

Fighting fire and fumes: risk awareness and protective practices among Western Australian firefighters

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ABSTRACT

Background. In Western Australia, the issue of bushfires (wildfires) poses a persistent health risk to both volunteer and career forestry firefighters, populations that have been historically understudied. **Aims.** This descriptive qualitative study aimed to examine firefighters' level of understanding concerning hazardous exposures, their Personal Protective Equipment (PPE) protocols and their decontamination practices. **Methods.** Guided by the socioecological model, 23 semi-structured interviews were conducted with firefighters representing both volunteer and forestry sectors. **Key results.** Results indicate a gap in knowledge regarding the health risks associated with bushfire-generated smoke and contaminants among volunteer firefighters. Forestry firefighters, conversely, showed a greater awareness of these risks. Social dynamics, such as peer pressure, were identified as historical deterrents to PPE use, although recent trends indicate positive change. Forestry firefighters also highlighted systemic shortcomings, including inadequate provision of respiratory protection and lack of decontamination facilities for cleaning themselves and their PPE. **Conclusion.** This study underscores the critical need for educational initiatives to address these gaps in understanding, along with organisational reforms to promote a culture encouraging PPE use and to provide essential resources for effective decontamination. **Implications.** This research emphasises that a multi-level approach is essential for safeguarding the health of firefighters in bushfire-prone environments.

Keywords: Australia, bushfire, decontamination, forestry firefighter, personal protective equipment (PPE), smoke exposure, social dynamics, socioecological model, volunteer firefighter, Western Australia, wildfire.

Introduction

Bushfires, or wildfires, are frequent, natural occurrences across Australia that often threaten human life, property, flora and fauna. Smoke from burning vegetation contains many harmful components. Small particles emitted from bushfires with a diameter of less than 2.5 μm ($\text{PM}_{2.5}$) are particularly abundant and can enter the lower respiratory system, exacerbating existing cardiopulmonary conditions (Alves *et al.* 2010; Navarro *et al.* 2023). These small particles may also transport polycyclic aromatic hydrocarbons (PAH), known carcinogens, into the body (Baird *et al.* 2005). Bushfires also emit noxious gases linked to adverse health outcomes in those exposed (Goldstein 2008; Li *et al.* 2015; Zhang 2018; The National Institute for Occupational Safety and Health 2019). Knowing these hazards exist in the workplace is an important aspect of worker safety (Safe Work Australia 2023), particularly as firefighting was classified as a group 1A carcinogenic occupation by the International Agency for Research on Cancer (IARC) in 2021, as there is convincing evidence that this occupation is harmful to humans (Demers *et al.* 2022; DeBono *et al.* 2023; IARC 2023).

In Western Australia (WA), different firefighting brigades collectively respond to bushfire threats, given the state's vast and varying landscape. The Career Fire and Rescue Service (CFRS) consists of the state's full-time employed firefighters who primarily respond to structural fires and conduct emergency rescues. Owing to their specialised

appliances, the CFRS has limited effectiveness in bushfires. The CFRS is managed by the governmental Department of Fire and Emergency Service (DFES), which oversees all emergency incidents across the state (Department of Fire and Emergency Services 2021).

The largest service, with over 26,000 members, is the Volunteer Bushfire Service (hereafter referred to as volunteer firefighters), with over 500 brigades in WA, funded by their local government and also managed by Department of Fire and Emergency Services (2021). These brigades are provided with specialised appliances that excel in off-road and bushfire environments. The volunteer fire brigades across the state use standard operating procedures mandated by DFES but are largely responsible for the training and day-to-day management of their firefighters.

A separate government department, the Department of Biodiversity, Conservation and Attractions (DBCA) also operates its own career firefighting force called ‘conservation employees’. DBCA firefighters (hereafter referred to as forestry firefighters) respond to bushfires across State-owned land during the summer months and conduct prescribed burning campaigns and national park maintenance in the cooler months. DBCA have their own protocols applicable to forestry firefighters that are distinct from those prescribed by DFES across their fire services.

Fire management bodies in the Australasian region consider the best protection for firefighters against possible contaminants from bushfires is to wear personal protective equipment (PPE) (Australasian Fire and Emergency Services Authorities (AFAC) Council 2021). PPE for firefighters typically includes a fire-retardant tunic, pants, fire-safe boots, a helmet with visor and neck protection, gloves and respiratory protective equipment (RPE). RPE is an essential piece of PPE, proven as crucial to minimise harm from bushfire smoke and increase operational effectiveness during bushfires (Garg *et al.* 2023). Disposable RPE such as P2 (or equivalent N95) masks may offer some protection, but full-face P3 RPE equipped with combination cartridges for gases and particulates offers the best protection against these contaminants (Garg *et al.* 2023). As a result, many (but not all) Australian firefighting agencies have started implementing a standard for P3 RPE to be carried and worn when attending bushfire incidents (NSW Rural Fire Service 2022).

Where PPE is required, appropriate maintenance is critical to ensure it continues to provide effective protection to the wearer. Multiple studies suggest contaminants remain on PPE after structural fires (Banks *et al.* 2021; Krzemińska and Szewczyńska 2022; Szymytko *et al.* 2022). Preliminary results from an investigation conducted in WA suggest that bushfires and prescribed burn smoke may also contaminate PPE and may be a secondary exposure source for firefighters.

Currently, there is little research on how volunteer and forestry firefighters perceive their risk of exposure to

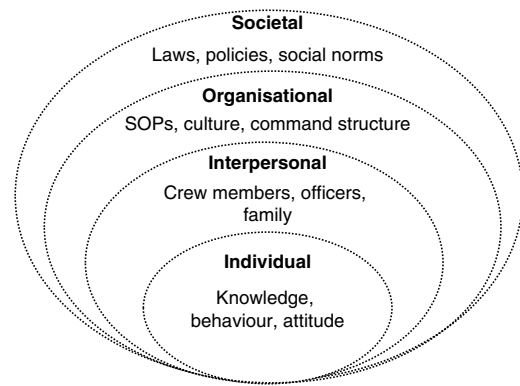


Fig. 1. Socioecological model (SEM). SOP, standard operating procedure.

harmful contaminants during bushfires. Increasing firefighters’ understanding of risk and how to protect themselves and their equipment during and after a fire could lead to improved health outcomes. This study therefore aimed to understand the behaviours and attitudes of forestry and volunteer bushfire firefighters regarding possible harmful exposures at bushfires, PPE wearing, cleaning of PPE and personal decontamination.

This study was underpinned by the socio-ecological model (SEM) (Bronfenbrenner 1994), which posits that behaviour does not happen in a vacuum and that individual behaviour is influenced by the environment where people live, work and play (McLeroy *et al.* 1988). The model (Fig. 1) considers individual behaviour as dynamic, influenced by individual characteristics, interpersonal processes, organisational interactions, community factors and public policy (Salihu *et al.* 2015), recognising interactions across these levels and highlighting the multiple influences affecting behaviour. In the context of firefighting, behaviour may be influenced by an individual’s past experience, senior colleagues in positions of authority or organisational policy.

Methods

Study design

A descriptive, qualitative study design was adopted to gather data about the perceptions of firefighters. It allowed exploration of the phenomena in its natural setting and built an understanding of the context of wildland firefighting in which perceptions and subsequent behaviours of firefighters occur (Kolb 2014). Ethical approval was granted by the Human Research Ethics Committee at Edith Cowan University (2022-03698-PADAMSEY).

Participants and recruitment

Participants included volunteer and forestry firefighters with bushfire experience. Volunteer firefighters were

members of a volunteer bushfire brigade located in metropolitan WA. Forestry firefighters were stationed at a work centre in metropolitan WA.

Participants were initially identified through fieldwork conducted during the quantitative data collection arm of a broader PhD project that quantified potential bushfire exposures of firefighters. Firefighters were approached to gauge their interest and obtain contact details. Volunteer firefighters were contacted individually and asked to participate in the interviews. Managers at DBCA were asked to gauge the interest of forestry firefighters, a list of interested participants was collated and interviews were organised.

Data collection

In-depth, semi-structured, face-to-face interviews were conducted in a private room at the brigade for volunteer firefighters and at the work depot for forestry firefighters. Written informed consent was obtained prior to each interview. An interview guide consisting of 10 open-ended questions was tested in an initial pilot study and used to guide the interviews. Questions related to the participant's experience of firefighting, their understanding of bushfire smoke, their PPE-wearing behaviours and their routines surrounding personal hygiene, and facilitated participants recounting their own stories (Boyce and Neale 2006). Participants were not informed about the recent carcinogenic classification of wildland firefighting by the IARC to minimise bias. Interviews lasted 20–60 min, were audio-recorded for ease of transcription and future analysis, and to allow the interviewer to focus on the conversation (Kelly 2010). Interviews continued until data saturation was reached, that is, there was no new information emerging (Busetto *et al.* 2020).

Data analysis

Interview recordings were transcribed manually with participant pseudonyms assigned to protect anonymity. Data were uploaded to NVivo 12 (Lumivvero 2020) for analysis using Braun and Clarke's (2006) six-step guideline for qualitative analysis. Firstly, the interviewer became familiar with the data, and then reviewed transcripts for accuracy. Then, thematic analysis identified codes and themes. Themes were defined according to the SEM with narrative passages developed for each theme, with supporting quotes combined with the narrative to convey findings (Braun and Clarke 2006).

Table 1. Socioecological model: factors influencing forestry and volunteer firefighters.

Individual	Interpersonal	Organisational
Knowledge of harmful bushfire exposures	Peer pressure on PPE wearing	Historical and contemporary provision of RPE
Knowledge of exposures influences subsequent behaviour	Cultural shift in PPE wearing behaviour	Personal and PPE decontamination procedures

PPE, personal protective equipment; RPE, respiratory protective equipment.

Rigour

The interview guide and method were pilot-tested to test the questions and improve interviewer skills (Majid *et al.* 2017). Transcriptions were double-checked with the recording to confirm accuracy and data were reviewed by a research supervisor to verify initial codes and themes (Creswell and Clark 2017). The primary investigator reflected on any existing bias using bracketing, as he is also a firefighter. This involved discussing potential biases with supervisors and taking time before each data collection session to consciously acknowledge and set aside any personal beliefs that could affect the research process to ensure self-awareness (Tufford and Newman 2012). This thorough approach of member checking and coding ensures that the small sample sizes typical of qualitative research do not detract from the study's validity (Flick 2013).

Findings

This study aimed to understand the behaviours and attitudes of forestry and volunteer bushfire firefighters regarding possible harmful exposures at bushfires, PPE wearing, cleaning of PPE and personal decontamination. The key themes that emerged from the data are organised according to the levels of individual, interpersonal and organisational influence under the SEM (Table 1). The interviews did not explore factors at the societal level.

Participant information

Nine volunteer firefighters and 14 forestry firefighters were interviewed, a total of $n = 23$ participants. In both groups, most firefighters were male, with ages ranging between 21 and 73 years and average service length of 8 years (volunteers) and 12 years (forestry firefighters) (Table 2).

Knowledge of the harms associated with bushfire exposures

In this section, participants' individual knowledge, attitudes and beliefs about bushfire smoke are presented. Participants from both services demonstrated a lack of knowledge about potential adverse health effects associated with bushfire smoke exposure while firefighting. Two subthemes unpack this concept: first, volunteer firefighters have less knowledge about the harms of bushfire smoke compared with

Table 2. Participant information.

Service	Interviews (n)	Female n (%)	Male n (%)	Age range (years)	Average service (years)
Volunteer	9	1 (11)	8 (89)	25–54	8
Forestry	14	3 (21)	11 (79)	21–73	12

forestry firefighters. Second, firefighter knowledge of potential exposures while fighting bushfires influences subsequent behaviour around exposure avoidance and PPE wearing.

Knowledge of volunteer firefighters

Data revealed that all volunteer firefighter participants had limited knowledge about the potential health risks associated with bushfire smoke. They perceived bushfire smoke as a natural product and, therefore, did not consider it harmful. For example, Jordan, a senior volunteer firefighter with over 10 years of experience explained how he was educated when he began his service:

When we started [with the brigade], we were told that bushfire smoke classified as Class A [contaminant], which consists of naturally occurring fuel, was believed to be less toxic than some processed plastics and fuels. We were told it was ‘good smoke’ and that it was okay to breathe it in.

A majority of these participants reported that their training did not include information about contaminants they might be exposed to while combatting bushfires. This is highlighted by the lack of awareness and uncertainty about compounds present in bushfire smoke noted by participants. For example, Michael, a volunteer firefighter of 9 years and a lieutenant, stated:

I don’t know. It’s unknown to me. I don’t even think about it because I simply have no knowledge. I can make guesses based on what’s in front of me, but I’m not a chemist and I have no idea what compounds are present in the bush.

These findings highlight the need to address knowledge gaps among volunteer firefighters as smoke emitted from burning vegetation is known to be harmful (Reisen *et al.* 2011). Furthermore, firefighters’ knowledge of possible personal health risks arising from exposure to bushfires is crucial as it may influence their decision-making, particularly around risk-taking behaviours (Kruger and Beilin 2014). Volunteer firefighters reported their awareness that career firefighters attend a 2-day course dedicated to the exposures they may experience at different types of fires, highlighting education inequities between different services. Previous research from Sadler *et al.* (2007) supports these findings, indicating a low understanding of risk among

volunteer firefighters compared with their paid full-time counterparts (i.e. career firefighters). Our findings suggest that little has changed in the last 16 years since Sadler *et al.* published their research, highlighting the need for urgent education programs to protect the health of volunteer firefighters.

Knowledge of forestry firefighters

Whereas volunteer firefighters lacked knowledge about the potential exposures they might experience, forestry firefighters consistently demonstrated greater overall knowledge about burning vegetation being harmful to health.

Jane, a forestry firefighter with only 1 year of service and a degree in conservation biology, drew on her tertiary studies to link her knowledge of contaminants found in bushfire smoke with their potential negative effects on her health:

Given the poisonous nature of certain chemicals found in our native bushes, it’s reasonable to assume that inhaling the smoke would have negative effects on us as well. While I’m uncertain about the exact extent of these effects, breathing in such chemicals can’t be good for us.

Jane highlights that education is key, as the knowledge she gained from her tertiary studies leads to a better understanding of the potential harms. This knowledge among forestry firefighters may also be attributed to their greater exposure to fires compared with their volunteer counterparts offering increased opportunities for on-the-job learning (Sommer and Njå 2011). Whereas volunteer firefighters typically attend 5–10 bushfires per season, forestry firefighters spend approximately 9 months of the year working on prescribed burning or fighting bushfires. This increased experience appeared to contribute to their understanding of the differing ecological regions of WA, the influence of weather on smoke conditions and the specific species of plants burning, all factors affecting the makeup of smoke (Dong *et al.* 2020; Hou and Orth 2020; Price *et al.* 2023).

Roy, a forestry firefighter, explained his understanding of different types of bushfire smoke built from 15 years of experience on the fireground and no formal training:

The way something burns and the type of smoke it produces significantly impact our breathing. When we are in swampy areas like Swan Coastal, for instance, it tends to burn hotter and produce a different type of smoke compared to the regions in the east or north. It’s not just the

excess moisture in the ground; it also depends on the type of plants burning.

Although Roy's observations do align with the current knowledge of the factors that affect the toxicity of bushfire smoke, potentially, these assumptions could be incorrect. Providing training on the potential adverse health effects of bushfire smoke and how to mitigate these risks should be prioritised, as this is a topic not routinely addressed in the training currently offered to volunteers or forestry firefighters.

Individual knowledge influences behaviour

The level of knowledge among individual firefighters regarding the health risks associated with bushfire-associated smoke appeared to influence their risk and/or protective behaviours when fighting fires. Participants with more experience and knowledge of the health risks of bushfire smoke frequently reported how they became more cautious when fighting fires, striving to avoid bushfire smoke whenever possible. With more experience in the field, participants noted using increased patience, taking time to assess fire conditions before advancing to the fire line. Additionally, participants commonly reported their increasing knowledge about bushfire smoke prompted them to change their protective behaviours, with those having access to RPE using it more frequently, and some refusing to enter smoky conditions without it.

Cheryl, a senior firefighter with 9 years' experience spoke about how she changed her RPE behaviour over her career in response to feeling unwell following a shift:

I have gotten to the point where I am putting on [RPE] in the truck before I was getting out of the truck... I didn't want to have to feel sick afterwards [after her shift]. So, I would start [wearing RPE] right at the beginning, whereas at the beginning of my firefighting career, I would wait until I started feeling sick before I started putting any measures in place.

Conversely, it is important to note a small minority of participants expressed growing indifference towards potential exposures as they gained more firefighting experience. These participants viewed smoke exposure as an afterthought compared with the primary task of extinguishing fires. Michael, a volunteer firefighter with over 8 years' experience, said:

I would say it [care about potential exposures] has gone the other way. Like I just don't really care anymore. It is there, I'm not intentionally trying to get exposed or anything, it is just a part of it [firefighting]. If I focus on the exposures, I'm not paying attention to what might kill me right there and then.

Overall, our findings align with previous qualitative research on firefighters (Martinez-Fiestas *et al.* 2020) that

reported that increased experience and knowledge of potential risk factors can lead to varying behavioural responses depending on the individual. We found that the vast majority of firefighters evolved more protective behaviour and a small minority signalled riskier behaviour.

Factors influencing PPE-wearing behaviour

The interpersonal layer of the SEM highlights the impact of factors such as teamwork dynamics, peer support and social networks that play a crucial role in influencing behaviour. In this section, the influence of these interpersonal factors on firefighters' decisions to wear PPE is explored.

A prominent theme to emerge from both groups of participants was the influence exerted by their more experienced colleagues on their decision to wear PPE, specifically their RPE. This theme explores two distinct areas: first, the existence of a workplace culture that may negatively influence participants' use of RPE; secondly, a perceived positive shift in RPE-wearing culture through the role modelling of protective behaviours.

The influence of culture on RPE use

Many participants from the volunteer bushfire service shared stories of being influenced by older brigade members to forgo wearing RPE, underpinned by the notion they needed to learn how to cope with and work in a smoky environment. For example, Aaron, a volunteer bushfire firefighter with 3 years' experience, recalled one of his first firefighting experiences when a senior firefighter advised him not to wear a mask:

I remember going out with one firefighter when I first started, [...] it was just one of the pile burns we were at, and he [a senior firefighter] told us not to put on our masks because we needed to learn how to breathe inside the smoke. I followed his advice because, at the time, I didn't know any better.

Similarly, Jordan, a senior volunteer firefighter with over 10 years of experience, shared his experiences of being a novice firefighter. He recounts how he was actively discouraged from wearing RPE.

Wearing a mask was considered weak and discouraged. At that time, I was involved in semi-professional sports, so I didn't want to lose my cardio, which is why I religiously wore a mask. I faced ridicule for wearing it. Our training didn't include proper instruction on mask usage or when to use it. I even broke my first mask because I didn't know how to use it.

A few participants reported that they were not issued with RPE and had to purchase their own masks privately. Dane, a volunteer firefighter with 8 years' experience,

recalled his early days in the brigade when he had to endure smoke without proper protection:

I was given a tunic, helmet, and managed to find some gloves and pants. But there was no mask of any kind. I remember going to one of my first jobs, tears streaming down my face, unable to do anything... I actually bought my first mask because I couldn't handle it [the smoke].

A few volunteer firefighter participants discussed the previous existence of a culture within their brigade that influenced them against wearing RPE – at a cost to their health. For example, Jordan described how:

...some people have left the brigade due to health issues. Even a slight whiff of smoke triggers severe coughing fits in them, as if they had severe asthma, which they don't. Some individuals have inhaled embers and suffered throat damage, struggling to breathe comfortably for a long time before eventually leaving firefighting. If they had worn their PPE and not listened to the toxic culture, this wouldn't have happened...

Previous research has explored the potentially toxic aspects of the hegemonic masculine nature of bushfire firefighting (Mannick 2021), a pervasive problem found in fire brigades globally. A recent report, prompted after a young firefighter took his own life, highlighted the masculinity-fuelled bullying occurring in the firefighting profession (Afzal 2022).

Firefighters being discouraged from wearing PPE, specifically RPE, was also reported by Maglio *et al.* (2016), whose participants chose not to wear PPE to avoid ridicule and harassment from more experienced peers. However, our findings also found that individual will, fuelled by knowledge of contaminants in bushfire smoke, resulted in some participants (e.g. Jordan) overcoming these hurdles and choosing to wear RPE to protect their health.

A cultural shift in RPE use

The workplace culture where breathing protection was not routinely worn and coworkers were discouraged from wearing it, as described in the previous section, appears to be changing for the better. Now, most volunteer firefighter participants state that in recent years, their brigades have prioritised protection more. These same participants, now more experienced with bushfire smoke, PPE use, and firefighting tactics and strategies, recounted stories of how they now influence other firefighters to prioritise protection when attending bushfires, signalling a cultural shift.

Michael, a senior volunteer firefighter of 9 years, spoke about the positive cultural changes emerging:

Well, I think it's [the culture towards RPE] slowly changing now, which is a good thing. But when I first joined,

there was a prevalent attitude that wearing a mask made you weak or effeminate, with remarks like, 'Why are you wearing that, you homo?' That attitude is changing more and more as we bring in individuals with better education, different backgrounds, and understanding of the importance of safety.

Aaron, a novice volunteer firefighter who was advised he should 'learn how to breathe inside the smoke', ensures new firefighters follow the guidelines to wear their RPE:

... if I'm with any new people, I always tell them to put their masks on right away, no questions asked. Don't breathe in the smoke.

Dane spoke about new volunteer firefighters being equipped differently from when he started:

Now, over 5 years later, as soon as you walk in, you're given a full-face [P3] mask.

Jordan, the volunteer who broke his mask through lack of training and 'religiously wore his mask' in the face of ridicule to protect himself from smoke, spoke of the training new recruits must undertake:

But now, the formal training dedicates an entire section to managing full-face masks, including donning and doffing, cleaning and teaching new firefighters how to position themselves to avoid smoke exposure.

Although the forestry firefighters have struggled with gaining access to RPE (which is discussed in the next section), the PPE culture appears to also be shifting for the better. Peter, a forestry firefighter with 20 years' experience, has seen the cultural change around wearing PPE. He stated that he believed most firefighters now adhere to PPE requirements, partially owing to a younger work force whom he thought were more likely to prioritise safety:

Most people wear it. I'd say 99% of people adhere to the PPE requirements now. This is partly due to an increase in younger firefighters and a higher turnover rate. The older guys are set in their ways and are the most resistant to change.

Over the past decade, there has been a worldwide effort to improve the safety cultures of firefighting agencies (Pupulidy 2020). Overall, these findings demonstrate the complex dynamics of interpersonal influences on firefighters' decisions to wear PPE and RPE. The shift toward prioritising personal protection and positive role modelling among experienced firefighters is effecting a gradual cultural change in the bushfire firefighting profession. Participants' concerns for their health and their active

efforts to protect themselves and influence others to do the same highlight the importance of ongoing education and support within the firefighting community.

The provision of RPE

Forestry firefighters are given basic PPE, but unlike their volunteer counterparts who are managed by DFES, they are not currently provided with P3 full-face RPE. All forestry firefighters interviewed communicated their concerns about not being equipped with P3 RPE, speaking of their collective efforts to bring about change. Many long-serving participants spoke about their arduous fight to get any RPE. Todd, now a retired 48-year veteran forestry firefighter, spoke about his decades-long efforts to get even the simplest respiratory protection.

We only got some [RPE] at the end of my service [2019]. It's only the paper masks [P2] I had in the last few years I was here, and I found that was beneficial... we've been advocating [...] for years, wanting a mask of some kind.

The disposable (P2, N95 or equivalent) masks are provided to forestry firefighters, but no participants considered them effective. Many explained these disposable masks were uncomfortable, did not fit properly, melted or became caught in vegetation in the bush. Peter, a forestry firefighter with 20 years' experience, sums up the consensus, sharing how he feels firefighters are viewed:

...having a paper mask doesn't really do much. It takes out the particulates, but not the gases, the toxic gases. And everyone knows that, but they [the department] just seem to go, oh, no, you're just expendable. That's what it feels like sometimes.

Research suggests that a correctly fitting P2 mask is effective at filtering particulate matter but less effective than fitted P3 variants at filtering gaseous emissions from bushfires (Garg *et al.* 2023). Participants also shared that they are not required to undertake respiratory fit testing (a process to test the fit of the mask to an individual's face) for these tight-fitting masks, (Regli *et al.* 2021) and, consequently, there is no evidence that the masks currently used by the firefighters are providing adequate respiratory protection.

Numerous forestry firefighter participants expressed frustration at not having full-face P3 masks, not only from a hazard to health perspective, but also the inability to breathe and see inside the smoke hampering their ability to work, causing additional frustration. Half-face masks (those only covering the nose and mouth) require firefighters to wear additional eye protection, often safety glasses or tight-fitting goggles. Many participants believed that additional pieces of PPE were cumbersome and viewed the full-

face version to be more practical and effective. Harrison, a forestry firefighter with 2 years' experience, expressed his thoughts about not being provided with face masks:

We are right in the fire. I just don't understand why we can't have masks. It's a safety issue. When you're on the back of a truck, the smoke obstructs your vision entirely. It feels like someone has to die before any action will be taken around here.

Forestry firefighters not wearing or having access to effective RPE is a common phenomenon seen worldwide (Navarro 2020). In our study, the reported absence of P3 full-face RPE contributed to forestry firefighter participants feeling vulnerable and perceiving that their safety was not prioritised by the department.

Decontamination procedures

In recent years, increased attention worldwide has been paid to post-incident decontamination of firefighters and firefighting equipment of fire services (Stricker 2023). This section explores the organisational-level issues around the lack of decontamination services provided to forestry firefighters. Two main decontamination issues are presented: PPE washing facilities and personal decontamination facilities.

PPE washing

All volunteer firefighters interviewed said that today they were provided with machine washing facilities in the station to decontaminate their PPE and that their brigade had an informal policy to wash their PPE after each use, which all interviewed volunteers said they followed strictly. Many participants shared that this culture of PPE washing was enforced by senior members reprimanding those wearing dirty PPE during training.

In sharp contrast, every forestry firefighter interviewed revealed no set procedures existed and there were no facilities provided to decontaminate PPE after fire events. All forestry firefighters conveyed a basic understanding of the risks of not cleaning their PPE. As a result of not having washing facilities at the workplace, some forestry firefighter participants said this meant their PPE was not cleaned often. Cameron, a forestry firefighter with over 15 years' experience, reported he would not wash his PPE for months:

I didn't [wash my PPE]. I'll just stuff it in my bag. And when I think it smells bad enough, I just put it in the wash. Simple as that.

Several forestry firefighters mirrored this response, emphasising that at some points, their jacket could 'stand up on its own', suggesting it was rigid from dirt and contaminant. Although a shift toward better cleaning practices

has occurred in recent years, participants stated that when they did wash their PPE, it was always, without exception, done in their home washing machines. Sarah, a forestry firefighter of 8 years, expressed her concerns about washing PPE at home:

I personally don't like to wear it much at all [i.e. multiple times]. I would prefer to wash it after it's been worn [once] because I know that the toxic carcinogens would sit on your clothes. Probably not great to be against your skin... and this is something I also don't agree with that we are forced to wash our own clothing in our home machines.

This was a common sentiment expressed by all forestry firefighter participants. Those with children expressed their unease about washing their dirty PPE at home, believing it could potentially harm their family. Jake described the complex home laundry routine he practised in an attempt to protect his family from perceived contaminants:

[I wash my gear] in my everyday washing machine at home, I try to get my missus to wash all her stuff and all my other clothing non-related to work first. And then I'll wash mine [PPE] afterwards at the end, then I'll do two drum cleans and hope that it gets rid of the particulates, I am worried about the particles that will come off the clothing and impact the kids one day.

Our findings reinforce results from other studies in which US wildland firefighters reported not isolating contaminated PPE, washing it at home and transporting it in personal vehicles – all significant deviations from US wildland firefighting standards (McQuerry and Easter 2022). There is a need to better protect forestry firefighters and their families from unnecessary and avoidable secondary exposures.

Showering facilities

Firefighters' skin may be exposed to contaminants during bushfire firefighting activities, making personal decontamination an important process to protect their health and well-being (Fent *et al.* 2017). At most WA volunteer firefighter stations, there are limited showering facilities for firefighters. Volunteer firefighter participants shared that their station had two showers for the crews to decontaminate after their shift; however, there were no strict procedures or policies to enforce showering after a shift.

However, all forestry firefighters reported no specific decontamination workplace showering facilities were available but the collective desire for these to be provided was apparent. Forestry firefighters collectively expressed their frustration in having to drive, dirty from a shift, to shower at home, believing it was their employer's duty to provide appropriate facilities. Harrison, a forestry firefighter, explained why this is necessary:

...having showers, just so you can go finish your shift, have a shower, get home, and you just leave everything at work. Because when you get home, you got ticks on you, you're covered in black stuff. Your house stinks of smoke, your car stinks of smoke.

Some forestry firefighting work centres do have shower facilities, but these are not specifically designed for personal decontamination after fire events. Charlie, a forestry firefighter for 21 years, said:

We've got one shower here for 20 blokes! So it's not really designed for us to be showering here, so we don't shower until we get home. So, you're still taking it [contaminants] home with you. It is like designed for you not to get clean before you go home.

Research on the barriers preventing these procedures from being adopted by worldwide forestry firefighting forces is still under study. However, our research supports the findings of other studies (Stricker 2023), suggesting the need for clear policies, procedures and facilities for personal and equipment decontamination.

Strengths and limitations

This study has given a voice to previously unheard forestry and volunteer firefighters in WA regarding their knowledge of bushfire exposures and issues surrounding PPE, providing rich descriptions of these potentially harmful issues.

By employing bracketing techniques, this study minimises researcher bias, enhancing the validity and reliability of the findings and offering a more authentic perspective on the subject matter. Although we met saturation in our study site, the small sample size nevertheless means that caution should be used in applying our findings beyond our study area. A limitation of our study is the lack of participants from regional or remote areas of WA; therefore, the data presented here may not represent the views of all volunteer or forestry firefighters in WA or wider Australia.

Implications and recommendations

Policymakers and brigade management, alongside volunteer and forestry firefighters themselves, must act to safeguard their health and that of firefighters' families considering the multiple levels of influence of the complex nature of fighting bushfires. Based on our findings, we make the following recommendations aligning with each level of influence:

Organisational level

- Provide decontamination facilities for forestry firefighters in the form of showers and laundering facilities.

- Develop and implement training programs for all firefighters engaged in wildland firefighting activities. These programs should comprehensively educate firefighters about the diverse health risks associated with bushfire firefighting.
- Ensure the provision of appropriate RPE to forestry firefighters, supported by comprehensive policy.

Interpersonal level

- Cultivate a culture within firefighting brigades that actively encourages and supports firefighters in adhering to new RPE/PPE policies.
- Encourage peer support and promoting safety compliance among fellow firefighters to achieve this objective.

Individual level

- Empower individual firefighters by promoting positive attitudes towards the consistent use of PPE and RPE.
- Encourage a proactive mindset regarding personal safety and the safety of firefighter families in dealing with potential contaminants resulting from bushfire operations.

Conclusion

This study amplifies the unique and crucial perspectives of volunteer bushfire and forestry firefighters in Western Australia. It highlights that volunteer firefighters lack an understanding of the health risks they face when working in a bushfire environment. However, we found a positive shift in the PPE culture of volunteers toward greater personal protection. A concerning lack of RPE provision for forestry firefighters emerged, indicating that it is likely that many firefighters in WA are attending bushfires with no breathing protection. Furthermore, these forestry firefighters have no facilities to decontaminate themselves or their PPE after a shift on the fireground and must carry out these procedures in the family home. Several recommendations are proposed to support the health and safety of these vital members of the community, which will in turn ensure a healthy workforce to combat the increasing threat of future bushfires across the Australian continent.

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