

Understanding post-fire glove use in Washington firefighters with the Health Belief Model:  
results of a cross-sectional survey

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## **ABSTRACT**

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**Background and Objectives:** Dermal exposures to polycyclic aromatic hydrocarbons (PAHs) are a likely pathway explaining elevated cancer risk in firefighters. Current hand hygiene best practices have been shown to significantly reduce PAHs deposited on skin, however, increasing evidence suggests that compliance in use and quality of personal protective equipment (PPE) is needed to effectively prevent dermal PAH absorption. Research in this area has focused on structural firefighting PPE used during fire suppression. It is not clear how differences in PPE use post-fire suppression may act to mediate or exacerbate dermal PAH absorption. This research sought to address this gap by exploring post-fire glove use in Washington firefighters.

**Methods:** Between December 2022 and March 2023 an online survey was used to explore the types of gloves Washington firefighters wear during post-fire demobilization and the factors influencing firefighters' glove use. Informed by the Health Belief Model, the survey collected information about firefighters' perceptions related to PPE and health; knowledge and use of

decontamination best practices; and personal characteristics. Descriptive statistics and multinomial logistic regression were used to analyze survey responses stratified by glove use.

**Results:** Three hundred sixty-four firefighters from sixty-two fire departments completed the Washington Firefighter Glove Survey. Participants reported use of many different types of gloves post-fire. Relatively few firefighters reported use of structural firefighting gloves (n=103, 28%) or medical examination gloves (n=35, 10%). Most firefighters (n=169, 42%) reported use of “work” gloves (i.e., leather, mechanic, or gardening gloves). Type of glove use was best explained by a combination of modifying factors and health beliefs. However, only glove-related characteristics were statistically significant (Bonferroni-adjusted p-value <0.05).

**Conclusion(s):** Lack of specificity in current guidance appeared to influence firefighters’ reliance on personal PPE perceptions and assessment of risk related to their post-fire glove use. Our findings—namely that only 10% of firefighters wore medical gloves and roughly 5% didn’t wear gloves post-fire—emphasize the need for interventions at both the individual and organizational levels. Future research should focus on developing specific glove use policies and best practices that incorporate glove quality—in terms of chemical protection efficacy and useability—and firefighter health beliefs.

## **DEDICATION**

In memory of Richard Sturzenbecher.

You are always in my heart.

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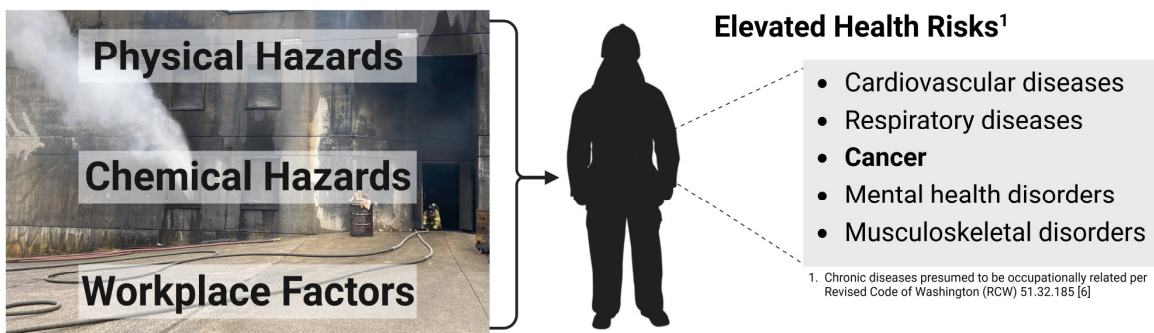
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# 1. INTRODUCTION

## 1.1 Firefighter Carcinogen Exposure

Firefighters are shown to be at elevated risk for cancer [1-4] and other chronic illnesses as a result of their occupation [5, 6] (**Figure 1**). Compared to the general population, firefighters have a 9% higher chance of being diagnosed with cancer and a 14% increase in cancer-related deaths [4]. In June 2022, the International Agency for Research on Cancer (IARC) designated occupational exposures of firefighters as “carcinogenic to humans” (Group 1) [1]. In particular, the IARC report cited polycyclic aromatic hydrocarbons (PAHs) as one of the plausible agents causing this excess burden [1]. PAHs are products of incomplete combustion [7] and include both known and probable carcinogens [1, 8, 9]. They are found in air and on surfaces at fire scenes [10-12]. While on scene, dermal absorption is presumed to be the predominant exposure pathway for PAHs given the level of respiratory protection provided by self-contained breathing apparatus (SCBA) (APF=10,000 [13]) typically worn by firefighters during active fire suppression [14, 15]. In fact, several studies demonstrate PAH dermal exposure even in firefighters who wear full turnout gear [16-18] and do not actively engage in fire suppression [19, 20].



**Figure 1.** Occupational exposure as a career firefighter.

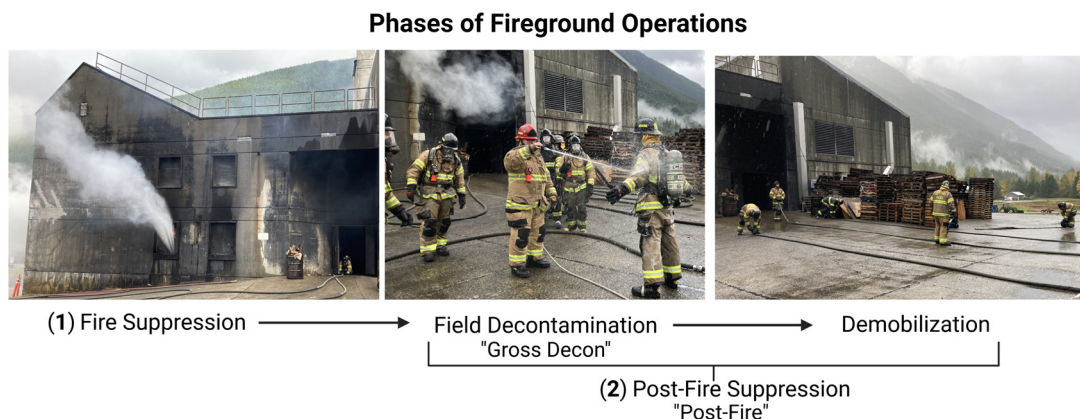
Note: In June 2022, the International Agency for Research on Cancer (IARC) classified firefighting as carcinogenic to humans [1], which is why it is bolded in the schematic.

Further examinations of the effectiveness of turnout gear to mitigate dermal exposure identify the hands and wrists as particularly susceptible to PAH contamination [14, 21, 22]. Of

the nine studies that have assessed on-skin PAHs in firefighters [11, 17, 23-29], six reported measurable concentrations of total PAHs on the hands or wrists [11, 17, 23-26], with three specifically finding carcinogenic PAHs present on these sites [11, 23, 26]. These studies highlight vulnerabilities in firefighter PPE—specifically gloves—to resist the ingress of carcinogens.

While current best practices to remove carcinogens via hand washing and/or wipe washing have been shown to effectively reduce PAHs deposited on hands [15, 26], increasing evidence suggest that decontamination is still an important area of intervention [15, 21, 24]. Both Fent et al. [24] and Keir et al. [15] found up to ~50% of PAHs may remain on skin after decontamination. Notably, Keir et al. [15] also found that post-fire dermal cleaning did not have a measurable effect on the internal dose of PAHs. The authors postulate dermal PAH absorption may occur within seconds to minutes, and thus decontamination efforts are too late to prevent biological uptake [15]. They point to compliance in use and quality of PPE to effectively prevent dermal PAH exposure [15].

In addition to exposures occurring during active firefighting activities, dermal carcinogen exposures may occur during post-fire “demobilization” [14, 24, 30], the phase of fireground operations that includes rolling fire hoses and loading equipment back onto the fire engine (Figure 2).



**Figure 2.** Fireground operations include field decontamination and demobilization. Note: Rolling fire hose is a primary task of demobilization.

Though exposures during demobilization have yet to be expressly characterized, various risk factors [31-33] that may contribute to dermal PAH absorption during this period include (1) on-skin PAH contamination even after decontamination; (2) the rigorous physical nature of demobilization tasks; and (3) the wet and humid post-fire work environment (**Figure 3**). Further, cross-transfer of contaminants on hoses, tools, and other equipment to firefighter skin may also occur [14, 30].



**Figure 3.** Visual representation and brief description of demobilization tasks.  
Note: Self-contained breathing apparatus is abbreviated as SCBA.

Based on current literature, structural firefighting glove use during demobilization is the presumed norm [14, 16, 17, 24, 31, 34]. However, a lack of specificity in standards, policies, and best practices related to glove use for this precise period challenges this assumption.

Given the weight of evidence that PPE-related limitations, namely glove design and fit, contribute to dermal absorption of PAHs [1, 14, 34], understanding firefighter glove use is imperative to further cancer mitigation efforts. It is currently not clear how differences in glove

quality and use during demobilization may act to mediate or exacerbate dermal PAH absorption. To our knowledge, few studies have explicitly investigated firefighters' behaviors related to PPE type and use compliance [34-37], with none specifically focusing on gloves. Focus is instead directed at PPE maintenance and decontamination [38-42]. Currently, best practices to mitigate cancer risk do not explicitly address post-fire demobilization [43-45]. To address this gap, our research aims to better understand post-fire glove use in Washington firefighters by specifically addressing the following research questions:

**RQ1.** What types of gloves do Washington firefighters use during demobilization?

**RQ2.** What factors influence post-fire glove use?

## **1.2 Fire Service Partnership**

This research was developed and conducted in partnership with representatives of the Washington Fire Service. Partners were identified through the Washington State Department of Labor and Industries (L&I) Firefighter Injury and Illness Reduction (FIIRE) Initiative [46]. This Initiative—which is comprised of L&I occupational health and safety compliance researchers, fire service coalition groups, and approximately 45 Washington fire departments—was developed in recognition of the need to improve health outcomes for firefighters under SB 5175 (“An Act Concerning Firefighter Safety” which passed in 2019) [47]. The purpose of the Initiative is to establish best practices to reduce firefighters' risk of cancer and other work-related illnesses and injuries [47].

To respond to firefighters' expressed concerns related to post-fire carcinogen exposures and the need to update best practices and recommendations, UW and select FIIRE members formed a collaborative firefighter research advisory group (AG). The group, which currently consists of 10 individuals, includes perspectives from local fire departments, the Washington State Council of Fire Fighters (WSCFF, a labor union), the Washington State Fire Training Academy (FTA), and L&I. The roles of the AG were to (1) assist in development of priority research questions; (2) provide feedback on proposed research methods; (3) facilitate broader

fire service stakeholder conversations; and (4) advise on return of results strategy. The AG was consulted through quarterly meetings and sharing of research materials (e.g., recruitment flyer).

### 1.3 Current Standards and Best Practices for Demobilization

On the national level, of the 300 fire service codes and standards provided by the National Fire Protection Association (NFPA), 93 directly or indirectly address contamination control [48]. To the best of our knowledge, only one of these standards, NFPA 1584 (“Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises”) details guidance precisely for demobilization [49]. The extent of this guidance includes:

- A plan for PPE and equipment decontamination
- Time for post-incident personal hygiene
  - o Handle soiled or contaminated PPE with medical examination (EMS) gloves
    - Clean PPE according to NFPA 1851 (which requires medical gloves) [50]
  - o Warm shower with soap as soon as possible

In Washington state, the “Healthy In, Healthy Out Best Practices Manual for Reducing Fire Fighter Risk of Exposures to Carcinogens” identifies processes and procedures to perform post-fire suppression [43]. While these best practices do not precisely address demobilization like NFPA 1584, they are similar in their identification of medical (EMS) gloves to package and clean turnouts [43] (**Figure 4**).

As depicted in **Figure 4**, despite current standards and best practices mentioning removal of structural firefighting gloves for medical examination gloves post-fire suppression, it is unclear when exactly this should occur (i.e., before or after demobilization) [43, 49] and if other types of gloves are “appropriate” [43]. This ambiguity presents a clear research need and opportunity to further address firefighter carcinogen exposures.

## Current Guidance Related to Firefighter Glove Use

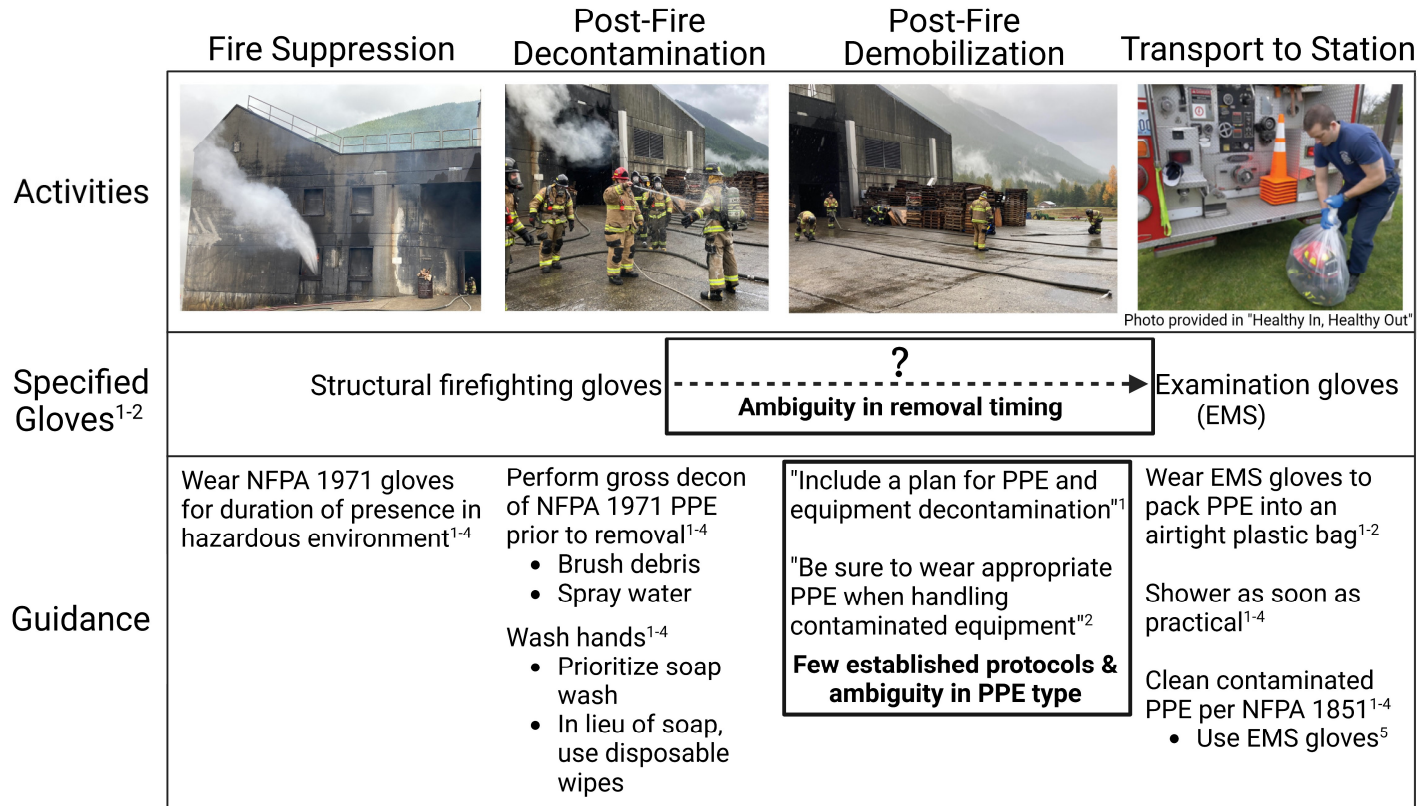


Photo provided in "Healthy In, Healthy Out"

Research needs captured in the Washington Firefighter Glove Survey Study.

1. National Fire Protection Association (NFPA) [49]
2. Washington State Council of Fire Fighters (WSCFF) [43]
3. International Association of Fire Chiefs (IAFC) and National Volunteer Fire Council (NVFC) [44]
4. Firefighter Cancer Support Network (FCSN) [45]
5. National Fire Protection Association (NFPA) [50]

**Figure 4.** Gap in current guidance for glove use during demobilization.

Note: Personal protective equipment is abbreviated as PPE.

To the best of our knowledge, only NFPA 1584 ("Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises") details guidance precisely for demobilization [49]. Like NFPA 1584, the "Healthy In, Healthy Out Best Practices Manual for Reducing Fire Fighter Risk of Exposures to Carcinogens" mentions removing structural firefighting gloves for medical examination gloves post-fire suppression, but it is unclear when exactly this should occur (i.e., before or after demobilization), and if other types of gloves are "appropriate" [43].

## 2. METHODS

### 2.1 Survey Development

The Washington Firefighter Glove Survey was developed in two phases and then distributed to firefighters in a third phase (**Figure 5**). In phase 1, survey questions were designed using constructs of the Health Belief Model [51] and themes derived from semi-structured interviews [data unpublished]. In phase 2, questions were reviewed by the firefighter research advisory group for content and clarity. In phase 3, survey recruitment and enrollment were conducted.



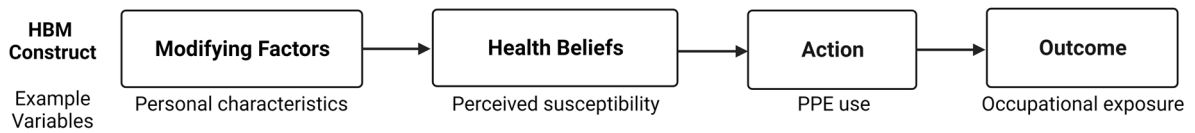
**Figure 5.** Research phases and outcomes of the Washington Firefighter Glove Survey.

#### 2.1.1. Phase 1: Survey Design

##### 2.1.1.a. Conceptual Framework

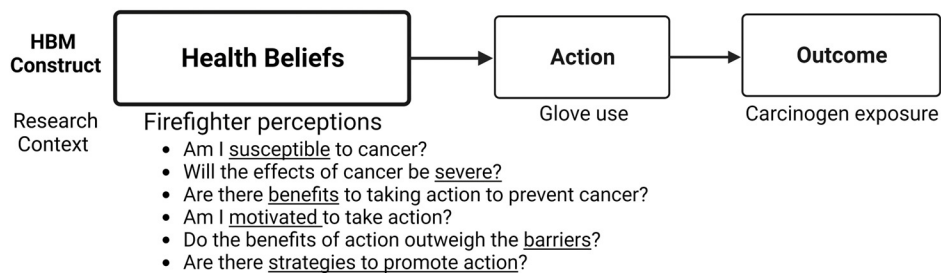
This research used the Health Belief Model (HBM) as a conceptual framework to better understand post-fire glove use [51]. According to HBM, two primary constructs—modifying factors and health beliefs—predict individual behavior [51-53] (**Figure 6a**). Modifying factors include variables that are likely to influence health beliefs, such as personal characteristics [52, 53]. Health beliefs comprise perceived susceptibility, perceived severity, perceived benefits, health motivation, perceived barriers, and cues to action [52, 53] (**Figure 6b**).

### Health Belief Model Conceptual Framework



**Figure 6a.** Conceptual framework of the Health Belief Model used to explore factors that influence firefighter occupational exposure [51-53].

Note: Health Belief Model is abbreviated as HBM. Personal protective equipment is abbreviated as PPE.



**Figure 6b.** Contextualization of firefighter health beliefs relevant to glove use [52-53].

Note: Health Belief Model is abbreviated as HBM.

Within this framework, if firefighters believe (1) they are susceptible to cancer; (2) cancer has potentially serious consequences; (3) there are benefits to glove use; (4 and 5) there are motivations and actions to overcome perceived barriers to glove use; and (6) anticipated benefits outweigh barriers, they are expected to take self-protective action to prevent exposure (Figure 6b).

#### 2.1.1.b. Survey Content

Survey questions were informed by behaviors and key themes reported in discussions with firefighters about demobilization (Appendix A). Inductive thematic analysis of semi-structured interviews [54] conducted with twenty Washington firefighters in Summer 2021 revealed a range of post-fire glove use influenced by factors of comfort, fit, function, protection, availability, and satisfaction with employer-provided options [data unpublished]. Incorporating insights gleaned from interviews, the Washington Firefighter Glove Survey consisted of 14 questions (Appendix B).

Topics included:

- Types of gloves used during demobilization
- Reasons for glove use
- Frequency of post-fire decontamination behaviors
- Health beliefs
- Personal and job characteristics

### 2.1.2. Phase 2: Survey Review

Survey topics were reviewed by the research advisory group, which was comprised of partners representing local fire departments, fire service organizations, and the Washington State Department of Labor and Industries (L&I). Of the recommendations provided by partners, specific items related to decontamination [43-45] and firefighter demographics were incorporated into the final version of the Washington Firefighter Glove Survey (**Figure 5**).

## 2.2 Survey Distribution

### 2.2.1. Setting

Sixty-two fire departments participated in this research (**Figure 7**). These departments span the geographic regions of Washington state [55] and account for ~15% of all WA fire departments [56].



**Figure 7.** Map of the study area and locations of participating fire departments (black dots). Note: Map generated using Google My Maps [55].

All department sizes (very small to very large) and fire department types (primarily career, combination, and primarily volunteer) were represented in this research. Department size was determined by the number of reported full-time equivalent (FTE) employees [57, 58] and ranged from fewer than ten FTEs (very small departments) to greater than one hundred FTEs (very large departments).

### 2.2.2. Recruitment

Career firefighters were the primary population of interest for this research. Targeted outreach to career and combination fire departments included:

- Individual emails to fire departments with a request to distribute recruitment material (**Appendix C**) via listserv
  - o Sent to administrative contacts of 116 fire departments
- Recruitment material shared with the Washington State Council of Fire Fighters (WSCFF) membership via email and magazine
- Informational research presentations (~30 minutes held over Zoom) given to current FIIRE contacts and Puget Sound PPE Advisory members

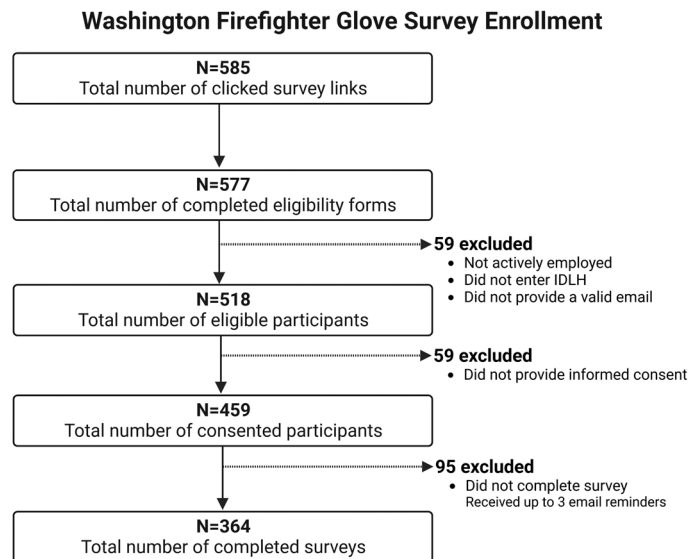
The recruitment approach and materials utilized were approved by the institutional review board at the University of Washington (#00016481).

### 2.2.3. Data Collection

Data were collected December 2022–March 2023 via Research Electronic Data Capture (REDCap) [59, 60] hosted at the Institute of Translational Health Sciences [61]. Potential participants were prescreened for eligibility, received informed consent, and, if eligible and consented, sent a unique link to a provided e-mail to complete the survey (**Figure 8**).

Firefighters were eligible to participate if they reported being 18 years or older, were actively employed as a firefighter, and their current employment responsibilities included fire suppression activities (as established by answering “Yes” to a question about entering the environment immediately dangerous to life and health, **Appendix D**). Those who were eligible to participate were informed of the study procedures and asked to provide their consent (of

which they received an electronic copy, **Appendix E**). No incentives were provided for participation.



**Figure 8.** Study inclusion criteria and enrollment process.

Note: Environment immediately dangerous to life and health is abbreviated as IDLH.

#### 2.2.4. Participation

A total of 577 firefighters completed the eligibility questionnaire (**Figure 8**). Of these, 518 met the eligibility criteria and 459 consented to participate. Those that consented received up to three weekly reminders to complete the survey. 364 firefighters completed the survey in its entirety. The estimated time for completion was ~15 minutes.

### 2.3 Survey Analysis

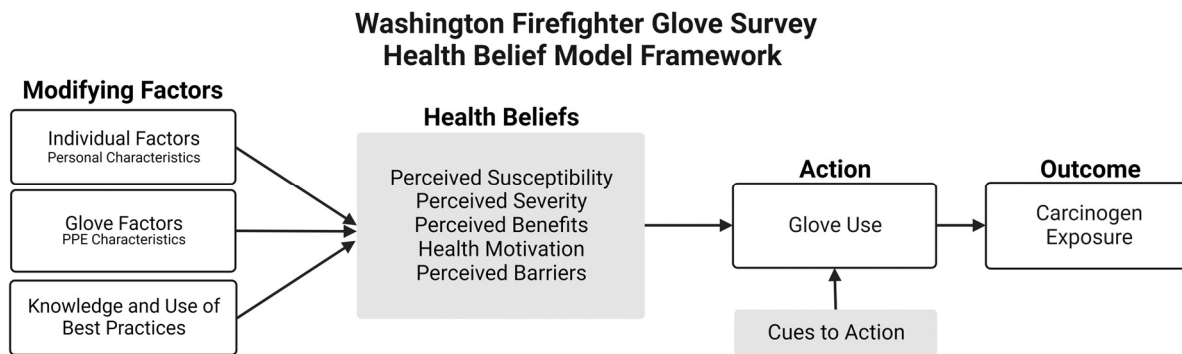
Following the framework of HBM, post-fire glove use was the outcome of interest while modifying factors and health beliefs were the inputs of interest (**Figure 6**). For the outcome of glove use, participants were asked to select the type of glove they have used most often in the past 12 months to perform demobilization (**Figure 9**). Glove options were informed by interview findings and included: structural firefighting gloves, leather gloves, extrication gloves, mechanic gloves, gardening gloves, medical gloves, combinations of gloves, no gloves, and other. Participants who chose “combination” or “other” were asked to specify their glove use.

**What gloves do you use during demobilization?** Please select the gloves you have used MOST OFTEN in the past 12 months.



**Figure 9.** Types of glove use considered in the Washington Firefighter Glove Survey. Note: Leather, mechanic, and gardening gloves are often referred to by firefighters as “work” gloves.

Modifying factors were categorized into three groups: personal characteristics (i.e., individual factors), PPE characteristics (i.e., glove factors), or knowledge and use of best practices (**Figure 10**). These groupings were based on interview findings and previous research by Geer et al. [53].



**Figure 10.** Constructs of the Health Belief Model used to explore Washington firefighters’ post-fire glove use. Adapted from Geer et al. [53]. Note: Personal protective equipment is abbreviated as PPE.

### 2.3.1. Measures

#### 2.3.1.a. Individual Factors

Demographic and job-related characteristics presumed to influence glove use included gender, age, job ranking, department affiliation, total number of years in the fire service, and the monthly average number of fire dispatches in the past year [62-64] (**Table 1**). For most variables, participants were asked to choose from selected categories of answers. Free response answers for age, rank, and fire department were categorized into the groups presented in **Table 1**. Participants were given the option not to specify any demographic information except their age. In these cases, fire department affiliation was assumed by the

work email, if provided (n=7, 2%). Frequencies and percents of nonresponse data are provided in **Table 1**.

#### 2.3.1.b. Glove Factors

Comfort, fit, function, protection, and availability were factors considered in this research and similar studies to be important in decisions related to PPE use [65-68]. Within these categories, participants were asked to select all reasons for their type of glove use. As shown in **Table 2**, a total of eight options were available.

Satisfaction with employer-provided glove options was considered another important factor in glove use [69-71]. Participants had the option to select from three statements related to their satisfaction with the gloves provided by their current employer: “satisfied”, “not satisfied”, or “not provided.”

#### 2.3.1.c. Knowledge and Use of Best Practices

Current knowledge and adherence to decontamination best practices are likely to play a role in post-fire glove use [34, 72, 73]. For example, previous research indicates that while firefighters generally believe that decontamination activities will reduce their cancer risk, they report inconsistent or low rates of decontamination behaviors [34, 41, 74]. These findings highlight the need to consider the influence of factors related to decontamination best practices on glove use (**Table 3a**, **Table 3b**).

To assess knowledge of best practices, participants were asked to select if they were or were not familiar with recommendations provided by the Washington State Council of Fire Fighters (with a specific reference to the “Healthy In, Healthy Out Manual” [43]). For adherence to best practices, participants were asked to respond on a 5-point Likert scale (1=never to 5=always) to a total of 7 items regarding the frequency in which they performed activities after structural fire suppression. Items for measuring adherence were based on guidance provided by the NFPA [48, 50] and WSCFF [43]. Additional items (spot cleaning, machine cleaning, and no cleaning) were included at the recommendations of the research advisory group.

#### 2.3.1.d. Health Beliefs

Participants were asked to respond on a 5-point Likert scale (1=strongly disagree to 5=strongly agree) to a total of 17 items regarding perceived susceptibility, perceived severity, perceived benefits, health motivation, perceived barriers, and cues to action (**Table 4**). Survey items were adapted from Oh et al. [64] and Abdollahzadeh and Sharifzadeh [75]. Cronbach's alpha was used as a measure to determine the internal consistency of grouped items [76]. If  $\alpha < 0.6$  for grouped items, they were regrouped or considered separately [77].

- Perceived susceptibility measured perceptions about occupational exposures post-fire (four items,  $\alpha=0.72$ )
- Perceived severity measured perceptions of the impact that post-fire exposures could have on health outcomes (two items,  $\alpha=0.16$ )
  - o Chemical and physical exposures were considered separately
- Perceived benefits measured perceptions of benefits related to post-fire decontamination and glove use best practices (two items,  $\alpha=0.93$ )
- Health motivation measured feelings of competency (self-efficacy) to overcome perceived barriers to glove use best practices (three items,  $\alpha=0.54$ )
  - o Seeking out information was considered separately (two items,  $\alpha=0.62$ )
- Cues to action measured cues expected to promote glove use best practices (two items,  $\alpha=0.75$ )
- Perceived barriers measured perceptions of barriers that would inhibit decontamination and glove use best practices (four items,  $\alpha=0.74$ )

#### 2.3.2. Statistical Analysis

Raw data were downloaded from REDCap and analyzed with R statistical software [78-84]. Descriptive statistics, expressed as means and standard deviations for continuous variables and frequencies and percents for categorical variables, were calculated for modifying factors and health beliefs of all participants (referred to as "all") as well as each type of glove use (**Tables 1-4**).

### 2.3.2.a. Differences in Glove Use

Tests of significance were used to assess differences between glove users for all measures (**Tables 1-4**). For differences in continuous measures between glove users, Kruskal-Wallis tests were used [85]. These tests are well-suited for comparisons of three or more groups on non-normally distributed data [85]. For differences in categorical variables, Pearson's chi-square tests were used [86]. The p-values for individual tests are included in **Tables 1-4**.

### 2.3.2.b. Factors Influencing Glove Use

Multinomial logistic regression was used to further explore the influence of individual and combined Health Belief Model constructs on glove use [87]. This analysis was chosen for its ability to model the log odds (and subsequent odds ratios) of using particular types of gloves based on a linear combination of predictor variables (e.g., glove factors) [87].

In total, six regression models were produced (**Table 5**). For each model, the Akaike information criterion (AIC), was used to assess model fit [88]. When comparing models, lower AICs were considered favorable [89]. Variables included in each model are provided in **Table 5**. All models incorporating demographic data (Models 1, 5 and 6) adjusted for survey responses per department. For age, tenure, and fire calls, a comparison of model AICs with categorical and continuous predictor variables was used to determine variable type. To produce the final adjusted model (Model 6), a backward stepwise variable selection approach was used [89]. The regression model with the lowest AIC was considered the most explanative of post-fire glove use.

### 3. RESULTS

#### 3.1 Survey Response

In total, 364 respondents completed the Washington Firefighter Glove Survey. Of these respondents, most reported employment with career or combination departments (career n=248, 68%; combination n=108, 30%) and large or very large departments (large department n=50, 13.7%; very large n=244, 67.0%).

Survey participation from the 62 fire departments represented in this research ranged from 1 to 82 responses per department. While 1 response per department was most common (n=23, 37%), about one-third of departments (n=21, 34%) had 5 or more respondents complete the survey. To account for differences in survey participation, responses from outlier departments (n=7 departments with 15 or more respondents) were adjusted for in regression analyses.

#### 3.2 Washington Firefighter Glove Use During Demobilization

##### 3.2.1. Types of Glove Use

Washington firefighters reported use of every type of glove considered in this research. While structural firefighting gloves were the single most common glove type used for demobilization (n=103, 28%), 72% of firefighters did not report this behavior. Out of the 261 firefighters not using structural gloves post-fire, most reported wearing leather gloves (n=79, 30%) or mechanic gloves (n=54, 21%).

Less than 5% of respondents reported using no gloves (n=18), a combination (n=13), or other gloves (n=2) during demobilization. Given the small sizes and varying behaviors reported within combination and other glove users (**Appendix F**), all participants (n=15) in these two groups were regrouped into "other." These glove users represent participants who used two pairs of gloves at once or no consistent glove option (**Appendix F**). With this regrouping, a total of eight types of glove use were considered for descriptive analyses. To explore how study measures differed among glove users, all data were stratified by type of glove use (**Tables 1-4**).

### 3.2.2. Individual Modifying Factors

**Table 1** and **Figures 11-12** summarize the personal and job-related characteristics of glove users. Similar to previously reported Washington firefighter cohort demographics, participants predominantly identified as male, were over the age of 30, had been working in the fire service for more than 10 years, and were line personnel (firefighters, lieutenants, captains, or battalion chiefs) [62]. Statistical comparisons between types of glove use indicated mean age, tenure, and fire calls as notable variables to consider for differences.

Compared to the overall cohort ( $\bar{x}_{\text{age}}=43$ ), medical, extrication, and other glove users were at least 4 years younger on average ( $\bar{x}_{\text{age}}\sim 39$ ), while no glove users were about 3 years older ( $\bar{x}_{\text{age}}=46$ ). For those aged 20-29 (the youngest age bracket), leather gloves (n=8, 22%) or medical gloves (n=8, 22%) were most frequently used. For those older than 50 (the oldest age bracket), structural gloves (n=36, 33%) or leather gloves (n=27, 25%) were commonly used.

While structural, leather, and mechanic glove use was common across all years of service, firefighters with 1-10 years on the job frequently used medical gloves (n=21, 17%). Comparatively, firefighters with greater than 10 years of service frequently used gardening gloves (n=27, 11%). The groups with the highest proportions of firefighters with 10 or fewer years of service included medical (n=21, 60%), extrication (n=10, 42%), and mechanic glove users (n=22, 41%). Structural, leather, and no glove users had the highest proportions of firefighters (>40%) with more than 20 years of service.

Most glove users participated in a similar distribution of fire calls as the overall cohort. Exceptions occurred in the lowest and highest call volume categories. For low call volumes, a higher proportion of mechanic glove users (48%) participated in less than 2 calls per month (overall cohort: ~40%). For higher call volumes, the proportion of firefighters participating in 6-8 fire calls per month was two to three times higher in extrication (25%) and other (33%) glove users (overall cohort: 11%). No glove users had the highest proportion of firefighters participating in 9+ fire calls per month (39% compared to 17% in overall cohort).

**Table 1. Personal and job characteristics of survey participants. Unit: n (%).**

Characteristic	Glove Use									p-value <sup>c</sup>
	All <sup>a</sup>	Structural	Leather	Mechanic	Gardening	Medical	Extrication	No Gloves	Other <sup>b</sup>	
Number of participants	364 (100%)	103 (28%)	79 (22%)	54 (15%)	36 (10%)	35 (10%)	24 (7%)	18 (5%)	15 (4%)	
Gender Identity										0.19
Man	324 (89.0%)	91 (88.3%)	72 (91.1%)	48 (88.9%)	31 (86.1%)	33 (94.3%)	20 (83.3%)	18 (100%)	11 (73.3%)	
Woman	25 (6.9%)	5 (4.9%)	6 (7.6%)	5 (9.3%)	3 (8.3%)	1 (2.9%)	4 (16.7%)	–	1 (6.7%)	
Non-binary	5 (1.4%)	2 (1.9%)	1 (1.3%)	–	–	1 (2.9%)	–	–	1 (6.7%)	
Unspecified	10 (2.7%)	5 (4.9%)	–	1 (1.9%)	2 (5.6%)	–	–	–	2 (13.3%)	
Age										0.27
20-29	37 (10.2%)	5 (4.9%)	8 (10.1%)	5 (9.3%)	2 (5.6%)	8 (22.9%)	4 (16.7%)	2 (11.1%)	3 (20.0%)	
30-39	93 (25.5%)	28 (27.2%)	16 (20.3%)	14 (25.9%)	9 (25.0%)	11 (31.4%)	7 (29.2%)	3 (16.7%)	5 (33.3%)	
40-49	125 (34.3%)	34 (33.0%)	28 (35.4%)	19 (35.2%)	16 (44.4%)	8 (22.9%)	10 (41.7%)	5 (27.8%)	5 (33.3%)	
50+	109 (29.9%)	36 (35.0%)	27 (34.2%)	16 (29.6%)	9 (25.0%)	8 (22.9%)	3 (12.5%)	8 (44.4%)	2 (13.3%)	
Mean (SD)	43.3 (10.3)	45.4 (10.5)	43.5 (9.8)	43.6 (9.8)	44.0 (8.7)	39.3 (11.4)	39.0 (9.2)	46.4 (11.6)	38.3 (9.3)	0.01
Tenure										0.02
<1 year	3 (0.8%)	–	2 (2.5%)	1 (1.9%)	–	–	–	–	–	
1-5 years	65 (17.9%)	17 (16.5%)	9 (11.4%)	10 (18.5%)	3 (8.3%)	14 (40.0%)	7 (29.2%)	4 (22.2%)	1 (6.7%)	
6-10 years	58 (15.9%)	10 (9.7%)	15 (19.0%)	11 (20.4%)	5 (13.9%)	7 (20.0%)	3 (12.5%)	2 (11.1%)	5 (33.3%)	
11-15 years	44 (12.1%)	15 (14.6%)	7 (8.9%)	7 (13.0%)	4 (11.1%)	4 (11.4%)	3 (12.5%)	–	4 (26.7%)	
16-20 years	45 (12.4%)	10 (9.7%)	9 (11.4%)	6 (11.1%)	10 (27.8%)	1 (2.9%)	4 (16.7%)	4 (22.2%)	1 (6.7%)	
20+ years	147 (40.4%)	51 (49.5%)	37 (46.8%)	18 (33.3%)	13 (36.1%)	9 (25.7%)	7 (29.2%)	8 (44.4%)	4 (26.7%)	
Unspecified	2 (0.5%)	–	–	1 (1.9%)	1 (2.8%)	–	–	–	–	
Rank										0.82
Firefighter	199 (54.7%)	53 (51.5%)	40 (50.6%)	33 (61.1%)	21 (58.3%)	23 (65.7%)	15 (62.5%)	6 (33.3%)	8 (53.3%)	
Lieutenant	56 (15.4%)	19 (18.4%)	14 (17.7%)	6 (11.1%)	4 (11.1%)	5 (14.3%)	2 (8.3%)	2 (11.1%)	4 (26.7%)	
Captain	57 (15.7%)	17 (16.5%)	9 (11.4%)	8 (14.8%)	7 (19.4%)	4 (11.4%)	4 (16.7%)	6 (33.3%)	2 (13.3%)	
Battalion Chief	22 (6.0%)	7 (6.8%)	5 (6.3%)	3 (5.6%)	2 (5.6%)	1 (2.9%)	2 (8.3%)	2 (11.1%)	–	
Deputy or Assistant Chief	16 (4.4%)	4 (3.9%)	7 (8.9%)	2 (3.7%)	1 (2.8%)	–	1 (4.2%)	1 (5.6%)	–	
Fire Chief	5 (1.4%)	3 (2.9%)	1 (1.3%)	–	–	1 (2.9%)	–	–	–	
Other <sup>d</sup>	4 (1.1%)	–	2 (2.5%)	1 (1.9%)	–	–	–	–	1 (6.7%)	
Unspecified	5 (1.4%)	–	1 (1.3%)	1 (1.9%)	1 (2.8%)	1 (2.9%)	–	1 (5.6%)	–	
Department Size										0.80
Very Small	12 (3.3%)	4 (3.9%)	1 (1.3%)	1 (1.9%)	1 (2.8%)	1 (2.9%)	2 (8.3%)	1 (6.7%)	1 (5.6%)	
Small	23 (6.3%)	9 (8.7%)	4 (5.1%)	5 (9.3%)	1 (2.8%)	2 (5.7%)	–	1 (6.7%)	1 (5.6%)	
Medium	32 (8.8%)	5 (4.9%)	11 (13.9%)	7 (13.0%)	3 (8.3%)	2 (5.7%)	3 (12.5%)	–	1 (5.6%)	
Large	50 (13.7%)	15 (14.6%)	12 (15.2%)	9 (16.7%)	3 (8.3%)	7 (20.0%)	2 (8.3%)	1 (6.7%)	1 (5.6%)	
Very Large	244 (67.0%)	70 (68.0%)	51 (64.6%)	31 (57.4%)	27 (75.0%)	23 (65.7%)	17 (70.8%)	12 (80.0%)	13 (72.2%)	
Unspecified	3 (0.8%)	–	–	1 (1.9%)	1 (2.8%)	–	–	–	1 (5.6%)	
Fire Calls										0.05
0-2 per month	144 (39.6%)	39 (37.9%)	34 (43.0%)	26 (48.1%)	15 (41.7%)	11 (31.4%)	9 (37.5%)	5 (27.8%)	5 (33.3%)	
3-5 per month	116 (31.9%)	31 (30.1%)	31 (39.2%)	18 (33.3%)	10 (27.8%)	14 (40.0%)	4 (16.7%)	4 (22.2%)	4 (26.7%)	
6-8 per month	39 (10.7%)	10 (9.7%)	6 (7.6%)	5 (9.3%)	3 (8.3%)	2 (5.7%)	6 (25.0%)	2 (11.1%)	5 (33.3%)	
9+ per month	63 (17.3%)	22 (21.4%)	8 (10.1%)	5 (9.3%)	7 (19.4%)	8 (22.9%)	5 (20.8%)	7 (38.9%)	1 (6.7%)	
Unspecified	2 (0.5%)	1 (1.0%)	–	–	1 (2.8%)	–	–	–	–	

Note: Dashed lines indicate no response.

<sup>a</sup> Survey participants were affiliated with 62 fire departments. Mean, median and mode responses per department were: 6, 2 and 1 respectively.

<sup>b</sup> Includes firefighters who reported using combinations of gloves or no consistent glove use.

<sup>c</sup> Results of statistical comparisons amongst types of glove use. Pearson's chi-square tests were performed for all variables. An additional Kruskal-Wallis test was performed for age.

<sup>d</sup> Includes job titles with fire marshal and/or fire investigator.

### 3.2.3. Glove Modifying Factors

**Table 2** and **Figure 13** provide the PPE characteristics related to firefighters' glove use during demobilization. Out of the glove factors considered in this research, function and protection were most frequently selected by Washington firefighters. More than half of respondents indicated that their gloves being well-suited for tasks (n=188, 52%) and physically protective (n=185, 51%) were why they wore them. Notably, chemical protection was not a characteristic firefighters commonly selected (n=40, 11%). Range of motion and comfort were other common reasons Washington firefighters wore their gloves. At least 45% of respondents selected these characteristics.

Although function, protection, and comfort were top glove factors for all users, there were distinct combinations of reasons for each type of glove use (**Figure 13a, 13b**). Comparatively, comfort and fit were particularly important to mechanic glove users; chemical protection and accessibility on scene were important to medical glove users; and gloves being employer-provided was important to structural glove users.

As indicated by the statistical comparisons between types of glove use provided in **Table 2**, all glove factors, including satisfaction, appeared to play a role in behaviors (**Figure 13c**). While most firefighters were satisfied with the gloves provided by their employer (n=233, 64%), medical glove users (n=30, 86%) and structural glove users (n=75, 73%) reported the highest frequencies of satisfaction. Conversely, no glove users (n=10, 56%) and other glove users (n=7, 47%) reported the highest frequencies of dissatisfaction. Interestingly, a comparatively high proportion of mechanic glove users reported that their primary employer does not provide gloves (9% compared to 3% for overall cohort).

### 3.2.4. Knowledge and Use of Best Practices

Self-reported post-fire decontamination activities performed by Washington firefighters are displayed in **Table 3a**. Of these activities, soap washing of hands (n=306, 85%), wipe washing of hands (n=223, 62%), and machine cleaning of gloves (n=195, 54%) were frequently

(often or always) performed by all firefighters. Activities that were frequently performed by fewer than half of firefighters included field decontamination (n=180, ~50%), spot cleaning (n=67, 18%), and hand washing of gloves (n=43, 12%). A total of 33 firefighters (9%) reported no cleaning activities at least some of the time.

In terms of best practices, cleaning gloves by hand (as opposed to placing them in a machine) occurred much less frequently on average than other activities (**Table 3b, Figure 14a**). As presented in **Table 3b**, firefighters rarely performed this activity ( $\bar{x}_{\text{hand cleaning of gloves}}=1.98$ ), whereas they sometimes decontaminated their gloves in the field ( $\bar{x}_{\text{field decontamination}}=3.37$ ) and often washed their hands ( $\bar{x}_{\text{soap}}=4.32$ ;  $\bar{x}_{\text{wipe}}=3.63$ ).

Generally, extrication glove users reported the highest frequencies of best practice activities while no glove users reported the lowest. More specifically, no glove users had the highest proportion of firefighters reporting no cleaning activities post-fire (n=4, 22%). In line with a low frequency of decontamination behaviors, no glove users were also the least familiar with best practice recommendations (n=12, 67%) (**Table 3b**).

Despite high adherence to best practices, extrication glove users did not report the highest frequency of familiarity with best practice recommendations. Compared to extrication glove users (n=14, 58%), mechanic (n=35, 65%), gardening (n=23, 64%), and leather (n=49, 62%) glove users had higher proportions of firefighters who reported knowledge of recommendations provided by the Washington State Council of Fire Fighters (**Figure 14b**). Statistical comparisons across types of glove use did not indicate significant differences in knowledge and use of best practices (with the exception of hand wipe washing, **Table 3b**). Overall, no glove users reported low scores in all measures.

### 3.2.5. Health Beliefs

**Table 4** shows the mean scores of items used to measure firefighters' perceived susceptibility, perceived severity, perceived benefits, health motivation, perceived barriers, and cues to action related to occupational exposure post-fire. Due to low internal consistency

(Cronbach's  $\alpha < 0.6$ ), grouped items measuring firefighters' perceived severity (chemical exposure and physical exposure) and health motivation (feel, learn, and search) were considered separately [77].

Average scores indicated that Washington firefighters tended to agree with statements about the perceived risk of post-fire exposures ( $\bar{x}_{\text{susceptibility}}=3.35$ ;  $\bar{x}_{\text{chemical severity}}=4.26$ ) as well as the benefits and importance of glove use best practices ( $\bar{x}_{\text{benefits}}=3.89$ ;  $\bar{x}_{\text{feel and learn}}=4.05$ ). They tended to disagree with statements about action expected to promote glove use behaviors ( $\bar{x}_{\text{search}}=2.39$ ) and barriers to best practices ( $\bar{x}_{\text{barriers}}=2.17$ ). As depicted in **Figure 15**, cues to action like current departmental policies on glove practices and firefighters' motivation to search for new information about glove best practices did not appear to facilitate post-fire glove use ( $\bar{x}_{\text{policies}}=2.73$ ;  $\bar{x}_{\text{search}}=2.39$ ). On the other hand, barriers to glove use best practices (e.g., discomfort) did not appear particularly prohibitive ( $\bar{x}_{\text{discomfort}}=2.28$ ).

Differences in perceived susceptibility, health motivation, and perceived barriers were observed in no glove users (**Table 4**). For every item measuring concerns about occupational exposure and seeking out information about best practices, no glove users reported the lowest scores on average ( $\bar{x}_{\text{susceptibility}}=2.69$ ;  $\bar{x}_{\text{search}}=1.89$ ). Conversely, for barriers perceived to inhibit glove use—including interfering with task completion, discomfort, and time—no glove users reported the highest average scores ( $\bar{x}_{\text{interference}}=2.72$ ;  $\bar{x}_{\text{discomfort}}=3.28$ ;  $\bar{x}_{\text{time}}=2.94$ ). Opposite trends were observed with medical glove users who reported the highest scores in relation to risk, benefits, and action ( $\bar{x}_{\text{contamination}}=4.09$ ;  $\bar{x}_{\text{health}}=4.18$ ;  $\bar{x}_{\text{action}}=2.99$ ) and the lowest scores related to glove use barriers ( $\bar{x}_{\text{barriers}}=1.82$ ).

**Table 2.** PPE characteristics related to type of glove use. Unit: n (%).

Characteristic	Glove Use									p-value <sup>a</sup>
	All N=364	Structural N=103	Leather N=79	Mechanic N=54	Gardening N=36	Medical N=35	Extrication N=24	No Gloves N=18	Other N=15	
Comfort										
These gloves are comfortable.	167 (45.9%)	17 (16.5%)	46 (58.2%)	44 (81.5%)	25 (69.4%)	11 (31.4%)	12 (50.0%)	4 (22.2%)	8 (53.3%)	<0.001
Fit										
These gloves fit well.	155 (42.6%)	11 (10.7%)	42 (53.2%)	41 (75.9%)	21 (58.3%)	16 (45.7%)	15 (62.5%)	2 (11.1%)	7 (46.7%)	<0.001
Function										
These gloves are well-suited for tasks.	188 (51.6%)	45 (43.7%)	50 (63.3%)	32 (59.3%)	20 (55.6%)	18 (51.4%)	9 (37.5%)	3 (16.7%)	11 (73.3%)	0.003
These gloves provide full range of motion.	164 (45.1%)	8 (7.8%)	44 (55.7%)	41 (75.9%)	24 (66.7%)	15 (42.9%)	18 (75.0%)	5 (27.8%)	9 (60.0%)	<0.001
Protection										
These gloves provide physical protection.	185 (50.8%)	57 (55.3%)	50 (63.3%)	30 (55.6%)	16 (44.4%)	10 (28.6%)	15 (62.5%)	–	7 (46.7%)	<0.001
These gloves provide chemical protection.	40 (11.0%)	16 (15.5%)	–	1 (1.9%)	3 (8.3%)	17 (48.6%)	1 (4.2%)	–	2 (13.3%)	<0.001
Availability										
These gloves are accessible on scene.	138 (37.9%)	54 (52.4%)	23 (29.1%)	16 (29.6%)	7 (19.4%)	26 (74.3%)	6 (25.0%)	1 (5.6%)	5 (33.3%)	<0.001
These gloves were provided to me by my department.	149 (40.9%)	75 (72.8%)	30 (38.0%)	6 (11.1%)	9 (25.0%)	15 (42.9%)	9 (37.5%)	–	5 (33.3%)	<0.001
Satisfaction										0.002
Yes, I am satisfied with the gloves provided by my employer.	233 (64.0%)	75 (72.8%)	52 (65.8%)	26 (48.1%)	18 (50.0%)	30 (85.7%)	17 (70.8%)	7 (38.9%)	8 (53.3%)	
No, I am NOT satisfied with the gloves provided by my employer.	115 (31.6%)	28 (27.2%)	22 (27.8%)	22 (40.7%)	14 (38.9%)	5 (14.3%)	7 (29.2%)	10 (55.6%)	7 (46.7%)	
My primary employer does not provide gloves.	11 (3.0%)	–	4 (5.1%)	5 (9.3%)	1 (2.8%)	–	–	1 (5.6%)	–	
Unspecified	5 (1.4%)	–	1 (1.3%)	1 (1.9%)	3 (8.3%)	–	–	–	–	

Note: Survey participants were asked to select all applicable reasons for their glove use. Dashed lines indicate no response.

<sup>a</sup> Results of statistical comparisons amongst types of glove use. Pearson's chi-square tests were performed for all nine glove-related characteristics/statements.

**Table 3a.** Frequencies and percentages of post-fire decontamination behaviors reported by Washington firefighters. Unit: n (%).

Decontamination Behavior	Setting <sup>a</sup>	Frequency					
		Never	Rarely	Sometimes	Often	Always	Unspecified
Field decontamination of gloves	On scene	38 (10.4%)	49 (13.5%)	94 (25.8%)	101 (27.7%)	79 (21.7%)	3 (0.8%)
Spot cleaning of gloves	Fire station	103 (28.3%)	100 (27.5%)	87 (23.9%)	50 (13.7%)	17 (4.7%)	7 (1.9%)
Hand cleaning of gloves	Fire station	165 (45.3%)	89 (24.5%)	57 (15.7%)	29 (8.0%)	14 (3.8%)	10 (2.7%)
Machine cleaning of gloves <sup>b</sup>	Fire station	52 (14.3%)	36 (9.9%)	78 (21.4%)	87 (23.9%)	108 (29.7%)	3 (0.8%)
Wipe wash of hands	On scene	37 (10.2%)	35 (9.6%)	67 (18.4%)	108 (29.7%)	115 (31.6%)	2 (0.5%)
Soap wash of hands	On scene	16 (4.4%)	16 (4.4%)	23 (6.3%)	89 (24.5%)	217 (59.6%)	3 (0.8%)
No cleaning activities	na	na	na	23 (6.3%)	7 (1.9%)	3 (0.8%)	23 (6.3%)

<sup>a</sup> Ideal location for the behavior to occur according to the National Fire Protection Association (NFPA) [50] and the Washington State Council of Fire Firefighters (WSCFF) [43].

<sup>b</sup> Includes vendor cleaning.

**Table 3b.** Firefighter knowledge and behaviors related to decontamination best practices. Units: n (%); mean (SD).

Knowledge and Use of Best Practices	Glove Use									p-value <sup>a</sup>
	All N=364	Structural N=103	Leather N=79	Mechanic N=54	Gardening N=36	Medical N=35	Extrication N=24	No Gloves N=18	Other N=15	
Familiar with state recommendations <sup>b</sup>										0.17
Yes	204 (56.0%)	51 (49.5%)	49 (62.0%)	35 (64.8%)	23 (63.9%)	17 (48.6%)	14 (58.3%)	6 (33.3%)	9 (60.0%)	
No	158 (43.4%)	51 (49.5%)	30 (38.0%)	19 (35.2%)	12 (33.3%)	18 (51.4%)	10 (41.7%)	12 (66.7%)	6 (40.0%)	
Unspecified	2 (0.5%)	1 (1.0%)	–	–	1 (2.8%)	–	–	–	–	
Best practice behaviors <sup>b,c</sup>										
Field decontamination of gloves	3.37 (1.26)	3.27 (1.24)	3.47 (1.28)	3.50 (1.22)	3.43 (1.38)	3.49 (1.25)	3.29 (1.20)	2.94 (1.21)	3.27 (1.39)	0.71
Hand cleaning of gloves	1.98 (1.15)	1.88 (1.15)	2.11 (1.24)	1.96 (1.15)	1.91 (1.23)	2.03 (1.02)	2.38 (1.24)	1.65 (0.79)	1.73 (0.80)	0.43
Wipe wash of hands	3.63 (1.30)	3.54 (1.35)	3.33 (1.36)	3.93 (1.24)	3.57 (1.29)	3.89 (0.90)	4.17 (0.87)	3.00 (1.53)	4.27 (1.22)	0.01
Soap wash of hands	4.32 (1.07)	4.37 (0.95)	4.22 (1.23)	4.32 (1.07)	4.49 (0.92)	4.34 (1.08)	4.58 (0.58)	3.61 (1.65)	4.40 (0.74)	0.66

Note: Higher scores indicate stronger agreement with statements (1=strongly disagree to 5=strongly agree).

<sup>a</sup> Results of statistical comparisons amongst types of glove use. A Pearson's chi-square test was performed for knowledge of best practices. Kruskal-Wallis tests were performed for measures of adherence to best practices.

<sup>b</sup> In Washington state, the "Healthy In, Healthy Out Manual" provides best practices for reducing firefighter risk of exposure to carcinogens [43].

<sup>c</sup> The National Fire Protection Association (NFPA) states that gloves exposed to products of combustion should undergo preliminary exposure reduction and advanced cleaning (unless otherwise noted, gloves should be hand washed) [50].

**Table 4.** Measures of firefighter health beliefs. Unit: mean (SD).

Health Beliefs	Glove Use									p-value <sup>a</sup>
	All N=364	Structural N=103	Leather N=79	Mechanic N=54	Gardening N=36	Medical N=35	Extrication N=24	No Gloves N=18	Other N=15	
Perceived Susceptibility <sup>b</sup>	3.35 (0.83)	3.42 (0.90)	3.46 (0.75)	3.49 (0.67)	3.21 (0.88)	3.19 (0.81)	3.21 (0.77)	2.69 (0.95)	3.47 (0.78)	0.01
I am worried about skin contamination during demobilization.	3.77 (1.00)	3.84 (1.01)	3.73 (1.02)	3.67 (0.99)	3.63 (1.11)	4.09 (0.82)	3.83 (0.82)	3.17 (1.15)	4.07 (0.80)	
I am worried about strains and sprains during demobilization.	3.22 (1.18)	3.34 (1.21)	3.41 (1.12)	3.49 (0.93)	3.03 (1.15)	2.74 (1.27)	3.00 (1.13)	2.50 (1.38)	3.27 (1.28)	
I am worried about cuts and abrasions during demobilization.	3.43 (1.14)	3.32 (1.20)	3.67 (1.05)	3.67 (1.01)	3.31 (1.11)	3.23 (1.31)	3.50 (1.06)	2.61 (1.09)	3.60 (1.12)	
I am worried about eye injuries during demobilization.	2.94 (1.14)	3.13 (1.19)	3.00 (1.04)	3.04 (1.10)	2.82 (1.06)	2.74 (1.19)	2.46 (1.18)	2.50 (1.20)	2.93 (1.10)	
Perceived Severity - Chemical Exposure										0.31
Dermal exposure to chemicals during demobilization contributes to cancer risk.	4.26 (0.83)	4.24 (0.90)	4.23 (0.93)	4.28 (0.60)	4.31 (0.58)	4.51 (0.56)	4.33 (0.92)	3.72 (1.23)	4.33 (0.62)	
Perceived Severity - Physical Exposure										0.25
Poor hand mobility during demobilization contributes to strains and sprains.	3.19 (1.11)	3.02 (1.15)	3.33 (1.08)	3.37 (0.96)	3.24 (0.96)	2.91 (1.34)	3.46 (1.02)	2.94 (1.21)	3.33 (1.18)	
Perceived Benefits	3.89 (0.90)	3.79 (0.99)	3.94 (0.75)	3.85 (0.85)	3.90 (0.94)	4.12 (0.75)	4.17 (0.76)	3.50 (1.18)	3.97 (1.08)	0.41
Post-fire glove best practices keep me safe.	3.86 (0.92)	3.76 (0.99)	3.92 (0.77)	3.83 (0.84)	3.89 (0.93)	4.06 (0.85)	4.17 (0.82)	3.33 (1.19)	4.00 (1.07)	
Post-fire glove best practices protect my health.	3.91 (0.94)	3.83 (1.04)	3.94 (0.81)	3.85 (0.93)	3.91 (0.98)	4.18 (0.72)	4.17 (0.76)	3.67 (1.24)	3.93 (1.16)	
Health Motivation - Feel and Learn	4.05 (0.74)	3.98 (0.81)	4.08 (0.75)	4.17 (0.53)	3.94 (0.69)	4.22 (0.63)	3.96 (0.69)	3.81 (1.11)	4.27 (0.62)	0.47
I feel it is important to adopt post-fire glove best practices.	4.20 (0.77)	4.14 (0.80)	4.23 (0.83)	4.20 (0.56)	4.23 (0.65)	4.41 (0.56)	4.21 (0.78)	3.89 (1.23)	4.33 (0.82)	
I want to learn more about post-fire glove best practices.	3.90 (0.96)	3.83 (1.06)	3.94 (0.94)	4.13 (0.75)	3.66 (1.06)	4.03 (0.90)	3.71 (0.96)	3.72 (1.13)	4.20 (0.68)	
Health Motivation - Search <sup>c</sup>										0.003
I search for new information about post-fire glove best practices.	2.39 (1.02)	2.54 (1.13)	2.20 (0.97)	2.52 (0.89)	2.06 (0.91)	2.58 (0.87)	2.21 (1.10)	1.89 (0.76)	3.00 (1.07)	
Perceived Barriers <sup>d</sup>	2.17 (0.79)	2.22 (0.86)	2.06 (0.67)	2.26 (0.76)	2.03 (0.79)	1.82 (0.71)	2.14 (0.71)	2.78 (0.75)	2.45 (0.86)	0.004
Glove use and decontamination interferes with my ability to complete demobilization tasks.	1.96 (0.94)	2.05 (1.00)	1.85 (0.83)	2.09 (0.95)	1.77 (0.84)	1.59 (0.74)	1.92 (0.88)	2.72 (1.23)	1.86 (0.77)	
It is uncomfortable to use and decontaminate my gloves post fire.	2.28 (1.05)	2.33 (1.08)	2.20 (0.98)	2.41 (1.00)	2.14 (1.03)	1.74 (0.86)	2.25 (0.99)	3.28 (1.02)	2.29 (1.14)	
I don't have enough time to use and decontaminate my gloves post fire.	2.26 (1.08)	2.24 (1.07)	2.17 (1.05)	2.35 (1.15)	1.91 (0.78)	2.09 (1.06)	2.33 (1.01)	2.94 (1.26)	2.79 (1.31)	
I don't have the materials I need to use and decontaminate my gloves.	2.18 (1.13)	2.25 (1.13)	2.01 (1.10)	2.30 (1.10)	2.24 (1.18)	1.88 (1.09)	2.04 (1.12)	2.17 (1.10)	2.86 (1.29)	
Cues to Action <sup>e</sup>	2.88 (1.00)	2.92 (1.01)	2.99 (1.02)	2.63 (0.92)	2.96 (1.04)	2.99 (1.05)	2.90 (0.90)	2.72 (1.05)	2.70 (1.05)	0.36
My department has adequate policies on post-fire glove use.	2.73 (1.06)	2.83 (1.03)	2.81 (1.05)	2.50 (1.02)	2.69 (1.11)	2.83 (1.10)	2.75 (1.11)	2.61 (1.04)	2.33 (1.11)	
I have received effective training on post-fire chemical exposure.	3.03 (1.18)	3.01 (1.21)	3.16 (1.18)	2.76 (1.11)	3.18 (1.14)	3.14 (1.24)	3.04 (1.12)	2.83 (1.15)	3.07 (1.39)	

Note: Higher scores indicate stronger agreement with statements (1=strongly disagree to 5=strongly agree).

<sup>a</sup> Results of Kruskal-Wallis tests amongst types of glove use. The two items of perceived severity and one item of health motivation were considered separately (hence multiple p-values for these variables).

Missing responses accounted for less than 5% of the data in all cases except for:

<sup>b</sup> Two responses missing from gardening glove users (5.6%).

<sup>c</sup> Two responses missing from medical users (5.7%).

<sup>d</sup> Two responses missing from gardening glove users (5.6%) and one from other glove users (6.7%).

<sup>e</sup> Two responses missing from gardening glove users (5.6%).

### 3.3 Factors Influencing Post-Fire Glove Use

#### 3.3.1 Regression of HBM Constructs

To further explore how modifying factors and health beliefs influence post-fire glove use in Washington firefighters, we developed the six multinomial logistic regression models presented in **Table 5**. In each of these models, the outcome of interest was structural, leather, mechanic, gardening, medical, extrication or no glove use. Other glove use was excluded from analysis given small sample size and difficulty in interpretation (**Appendix F**). To account for differences in survey participation based on fire department affiliation, all models incorporating demographic data (Models 1, 5 and 6) adjusted for survey responses per department.

##### 3.3.1.a. Single Construct Models

A comparison of the Akaike information criterion (AIC) for the four models (Models 1-4) used to investigate specific constructs of HBM indicated that glove factors were the most explanative of post-fire glove use (AIC=921). Based on McFadden's R-squared, factors related to comfort, fit, function, protection, availability, and satisfaction accounted for 36% of the variation in firefighter glove use (**Table 5**).

Comparatively, knowledge and use of post-fire best practices, the next most explanative model (AIC=1167), accounted for only 5% of the variability in glove use. Personal characteristics and health beliefs were less explanative (AIC<sub>individual factors</sub>=1256; AIC<sub>health beliefs</sub>=1190), but accounted for more variability than knowledge and use of best practices ( $R^2_{\text{individual factors}}=0.16$ ;  $R^2_{\text{health beliefs}}=0.07$ ).

##### 3.3.1.b. Combined Models

Informed by our conceptual model (**Figure 6**), all variables measured in the Washington Firefighter Glove Survey were included in a full logistic regression model (**Table 5, Figure 16a**). In comparison to the single construct regression models (Models 1-4), this full model (Model 5) was substantially more explanative of glove use and accounted for a large amount of variation (AIC=769;  $R^2=0.77$ ). Both the full regression model (Model 5) and our final adjusted regression

model (Model 6), which was produced using a backward stepwise variable selection process, are presented in **Table 5** and **Figure 16**. Notably, the final model retained all constructs of HBM (**Figure 16b**). As highlighted in **Figure 16b**, of all the variables included in Model 6, only glove factors were statistically significant in explaining post-fire glove use (Bonferroni-corrected  $p < 0.05$ ). More specifically, fit, range of motion, physical protection, chemical protection, and gloves being employer-provided were especially important factors to consider.

To better understand the role that these PPE characteristics played in types of glove use, each variable was used as a predictor variable in our logistic regression model (**Table 6**). As shown in **Table 6**, when holding all other variables constant (i.e., tenure, fire calls, decontamination behaviors, health beliefs, glove satisfaction, and affiliation with fire departments with fewer than 15 survey respondents), fit, range of motion, physical protection, and chemical protection were especially explanative. The results of Model 6 denote the odds of using structural, medical, extrication, or leather gloves based on a firefighter selecting fit, range of motion, physical protection, or chemical protection as the single reason for their type of glove use (and holding all other variables noted above, constant). With these model adjustments, gloves being employer-provided was not significantly explanative.

The odds ratios (ORs) presented in **Table 6** provide insight into the relative importance of fit, range of motion, physical protection, and chemical protection to different glove users. For example, the odds of using extrication gloves was 36 times higher in firefighters who selected range of motion as compared to those who did not select this reason for their type of glove use ( $p = 0.05$ ). In comparison, the odds of using structural gloves was 20 times lower under the same conditions ( $OR = 0.05$ ;  $p = 0.01$ ). Out of the other variables provided in **Table 6**, fit appeared very important to medical glove users ( $OR > 100$ ,  $p = 0.0003$ ), whereas physical protection and chemical protection did not appear particularly important to medical glove users or leather glove users respectively ( $ORs < 0.05$ ).

**Table 5.** Multinomial logistic regression analysis of Health Belief Model (HBM) constructs and firefighter glove use.

Model Description <sup>a</sup>	Predictor Variables <sup>b</sup>	Akaike Information Criterion <sup>c</sup> AIC	McFadden's R-squared R <sup>2</sup>
Model 1 <sup>d</sup> Individual Factors df=323	Gender Age (continuous) Tenure (continuous) Rank <sup>e</sup> Department size Fire calls (continuous)	1256	0.16
Model 2 Glove Factors df=333	Comfort Fit Well-suited for tasks Range of motion Physical protection Chemical protection Accessible on scene Provided by employer Satisfaction	921	0.36
Model 3 Knowledge and Use of Best Practices df=309	Familiarity with state recommendations Field decontamination of gloves Spot cleaning of gloves Hand cleaning of gloves Machine cleaning of gloves Wipe wash of hands Soap wash of hands No cleaning activities	1167	0.05
Model 4 Health Beliefs df=316	Perceived susceptibility Perceived severity – chemical exposure Perceived severity – physical exposure Perceived benefits Health motivation – learn & feel Health motivation – search Perceived barriers Cues to action	1190	0.07
Model 5 <sup>d</sup> Full Health Belief Model df=248	Variables included in Models 1-4	769	0.77
Model 6 <sup>d</sup> Final Adjusted Health Belief Model df=279	Individual Factors Tenure Fire calls  Glove Factors Comfort Fit Range of motion Physical protection Chemical protection Accessible on scene Provided by employer Satisfaction  Knowledge and Use of Best practices Machine cleaning of gloves Wipe wash of hands Soap wash of hands No cleaning  Health Beliefs Perceived susceptibility Perceived benefits Health motivation – search Perceived barriers	751	0.59

Note: Degrees of freedom is abbreviated as df.

<sup>a</sup> The outcome of interest was post-fire glove use. “Other” glove use was excluded from analysis.

<sup>b</sup> Unless noted, categorical variables were inputted as factors.

<sup>c</sup> Lower AIC values indicate better model fit [89].

<sup>d</sup> Model adjusted for survey responses per department.

<sup>e</sup> Rank inputted as line, administrative, or unspecified categories.

**Table 6.** Results of final adjusted logistic regression model for post-fire glove use.

<b>Predictor<sup>a</sup></b>	<b>Glove Use</b>	<b>Odds Ratio<sup>b</sup></b>	<b>p-value</b>
Fit	Structural gloves	0	0.0433
	Medical gloves	338.5	0.0003
Range of motion	Structural gloves	0.05	0.0206
	Medical gloves	0.01	0.0498
	Extrication gloves	36.2	0.0077
Physical protection	Medical gloves	0.001	0.0013
Chemical protection	Leather gloves	0	0.0155

Note: The final model (Model 6) adjusted for tenure (16-20 years); fire calls (3-5 per month); decontamination behaviors (mean frequency of machine cleaning of gloves, wipe wash of hands, soap wash of hands, and no cleaning activities); health beliefs (mean perceived susceptibility, perceived benefits, health motivation and perceived barriers); glove satisfaction (satisfied); all other glove factors (comfort, accessible on scene, and provided by employer not selected as reasons for type of glove use); and survey responses per department (departments with less than 15 responses).

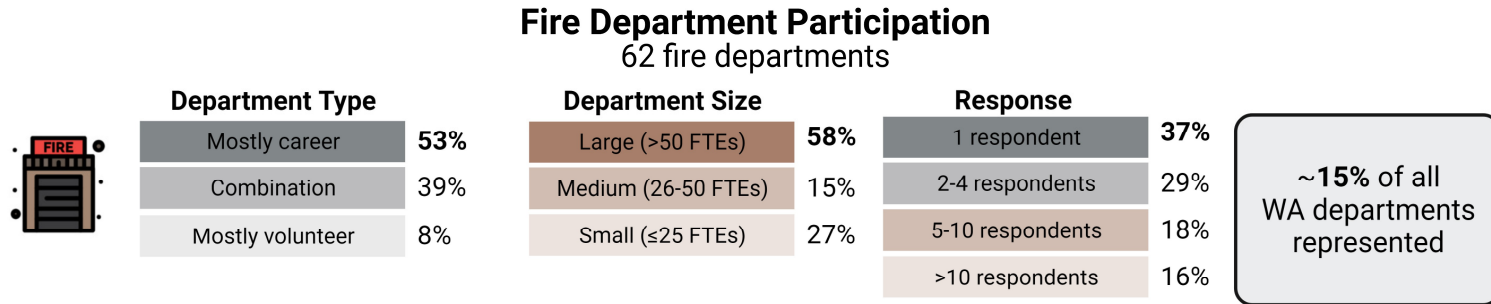
<sup>a</sup> Only predictor variables with Bonferroni-adjusted p-values <0.05 are presented.

<sup>b</sup> Odds ratios indicate the odds of using a specific type of glove in firefighters who selected the predictor variable (e.g., fit) as compared to those who did not (and holding all other variables constant).

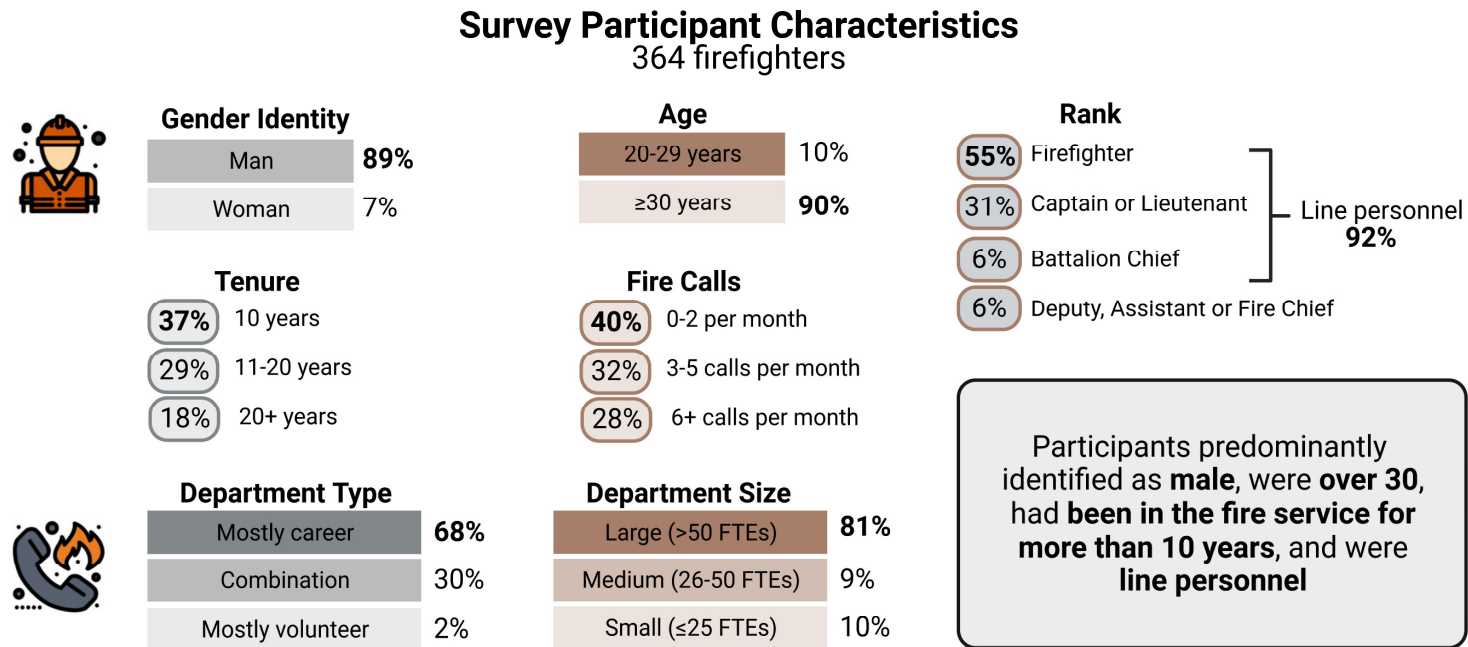
### 3.4 Return of Results to Fire Service Partners

To enhance the accessibility of the survey data and best communicate results to the fire service members who contributed to this research, **Figures 11-16** are provided. Informed by the Centers for Disease Control and Prevention (CDC) “Clear Communication Index” [90], each figure presents a visual summary to the text provided in **Tables 1-6**.

- **Table 1:** Survey participants’ personal and job characteristics, see **Figure 11**
- **Table 1:** Types of glove use, see **Figure 12**
- **Table 2:** Glove characteristics related to type of use, see **Figure 13**
- **Table 3:** Frequencies of post-fire decontamination behaviors, see **Figure 14**
- **Table 4:** Measures of firefighter health beliefs, see **Figure 15**
- **Tables 5-6:** Results of statistical modeling, see **Figure 16**



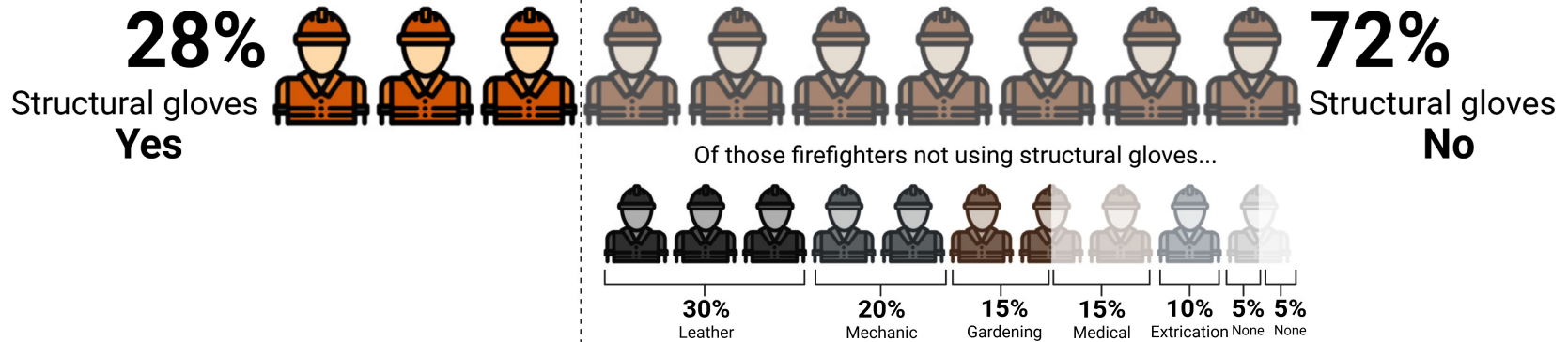
**Figure 11a.** Characteristics of fire departments represented in the Washington Firefighter Glove Survey.



**Figure 11b.** Characteristics of respondents who completed the Washington Firefighter Glove Survey.

Note: Percentages may not add to 100% due to rounding and exclusion of some categories (e.g., unspecified gender). Bolded percentages indicate the highest proportions in responses.

## What types of gloves do firefighters use during demobilization?



**Figure 12a.** Comparison of structural glove use to all other types of glove use during demobilization.  
 Note: Out of the 261 firefighters who reported not using structural gloves, most (n=79) used leather gloves.

## What types of gloves do firefighters use during demobilization?



Of the types of gloves firefighters used for demobilization...

"Work" gloves (leather, mechanic and gardening) were **most common**

Medical examination gloves were **not very common**

No gloves were **not common, but reported**

**Figure 12b.** Differences in Washington firefighter glove use during demobilization.

Note: Total respondent n=364. Other glove users (n=15) included participants who used two pairs of gloves at once (n=4) or no consistent glove option (n=11) (see **Appendix F** for more details).

### Why do firefighters use their gloves during demobilization?

Comfort		Fit		Well-Suited for Tasks		Range of Motion	
All firefighters	46%	All firefighters	43%	All firefighters	52%	All firefighters	45%
Mechanic glove users	<b>82%</b>	Mechanic glove users	<b>76%</b>	Other glove users	<b>73%</b>	Mechanic glove users	<b>76%</b>
Gardening glove users	69%	Extrication glove users	63%	Leather glove users	63%	Extrication glove users	75%
Physical Protection		Chemical Protection		Accessible On Scene		Provided by Department	
All firefighters	51%	All firefighters	11%	All firefighters	38%	All firefighters	41%
Leather glove users	<b>63%</b>	Medical glove users	<b>49%</b>	Medical glove users	<b>74%</b>	Structural glove users	<b>73%</b>
Extrication glove users	<b>63%</b>	Structural glove users	16%	Structural glove users	53%	Leather glove users	38%

When asked about the reasons for their glove use...

**Most** firefighters chose function and physical protection

**About half** of firefighters chose comfort and range of motion

**Less than one-fifth** of firefighters chose chemical protection

**Figure 13a.** Glove characteristics Washington firefighters selected when asked why they wear their gloves during demobilization. Note: Types of glove use with the highest percentages of firefighters who chose each characteristic are presented as a comparison to all. Bolded percentages indicate glove users who had the single highest proportion of selected responses.

### What are the top three reasons firefighters used their gloves during demobilization?

Glove Use	Structural Gloves	Leather Gloves	Mechanic Gloves	Gardening Gloves	Medical Gloves	Extrication Gloves	No Gloves	Other
Glove Characteristics	 <p><b>Provided by employer</b> Physical protection Accessible on scene</p>	 <p><b>Well-suited for tasks</b> <b>Physical protection</b> Comfort</p>	 <p><b>Comfort</b> Fit Range of motion</p>	 <p><b>Comfort</b> Range of motion Fit</p>	 <p><b>Accessible on scene</b> Well-suited for tasks Chemical protection</p>	 <p><b>Range of motion</b> Physical protection Fit</p>	 <p><b>Range of motion</b> Comfort Well-suited for tasks</p>	 <p><b>Well-suited for tasks</b> Range of motion Comfort</p>

**Figure 13b.** Differences in glove characteristics selected by Washington firefighters, stratified by glove use. Note: Bolded text indicates the highest number of selected responses (i.e., top reason).

### Are firefighters satisfied with the gloves provided by their fire department?

**64%** **Satisfied** with the gloves provided by their department

**32%** **Not satisfied** with the gloves provided by their department

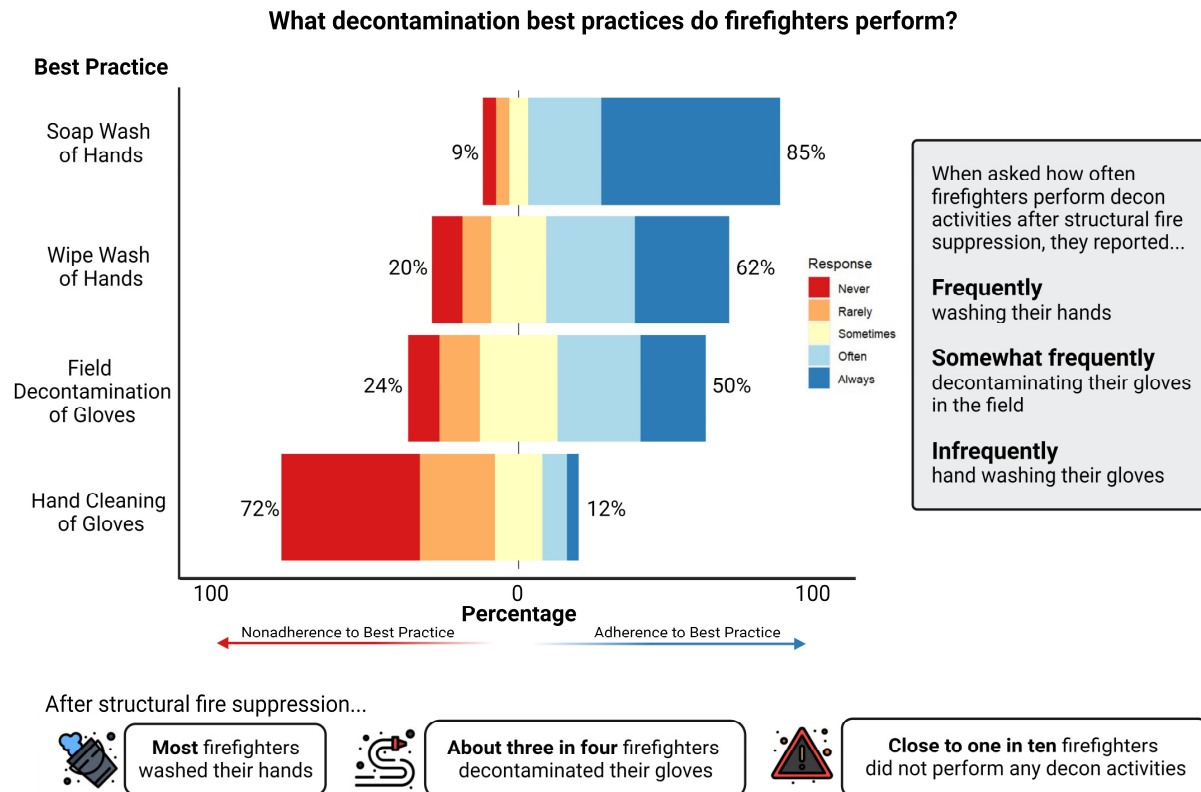
**3%** Department did not provide gloves

When asked about glove satisfaction...

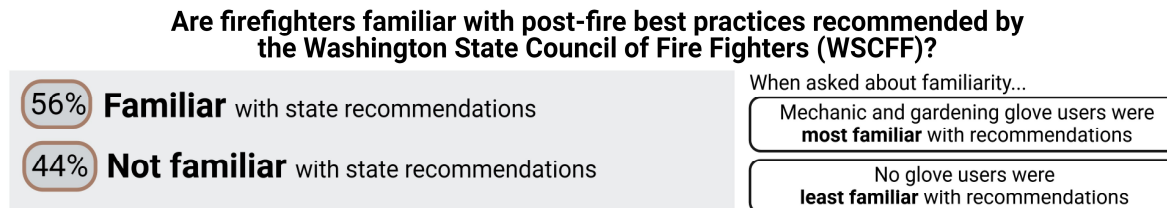
Medical and structural glove users were **most satisfied**

No glove users and other glove users were **least satisfied**

**Figure 13c.** Glove satisfaction reported by Washington firefighters.

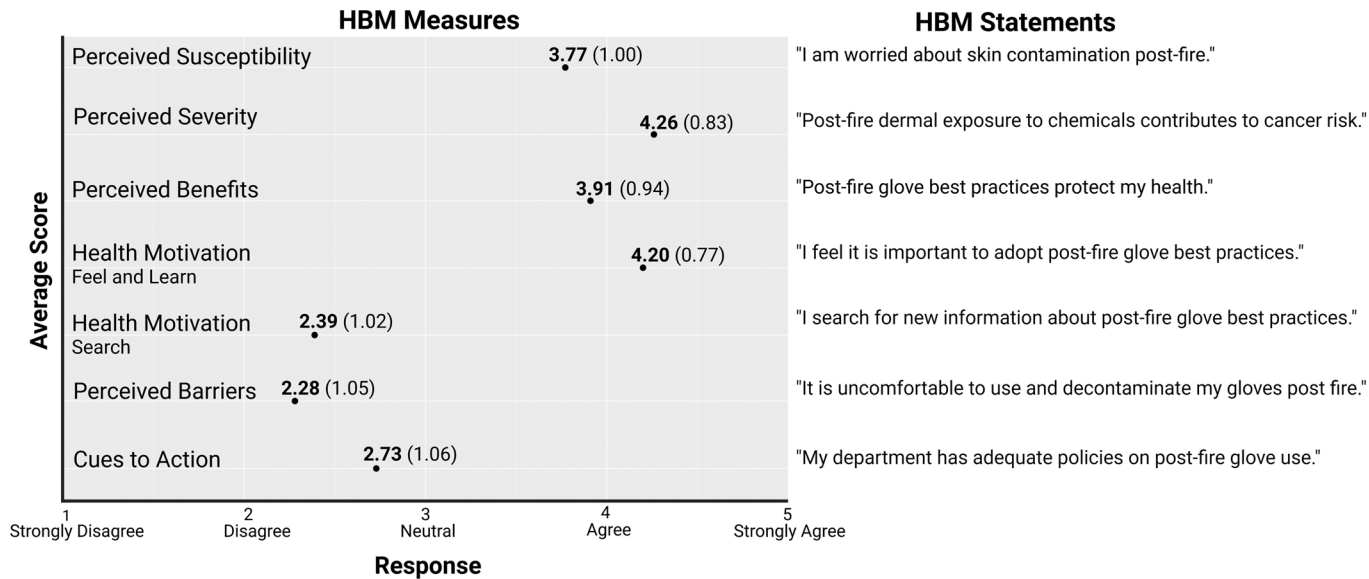


**Figure 14a.** Frequency of post-fire decontamination best practices performed by Washington firefighters.  
 Note: The activities presented are recommended in NFPA 1851 [50] and “Healthy In, Healthy Out” [43].



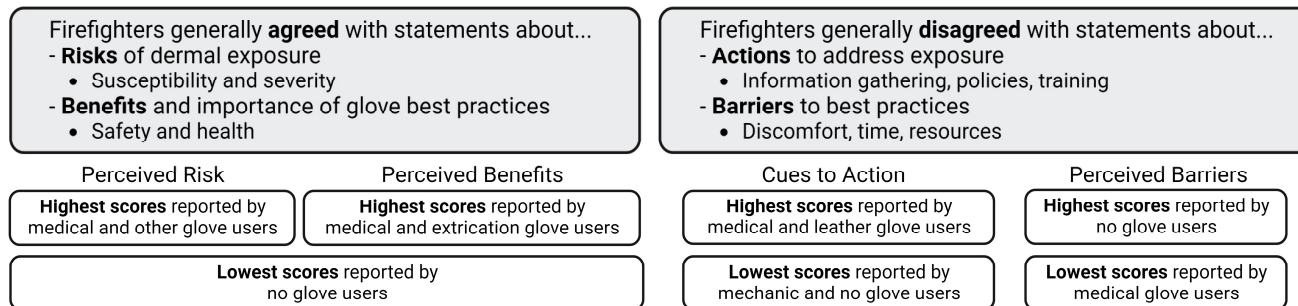
**Figure 14b.** Washington firefighters’ familiarity with post-fire decontamination best practices.  
 Note: Survey question specifically referenced “Healthy In, Healthy Out” [43] as an example.

### What are Washington firefighters' health beliefs related to post-fire glove use?

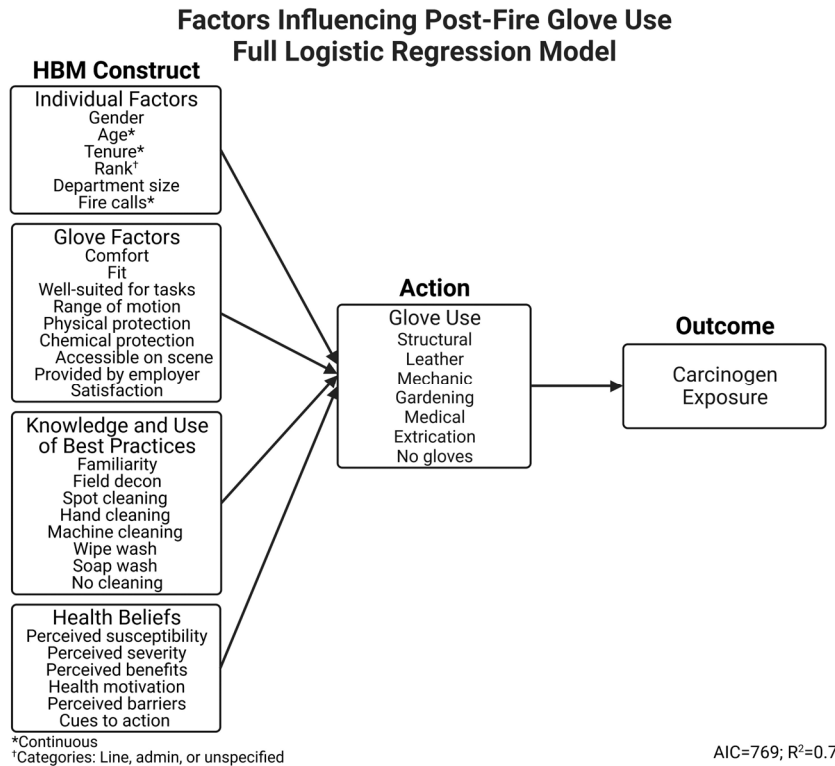


**Figure 15a.** Statements used to assess Washington firefighter health beliefs related to cancer. Unit of measure: mean (SD). Note: Only select statements related to carcinogens are presented here. A total of 17 statements were used to assess firefighters' overall health perceptions.

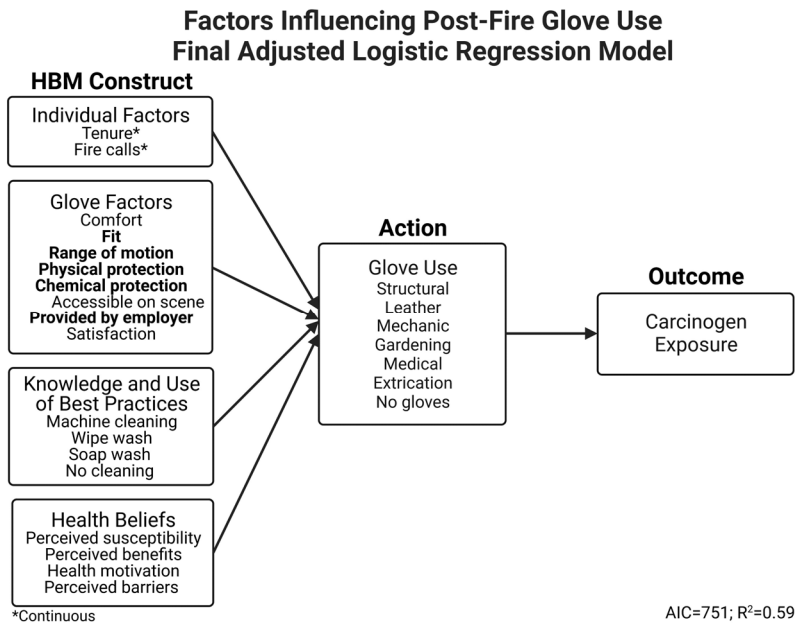
### Summary of Firefighters' Health Perceptions Related to Post-Fire Glove Use



**Figure 15b.** Summary of Washington firefighters' health beliefs. Note: A total of 17 statements were used to assess firefighters' health perceptions.



**Figure 16a.** Variables included in the full logistic regression model used to explore post-fire glove use in Washington firefighters.  
 Note: Health Belief Model is abbreviated as HBM. Other glove use was excluded from analysis due to small sample size and lack of interpretability. Model adjusted for survey responses per department.



**Figure 16b.** Variables retained in the final logistic regression model.  
 Note: Bolded glove factors were statistically significant in explaining glove use (Bonferroni-adjusted p<0.05). Other glove use was excluded from analysis due to small sample size and lack of interpretability. Model adjusted for survey responses per department.

## 4. DISCUSSION

### 4.1 Washington Firefighters' Variable Glove Use During Demobilization

This research explored the types of gloves firefighters use during demobilization and the factors that influence post-fire glove use. Through distribution of a cross-sectional survey informed by the Health Belief Model, this study identified a wide range of reported glove use. Despite common assumptions, most firefighters (72%) did not report use of structural firefighting gloves. Close to half (46%) of all surveyed firefighters (n=364) reported use of “work” gloves—either leather (n=79), mechanic (n=54), or gardening (n=36) gloves—during demobilization. Only about 10% reported use of medical examination gloves (n=35), and another 5% used no gloves (n=18).

The variation in reported glove use underscores the ambiguity in current standards, best practices, and policies related to demobilization. While both national and state recommendations identify removal of structural firefighting gloves for medical examination gloves post-fire suppression [43, 50], when exactly firefighters should make this exchange is unclear (**Figure 4**). Moreover, vague language in current recommendations [43] may further add confusion by directing firefighters, to use “appropriate” gloves. At worst, this ambiguity may lead to policies that conflict with standards, as is the case with a policy stating firefighters shall “wear leather gloves in situations where rough edges are likely to be encountered” [91].

Adding further complexity to the matter is the fact that within a single fire department, multiple brands and/or types of gloves may be provided to firefighters, which could introduce glove quality concerns. For example, it is not uncommon for fire departments to issue three sets of gloves: one for structural firefighting, one for wildland firefighting (leather gloves), and one for rescue operations (extrication gloves). And while Washington firefighters are required by state law to wear structural firefighting gloves during and immediately after fire suppression [92], what gloves they wear after they have performed an on-scene gross decontamination is at the discretion of their employer [92].

Notably, differences in glove designs and use have yet to be addressed in research related to firefighter PAH exposures [14, 21, 22]. These often overlooked differences are essential to consider in cancer mitigation efforts [34]. As previously noted, structural firefighting turnout gear does not provide full protection from carcinogens [1, 16-18]. Despite strict design and performance criteria [93], structural gloves are not chemical-resistant [22] and may actually increase dermal PAH absorption due to material thickness and its impact on increased body temperatures and moisture [22, 31, 32]. Furthermore, structural gloves used for fire suppression present a secondary source of PAH contamination post-fire [14, 42, 94].

Depending on when—and if—firefighters exchange their structural gloves for medical examination gloves may have serious consequences for firefighter cancer mitigation efforts. Our findings—namely that only 10% of firefighters wore medical gloves and roughly 5% didn't wear gloves during demobilization—emphasize the need to consider differences in glove designs and compliance in use to effectively prevent dermal PAH exposure [1, 14, 15, 34].

#### **4.2 Factors Influencing Washington Firefighters' Post-Fire Glove Use**

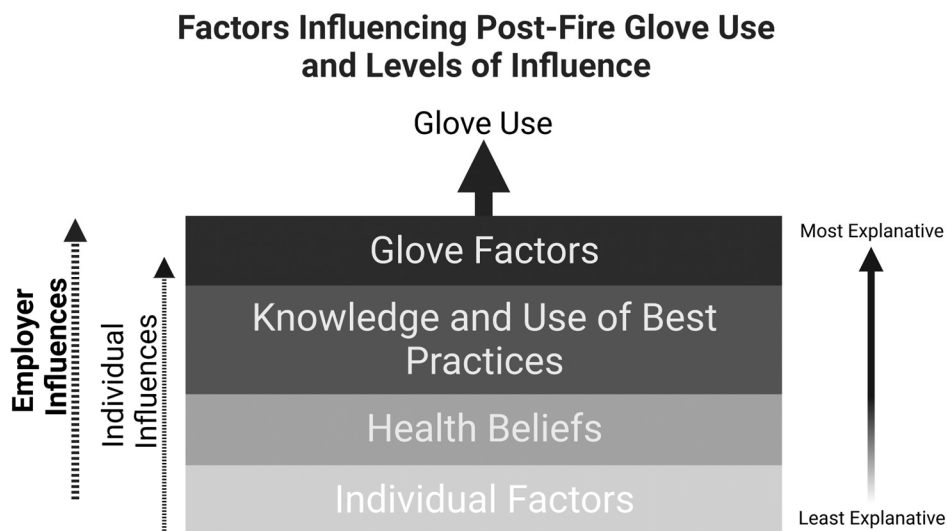
There exists a need to develop best practices and recommendations that incorporate modifying factors influencing glove use [34, 63, 73]. Based on the results of our multiple logistic regression models, post-fire glove use was best explained by a combination of modifying factors and health beliefs. While firefighters' personal characteristics ( $R^2=0.16$ ), health perceptions ( $R^2=0.07$ ), and knowledge and behaviors ( $R^2=0.05$ ) related to decontamination accounted for some variation in glove use during demobilization, glove factors accounted for much more variability ( $R^2=0.36$ ) and were the only statistically significant variables in our final adjusted logistic regression model. This finding generally aligns with other firefighter PPE research demonstrating broader influences like fire service culture as drivers of firefighters' actions [37, 39, 73, 95]. To our knowledge, this is the first study demonstrating broad heterogeneity in modifying factors influencing glove use post-fire.

Similar to other cohorts [34, 63, 64], despite health beliefs theoretically conducive to following best practices (i.e., high perceived risk and benefits; low perceived barriers), few Washington firefighters reported use of medical gloves during demobilization, which is the recommended practice [43, 50]. Several authors assert that lack of clear guidance and enforcement are primary reasons for this discrepancy [37, 39]. It appears that without these things, Washington firefighters are alike to other cohorts in relying largely on personal PPE-related judgements (e.g., comfort) and assessment of risk [37, 39]. In terms of personal judgements related to glove factors, Washington firefighter glove users diverged significantly (**Table 6**). While on-scene accessibility and chemical protection were among the top reasons firefighters wore medical gloves (**Figure 13b**), range of motion and comfort were most often selected by firefighters who wore no gloves.

Perceived risk is an important tenet of the Health Belief Model. In our study, no glove users reported low perceived risk ( $\bar{x}_{\text{susceptibility}}=2.69$ ;  $\bar{x}_{\text{chemical severity}}=3.72$ ), familiarity ( $n_{\text{unfamiliar}}=12$ , 67%), and behaviors ( $\bar{x}_{\text{field decontamination}}=2.94$ ) related to glove use best practices. As noted by Wolffe et al. [39], a reliance on personal judgements and assessment of risk could be detrimental for firefighters who are not fully aware or are desensitized to the potential dangers of not adhering to PPE policies. No glove users' additional indication of low perceived benefits ( $\bar{x}_{\text{benefits}}=3.50$ ) and cues to action ( $\bar{x}_{\text{cues}}=2.72$ ) and high perceived barriers ( $\bar{x}_{\text{barriers}}=2.78$ ) of glove use further support this notion. Importantly, despite medical glove users' high perceived risk ( $\bar{x}_{\text{susceptibility}}=3.19$ ;  $\bar{x}_{\text{chemical severity}}=4.51$ ) and benefits ( $\bar{x}_{\text{benefits}}=4.12$ ) of glove use, they similarly indicated lack of familiarity with best practices ( $n_{\text{unfamiliar}}=18$ , 51%) and general disagreement with efficacy of departmental policies and training ( $\bar{x}_{\text{cues}}=2.99$ ). These findings point to improved education and awareness in combination with more precise departmental policies to improve Washington firefighters' post-fire glove use.

### 4.3 Implications for the Washington Fire Service

Employers and the broader fire service community play an outsized role in addressing firefighter carcinogen exposures. As **Figure 17** makes clear, employer-level influences associated with glove selection and decontamination are essential to consider in Washington firefighters' post-fire glove use. Broader PPE compliance studies similarly highlight influences beyond the individual as most meaningful to prioritize [69-71, 96]. Among the proposed actions fire service employers can directly influence to improve post-fire glove use include glove quality and availability considerations (**Table 7**). Additionally, employers can oversee improvements to glove use policies, procedures, and educational materials (**Table 7**). Given the magnitude of influence fire service employers can have on post-fire glove use, prioritization of these employer-level actions will effectively lead to improved PPE compliance.



**Figure 17.** Factors influencing Washington firefighters' post-fire glove use.

Note: Bolded text indicates that the most explanative factors of post-fire glove use are largely influenced by fire service employers (as opposed to individual fire service members). Glove factors (AIC=921,  $R^2=0.36$ ) and knowledge and use of best practices (AIC=1167,  $R^2=0.05$ ) were most explanative of glove use; health beliefs (AIC=1190,  $R^2=0.07$ ) and individual factors (AIC=1256,  $R^2=0.16$ ) were least explanative.

Fire service members also play an important role in carcinogen exposure reduction. Of the proposed actions provided in **Table 7**, a key theme is the involvement of firefighters—the glove users—in the selection and testing of interventions to improve glove use. As asserted by

several authors, proper usage of PPE can be achieved only when user needs are addressed [65, 67, 69]. Thus, without an understanding of firefighters' perceptions—in terms of meeting job demands and providing carcinogen exposure protection—improper use or no use of gloves during demobilization will likely continue. To avoid this, fire service leadership should make a point of soliciting user input and feedback. Importantly, these insights should then be shared with glove vendors and manufacturers to ensure protection, performance, and comfort for all users [65, 67, 69]. In providing feedback on glove varieties, styles, and brands, fire service members can drive change within fire departments and across the broader firefighter PPE industry.

#### **4.4 Implications for Future Research**

Current guidance recommends use of medical examination gloves while handling and cleaning contaminated equipment [43, 50]. Our study results suggest that there are several individual-level influences—in addition to the employer-level suggestions provided—that may lead to an increase in the usage of medical examination gloves post-fire suppression (**Figure 17**). Interventions aimed at changing post-fire glove use should therefore attempt to capture individual-level differences. Our study found that medical glove users tended to be younger ( $\bar{x}_{\text{age}} \sim 39$ ) and have fewer years in the fire service ( $n=21$ , 60% with 10 or fewer years of service) than no glove users ( $\bar{x}_{\text{age}}=46$ ;  $n=8$ , 44% with more than 20 years of service). It was also found that medical glove users and no glove users had mismatched health and PPE perceptions. Whereas most medical glove users were satisfied ( $n=30$ , 86%) with the gloves provided by their employer, no glove users expressed the highest proportion of dissatisfaction ( $n=10$ , 56%). These findings emphasize the need for future interventions to address individual-level differences.

Whilst research into specific interventions to reduce firefighter carcinogen exposures is limited [15, 24, 34, 73, 97], one intervention that could serve as a model for post-fire glove use was designed by Harrison et al. [73]. The primary components of this intervention are integrated

into proposed actions provided in **Table 7**. Overall, Harrison et al.'s intervention was significant in increasing firefighters' attitudes and perceived norms toward contamination control [73]. This success stresses the importance of designing glove use interventions that pay close attention to individuals' health and PPE perceptions. We recommend that any intervention incorporate the following essential components:

- Highlight benefits of glove use to address fatalistic views held by many long-serving firefighters [98]
  - Behavioral research studies suggest that firefighters who are repeatedly subjected to hazardous experiences, may, over time, pay less attention or take less caution over their exposure to toxins [99, 100]
- Develop and evaluate relevant resources to promote glove use best practices
  - Messages should address differences in self-efficacy and barriers
    - Formative research points to firefighters delivering messages and demonstrating desired behaviors as a key element of receptiveness [73]
    - Additional research recommends regular training updated with the latest scientific evidence on contaminants [39]
  - Educational materials should be designed for the built environment of firefighting
    - Formative research points to success with magnets for personal lockers and compartments of fire engines; posters in common areas of the fire station, and stickers for gear boxes [73]
  - Ensure resources are tailored/customized to membership
    - Previous findings by Wolffe et al. [39] imply that long-serving firefighters may never have received training on the health effects of contaminant exposure, and continue to be overlooked in terms of training
      - This finding emphasizes no glove users as a target population for training
    - Wolffe et al. [39] also found that considerable proportions of firefighters who did receive training indicated nonadherence to best practices
      - This finding emphasizes no glove users as a target population for tailored messaging

- Harrison et al. [73] found differences in intervention effectiveness across fire departments, highlighting the need for customization to the specific organization

Ultimately, the most effective interventions will target firefighters' perceptions at both the individual and organizational levels [37, 39, 73, 95]. To do this, future research should focus on developing specific glove use policies and best practices with glove quality—in terms of chemical protection efficacy and useability—and health beliefs at the forefront.

**Table 7.** Actions, interventions, and future research to promote firefighter glove use and carcinogen exposure reduction.

HBM Construct	Factors Influencing Glove Use	Proposed Actions
Glove Factors	Comfort	<u>Fire Service</u> – Consider glove options available in your department <i>Are multiple glove types issued? Are multiple pairs issued?</i> <i>Are there a range of sizes available? Are there brand variations?</i> – Gather feedback from leadership and membership on current glove options <i>Are gloves meeting user needs?</i> <i>Are gloves meeting health and safety needs?</i> <u>Future Research</u> – Chemical protection efficacy of glove varieties and brands – Glove useability testing
	Fit	
	Range of motion	
	Physical protection	
	Chemical protection	
	Accessible on scene	
	Provided by employer	
Satisfaction		
Knowledge and Use of Best Practices	Machine cleaning of gloves	<u>Fire Service</u> – Integrate contamination control into field operations <ul style="list-style-type: none"> <li>• Provide materials to perform on-scene gross decontamination and frequent handwashing                              Materials: Bucket, bristle brush, soap, wet wipes</li> </ul> – Develop (or revise) and implement a SOP detailing post-fire glove use and cleaning procedures <ul style="list-style-type: none"> <li>• Subject contaminated gloves to proper cleaning, preferably hand cleaning                              Materials: Medical gloves, protective eyewear, mild detergent</li> </ul> <u>Future Research</u> – Development of best practices explicitly for demobilization
	Wipe wash of hands	
	Soap wash of hands	
	No cleaning	
Health Beliefs	Perceived susceptibility	<u>Fire Service</u> – Frequently communicate with membership about post-fire contamination issues <ul style="list-style-type: none"> <li>• Highlight risk and benefits of contamination control                              Example Resource: Healthy In, Healthy Out</li> </ul> – Review current policies and procedures related to post-fire glove use <i>Do they specifically address demobilization? Do they state use of medical examination (EMS) gloves?</i> <i>Do training materials incorporate best practices? Are resources easily accessible?</i> <u>Future Research</u> – Design of interventions to promote best practices
	Perceived benefits	
	Health motivation – search	
	Perceived barriers	
Individual Factors	Tenure	<u>Fire Service</u> – Conduct initial and subsequent training on contamination control best practices <ul style="list-style-type: none"> <li>• Evaluate relevancy and effectiveness</li> </ul> – Ensure apparatus are stocked with EMS gloves <ul style="list-style-type: none"> <li>• Place in a location easily accessible on scene</li> <li>• Provide multiple brands and sizes</li> </ul> <u>Future Research</u> – Design of tailored messages and materials to promote EMS glove use
	Fire calls	

Note: This list is not exhaustive. The intention of these suggestions is to provide a starting point for fire service members and the broader research community.

#### 4.5 Study Strengths and Limitations

To the best of our knowledge, the Washington Firefighter Glove Survey is the first to explore post-fire glove use in firefighters [34-42]. It is also the first study to use the Health Belief Model as a framework to investigate firefighter glove use [40, 41, 63, 64, 73]. While several studies have assessed firefighters' health beliefs regarding PPE maintenance and decontamination, these studies do not specifically address glove compliance, nor do they consider variations beyond NFPA 1971 structural firefighting gear [40, 41, 63, 64, 73]. Contrary to common assumptions and current recommendations, we found that firefighters predominately did not wear structural firefighting gloves (n=103, 28%) or medical examination gloves (n=35, 10%) post-fire suppression. Instead, firefighters largely wore "work" gloves (n=169, 46%).

In addition to the variable post-fire glove use identified, our study found an array of influential factors, namely glove factors and current decontamination practices as most explanative. These findings confirmed the expressed need for specificity in standards, policies, and best practices related to post-fire glove use. They also show the necessity of firefighter cancer mitigation interventions based on a combination of firefighters' PPE and health perceptions.

Our study was able to capture a sizeable sample of Washington firefighters (participant n=364; fire department n=62), potentially lending insight into glove use and decontamination trends within the Washington Fire Service. However, given that this sample accounts for less than 5% of the state's total career firefighter population [62, 101], generalizations should be made with caution.

Given a lack of data on the total number of firefighters who received a request to participate in our study, we were unable to obtain a survey response rate. This limitation, in addition to relatively few survey questions about demographic information may add further caution to generalization. Of the select sociodemographic information we did gather, survey participants reflected broader Fire Service trends for most items apart from age [62, 102].

Comparatively, firefighters aged 40 and above were overrepresented in our study [62, 102]. For these reasons, future research should be conducted to discern applicability of trends in the fire service more generally, and in individual-level influences more specifically.

Due to the constraints of our conceptual model, organizational-level influences related to glove use may also require further study. While individual glove use was the primary outcome of interest in this research, questions to assess the impact of broader social or organizational pressures were not considered. For future work, understanding how modifying factors like camaraderie, safety climate, and organizational solidarity influence glove use will help to inform effective interventions.

A design limitation of this study is the potential for participation bias, whereby firefighters with interest in occupational exposure may have been more likely to participate. Survey responses therefore may not precisely reflect firefighters' actual personal experiences and/or adherence to best practices. While it is possible that participants may have felt pressured to answer more "favorably" (i.e., indicating that they adhere to best practices more frequently than they do in reality), survey data and open-ended comments provided by participants did not suggest this was a concern. For example, in addition to the 18 firefighters who reported most often using no gloves during demobilization, 3 firefighters categorized in "other" glove use commented that they occasionally used no gloves.

Small sample sizes in our stratified analyses may also not fully capture firefighters' experiences. Considering participants were not required to answer every survey question, nonresponse in particularly small subsets (e.g., no glove users) limits generalizability. Targeted intervention work should attempt to over-represent these smaller sample groups in future research.

Given the cross-sectional design of this study, only firefighters' current behaviors related to glove use and decontamination could be assessed. Therefore, we are unable to establish if—and how—current practices are representative of past practices. In turn, we are unable to

accurately account for how dermal carcinogen exposures have changed over time, or the specific reasons for this change.

In this study, the exploration of post-fire glove use was primarily limited to active-duty career firefighters who regularly engage in fire suppression. Future research should seek to gain an understanding of applicability beyond this cohort (e.g., volunteer wildland firefighters) and in industries with similarly hazardous work environments (e.g., foundries).

## 5. CONCLUSIONS

Dermal exposure to toxic polycyclic aromatic hydrocarbons (PAHs) present in air and on surfaces at fire scenes is associated with excess cancer incidence in firefighters. Given the weight of evidence that glove type, quality, and fit issues contribute to dermal absorption of PAHs, understanding firefighter glove use is imperative. In this study, we found a wide variety of post-fire glove use. Our results indicate that without specificity in current guidance related to glove use during demobilization, Washington firefighters rely largely on personal PPE perceptions and assessment of risk. This reliance on personal judgement could be detrimental for firefighters who are not fully aware or are desensitized to the potential dangers of PAH exposures, as appeared to be characteristic of no glove users. Our study findings are therefore valuable for the development of effective interventions, policies, and best practices to address firefighter carcinogen exposure risk.

At present, there nearly 7,500 career firefighters in Washington state [62, 102] that respond to more than 20,000 structural fire calls each year [103]. To better protect these firefighters, as well as the thousands of volunteer firefighters who may also engage in structural fire suppression, improved guidance on post-fire glove use is needed. Future improvements should seek to elucidate exactly when, and with what type of glove, firefighters perform demobilization. These recommendations should be based on findings from current research to determine the chemical protection efficacy and useability of various gloves to ensure protection, performance, and comfort for all glove users.

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## **Appendix A - Semi-Structured Interview Questions**

### Firefighter Tasks

What tasks do you commonly perform that require use of gloves?

*Prompt: Please consider tasks that occur during fire suppression.*

*Please consider tasks that occur after a fire is suppressed.*

For the remainder of this call, we will focus on tasks that occur after a fire is suppressed.

What motor skills are required to perform each of these tasks?

*Prompt: Are there tasks that require fine motor skills (example pressing buttons on a radio)?*

*Are there tasks that require sustained grip?*

*Are there tasks that require significant twisting or torque?*

What hazards are you exposed to while performing these tasks?

*Prompt: Consider hazards such as residual heat (or even fire), puncture, abrasion, crushing, muscle fatigue.*

### Current Glove Use

What size gloves do you wear?

How did you determine your glove size?

What gloves do you use for structural firefighting?

What gloves do you use for other tasks (listed above)?

How old are the gloves you currently wear?

How were gloves administered to you/are administered to new recruits?

How often do you replace your gloves?

### Glove Characteristics

Please describe the physical features of your gloves.

Please describe any chemical features.

Please describe any ergonomic features.

### Glove Care

How often do you clean your gloves?

Please describe any cleaning process.

### Desired Features of Gloves

What do you like most about your current gloves?

What do you like least?

What characteristics/features do you wish your gloves had?

### Misc.

What concerns (if any) do you have about your current gloves?

Do you want different types of gloves for different tasks, or one pair that performs well across most tasks?

### Description of Participants

What is your rank?

How long have you worked as a firefighter?

What hours do you typically work?

# Firefighter PPE Survey Questions

Welcome to the Firefighter PPE Survey. Please answer the questions below. Thank you!

In this survey, we ask about PPE use during demobilization. We define demobilization as the phase of fireground operations that includes rolling hose and loading equipment onto a fire engine post-fire suppression.

## Phases of Fireground Operations



1) What gloves do you use during demobilization?



Structural Firefighting Gloves



Leather Gloves



Extrication Gloves



Work Gloves - Mechanic



Work Gloves - Gardening



Medical Gloves



Combination



No Gloves

---

Please select the gloves you have used MOST OFTEN in the past 12 months.

- Structural Firefighting Gloves
- Leather Gloves
- Extrication Gloves
- Work Gloves - Mechanic Style
- Work Gloves - Gardening Style
- Medical Gloves
- Combination of Gloves
- No Gloves
- Other

---

Are the structural gloves that you use during demobilization the same pair you use for fire suppression? Please select the option that BEST DESCRIBES your glove use.

- Yes, I don and doff ONE PAIR of structural gloves at a fire scene.
- No, I don and doff TWO PAIRS of structural gloves at a fire scene.

---

Please describe the gloves you wear.

\_\_\_\_\_

---

2) Why do you wear [glove\_type\_survey] most often during demobilization? Please select ALL that apply.

- These gloves are comfortable
- These gloves fit well
- These gloves are well-suited for the task
- These gloves provide physical protection
- These gloves provide chemical protection
- These gloves provide full range of motion
- These gloves are accessible on scene
- These gloves were provided to me by my department
- Other

---

Please explain why you wear [glove\_type\_survey].

\_\_\_\_\_

---

3) Are you satisfied with the gloves provided by your fire department? Please select the option that best describes your glove satisfaction with your primary employer in the past 12 months.

- Yes, I am SATISFIED with the gloves provided by my employer.
- No, I am NOT SATISFIED with the gloves provided by my employer.
- My primary employer does not provide gloves.

---

In the past 12 months, have you purchased gloves for demobilization?

- Yes
- No

**4) In the past 12 months, how often did you perform the following activities after structural fire suppression?**

	Never	Rarely	Sometimes	Often	Always
On-scene gross decontamination of gloves	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Spot cleaning of gloves	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thorough cleaning of gloves - by hand	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thorough cleaning of gloves - by machine (includes vendor cleaning)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wipe wash of hands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Soap and water wash of hands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
No cleaning activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**5) Please select how much you agree or disagree with the following statements.**

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Glove use and decontamination interferes with my ability to complete demobilization tasks.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is uncomfortable to use and decontaminate my gloves post fire.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I don't have enough time to use and decontaminate my gloves post fire.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I don't have the materials I need to use and decontaminate my gloves.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**6) Please select how much you agree or disagree with the following statements.**

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Post-fire glove best practices keep me safe.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Post-fire glove best practices protect my health.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel it is important to adopt post-fire glove best practices.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I want to learn more about post-fire glove best practices.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I search for new information about post-fire glove best practices.

**7) Please select how much you agree or disagree with the following statements.**

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I am worried about skin contamination during demobilization.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am worried about strains and sprains during demobilization.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am worried about cuts and abrasions during demobilization.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am worried about eye injuries during demobilization.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dermal exposure to chemicals during demobilization contributes to cancer risk.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Poor hand mobility during demobilization contributes to strains and sprains.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**8) Please select how much you agree or disagree with the following statements.**

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
My department has adequate policies on post-fire glove use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have received effective training on post-fire chemical exposure.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9) Are you familiar with post-fire best practices recommended by the Washington State Council of Fire Fighters (e.g., Healthy In, Healthy Out Manual)?  Yes  No

How frequently do you follow WSCFF best practice recommendations? Please select the option that best describes your behavior in the past 12 months.  All (100%) of my fire-related calls  Most (≥50%) of my fire-related calls  Some (≤50%) of my fire-related calls  None (0%) of my fire-related calls

10) What is your gender identity?  Man  Woman  Transgender  Non-binary/non-conforming  Other  Prefer not to answer

- 
- 11) How many years have you served in the fire service?
- < 1 year
  - 1-5 years
  - 6-10 years
  - 11-15 years
  - 16-20 years
  - 20+ years

- 
- 12) Over the past 12 months, how many fire-related calls did you participate in (on average)?
- 0-2 calls/month
  - 3-5 calls/month
  - 6-8 calls/month
  - 9+ calls/month

- 
- 13) What is the primary fire department you have been affiliated with in the past 12 months?
- \_\_\_\_\_

- 
- 14) What is your rank?
- \_\_\_\_\_

---

Is there anything you would like to tell us about your post-fire glove use? Options include (but are not limited to): brands you recommend, glove features you desire, any concerns you have.

\_\_\_\_\_

## Appendix C - Recruitment Flyer Firefighters – UW researchers want to hear from you!

During fire suppression, standard use of firefighter personal protective equipment (PPE) provides important exposure control. Post-fire suppression, variation in individual PPE use and its impact on firefighter exposures remains poorly understood.

UW aims to address this research gap by examining PPE use behaviors during demobilization – the phase of fireground operations that includes rolling hose and loading equipment back onto a fire engine.

### Phases of Fireground Operations



Fire Suppression → Gross Decontamination "Gross Decon" → Demobilization

With support from the WA Department of Labor & Industries, Safety & Health Investment Projects, we are working with local fire departments and the Washington State Council of Fire Fighters to better understand post-fire PPE use on a broad scale.

We want to learn about your PPE use during demobilization. **Your participation in an anonymous and confidential survey will help address post-fire exposures.** Your responses are key in identifying effective strategies to protect firefighter health.



### What PPE do you use during demobilization?

Participate in a short survey to help develop effective strategies to reduce firefighter exposures post-fire suppression!



If you are interested in participating in the University of Washington's PPE Survey, please follow the steps below:

1. Complete a brief [eligibility questionnaire](#) (~2 minutes). You can also copy and paste this link: [https://redcap.link/ppe\\_survey](https://redcap.link/ppe_survey) or scan the QR code provided.
2. Read and sign a research consent form (~5 minutes).
3. Respond to an email invitation to complete the PPE survey (~15 minutes).



# Appendix D - Eligibility Questions

## PPE Survey Eligibility Questions

Welcome to the University of Washington's Firefighter PPE Survey!

Researchers at the University of Washington's Department of Environmental and Occupational Health Sciences are partnering with the Washington State Council of Fire Fighters and local fire departments to learn more about firefighter PPE use post-fire suppression. Funding and support for this project has been provided by the State of Washington, Department of Labor & Industries, Safety & Health Investment Projects.

If interested, please answer the questions below:

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What is your birth year? Please format as YYYY.

\_\_\_\_\_

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Are you 18 years of age or older?

- Yes  
 No

---

What is your current employment status as a firefighter?

- Active firefighter  
 Retired firefighter  
 Not currently employed

---

Do your current employment responsibilities include entering the IDLH environment?

- Yes  
 No

---

Please provide an email address.

\_\_\_\_\_

(ONLY research-related communications will be sent to this email (e.g., survey link and copy of consent). This address WILL NOT be shared.)

# Appendix E - Informed Consent Firefighter PPE Survey Consent Form

Please review and sign the form below.

Thank you!

---

## UW RESEARCH TEAM

Dr. Elena Austin, UW Professor, Environmental and Occupational Health, [elaustin@uw.edu](mailto:elaustin@uw.edu)  
Asheton Gilbertson, UW Research Assistant, Occupational Hygiene, [akmg2@uw.edu](mailto:akmg2@uw.edu)

## INTRODUCTION

Please read carefully. We are asking you to be in a research study. This form gives you information to help you decide whether to participate in the study. Participation is voluntary. You may ask any questions about the study at any time. After reviewing this information, you can accept or decline the invitation to participate.

## PURPOSE OF THE STUDY

Previous research demonstrates the efficacy of firefighter personal protective equipment (PPE). However, little is known about the specific impact of firefighter choice and use of PPE during demobilization. This study aims to better understand individual PPE use post-fire suppression. The answers you provide will be used to inform effective strategies to reduce firefighter exposures.

## STUDY PROCEDURES

As part of this study, we will be examining post-fire PPE use behaviors. You will be asked to complete a survey that includes questions related to your occupation, PPE behaviors, and fire service culture.

## RISKS, STRESS, OR DISCOMFORT

There are minimal expected risks associated with participation in this study.

## BENEFITS OF THE STUDY

While there are no immediate direct benefits of participation in this study, we anticipate that findings from this research will be used to develop recommendations for PPE best practices. In turn, we aim to promote long-term firefighter health.

## SOURCE OF FUNDING

The research team, and the University of Washington are receiving funding from the Washington State Department of Labor and Industries (LNI) for the time spent collecting and analyzing data.

## CONFIDENTIALITY OF RESEARCH INFORMATION

All collected data will be stored on a secure server with confidential identifiers, but there is always the risk of a data breach and loss of privacy.

## USING YOUR DATA IN FUTURE RESEARCH

The information that we obtain from you for this study might be used for future studies. We will remove anything that might identify you from the information. If we do so, the information may then be used for future research studies or given to another investigator without getting additional permission from you. It is also possible that in the future we may want to use or share study information that might identify you. If we do, a review board will decide whether or not we need to get additional permission from you.

## OTHER INFORMATION

You may refuse to participate, and you are free to withdraw from this study at any time without penalty or loss of benefits to which you are otherwise entitled. If you wish to withdraw, please contact the researcher listed at the beginning of this consent form.

A copy of the consent form will be emailed to you at an email address that you provide. It will be a "PDF" document. Most computers already have PDF viewer software installed, which will allow you to open, read, or print the consent form. The email we send you will include a link to PDF viewer software (such as Adobe Acrobat Reader) in case your computer doesn't already have it. If you would prefer to receive a paper copy of the consent form at no cost to you, please contact the researcher listed at the beginning of this consent form.

## RESEARCH-RELATED INJURY

If you think you have been harmed from participating in this research, contact Dr. Austin at [elaustin@uw.edu](mailto:elaustin@uw.edu).

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1) Subject's Statement  
This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, or if I have been harmed by participating in this study, I can contact one of the researchers listed at the beginning of this consent form. If I have questions about my rights as a research subject, I can call the Human Subjects Division at (206) 543-0098 or call collect at (206) 221-5940. I will receive a copy of this consent form.

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2) First Name:

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3) Middle Initial:

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(Leave blank if not applicable)

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4) Last Name:

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## Appendix F - Other Glove Users

Participant #	Free Response Answers to "Please specify glove use."
1	Sometimes medical, sometimes no gloves
2	Medical, extrication, combination, or no gloves
3	Medical with work gloves (i.e., double gloving)
4	Leather or gardening gloves
5	Work gloves or medical gloves
6	Medical with leather gloves (i.e., double gloving)
7	Structural or leather gloves
8	Medical with leather gloves (i.e., double gloving)
9	Medical with gardening gloves (i.e., double gloving)
10	Extrication or structural gloves
11	Extrication or work gloves
12	Structural or work gloves
13	Leather or medical gloves
14	Medical or no gloves
15	Many types