is a bit*  
19  
20 293 *tougher” (P3, wildland firefighter)*

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23  
24 294 **2) Organizational fit of mitigation strategies:** Participants emphasized any mitigation strategy  
25  
26 295 be worker-centred, reflect worker priorities and needs, and be developed with employees. This  
27  
28 296 was reflected in participants discussing management may not always have a feel for what it is  
29  
30 297 like to work on the front-line and any mitigation or management strategy not aligning with  
31  
32 298 organizational realities would have minimal uptake.

33  
34  
35 299 *“people are so resistant to like any change, any, and I think it’s a part of that whole*  
36  
37 300 *disparity between management – like this is something else management’s pushing down,*  
38  
39 301 *oh they have no concept, like just ignore it...like that whole dynamic of like, just like,*  
40  
41 302 *people sitting in office, and us like grinding out there” (P5, wildland firefighter)*

42  
43  
44 303 Relatedly, participants discussed how organizational culture and resistance to change could  
45  
46 304 present a barrier to implementing mitigation strategies:

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48  
49 305 *“the biggest challenge I come across is like the ‘this is the way we do things’ kind of*  
50  
51 306 *attitude” (P8, researcher)*



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3 307 *“And then the organizational culture about, sort of a can-do organization and you know,*  
4  
5 308 *we can, we get a lot done – yes – we can take care of things, and this is the way we’ve*  
6  
7 309 *always done it. And uh, yeah, it’s certainly an organization, I think. The – yeah – so just*  
8  
9  
10 310 *sort of pushing through that organizational culture”* (P13, administrative/office role)

## 11 **DISCUSSION**

12  
13  
14 312 The aim of this project was to identify health research priorities for wildland firefighters  
15  
16 313 and related personnel. Despite the provincial focus of this work, national and international  
17  
18 314 representation in surveys and our adherence to best practice guidelines for research priority  
19  
20 315 setting [4-5] indicate broad relevance and applicability of our findings. Five research topics  
21  
22 316 achieved consensus across the entire sample: *understanding & mitigating effects of smoke*  
23  
24 317 *inhalation on respiratory health, fatigue & sleep, mental health, stress, and work structure &*  
25  
26 318 *organizational culture. A sixth research topic, long-term risk & prevalence of disease other than*  
27  
28 319 *respiratory, nearly reached consensus (67% agreement) and was ranked highly by all*  
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30  
31 320 participants. Based on interviews with relevant stakeholders, we have developed specific areas of  
32  
33 321 study within each research topic. We identified two themes common to all research topics: 1)  
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35 322 understand the dynamic risk environment across wildland fire seasons and roles; 2)  
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37 323 organizational fit of mitigation strategies. Despite a different risk environment, the health  
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39 324 concerns identified by participants in the current study parallel those by structural firefighters  
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41 325 [21], although there is considerably less knowledge specific to health outcomes associated with  
42  
43 326 wildland fire exposure.

44  
45 327 The most important research topic identified by participants was related to smoke  
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47 328 exposure and respiratory health, with 89% of participants indicating it was extremely or very  
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49 329 important. During interviews, participants focused on the need for a better understanding of the  
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3 330 exposures and health risks associated with wildland fire smoke and the desire for feasible,  
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5 331 effective personal protective equipment to protect against smoke inhalation. While many  
6  
7 332 participants mentioned masks, they also noted the difficulties and practicality of wearing a mask  
8  
9 333 in the field while fighting fire for long hours. Two recent papers have explored mask wearing to  
10  
11 334 protect against wildland fire smoke, suggesting they may be effective at reducing particulate  
12  
13 335 matter exposure even if used for only part of a shift; however, neither study reported any data on  
14  
15 336 user experience [22-23]. Ultimately, participants expressed the desire to be engaged in the  
16  
17 337 process of the development of any mitigation strategy and corresponding occupational health  
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19 338 policy as essential to ensure uptake.

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24 339 Participants indicated a need to understand the cumulative mental and physical health toll  
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26 340 of both busy and quiet fire seasons, and recovery in the off-season. Of particular concern was the  
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28 341 increasing length of fire seasons which can reduce downtime and opportunity to recover.  
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30 342 Notably, while the research topic *long-term risk & prevalence of disease other than respiratory*  
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32 343 did not reach consensus among the entire sample, it was ranked highly and reached consensus  
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34 344 (81%) among people involved in direct fire suppression. Designing and conducting research to  
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36 345 understand the cumulative impacts of multiple seasons of wildland fire exposure is a  
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38 346 considerable challenge and critical gap in academic literature [24]. Many front-line wildland  
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40 347 firefighters in BC are post-secondary students hired as auxiliary employees during the summer  
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42 348 (May – August) wildland fire season. The transient and mobile workforce creates considerable  
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44 349 challenges to evaluating risk related to morbidity and mortality outcomes over multiple seasons.  
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46 350 Similarly, the unpredictability of a given fire season means generating consistent evidence or  
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48 351 changes in health outcomes across any one season is challenging due to the variable exposure.  
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52 352 For example, some participants mentioned unique challenges during less active fire seasons such  
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3 353 as a different mental health toll from not being able to engage in work they enjoy and find  
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5 354 meaningful. Thus, while some fire seasons may be ‘quieter’ in terms of fire activity and  
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7 355 respiratory health risk (e.g., lower smoke exposure), they may impose a different mental health  
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9 356 risk. While our research priorities can be used to support researchers to make decisions on  
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11 357 prioritizing collective research efforts, findings also suggest the need for sustainable, flexible  
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13 358 research infrastructure to adapt and understand variable risk environments.  
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### 15 359 *Limitations*

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17 360 The email invitation to participate was sent in March 2020. This was done to ensure data  
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19 361 collection was not impacted by the busiest point in the fire season (typically June – August in  
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21 362 BC). Because of this, many auxiliary/seasonal staff had not yet started work and may be  
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23 363 underrepresented in our sample. Participants were asked to list their top 10 research priorities for  
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25 364 wildland firefighters and related personnel separately in the first survey. Based on very similar  
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27 365 research topics identified for both job categories and suggestions by participants in the open field  
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29 366 question, we collapsed the two job categories for the stage 2 survey. This may have reduced our  
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31 367 ability to tease out specific research topics for related personnel and identified research priorities  
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33 368 are likely more applicable to wildland firefighters.  
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### 40 369 **Conclusions**

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42 370 This project represents the first attempt to develop a comprehensive set of research  
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44 371 priorities for wildland firefighters and related personnel. Our process included a broad range of  
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46 372 stakeholders, from frontline staff to those working in occupational health and safety policy, with  
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48 373 national and international representation. Stakeholders consistently identified the need for  
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50 374 research to understand the physical and mental health risks of their job, and to work to  
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52 375 understand how this risk may lead to long-term morbidity and mortality across multiple fire  
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3 376 seasons or an entire career. Appropriate, feasible mitigation, prevention, and/or management  
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5 377 strategies are urgently needed to address health concerns for workers directly or indirectly  
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8 378 engaged in wildland fire suppression.  
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12 380 **Additional file 1.** Survey 1: Identifying health research priorities for wildland firefighters and  
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14 381 related personnel.

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17 382 **Additional file 2.** Survey 2: Ranking health research priorities for wildland firefighters and  
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19 383 related personnel.

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21 384 **Additional file 3.** Interview Schedule

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25  
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27  
28 387 **Competing interests:** The authors declare they have no competing interests.

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30 388 **Data sharing statement:** No additional data are available.

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33 389 **Ethics approval:** This study was approved by the University of Northern British Columbia  
34  
35 390 Research Ethics Board (E2019.1220.076.00).

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38 391 **Author contributions:** CP lead study conception and design, data collection, analysis, and  
39  
40 392 manuscript writing. CR was involved in the development, distribution, and analysis of online  
41  
42 393 survey, and assisted in preparation of the manuscript. KB supported interview data collection,  
43  
44 394 transcription, interview analysis, and preparation of the manuscript. TF, EK, and KC provided  
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46 395 critical feedback on data collection, study design, assisted with survey and interview analysis.  
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49 396 All authors participated in the interpretation of the results, provided critical revision of and  
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51 397 approved the final manuscript.  
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399 **Figure Legends**

400 Figure 1. Consensus rating of research topics.

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518 Table 1. Participant demographics.

	Survey 1 (n = 132)	Survey 2 (n=75)	Interviews (n=14)
<b>Gender (n, %)</b>			
Woman	40, 30%	27, 36%	N/A
Man	92, 70%	48, 64%	N/A
<b>Age (n, %)</b>			
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
<b>Role in Last Firefighting Season</b>			
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
<b>Specific to respondents with BCWS role</b>	<b>Survey 1 (n=116)</b>	<b>Survey 2 (n=66)</b>	<b>Interviews (n=11)</b>
<b>Years of Employment with BCWS</b>			
1-5	48	29	2
6-10	28	13	4
11-15	15	9	4
16-20	11	5	0
21+	14	9	1
<b>Years in Direct Fire Suppression</b>			
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
<b>Fire Center Most Recently Working</b>			
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

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

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525 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

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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	<p>“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)</p> <p>“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)</p> <p>“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)</p>
	Understand exposure	<p>“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)</p> <p>“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)</p>
Fatigue & sleep	Determine optimal amounts of sleep	<p>“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)</p> <p>“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,</p>

		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)

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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)

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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)

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545 PPE, personal protective equipment

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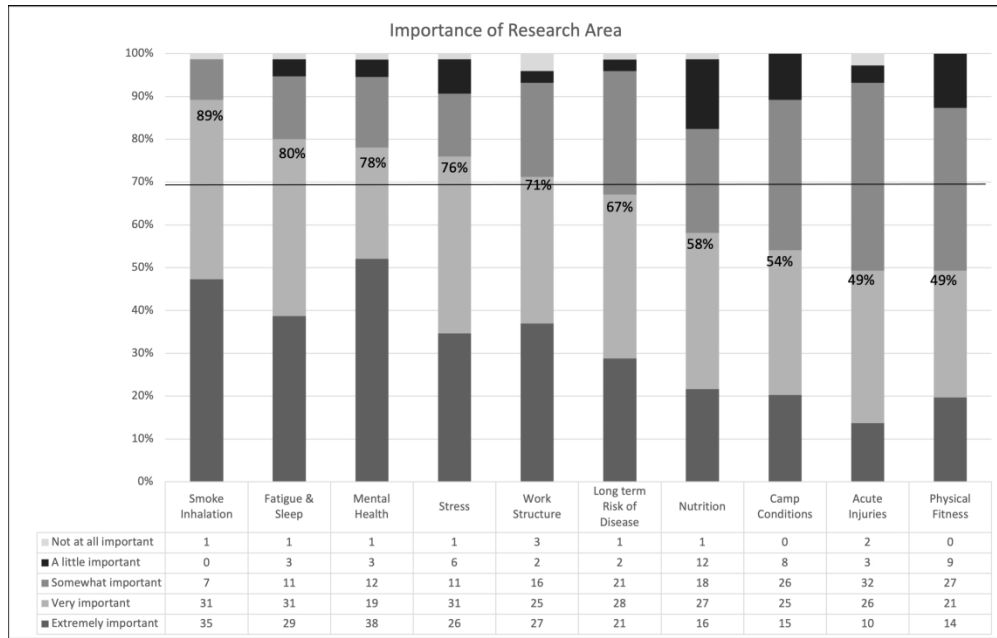


Figure 1

**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 being conducted 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](mailto: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](mailto: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.

1 \* Do you agree to participate in the survey?  
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Yes

No  
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6 If you would like to receive an emailed copy of the summary, please provide your email address here:  
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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

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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)

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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)?

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

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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	<input type="text"/>
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Research Topic	<input type="text"/>

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

<input type="text"/>
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1 Thank you for completing Phase 1 of the stakeholder consultation.

2 Phase 2 will involve ranking the most common answers regarding priority topics for research.

3 If you would like to participate in Phase 2 please provide your email address below (non-governmental email  
4 preferred).

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

12  Yes

13  No

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16 email address

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20 If you would like to contact the research team please email us at: [wildfirestudy@unbc.ca](mailto:wildfirestudy@unbc.ca)



## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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.

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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

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Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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 - Phase 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)?

1 How many of these years/seasons worked were spent participating in direct fire suppression on the fireline (for  
2 example, as a crew member/leader)?  
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## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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

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Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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](mailto: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 sectional reporting guidelines, and cite them as:

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

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

		recruitment, exposure, follow-up, and data collection	
1			
2	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of	7
3		participants.	
4			
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6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	6-8
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	6-8
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
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17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	N/A
18			
19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	N/A
20			
21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	7/8
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	7/8
26	methods	confounding	
27			
28			
29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	N/A
30	methods		
31			
32			
33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	N/A
34	methods		
35			
36			
37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	N/A
38	methods	strategy	
39			
40			
41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	N/A
42	methods		
43			
44	<b>Results</b>		
45			
46	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	9/10
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
51			
52			
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54			
55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	N/A
56			
57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	N/A
58			
59			
60			

1	Descriptive data	<a href="#">#14a</a>	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
2				
3				
4				
5				
6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	N/A
7				
8				
9				
10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
11				
12				
13				
14	Main results	<a href="#">#16a</a>	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
15				
16				
17				
18				
19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	N/A
20				
21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
22				
23				
24				
25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9/10
26				
27				
28				
29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	14/15
32				
33				
34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	16
35				
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38				
39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
40				
41				
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43				
44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	14-16
45				
46				
47	<b>Other</b>			
48	<b>Information</b>			
49				
50				
51	Funding	<a href="#">#22</a>	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
52				
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# BMJ Open

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

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3 **1 Health research priorities for wildland firefighters: a modified Delphi study with**  
4 **2 stakeholder interviews**  
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3 39 **ABSTRACT**  
4

5 40 **Objectives:** The increase in global wildland fire activity has accelerated the urgency to  
6  
7 41 understand health risks associated with wildland fire suppression. The aim of this project was to  
8  
9 42 identify occupational health research priorities for wildland firefighters and related personnel.  
10  
11

12 43 **Design:** In order to identify, rank, and rate health research priorities, we followed a modified  
13  
14 44 Delphi approach. Data collection involved a two-stage online survey followed by semi-structured  
15  
16 45 interviews.  
17  
18

19 46 **Setting:** British Columbia, Canada  
20

21 47 **Participants:** Participants included any current or past wildland firefighter or individuals  
22  
23 48 engaged in related roles. There were 132 respondents to the first survey. Responses to the first  
24  
25 49 survey were analyzed to produce 10 research topics which were ranked by 75 participants in the  
26  
27 50 second survey (response rate: 84%).  
28  
29

30 51 **Primary and secondary outcome measures:** The primary outcome was the identification,  
31  
32 52 ranking, and level of agreement of research priorities through a two-round online survey. We  
33  
34 53 contextualized these findings through deductive and inductive qualitative content analysis.  
35  
36

37 54 **Results:** The most important research priorities identified were (% consensus): effects of smoke  
38  
39 55 inhalation on respiratory health (89%), fatigue & sleep (80%), mental health (78%), stress  
40  
41 56 (76%), and long-term risk of disease (67%). Interviews were completed with 14 individuals. Two  
42  
43 57 main themes were developed from an inductive content analysis of interview transcripts: 1)  
44  
45 58 understand the dynamic risk environment; and 2) organizational fit of mitigation strategies.  
46  
47  
48

49 59 **Conclusions:** Participants expressed a general concern with the unknown mental and physical  
50  
51 60 health impacts of their jobs, including the long-term risk of morbidity and mortality. Future  
52  
53 61 research must address knowledge gaps in our understanding of the health impacts of wildland  
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3 62 fire and work to develop appropriate mitigation strategies while considering the needs of workers  
4  
5 63 and unpredictable environment.  
6

7  
8 64 **Registration:** Open Science Framework, [osf.io/ugz4](https://osf.io/ugz4).  
9

10 65 **Keywords:** wildfires, wildland fires, firefighters, Delphi technique, research priorities  
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## 80 STRENGTHS AND LIMITATIONS OF THIS STUDY

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

## 103 INTRODUCTION

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

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

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2  
3 125 defined in scope, inclusive with broad representation, relevant to decision makers, and consider  
4  
5 126 the specific research context [6-8].  
6

7  
8 127 Research priorities have been established to advance fire suppression knowledge [9] and  
9  
10 128 for understanding general public health impacts of wildland fire smoke [10]. We are not aware of  
11  
12 129 any stakeholder-identified health research priorities related to wildland firefighters or other  
13  
14 130 personnel involved in wildland fire suppression. Health research priorities are needed to ensure a  
15  
16 131 coordinated and effective research plan, direct research funding by organizations and  
17  
18 132 governments, support the development of appropriate mitigation strategies, and ultimately  
19  
20 133 improve health and wellbeing for all workers engaged in wildland fire suppression. The purpose  
21  
22 134 of this project was to identify health research priorities for wildland firefighters and related  
23  
24 135 personnel.  
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## 28 136 **METHODS**

29  
30  
31 137 This study is part of a larger project to establish health research funding priorities for the  
32  
33 138 British Columbia Wildfire Service (BCWS) based on gaps in literature and stakeholder priorities.  
34  
35 139 The protocol for this project has been previously published [11] and registered ([osf.io/ugz4](https://osf.io/ugz4)). To  
36  
37 140 align with public health guidelines on physical distancing during the COVID-19 pandemic, we  
38  
39 141 did not conduct meetings with stakeholders to discuss research priorities as indicated in our  
40  
41 142 original protocol. Instead, we conducted virtual semi-structured individual interviews with a  
42  
43 143 sample of survey respondents to contextualize identified research priorities, and enable broad  
44  
45 144 representation given COVID-19 public health guidelines on travel and the realities of the  
46  
47 145 wildland fire season. Research ethics approval was provided by the University of Northern  
48  
49 146 British Columbia Research Ethics Board and informed consent was obtained from all  
50  
51  
52  
53 147 participants.  
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3 148 The Delphi method is a process to gather stakeholder knowledge and experience and is  
4  
5 149 commonly used to identify occupational health research priorities [12-16]. The Delphi process  
6  
7 150 allows for the collection of opinions from a variety of stakeholders followed by the presentation  
8  
9 151 of ideas back to participants in iterative ‘rounds’ until consensus is reached [16]. For this study,  
10  
11 152 we have followed a modified Delphi method involving a two-stage online survey  
12  
13 153 (SurveyMonkey, California, USA) with follow-up semi-structured interviews. We modified a  
14  
15 154 traditional Delphi approach by combining qualitative and quantitative data and by not having an  
16  
17 155 expert panel meeting to achieve consensus following the multiple round survey, instead opting to  
18  
19 156 use this approach to obtain a ranked list of research priorities by inviting stakeholder (e.g.,  
20  
21 157 people with lived experience as experts). Based on similar work to establish research priorities  
22  
23 158 using a modified Delphi approach, we established *a priori* to conduct two survey rounds [13,14,  
24  
25 159 17] and determined consensus was achieved when at least 70% of respondents indicated the  
26  
27 160 research priority was “*very important*” or “*extremely important*” during the second-round survey  
28  
29 161 [18]. Participants were eligible to participate if they were current or past employees of BCWS (as  
30  
31 162 frontline wildland firefighters or in officer/managerial roles), researchers or trainees with an  
32  
33 163 interest in wildland fire, or employed in occupational health and safety. Both surveys included a  
34  
35 164 basic demographic questionnaire querying age, gender, and role as it related to wildland fire.  
36  
37 165 People employed by BCWS were also asked to identify the fire centre most recently worked,  
38  
39 166 years working, and current or prior relevant roles. At the end of each survey, participants could  
40  
41 167 enter a draw to win one of five \$50 Amazon gift cards. All interview participants were offered a  
42  
43 168 \$10 gift card to a food or retail vendor of their choice.  
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3 171 *Round 1: Identifying research priorities*  
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5 172 An invitation to participate in the first survey was circulated in March 2020 via email to  
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8 173 BCWS employees, occupational health policy makers (identified through our BCWS partners),  
9  
10 174 and researchers who had recently published in the field (e.g., contact information available on  
11  
12 175 websites or as corresponding author). Participants were asked to list up to 10 research priorities  
13  
14 176 of concern for wildland firefighters and up to 10 research priorities for related personnel in two  
15  
16 177 separate lists (see supplementary file 1). We conducted an inductive qualitative content analysis  
17  
18 178 [19-21] of responses. Three members of the research team read and re-read open-field responses  
19  
20 179 to identify codes and key concepts provided by participants. Codes were then grouped into  
21  
22 180 categories sharing common features. Discussion was used to reach consensus on final research  
23  
24 181 topics. The two job categories, wildland firefighters and related personnel, were collapsed for the  
25  
26 182 second survey because the topics identified by participants were similar.  
27  
28  
29

30  
31 183 *Round 2: Rating and ranking research priorities*  
32

33 184 The second survey was sent in June 2020 to participants who completed the first survey  
34  
35 185 and expressed interest in continuing their participation. In the second survey, respondents were  
36  
37 186 presented with the research topics identified in survey 1 and asked to indicate the importance of  
38  
39 187 each topic on a modified five-point Likert scale ranging from “*not at all important*” to  
40  
41 188 “*extremely important*” (see supplementary file 2). To prevent a bias resulting from question  
42  
43 189 order, the order of research topics was randomized for each survey respondent.  
44  
45  
46

47 190 To determine the relative importance of each research topic, respondents were presented  
48  
49 191 with all research topics and asked to rank them from most important to least important. To  
50  
51 192 calculate the weighted average, each research topic in the data set was multiplied by the rank-  
52  
53 193 weight assigned by each participant before the final means were calculated. For example, a  
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3 194 weight of 10 would be given to the respondents' highest priority, 9 to the second highest priority  
4  
5 195 and so on. This was repeated for each respondent's ranked research priorities. The mean  
6  
7  
8 196 weighted average was calculated for each research topic. Participant responses were separated by  
9  
10 197 job category (e.g., wildland firefighter, aviation crew) to determine if there was any difference in  
11  
12 198 identified research priorities based on role.

### 14 199 *Round 3: Semi-structured interviews*

16  
17 200 Semi-structured interviews allowed the opportunity for participants to provide a nuanced  
18  
19 201 description of identified research topics and to identify specific projects within each umbrella  
20  
21 202 topic. Eligible interview participants were at least 18 years of age and had completed both  
22  
23 203 surveys. We aimed for diversity in our sample based on length of time working in a wildland  
24  
25 204 fire-related role and across different job categories (e.g., researchers, wildland firefighter).

26  
27  
28 205 Interviews were conducted by two research team members over Zoom videoconference  
29  
30 206 or telephone. One researcher took detailed field notes and the other facilitated the interview  
31  
32 207 using a semi-structured interview schedule. Interviews were between 22-49 minutes in length  
33  
34 208 (average: 34 minutes). The interview schedule (see supplementary file 3) included open ended  
35  
36 209 questions about work-related health concerns, potential mitigation strategies, and research  
37  
38 210 questions or specific projects for each of the top five ranked research priorities.

39  
40  
41 211 Interviews were transcribed verbatim by a study team member. Field notes were used  
42  
43 212 during analysis to provide additional contextual information. Analysis was conducted in two  
44  
45 213 phases using a qualitative content analysis [19-20] by two team members. First, we took a  
46  
47 214 deductive approach to provide examples and nuanced description of each of the research topics  
48  
49 215 identified in the survey. A structured categorization matrix was created for the top 5 research  
50  
51 216 topics based on ranking and consensus. The interview transcripts were coded for correspondence  
52  
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217 with each research topic (category); only data aligning to the matrix (e.g., matched to a category  
218 or research topic) was chosen for the deductive phase of the analysis [20]. Data within each  
219 category was examined to determine if any sub-categories were necessary [21]. Items not  
220 explicitly aligned to one of the pre-identified research topics were analyzed using an inductive  
221 approach to identify additional themes [22]. Inductive open coding was completed to ensure we  
222 comprehensively represented content communicated by participants and to understand issues  
223 discussed by participants not directly related to the pre-identified research topics [19,20].

#### 224 *Patient and Public Involvement*

225 Patients were not involved in this study.

## 226 **RESULTS**

### 227 *Participants*

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

234 [INSERT TABLE 1]

### 235 *Research Priorities*

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

1  
2  
3 240 *mental health (78% consensus)* were the research topics with the greatest consensus. While  
4  
5 241 consensus was not reached across the entire cohort of respondents regarding the priority of *long-*  
6  
7 242 *term risk & prevalence of disease other than respiratory (67% consensus across entire sample)*,  
8  
9 243 within the subset of wildland firefighters and aviators, there was 81% consensus on the priority  
10  
11 244 of the topic. Additionally, for the research topic *camp conditions*, there was consensus (74%)  
12  
13 245 within the subset of zone and control staff.  
14  
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17 246  
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19 247 [INSERT FIGURE 1]  
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21 248  
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25  
26 250 When looking at the weighted rank of each research priority, the pattern was consistent  
27  
28 251 with those research priorities achieving consensus, with two notable differences. *Work structure*  
29  
30 252 *& organizational culture* was the fifth topic to satisfy the consensus requirement of a rating  
31  
32 253 greater than 70%; however, it had the sixth highest weighted average. *Long-term risk &*  
33  
34 254 *prevalence of disease other than respiratory* was ranked 4th by participants when considering  
35  
36 255 the weighted average; however, it did not reach consensus (67%; Table 2). The role of a  
37  
38 256 respondent did not appear to influence the ranking of research priorities. Four of the top five  
39  
40 257 areas of research as identified through the weighted average (*Understanding & mitigating effects*  
41  
42 258 *of smoke inhalation on respiratory health, fatigue & sleep, mental health, and stress*) also have  
43  
44 259 consensus ratings greater than 70%; therefore, any further research in these four areas would be  
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49 260  
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51 261 addressing priority areas as identified by stakeholders.  
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261 [INSERT TABLE 2]

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3 263 *Interview Findings*  
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5 264 In general, interview participants agreed with the ranked list of research priorities. Based  
6  
7  
8 265 on a deductive analysis of interviews, we generated areas of focus (sub-categories) for three of  
9  
10 266 the top five-ranked research topics (Table 3). For some research topics, no sub-categories were  
11  
12 267 developed.  
13

14 268  
15  
16  
17 269 [INSERT TABLE 3]  
18

19 270  
20  
21 271 From the inductive interview analysis, we developed two overarching principles as  
22  
23  
24 272 themes relevant to every research topic:  
25

26 273 **1) Understanding the dynamic risk environment:** Participants described the importance of  
27  
28 274 understanding health risk and exposure across different roles. For example, people who work in  
29  
30  
31 275 office environments do not face the same exposures:  
32

33 276 *“the office stuff or the staff that are there, I don’t think they have the same concerns*  
34  
35 277 *around smoke exposure and physiological toxins”* (P8, researcher)  
36

37  
38 278 This different exposure may translate to different health research priorities. For instance,  
39  
40 279 auxiliary staff who are typically students hired during the summer wildland fire season (typically  
41  
42 280 May – August) may not be as concerned with long-term health risk when compared to people  
43  
44 281 who work in wildland fire related roles for their entire career:  
45

46  
47 282 *“if we’re looking at an older population of firefighters, whether that be more the career*  
48  
49 283 *wildland firefighters, I think the health priorities, the health shifts a bit. Um, in that, I’d*  
50  
51 284 *be more concerned about a mixture of cardio-respiratory factors. Um, whether or not*  
52  
53 285 *long-term exposure to wildland smoke might be related to later in life – like, um, uh, like*  
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3 286 *lung pathologies or you know, if there's any risk factors for cardiovascular disease"* (P6,  
4  
5 287 researcher)

7  
8 288 It is also important to understand and explore risks across multiple seasons because the  
9  
10 289 unpredictability in fire activity may contribute to different health risks:

11  
12 290 *"We think of those big fire seasons, 2017, 2018, even 2015, and like the work component*  
13  
14 291 *is very fatiguing, but um, it's also very engaging. And then we have slower seasons like*  
15  
16 292 *this one [2020] and we may not think of it as harder on our mental health, because we're*  
17  
18 293 *not doing as much. But I do think it actually creates different challenges for people. So, I*  
19  
20 294 *think that's something that we need to be aware of – even though we're not on fires, there*  
21  
22 295 *are stressors associated with the job and it might actually be harder for people because*  
23  
24 296 *they [do not] have that active engagement in what we see as really fulfilling work"* (P4,  
25  
26 297 wildland firefighter)

27  
28 298 *"It really depends on the year. Because some, uh, some seasons they're so busy, and*  
29  
30 299 *some seasons they're so slow. There's going to be like different, there's different things*  
31  
32 300 *people care about in each, kind of different, when things are busy"* (P1, wildland  
33  
34 301 firefighter)

35  
36 302 Finally, the unpredictable work structure and schedule imposes barriers and challenges to  
37  
38 303 conducting research:

39  
40 304 *"I mean our unpredictable work schedule could be tough for research, but the way you*  
41  
42 305 *guys have been sending out like the surveys that we do on our own time has been*  
43  
44 306 *awesome. Like, if we can just sit down and just take 20 minutes, then by all means. But if*  
45  
46 307 *you need to like come into our workplace and try to organize that research is a bit*  
47  
48 308 *tougher"* (P3, wildland firefighter)

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3 309 **2) Organizational fit of mitigation strategies:** Participants emphasized any mitigation strategy  
4  
5 310 be worker-centred, reflect worker priorities and needs, and be developed with employees. This  
6  
7 311 was reflected in participants discussing management may not always have a feel for what it is  
8  
9 312 like to work on the front-line and any mitigation or management strategy not aligning with  
10  
11 313 organizational realities would have minimal uptake.

14 314 *“people are so resistant to like any change, any, and I think it’s a part of that whole*  
15  
16 315 *disparity between management – like this is something else management’s pushing down,*  
17  
18 316 *oh they have no concept, like just ignore it...like that whole dynamic of like, just like,*  
19  
20 317 *people sitting in office, and us like grinding out there”* (P5, wildland firefighter)

23 318 Relatedly, participants discussed how organizational culture and resistance to change could  
24  
25 319 present a barrier to implementing mitigation strategies:

28 320 *“the biggest challenge I come across is like the ‘this is the way we do things’ kind of*  
29  
30 321 *attitude”* (P8, researcher)

33 322 *“And then the organizational culture about, sort of a can-do organization and you know,*  
34  
35 323 *we can, we get a lot done – yes – we can take care of things, and this is the way we’ve*  
36  
37 324 *always done it. And uh, yeah, it’s certainly an organization, I think. The – yeah – so just*  
38  
39 325 *sort of pushing through that organizational culture”* (P13, administrative/office role)

## 42 326 **DISCUSSION**

44 327 Following best practice guidelines for research priority setting [6,7], the aim of this  
45  
46 328 project was to identify health research priorities for wildland firefighters and related personnel.  
47  
48 329 Five research topics achieved consensus across the entire sample: *understanding & mitigating*  
49  
50 330 *effects of smoke inhalation on respiratory health, fatigue & sleep, mental health, stress, and work*  
51  
52 331 *structure & organizational culture.* A sixth research topic, *long-term risk & prevalence of*  
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3 332 *disease other than respiratory*, nearly reached consensus (67% agreement) and was ranked  
4  
5 333 highly by all participants. Based on interviews with relevant stakeholders, we have developed  
6  
7 334 specific areas of study within each research topic. We identified two themes common to all  
8  
9 335 research topics: 1) understand the dynamic risk environment across wildland fire seasons and  
10  
11 336 roles; 2) organizational fit of mitigation strategies. Despite a different risk environment, the  
12  
13 337 health concerns identified by participants in the current study parallel those by structural  
14  
15 338 firefighters [23], although there is considerably less knowledge specific to health outcomes  
16  
17 339 associated with wildland fire exposure and substantial gaps in knowledge on the long-term health  
18  
19 340 impacts [5].

20  
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23  
24 341 The most important research topic identified by participants was related to smoke  
25  
26 342 exposure and respiratory health, with 89% of participants indicating it was extremely or very  
27  
28 343 important. During interviews, participants focused on the need for a better understanding of the  
29  
30 344 exposures and health risks associated with wildland fire smoke and the desire for feasible,  
31  
32 345 effective personal protective equipment to protect against smoke inhalation. While many  
33  
34 346 participants mentioned masks, they also noted the difficulties and practicality of wearing a mask  
35  
36 347 in the field while fighting fire for long hours. Two recent papers have explored mask wearing to  
37  
38 348 protect against wildland fire smoke, suggesting they may be effective at reducing particulate  
39  
40 349 matter exposure even if used for only part of a shift; however, neither study reported any data on  
41  
42 350 user experience [24,25]. Ultimately, participants expressed the desire to be engaged in the  
43  
44 351 development of any mitigation strategy and corresponding occupational health policy as essential  
45  
46 352 to ensure uptake.

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51 353 Participants indicated a need to understand the cumulative mental and physical health toll  
52  
53 354 of both busy and quiet fire seasons, and recovery in the off-season. Of particular concern was the  
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3 355 need to understand the risk of chronic fatigue resulting from an increasing length of fire seasons  
4  
5 356 and reduced opportunity to recover. The nature of the occupation typically necessitates sleeping  
6  
7 357 at a fire camp, where wildland firefighters do not typically achieve appropriate quality of  
8  
9 358 quantity of sleep [26-28]. While research has documented poor sleep conditions and reduced  
10  
11 359 cognitive function in-field [26-28], research questions remain about the optimal work to rest  
12  
13 360 schedule for wildland firefighting, strategies for recovery in the off-season, and how to balance  
14  
15 361 sleep hygiene with the realities of wildland fire operations and crew management.

16  
17 362 Notably, while the research topic *long-term risk & prevalence of disease other than*  
18  
19 363 *respiratory* did not reach consensus among the entire sample, it was ranked highly and reached  
20  
21 364 consensus (81%) among people involved in direct fire suppression. Designing and conducting  
22  
23 365 research to understand the cumulative impacts of multiple seasons of wildland fire exposure is a  
24  
25 366 considerable challenge and the long-term health impacts of wildland firefighting are poorly  
26  
27 367 understood [4,5], although we do note ongoing work by the United States National Institute for  
28  
29 368 Occupational Safety and Health [29]. In BC, many front-line wildland firefighters are post-  
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31 369 secondary students hired as auxiliary employees during the summer (May – August) wildland  
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33 370 fire season. The transient and mobile workforce creates considerable challenges to evaluating  
34  
35 371 risk related to morbidity and mortality outcomes over multiple seasons. Similarly, the  
36  
37 372 unpredictability of a given fire season means generating consistent evidence or changes in health  
38  
39 373 outcomes across any one season is challenging due to the variable exposure. For example, some  
40  
41 374 participants mentioned unique challenges during less active fire seasons such as a different  
42  
43 375 mental health toll from not being able to engage in work they enjoy and find meaningful. Thus,  
44  
45 376 while some fire seasons may be ‘quieter’ in terms of fire activity and respiratory health risk (e.g.,  
46  
47 377 lower smoke exposure), they may impose a different mental health risk. While our research

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3 378 priorities can be used to support researchers to make decisions on prioritizing collective research  
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5 379 efforts, findings also suggest the need for sustainable, flexible research infrastructure to adapt  
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7  
8 380 and understand variable risk environments.  
9

### 10 381 *Limitations*

11  
12 382 The email invitation to participate was sent in March 2020. This was done to ensure data  
13  
14 383 collection was not impacted by the busiest point in the fire season (typically June – August in  
15  
16 384 BC). Because of this, many auxiliary/seasonal staff had not yet started work and may be  
17  
18  
19 385 underrepresented in our sample. Participants were asked to list their top 10 research priorities for  
20  
21 386 wildland firefighters and related personnel separately in the first survey. Based on very similar  
22  
23 387 research topics identified for both job categories and suggestions by participants in the open field  
24  
25 388 question, we collapsed the two job categories for the stage 2 survey. This may have reduced our  
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27  
28 389 ability to tease out specific research topics for related personnel and identified research priorities  
29  
30 390 are likely more applicable to wildland firefighters. Occupational health policy makers and  
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32 391 researchers were identified by convenience sampling through our partnership with BCWS and by  
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34 392 extracting contact information from recently published papers in the field, which may have  
35  
36  
37 393 limited the breadth of stakeholder participant perspectives.  
38  
39

### 40 394 **Conclusions**

41  
42 395 This project represents the first attempt to develop a comprehensive set of research  
43  
44 396 priorities for wildland firefighters and related personnel. Our process included a broad range of  
45  
46 397 stakeholders, from frontline staff to those working in occupational health and safety policy, with  
47  
48  
49 398 national and international representation. Stakeholders consistently identified the need for  
50  
51 399 research to understand the physical and mental health risks of their job, and to work to  
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53 400 understand how this risk may lead to long-term morbidity and mortality across multiple fire  
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3 401 seasons or an entire career. Appropriate, feasible mitigation, prevention, and/or management  
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5 402 strategies are urgently needed to address health concerns for workers directly or indirectly  
6  
7 403 engaged in wildland fire suppression.  
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10 404  
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12 405 **Additional file 1.** Survey 1: Identifying health research priorities for wildland firefighters and  
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14 406 related personnel.  
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16  
17 407 **Additional file 2.** Survey 2: Ranking health research priorities for wildland firefighters and  
18  
19 408 related personnel.  
20

21 409 **Additional file 3.** Interview Schedule  
22

23  
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33  
34 415 body had no role in the design of the study, interpretation of findings, or preparation of this  
35  
36 416 manuscript.  
37

38  
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40

41  
42 418 **Data sharing statement:** No additional data are available.  
43

44  
45 419 **Ethics approval:** This study was approved by the University of Northern British Columbia  
46  
47 420 Research Ethics Board (E2019.1220.076.00).  
48

49 421 **Author contributions:** CP lead study conception and design, data collection, analysis, and  
50  
51 422 manuscript writing. CR was involved in the development, distribution, and analysis of online  
52  
53 423 survey, and assisted in preparation of the manuscript. KB supported interview data collection,  
54  
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3 424 transcription, interview analysis, and preparation of the manuscript. TF, EK, and KC provided  
4  
5 425 critical feedback on data collection, study design, assisted with survey and interview analysis.  
6  
7  
8 426 All authors participated in the interpretation of the results, provided critical revision of and  
9  
10 427 approved the final manuscript.  
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13 428

## 14 429 **Figure Legends**

15  
16  
17 430 Figure 1. Consensus rating of research topics.  
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535 Table 1. Participant demographics.

	Survey 1 (n = 132)	Survey 2 (n=75)	Interviews (n=14)
<b>Gender (n, %)</b>			
Female	40, 30%	27, 36%	N/A
Male	92, 70%	48, 64%	N/A
<b>Age (n, %)</b>			
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
<b>Role in Last Firefighting Season</b>			
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
<b>Specific to respondents with BCWS role</b>			
	Survey 1 (n=116)	Survey 2 (n=66)	Interviews (n=11)
<b>Years of Employment with BCWS</b>			
1-5	48	29	2
6-10	28	13	4
11-15	15	9	4
16-20	11	5	0
21+	14	9	1
<b>Years in Direct Fire Suppression</b>			
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
<b>Fire Center Most Recently Working</b>			
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

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

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

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

560 Table 3. Top five ranked research topics and areas of focus identified by interview participants through deductive  
561 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	<p>“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)</p> <p>“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)</p> <p>“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)</p>
	Understand exposure	<p>“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)</p> <p>“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)</p>
Fatigue & sleep	Determine optimal amounts of sleep	<p>“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)</p> <p>“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,</p>

		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)

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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)

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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)

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PPE, personal protective equipment

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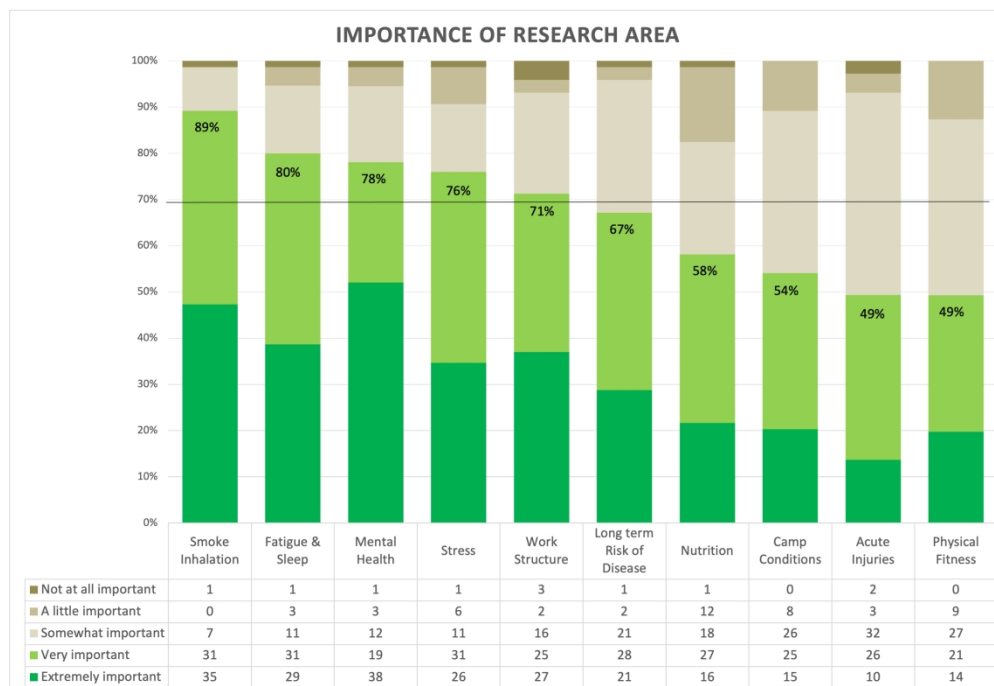


Figure 1

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 being conducted 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](mailto: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](mailto: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.

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\* 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:

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5 What is your current age?

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

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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)

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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)?

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How many of these years/seasons worked were spent participating in direct fire suppression 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

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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

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Research Topic

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

1 Thank you for completing Phase 1 of the stakeholder consultation.

2 Phase 2 will involve ranking the most common answers regarding priority topics for research.

3 If you would like to participate in Phase 2 please provide your email address below (non-governmental email  
4 preferred).  
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10 Would you like to be entered into a draw for one of five \$50 Amazon gift cards?

11  Yes

12  No

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20 If you would like to contact the research team please email us at: [wildfirestudy@unbc.ca](mailto:wildfirestudy@unbc.ca)  
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## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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?

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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?**

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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 - Phase 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

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## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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)?

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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 - Phase 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 - Phase 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 - Phase 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

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## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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

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Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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](mailto: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 sectional reporting guidelines, and cite them as:

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

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

		recruitment, exposure, follow-up, and data collection	
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2			
3	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of participants.	7
4			
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6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	6-8
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
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10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	6-8
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
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17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	N/A
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19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	N/A
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21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	7/8
22	variables	applicable, describe which groupings were chosen, and why	
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24			
25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	7/8
26	methods	confounding	
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29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	N/A
30	methods		
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33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	N/A
34	methods		
35			
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37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	N/A
38	methods	strategy	
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41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	N/A
42	methods		
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44	<b>Results</b>		
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46	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	9/10
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	N/A
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57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	N/A
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1	Descriptive data	<a href="#">#14a</a>	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
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	N/A
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
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14	Main results	<a href="#">#16a</a>	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
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19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	N/A
20				
21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9/10
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29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	14/15
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34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	16
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	14-16
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47	<b>Other</b>			
48	<b>Information</b>			
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51	Funding	<a href="#">#22</a>	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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# BMJ Open

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

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<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Research methods
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, QUALITATIVE RESEARCH, Protocols & guidelines < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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3 1 **Health research priorities for wildland firefighters: a modified Delphi study with**  
4 2 **stakeholder interviews**  
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3 39 **ABSTRACT**  
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5 40 **Objectives:** The increase in global wildland fire activity has accelerated the urgency to  
6  
7 41 understand health risks associated with wildland fire suppression. The aim of this project was to  
8  
9 42 identify occupational health research priorities for wildland firefighters and related personnel.  
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11

12 43 **Design:** In order to identify, rank and rate health research priorities, we followed a modified  
13  
14 44 Delphi approach. Data collection involved a two-stage online survey followed by semi-structured  
15  
16 45 interviews.  
17  
18

19 46 **Setting:** British Columbia, Canada  
20

21 47 **Participants:** Participants included any current or past wildland firefighter or individuals  
22  
23 48 engaged in related roles. There were 132 respondents to the first survey. Responses to the first  
24  
25 49 survey were analyzed to produce 10 research topics which were ranked by 75 participants in the  
26  
27 50 second survey (response rate: 84%).  
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30 51 **Primary and secondary outcome measures:** The primary outcome was the identification,  
31  
32 52 ranking and level of agreement of research priorities through a two-round online survey. We  
33  
34 53 contextualized these findings through deductive and inductive qualitative content analysis of  
35  
36 54 semi-structured interviews.  
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39 55 **Results:** The most important research priorities identified were (% consensus): effects of smoke  
40  
41 56 inhalation on respiratory health (89%), fatigue & sleep (80%), mental health (78%), stress (76%)  
42  
43 57 and long-term risk of disease (67%). Interviews were completed with 14 individuals. Two main  
44  
45 58 themes were developed from an inductive content analysis of interview transcripts: 1) understand  
46  
47 59 the dynamic risk environment; and 2) organizational fit of mitigation strategies.  
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50 60 **Conclusions:** Participants expressed a general concern with the unknown mental and physical  
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52 61 health impacts of their jobs, including the long-term risk of morbidity and mortality. Future  
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3 62 research must address knowledge gaps in our understanding of the health impacts of wildland  
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5 63 fire and work to develop appropriate mitigation strategies while considering the needs of workers  
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7  
8 64 and unpredictable workplace environment.  
9

10 65 **Registration:** Open Science Framework, [osf.io/ugz4](https://osf.io/ugz4).  
11

12 66 **Keywords:** wildfires, wildland fires, firefighters, Delphi technique, research priorities  
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## 81 STRENGTHS AND LIMITATIONS OF THIS STUDY

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

## 104 INTRODUCTION

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

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

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3 127 of the hazards from exposure to wildland fire smoke, wildland firefighters are exposed to  
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5 128 occupational stressors due to the nature of the profession (e.g., unpredictable extended  
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7 129 deployments, trauma from seeing homes or communities burned) and workplace culture (e.g.,  
8  
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10 130 masculine dominance). Studies focusing on mental health have identified an increased risk of  
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12 131 post-traumatic stress among wildland firefighters and increased suicide risk [18,19]. Fireline  
13  
14 132 deployments have been associated with fatigue resulting from poor sleep quality and quantity  
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17 133 [20]. Injuries are also commonly reported following work as a wildland firefighter, related to fire  
18  
19 134 complexity and seasonal timing [21,22]. Few studies have been published evaluating strategies to  
20  
21 135 reduce health risk. The broad focus of these intervention strategies include prescribed drinking  
22  
23 136 interventions to support better thermal regulation [23,24], mask wearing to reduce exposure to  
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25 137 particular matter [25,26], and enhanced skin hygiene (e.g., showering, laundering clothing) to  
26  
27 138 reduce polycyclic aromatic hydrocarbon exposure [26].  
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30  
31 139 Health research priority setting is an important component of participatory research  
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33 140 approaches, can maximize investments in research for funding organizations and governments  
34  
35 141 and help focus research efforts across broad fields of study [27,28]. Through research priority  
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37 142 setting, people who stand to benefit the most from research, known as stakeholders or knowledge  
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39 143 users, can contribute to the research process and direct research activities [27]. In relation to  
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41 144 wildland fire, stakeholder voices include frontline firefighters, people working in roles related to  
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43 145 or supporting direct fire suppression, occupational health and safety policy makers, and  
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45 146 researchers. Health research priority setting must be well defined in scope, inclusive with broad  
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47 147 representation, relevant to decision makers, and consider the specific research context [27-29].  
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51 148 Research priorities have been established to advance fire suppression knowledge [30] and  
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53 149 for understanding general public health impacts of wildland fire smoke [31]. We are not aware of  
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3 150 any stakeholder-identified health research priorities related to wildland firefighters or other  
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5 151 personnel involved in wildland fire suppression. Health research priorities are needed to ensure a  
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7 152 coordinated and effective research plan, direct research funding by organizations and  
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9 153 governments, support the development of appropriate mitigation strategies, and ultimately  
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11 154 improve health and wellbeing for all workers engaged in wildland fire suppression. The purpose  
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13 155 of this project was to identify health research priorities for wildland firefighters and related  
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15 156 personnel.  
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## 19 157 **METHODS**

20  
21 158 This study is part of a larger project to establish health research funding priorities for the  
22  
23 159 British Columbia Wildfire Service (BCWS) based on gaps in literature and stakeholder priorities.  
24  
25 160 The protocol for this project has been previously published [32] and registered ([osf.io/ugz4](https://osf.io/ugz4)). To  
26  
27 161 align with public health guidelines on physical distancing during the COVID-19 pandemic, we  
28  
29 162 did not conduct meetings with stakeholders to discuss research priorities as indicated in our  
30  
31 163 original protocol. Instead, we conducted virtual semi-structured individual interviews with a  
32  
33 164 sample of survey respondents to contextualize identified research priorities, and enable broad  
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35 165 representation given COVID-19 public health guidelines on travel and the realities of the  
36  
37 166 wildland fire season. Research ethics approval was provided by the University of Northern  
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39 167 British Columbia Research Ethics Board and informed consent was obtained from all  
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41 168 participants.  
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47 169 The Delphi method is a process to gather stakeholder knowledge and experience and is  
48  
49 170 commonly used to identify occupational health research priorities [33-36]. The Delphi process  
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51 171 allows for the collection of opinions from a variety of stakeholders followed by the presentation  
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53 172 of ideas back to participants in iterative 'rounds' until consensus is reached [37]. For this study,  
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3 173 we have followed a modified Delphi method involving a two-stage online survey  
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5 174 (SurveyMonkey, California, USA) with follow-up semi-structured interviews. We modified a  
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8 175 traditional Delphi approach by combining qualitative and quantitative data and by not having an  
9  
10 176 expert panel meeting to achieve consensus following the multiple round survey. Instead, we used  
11  
12 177 a modified Delphi approach to obtain a ranked list of research priorities by inviting a broad range  
13  
14  
15 178 of stakeholder (e.g., people with lived experience as experts) participants. Based on similar work  
16  
17 179 to establish research priorities using a modified Delphi approach, we established *a priori* to  
18  
19 180 conduct two survey rounds [33,34,38] and determined consensus was achieved when at least  
20  
21  
22 181 70% of respondents indicated the research priority was “*very important*” or “*extremely*  
23  
24 182 *important*” during the second-round survey [39].

25  
26 183 Participants were eligible to participate if they were current or past employees of BCWS  
27  
28 184 (as frontline wildland firefighters or in officer/managerial roles), researchers or trainees with an  
29  
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31 185 interest in wildland fire, or employed in occupational health and safety. Both surveys included a  
32  
33 186 basic demographic questionnaire querying age, gender, and role as it related to wildland fire.  
34  
35 187 People employed by BCWS were also asked to identify the fire centre most recently worked,  
36  
37  
38 188 years working, and current or prior relevant roles. Interview participants were asked to identify  
39  
40 189 their job role, but we did not collect further demographic information (e.g., age, gender) to  
41  
42 190 protect participant confidentiality. Given the relatively small sample pool, limited number of  
43  
44  
45 191 women working for the BCWS, and sensitive nature of the project in relation to the participants’  
46  
47 192 workplace, the identity of some participants may be easy to deduce based on their fire zone and  
48  
49 193 role and was thus not collected or reported. At the end of each survey, participants could enter a  
50  
51 194 draw to win one of five \$50 Amazon gift cards. All interview participants were offered a \$10 gift  
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54 195 card to a food or retail vendor of their choice.

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3 196 *Round 1: Identifying research priorities*  
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5 197 An invitation to participate in the first survey was circulated in March 2020 via email to  
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8 198 BCWS employees, occupational health policy makers (identified through our BCWS partners),  
9  
10 199 and researchers who had recently published in the field (e.g., contact information available on  
11  
12 200 websites or as corresponding author). Participants were asked to list up to 10 research priorities  
13  
14 201 of concern for wildland firefighters and up to 10 research priorities for related personnel in two  
15  
16 202 separate lists (see supplementary file 1). We conducted an inductive qualitative content analysis  
17  
18 203 of responses [40-42]. Three members of the research team read and re-read open-field responses  
19  
20 204 to identify codes and key concepts provided by participants. Codes were then grouped into  
21  
22 205 categories sharing common features. Discussion was used to reach consensus on final research  
23  
24 206 topics. The two job categories, wildland firefighters and related personnel, were collapsed for the  
25  
26 207 second survey because the topics identified by participants were similar.  
27  
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30  
31 208 *Round 2: Rating and ranking research priorities*  
32

33 209 The second survey was sent in June 2020 to participants who completed the first survey  
34  
35 210 and expressed interest in continuing their participation. In the second survey, respondents were  
36  
37 211 presented with the research topics identified in survey 1 and asked to indicate the importance of  
38  
39 212 each topic on a modified five-point Likert scale ranging from “*not at all important*” to  
40  
41 213 “*extremely important*” (see supplementary file 2). To prevent a bias resulting from question  
42  
43 214 order, the order of research topics was randomized for each survey respondent.  
44  
45  
46

47 215 To determine the relative importance of each research topic, respondents were presented  
48  
49 216 with all research topics and asked to rank them from most important to least important. To  
50  
51 217 calculate the weighted average, each research topic in the data set was multiplied by the rank-  
52  
53 218 weight assigned by each participant before the final means were calculated. For example, a  
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3 219 weight of 10 would be given to the respondents' highest priority, 9 to the second highest priority  
4  
5 220 and so on. This was repeated for each respondent's ranked research priorities. The mean  
6  
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8 221 weighted average was calculated for each research topic. Participant responses were separated by  
9  
10 222 job category (e.g., wildland firefighter, aviation crew) to determine if there was any difference in  
11  
12 223 identified research priorities based on role.

### 14 224 *Round 3: Semi-structured interviews*

16  
17 225 Semi-structured interviews allowed the opportunity for participants to provide a nuanced  
18  
19 226 description of identified research topics and to identify specific projects within each umbrella  
20  
21 227 topic. Eligible interview participants were at least 18 years of age and had completed both  
22  
23 228 surveys. We aimed for diversity in our sample based on length of time working in a wildland  
24  
25 229 fire-related role and across different job categories (e.g., researchers, wildland firefighter).

26  
27  
28 230 Interviews were conducted by two research team members over Zoom videoconference  
29  
30 231 or telephone. One researcher took detailed field notes and the other facilitated the interview  
31  
32 232 using a semi-structured interview schedule. Interviews were between 22-49 minutes in length  
33  
34 233 (average: 34 minutes). The interview schedule (see supplementary file 3) included open ended  
35  
36 234 questions about work-related health concerns, potential mitigation strategies, and research  
37  
38 235 questions or specific projects for each of the top five ranked research priorities.

39  
40 236 Interviews were transcribed verbatim by a study team member. Field notes were used  
41  
42 237 during analysis to provide additional contextual information. Analysis was conducted in two  
43  
44 238 phases using a qualitative content analysis [40,41] by two team members. First, we took a  
45  
46 239 deductive approach to provide examples and nuanced description of each of the research topics  
47  
48 240 identified in the survey. A structured categorization matrix was created for the top 5 research  
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50 241 topics based on ranking and consensus. The interview transcripts were coded for correspondence  
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3 242 with each research topic (category); only data aligning to the matrix (e.g., matched to a category  
4  
5 243 or research topic) was chosen for the deductive phase of the analysis [41]. Data within each  
6  
7 244 category was examined to determine if any sub-categories were necessary [42]. Items not  
8  
9 245 explicitly aligned to one of the pre-identified research topics were analyzed using an inductive  
10  
11 246 approach to identify additional themes [43]. Inductive open coding was completed to ensure we  
12  
13 247 comprehensively represented content communicated by participants and to understand issues  
14  
15 248 discussed by participants not directly related to the pre-identified research topics [40,41].  
16  
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#### 19 249 *Patient and Public Involvement*

20  
21 250 Patients were not involved in this study.

## 22 251 **RESULTS**

### 23 252 *Participants*

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26 253 Survey 1 was completed by 132 participants (92 males, 40 females; Table 1). We are  
27  
28 254 unable to calculate a response rate for the first survey because the invitation to participate was  
29  
30 255 primarily circulated through a BCWS mailing list. Survey 2 was sent to 89 potential participants  
31  
32 256 and completed by 75 respondents (response rate: 84%, 48 males, 27 females). Interviews were  
33  
34 257 conducted with 14 participants: six current or prior wildland firefighters, three researchers or  
35  
36 258 trainees, and five people with administrative or officer roles.  
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44 260 [INSERT TABLE 1]

45 261

### 46 262 *Research Priorities*

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48 263 More than 900 research areas were suggested from participants in survey 1 which were  
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50 264 organized into 10 categories or research topics ranked by participants in survey 2. Consensus  
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3 265 was achieved on five of the ten research topics (Figure 1). *Understanding & mitigating effects of*  
4  
5 266 *smoke inhalation on respiratory health (89% consensus), fatigue & sleep (80% consensus), and*  
6  
7 267 *mental health (78% consensus)* were the research topics with the greatest consensus. While  
8  
9  
10 268 consensus was not reached across the entire cohort of respondents regarding the priority of *long-*  
11  
12 269 *term risk & prevalence of disease other than respiratory (67% consensus across entire sample),*  
13  
14 270 within the subset of wildland firefighters and aviators, there was 81% consensus on the priority  
15  
16 271 of the topic. Additionally, for the research topic *camp conditions*, there was consensus (74%)  
17  
18 272 within the subset of zone and control staff.  
19  
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24 274 [INSERT FIGURE 1]  
25

26 275  
27  
28 276 When looking at the weighted rank of each research priority, the pattern was consistent  
29  
30 277 with those research priorities achieving consensus, with two notable differences. *Work structure*  
31  
32 278 *& organizational culture* was the fifth topic to satisfy the consensus requirement of a rating  
33  
34 279 greater than 70%; however, it had the sixth highest weighted average. *Long-term risk &*  
35  
36 280 *prevalence of disease other than respiratory* was ranked 4th by participants when considering  
37  
38 281 the weighted average; however, it did not reach consensus (67%; Table 2). The role of a  
39  
40 282 respondent did not appear to influence the ranking of research priorities. Four of the top five  
41  
42 283 areas of research as identified through the weighted average (*Understanding & mitigating effects*  
43  
44 284 *of smoke inhalation on respiratory health, fatigue & sleep, mental health, and stress*) also have  
45  
46 285 consensus ratings greater than 70%; therefore, any further research in these four areas would be  
47  
48 286 addressing priority areas as identified by stakeholders.  
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3 288 [INSERT TABLE 2]  
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8 290 *Interview Findings*

9  
10 291 In general, interview participants agreed with the ranked list of research priorities. Based  
11  
12 292 on a deductive analysis of interviews, we generated areas of focus (sub-categories) for three of  
13  
14 293 the top five-ranked research topics (Table 3). For some research topics, no sub-categories were  
15  
16 294 developed.  
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21 296 [INSERT TABLE 3]  
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25  
26 298 From the inductive interview analysis, we developed two overarching principles as  
27  
28 299 themes relevant to every research topic:  
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30  
31 300 **1) Understanding the dynamic risk environment:** Participants described the importance of  
32  
33 301 understanding health risk and exposure across different roles. For example, people who work in  
34  
35 302 office environments do not face the same exposures:  
36

37  
38 303 *“the office stuff or the staff that are there, I don’t think they have the same concerns*  
39  
40 304 *around smoke exposure and physiological toxins”* (P8, researcher)  
41

42 305 This different exposure may translate to different health research priorities. For instance,  
43  
44 306 auxiliary staff who are typically students hired during the summer wildland fire season (typically  
45  
46 307 May – August) may not be as concerned with long-term health risk when compared to people  
47  
48 308 who work in wildland fire related roles for their entire career:  
49

50  
51 309 *“if we’re looking at an older population of firefighters, whether that be more the career*  
52  
53 310 *wildland firefighters, I think the health priorities, the health shifts a bit. Um, in that, I’d*  
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3 311 *be more concerned about a mixture of cardio-respiratory factors. Um, whether or not*  
4  
5 312 *long-term exposure to wildland smoke might be related to later in life – like, um, uh, like*  
6  
7 313 *lung pathologies or you know, if there’s any risk factors for cardiovascular disease” (P6,*  
8  
9  
10 314 *researcher)*

11  
12 315 It is also important to understand and explore risks across multiple seasons because the  
13  
14 316 unpredictability in fire activity may contribute to different health risks:

15  
16  
17 317 *“We think of those big fire seasons, 2017, 2018, even 2015, and like the work component*  
18  
19 318 *is very fatiguing, but um, it’s also very engaging. And then we have slower seasons like*  
20  
21 319 *this one [2020] and we may not think of it as harder on our mental health, because we’re*  
22  
23 320 *not doing as much. But I do think it actually creates different challenges for people. So, I*  
24  
25 321 *think that’s something that we need to be aware of – even though we’re not on fires, there*  
26  
27 322 *are stressors associated with the job and it might actually be harder for people because*  
28  
29 323 *they [do not] have that active engagement in what we see as really fulfilling work” (P4,*  
30  
31 324 *wildland firefighter)*

32  
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34  
35 325 *“It really depends on the year. Because some, uh, some seasons they’re so busy, and*  
36  
37 326 *some seasons they’re so slow. There’s going to be like different, there’s different things*  
38  
39 327 *people care about in each, kind of different, when things are busy” (P1, wildland*  
40  
41 328 *firefighter)*

42  
43  
44 329 Finally, the unpredictable work structure and schedule imposes barriers and challenges to  
45  
46 330 conducting research:

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48  
49 331 *“I mean our unpredictable work schedule could be tough for research, but the way you*  
50  
51 332 *guys have been sending out like the surveys that we do on our own time has been*  
52  
53 333 *awesome. Like, if we can just sit down and just take 20 minutes, then by all means. But if*



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3 334 *you need to like come into our workplace and try to organize that research is a bit*  
4  
5 335 *tougher” (P3, wildland firefighter)*  
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7

8 336 **2) Organizational fit of mitigation strategies:** Participants emphasized any mitigation strategy  
9  
10 337 be worker-centred, reflect worker priorities and needs, and be developed with employees. This  
11  
12 338 was reflected in participants discussing management may not always have a feel for what it is  
13  
14 339 like to work on the front-line and any mitigation or management strategy not aligning with  
15  
16 340 organizational realities would have minimal uptake.  
17

18  
19 341 *“people are so resistant to like any change, any, and I think it’s a part of that whole*  
20  
21 342 *disparity between management – like this is something else management’s pushing down,*  
22  
23 343 *oh they have no concept, like just ignore it...like that whole dynamic of like, just like,*  
24  
25 344 *people sitting in office, and us like grinding out there” (P5, wildland firefighter)*  
26  
27

28 345 Relatedly, participants discussed how organizational culture and resistance to change could  
29  
30 346 present a barrier to implementing mitigation strategies:  
31

32  
33 347 *“the biggest challenge I come across is like the ‘this is the way we do things’ kind of*  
34  
35 348 *attitude” (P8, researcher)*  
36

37 349 *“And then the organizational culture about, sort of a can-do organization and you know,*  
38  
39 350 *we can, we get a lot done – yes – we can take care of things, and this is the way we’ve*  
40  
41 351 *always done it. And uh, yeah, it’s certainly an organization, I think. The – yeah – so just*  
42  
43 352 *sort of pushing through that organizational culture” (P13, administrative/office role)*  
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## 47 353 **DISCUSSION**

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49 354 Following best practice guidelines for research priority setting [27,28], the aim of this  
50  
51 355 project was to identify health research priorities for wildland firefighters and related personnel.  
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53 356 Five research topics achieved consensus across the entire sample: *understanding & mitigating*  
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3 357 *effects of smoke inhalation on respiratory health, fatigue & sleep, mental health, stress, and work*  
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5 358 *structure & organizational culture. A sixth research topic, long-term risk & prevalence of*  
6  
7 359 *disease other than respiratory, nearly reached consensus (67% agreement) and was ranked*  
8  
9 360 highly by all participants. Based on interviews with relevant stakeholders, we have developed  
10  
11 361 specific areas of study within each research topic. We identified two themes common to all  
12  
13 362 research topics: 1) understand the dynamic risk environment across wildland fire seasons and  
14  
15 363 roles; 2) organizational fit of mitigation strategies. Despite a different risk environment, the  
16  
17 364 health concerns identified by participants in the current study parallel those by structural  
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19 365 firefighters [44], although there is considerably less knowledge specific to health outcomes  
20  
21 366 associated with wildland fire exposure and substantial gaps in knowledge on the long-term health  
22  
23 367 impacts [8].

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25  
26 368 The most important research topic identified by participants was related to smoke  
27  
28 369 exposure and respiratory health, with 89% of participants indicating it was extremely or very  
29  
30 370 important. During interviews, participants focused on the need for a better understanding of the  
31  
32 371 exposures and health risks associated with wildland fire smoke and the desire for feasible,  
33  
34 372 effective personal protective equipment to protect against smoke inhalation. While many  
35  
36 373 participants mentioned masks, they also noted the difficulties and practicality of wearing a mask  
37  
38 374 in the field while fighting fire for long hours. Two recent papers have explored mask wearing to  
39  
40 375 protect against wildland fire smoke, suggesting they may be effective at reducing particulate  
41  
42 376 matter exposure even if used for only part of a shift; however, neither study reported any data on  
43  
44 377 user experience [25,26]. Ultimately, participants expressed the desire to be engaged in the  
45  
46 378 development of any mitigation strategy and corresponding occupational health policy as essential  
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48 379 to ensure uptake. Collaborative intervention development can help researchers better understand  
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3 380 the wildland fire occupational context, ensure alignment with organization policy and support  
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5 381 effective implementation - a process recently used to develop interventions to address  
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7  
8 382 psychosocial health and physical fitness of wildland firefighters in Ontario, Canada [45].  
9

10 383 Participants indicated a need to understand the cumulative mental and physical health toll  
11  
12 384 of both busy and quiet fire seasons, and recovery in the off-season. Of particular concern was the  
13  
14 385 need to understand the risk of chronic fatigue resulting from an increasing length of fire seasons  
15  
16 386 and reduced opportunity to recover. The nature of the occupation typically necessitates sleeping  
17  
18 387 at a fire camp, where wildland firefighters do not typically achieve appropriate quality and  
19  
20 388 quantity of sleep [20,46,47]. While research has documented poor sleep conditions and reduced  
21  
22 389 cognitive function in-field [20,46,47], research questions remain about the optimal work to rest  
23  
24 390 schedule for wildland firefighting, strategies for recovery in the off-season, and how to balance  
25  
26 391 sleep hygiene with the realities of wildland fire operations and crew management.  
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30 392 Notably, while the research topic *long-term risk & prevalence of disease other than*  
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32 393 *respiratory* did not reach consensus among the entire sample, it was ranked highly and reached  
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34 394 consensus (81%) among people involved in direct fire suppression. Designing and conducting  
35  
36 395 research to understand the cumulative impacts of multiple seasons of wildland fire exposure is a  
37  
38 396 considerable challenge and the long-term health impacts of wildland firefighting are poorly  
39  
40 397 understood [7,8], although we do note ongoing work by the United States National Institute for  
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42 398 Occupational Safety and Health [48]. In BC, many front-line wildland firefighters are post-  
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44 399 secondary students hired as auxiliary employees during the summer (May – August) wildland  
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46 400 fire season. The transient and mobile workforce creates considerable challenges to evaluating  
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48 401 risk related to morbidity and mortality outcomes over multiple seasons. Similarly, the  
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50 402 unpredictability of a given fire season means generating consistent evidence or changes in health  
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3 403 outcomes across any one season is challenging due to the variable exposure. For example, some  
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5 404 participants mentioned unique challenges during less active fire seasons such as a different  
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7 405 mental health toll from not being able to engage in work they enjoy and find meaningful. Thus,  
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10 406 while some fire seasons may be 'quieter' in terms of fire activity and respiratory health risk (e.g.,  
11  
12 407 lower smoke exposure), they may impose a different mental health risk. While our research  
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14 408 priorities can be used to support researchers to make decisions on prioritizing collective research  
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16 409 efforts, findings also suggest the need for sustainable, flexible research infrastructure to adapt  
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19 410 and understand variable risk environments.  
20

21  
22 411 *Limitations*

23  
24 412 The email invitation to participate was sent in March 2020. This was done to ensure data  
25  
26 413 collection was not impacted by the busiest point in the fire season (typically June – August in  
27  
28 414 BC). Because of this, many auxiliary/seasonal staff had not yet started work and may be  
29  
30 415 underrepresented in our sample. Participants were asked to list their top 10 research priorities for  
31  
32 416 wildland firefighters and related personnel separately in the first survey. Based on very similar  
33  
34 417 research topics identified for both job categories and suggestions by participants in the open field  
35  
36 418 question, we collapsed the two job categories for the stage 2 survey. This may have reduced our  
37  
38 419 ability to tease out specific research topics for related personnel and identified research priorities  
39  
40 420 are likely more applicable to wildland firefighters. Occupational health policy makers and  
41  
42 421 researchers were identified by convenience sampling through our partnership with BCWS and by  
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44 422 extracting contact information from recently published papers in the field, which may have  
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46 423 limited the breadth of stakeholder participant perspectives.  
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## 426 **Conclusions**

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

436

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

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

441 **Additional file 3.** Interview Schedule

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448 manuscript.

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2  
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4

5 450 **Data sharing statement:** No additional data are available.  
6

7  
8 451 **Ethics approval:** This study was approved by the University of Northern British Columbia  
9  
10 452 Research Ethics Board (E2019.1220.076.00).  
11

12 453 **Author contributions:** CP lead study conception and design, data collection, analysis, and  
13  
14 454 manuscript writing. CR was involved in the development, distribution, and analysis of online  
15  
16 455 survey, and assisted in preparation of the manuscript. KB supported interview data collection,  
17  
18 456 transcription, interview analysis, and preparation of the manuscript. TF, EK, and KC provided  
19  
20 457 critical feedback on data collection, study design, assisted with survey and interview analysis.  
21  
22 458 All authors participated in the interpretation of the results, provided critical revision of and  
23  
24 459 approved the final manuscript.  
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### 31 461 **Figure Legends**

32  
33 462 Figure 1. Consensus rating of research topics.  
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608 Table 1. Participant demographics.

	Survey 1 (n = 132)	Survey 2 (n=75)	Interviews (n=14)
<b>Gender (n, %)</b>			
Female	40, 30%	27, 36%	N/A
Male	92, 70%	48, 64%	N/A
<b>Age (n, %)</b>			
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
<b>Role in Last Firefighting Season</b>			
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
<b>Specific to respondents with BCWS role</b>	<b>Survey 1 (n=116)</b>	<b>Survey 2 (n=66)</b>	<b>Interviews (n=11)</b>
<b>Years of Employment with BCWS</b>			
1-5	48	29	2
6-10	28	13	4
11-15	15	9	4
16-20	11	5	0
21+	14	9	1
<b>Years in Direct Fire Suppression</b>			
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
<b>Fire Center Most Recently Working</b>			
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

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

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

616	<b>Research Priorities</b>	<b>Consensus Rating</b>	<b>Consensus Rank</b>	<b>Weighted Average</b>	<b>Rank</b>
617	Understanding & mitigating effects of smoke inhalation on respiratory health	89%	1st	7.70	1st
618	Fatigue & Sleep	80%	2nd	6.49	3rd
619	Mental health	78%	3rd	6.68	2nd
620	Stress	76%	4th	6.18	5th
621	Work structure & organizational culture	71%	5th	5.03	6th
622	Long-term risk & prevalence of disease other than respiratory	67%	6th	6.41	4th
623	Nutrition, diet, & hydration	58%	7th	4.59	7th
624	Fire camp conditions	54%	8th	4.11	8th
625	Acute injuries & conditions	49%	9th	4.10	9th
626	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)
Fatigue & sleep	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)
		“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)
Fatigue & sleep	Understand impacts of long-term fatigue	“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)
		“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)
	Optimize supports and strategies to increase awareness	<p>“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)</p> <p>“Important to have information on what we’re getting ourselves into and the long-term effects of this job” (P4, wildland firefighter)</p> <p>“The stigma and not really recognizing some of the effects of, you know, exposure and post-traumatic stress” (P6, researcher)</p> <p>“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)</p>
Stress		<p>“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)</p> <p>“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)</p>
Long-term risk & prevalence of disease other than respiratory		<p>“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)</p> <p>“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)</p>

635 PPE, personal protective equipment

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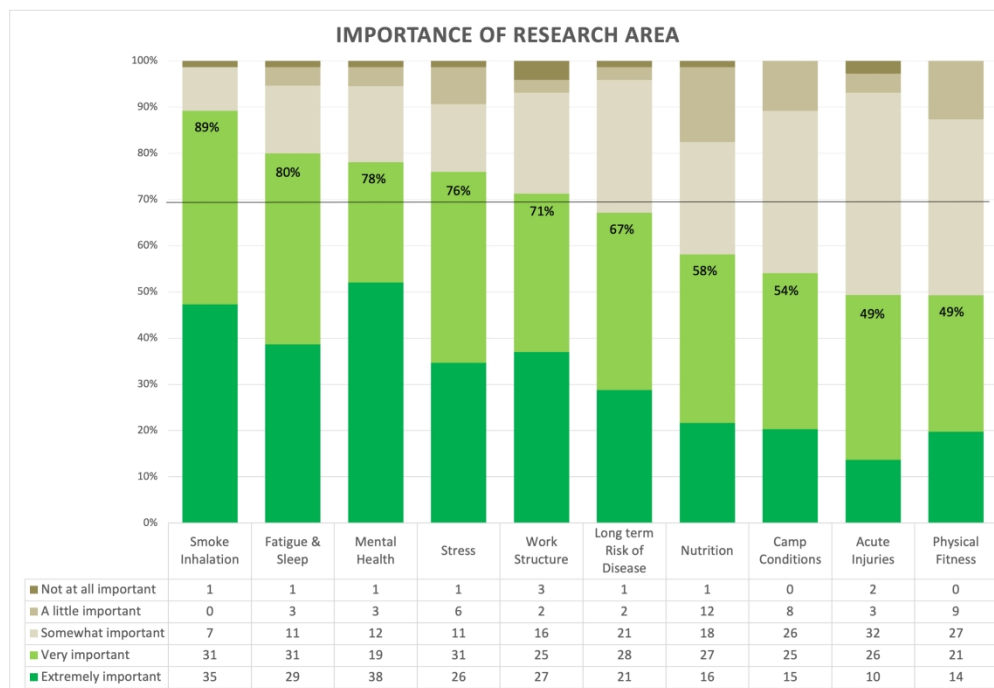


Figure 1

271x185mm (330 x 330 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 being conducted 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](mailto: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](mailto: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.

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\* Do you agree to participate in the survey?

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- No

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

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

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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)

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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)?

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How many of these years/seasons worked were spent participating in direct fire suppression 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

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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

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Research Topic

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

1 Thank you for completing Phase 1 of the stakeholder consultation.

2 Phase 2 will involve ranking the most common answers regarding priority topics for research.

3 If you would like to participate in Phase 2 please provide your email address below (non-governmental email  
4 preferred).

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

11  Yes

12  No

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16 email address

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20 If you would like to contact the research team please email us at: [wildfirestudy@unbc.ca](mailto:wildfirestudy@unbc.ca)

## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 being conducted 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](mailto: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](mailto: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 - Phase 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 - Phase 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 - Phase 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)?

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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 - Phase 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 - Phase 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 - Phase 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 - Phase 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 - Phase 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

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## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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

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## Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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 - Phase 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 - Phase 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 - Phase 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

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Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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

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Establishing Health Research Priorities for Wildland Firefighters and Related Personnel - Phase 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](mailto: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 sectional reporting guidelines, and cite them as:

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

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



		recruitment, exposure, follow-up, and data collection	
1			
2			
3	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of participants.	7
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6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	6-8
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
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10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	6-8
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
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17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	N/A
18			
19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	N/A
20			
21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	7/8
22	variables	applicable, describe which groupings were chosen, and why	
23			
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25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	7/8
26	methods	confounding	
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29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	N/A
30	methods		
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33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	N/A
34	methods		
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37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	N/A
38	methods	strategy	
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41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	N/A
42	methods		
43			
44	<b>Results</b>		
45			
46	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	9/10
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	N/A
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57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	N/A
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1	Descriptive data	<a href="#">#14a</a>	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
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	N/A
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
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14	Main results	<a href="#">#16a</a>	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
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19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	N/A
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21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9/10
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29	<b>Discussion</b>			
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31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	14/15
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34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	16
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	14-16
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46				
47	<b>Other</b>			
48	<b>Information</b>			
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50				
51	Funding	<a href="#">#22</a>	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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This checklist was completed on 12. March 2021 using <https://www.goodreports.org/>, a tool made by the

[EQUATOR Network](#) in collaboration with [Penelope.ai](#)

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