

Associations Between Firefighters Health Risks and Their Exposures to Fire Toxins

Short summary of the UK Firefighter Contamination Survey

Firefighters are directly exposed to potentially large quantities of toxins on a regular basis when attending fires. Research has found that these toxins are unknowingly transported back to stations/homes, further increasing firefighters' exposure. This puts firefighters at an increased risk of developing adverse health outcomes and emphasises the importance of managing those risks by implementing controls which protect against exposures.

The University of Central Lancashire was commissioned by the Fire Brigades Union to conduct the UK Firefighter Contamination Survey, in order to provide an evidence base for understanding the risks and common sources of contaminant exposure, informing decontamination and future research recommendations.

The survey probed UK firefighters' experiences and behaviours on a range of topics including exposure to fire toxins (duration, frequency etc.), contamination and decontamination practices, PPE (provision, maintenance, cleaning, storage, fit etc.), health (cancer, mental health), attitude/culture, awareness and training.

All serving UK firefighters were eligible to take part in the survey, which comprised 64 questions. A total of 10,649 responses were included for analysis, accounting for roughly 24% of the UK's firefighting workforce.

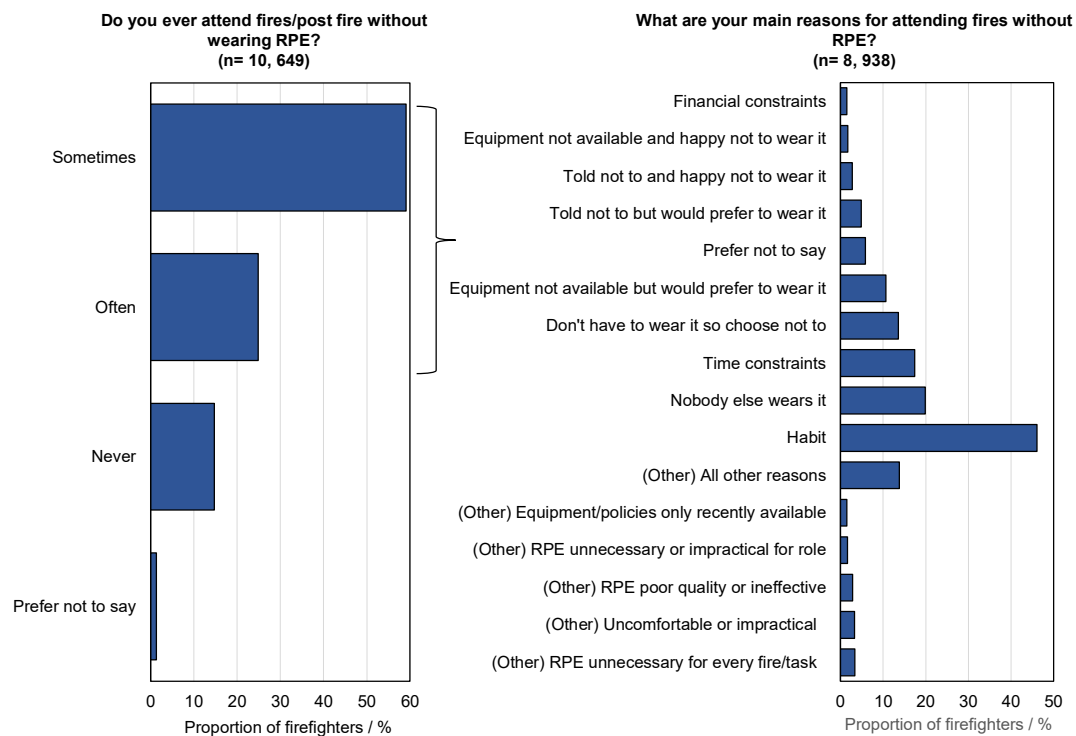
A variety of statistical measures are presented in the manuscripts, including "odds ratios" (OR). Odds ratios are a measure of association between an exposure (e.g. contaminants) and an outcome (e.g. cancer, mental health disorders etc.). Using cancer as an example, an OR of 1.0 means there is no difference between people who were and were not exposed to contaminants in terms of cancer diagnosis. An OR greater than 1.0 means that people exposed to contaminants were more likely to have cancer than those who were not exposed. An OR less than 1.0 means people exposed to contaminants were less likely to have cancer than those who were not exposed. ORs are presented with their 95% confidence intervals, a measure of the OR's precision. Confidence intervals represent a range, within which the true value of the association lies. Therefore, any confidence intervals which pass through 1.0 mean the OR is not significant.

PART 1: CONTAMINATION OF UK FIREFIGHTERS PERSONAL PROTECTIVE EQUIPMENT AND WORKPLACES

Citation: Wolffe, T.A.M., Clinton, A., Robinson, A. et al. Contamination of UK firefighters personal protective equipment and workplaces. *Sci Rep* 13, 65 (2023). <https://doi.org/10.1038/s41598-022-25741-x>

The UK Firefighter Contamination Survey uncovered considerable variation in terms of PPE provision, cleaning and storage in UK Fire and Rescue Services. Results revealed that:

- Most firefighters (84%) de-robe contaminated PPE/workwear after re-entering the appliance cab.
- There is a significant decreasing tendency to send PPE for cleaning after every incident with increasing seniority of role, length of service, and fire attendance frequency.
- Around one third of firefighters clean PPE after every incident.
- A number of issues arise through external professional cleaning services, e.g. shrinkage, fit, turn-around time, and stock of reserve/pooled PPE.
- PPE storage is a potential source of cross contamination, with almost half of firefighters (45%) indicating clean and dirty PPE is not stored separately.
- More than half of firefighters (57%) store fire gloves (an item sent for professional decontamination by only 19% of firefighters, and never cleaned by 20%) within other items of PPE such as helmets, boots and tunic/trouser pockets.



Attending fires without respiratory protective equipment.

Proportion of total surveyed firefighters who attend fires without respiratory protective equipment (RPE), and their reasons for doing so.

PART 2: CANCER INCIDENCE AMONGST UK FIREFIGHTERS

Citation: Wolffe, T.A.M., Robinson, A., Dickens, K. *et al.* Cancer incidence amongst UK firefighters. *Sci Rep* 12, 22072 (2022). <https://doi.org/10.1038/s41598-022-24410-3>

Firefighters continue to suffer chronic illnesses as a result of occupational exposure to fire toxins. Research has found that carcinogens from fire incidents not only remain on firefighters' personal protective equipment (PPE), but are also tracked back to fire stations.

The UK Firefighter Contamination Survey assessed firefighters' risk of developing cancer due to occupational exposure to fire toxins. Results revealed that:

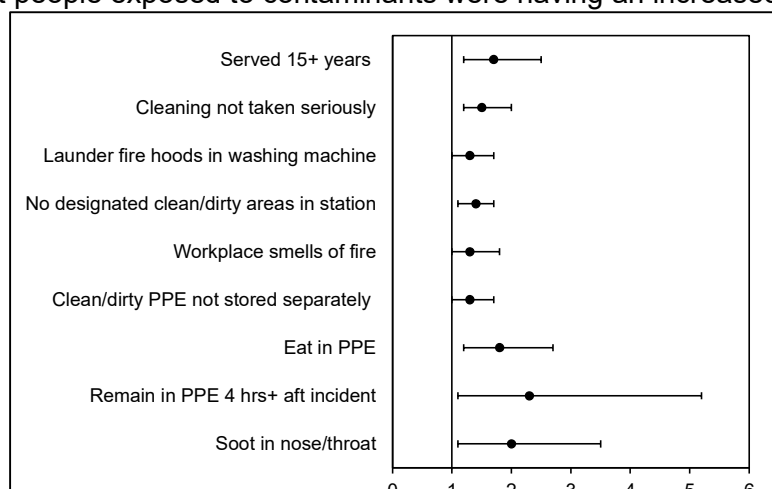
- Over 4% of surveyed firefighters have had a cancer diagnosis, with the age-specific cancer rate up to 323% higher (for 35-39 year olds) in firefighters compared to the general population.
- Firefighters who have served ≥ 15 years are 1.7 times more likely to develop cancer than those who have served less time.
- Firefighters are at least twice as likely to be diagnosed with cancer if they notice soot in their nose/throat (OR= 2.0, 1.1-3.5), or remain in their PPE for more than four hours after attending a fire incident (OR= 2.3, 1.1-5.2).
- Also associated with an increased likelihood of cancer was:
 - eating while wearing PPE (OR= 1.8, 1.2-2.7);
 - failing to store clean/dirty PPE separately (OR= 1.3, 1.0-1.7);
 - working in a station that smells of fire (OR= 1.3, 1.0-1.8)
 - not having designated (separated) clean and dirty areas (OR= 1.4, 1.1-1.7);
 - using an on-site washing machine to launder fire hoods (OR= 1.3, 1.0-1.7);
 - feeling that cleaning is not taken seriously at work (OR= 1.5, 1.2-2.0).

Interpreting Odds Ratios (OR): Odds ratios are a measure of association between an exposure (e.g. contaminants) and an outcome (e.g. cancer, mental health disorders etc.). Using cancer as an example, an OR of 1.0 means there is no difference between people who were and were not exposed to contaminants in terms of cancer diagnosis.

OR higher than 1.0 indicates that people exposed to contaminants were having an increased occurrence of cancers when compared to those who were not exposed.

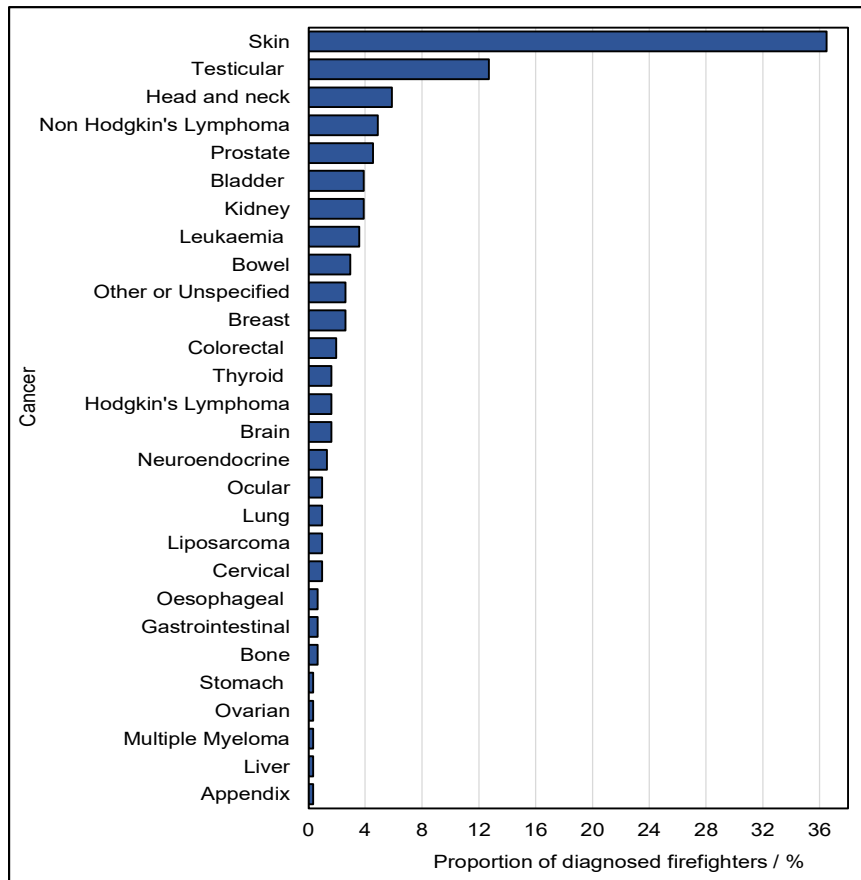
OR lower than 1.0 indicates that people exposed to contaminants were having lower rates of cancers than those who were not exposed.

ORs are presented with their 95% confidence intervals, a measure of the OR's precision. Therefore, any confidence intervals which pass through 1.0 mean the OR is not



Sources of contaminant exposure associated with a significant, increased likelihood of cancer diagnosis

significant. If it doesn't pass though 1 results are statistically significant.



Cancer in the UK Fire and Rescue Service. (A) The range and frequency of cancers reported by surveyed firefighters who were diagnosed after joining the Fire and Rescue Service.

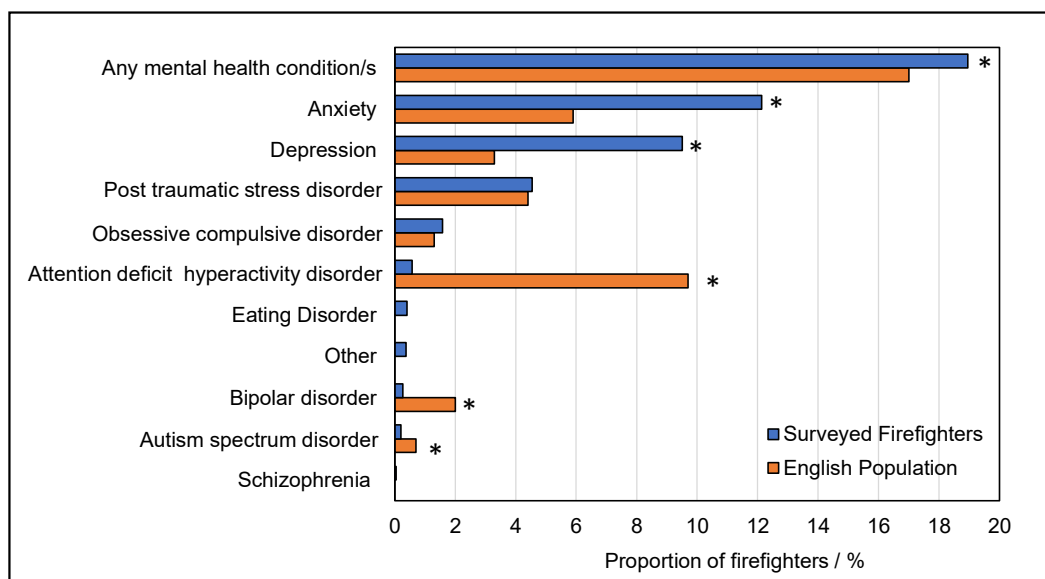
PART 3- MENTAL HEALTH OF UK FIREFIGHTERS

Citation: Wolffe, T.A.M., Robinson, A., Clinton, A. *et al.* Mental health of UK firefighters. *Sci Rep* 13, 62 (2023). <https://doi.org/10.1038/s41598-022-24834-x>

Mental health disorders can be caused by a combination of psychological, environmental, biological, and chemical factors. To date, research on firefighters' mental health has mainly focused on psychological factors such as direct exposure to trauma or occupational stress, finding firefighters to have an increased risk of depression, and post-traumatic stress disorder (PTSD). Studies have also investigated the effects of other occupational exposures, e.g. abrupt fire incident call-outs, disrupted sleep, as well as physical and/or emotional fatigue on firefighters' mental health. However, little is known about the relationship between firefighters' exposure to fire effluent and mental health.

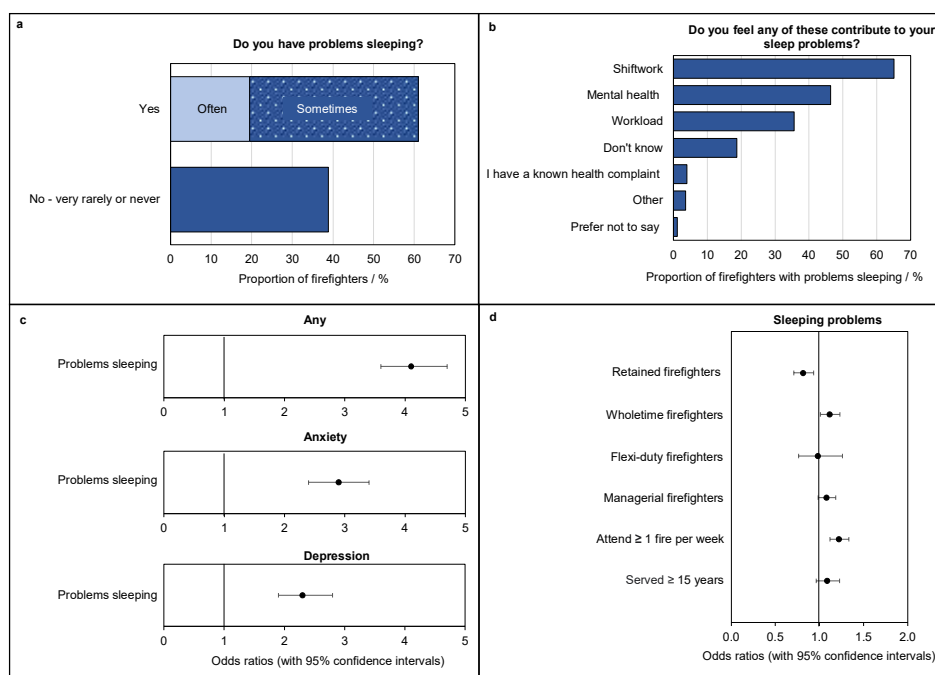
The UK Firefighter Contamination Survey explored the association between potential exposure to fire toxins and self-reported mental health disorders among UK firefighters. Results revealed that:

- Firefighters who notice soot in their nose/throat for more than a day after attending fires (OR=1.8, 1.4-2.4), and those who remain in their personal protective equipment (PPE) for over 4 hours after fires (OR=1.9, 1.2-3.1), were nearly twice as likely to report mental health disorders.
- Significantly increased odds ratios for all three outcomes of interest (anxiety, depression and/or any mental health disorders) were also found among firefighters who take PPE home to clean.
- Sleeping problems were reported by 61% of firefighters. These firefighters were 4.2 times more likely to report any mental health disorder (OR=4.2, 3.7-4.9), 2.9 times more likely to report anxiety (OR=2.9, 2.4-3.5) and 2.3 times more likely to report depression (OR=2.3, 1.9-2.8) when compared to firefighters who did not report sleep issues.



Firefighters' Mental Health Conditions.

The proportion of total surveyed firefighters with any, or specific, mental health disorders (blue). The prevalence of mental health disorders in the general English population is displayed for comparison (orange). * indicates significant differences in the proportion of mental health disorders in firefighters compared to the general population.



Firefighters' Sleeping Problems.

(A) The proportion of total surveyed firefighters who indicated whether they had sleeping problems. (B) The proportion of firefighters with sleeping problems listing the reasons for their sleep disturbances. Note that firefighters were able to select more than one reason. (C) Adjusted odds ratios (with 95% confidence intervals) for firefighters' mental health conditions due to sleeping problems. (D) Adjusted odds ratios (with 95% confidence intervals) for firefighters' sleeping problems due to demographic variables.

PART 4: CULTURE AND AWARENESS OF OCCUPATIONAL HEALTH RISKS AMONGST UK FIREFIGHTERS

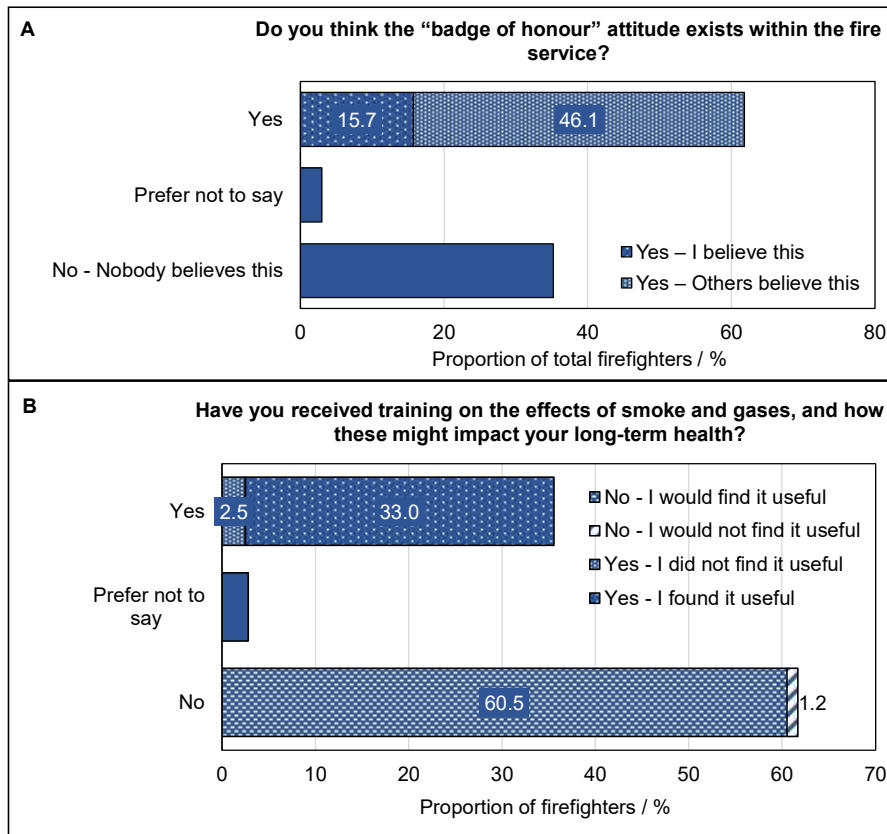
Citation: Wolffe, T.A.M., Turrell, L., Robinson, A. *et al.* Culture and awareness of occupational health risks amongst UK firefighters. *Sci Rep* 13, 97 (2023). <https://doi.org/10.1038/s41598-022-24845-8>

When firefighters are subjected to repeated similar experiences (such as fire attendances), over time, they may pay less attention or take less caution over their exposure to toxic substances. This puts them at risk of gradually resuming bad habits and routines, leading to illness or accidents.

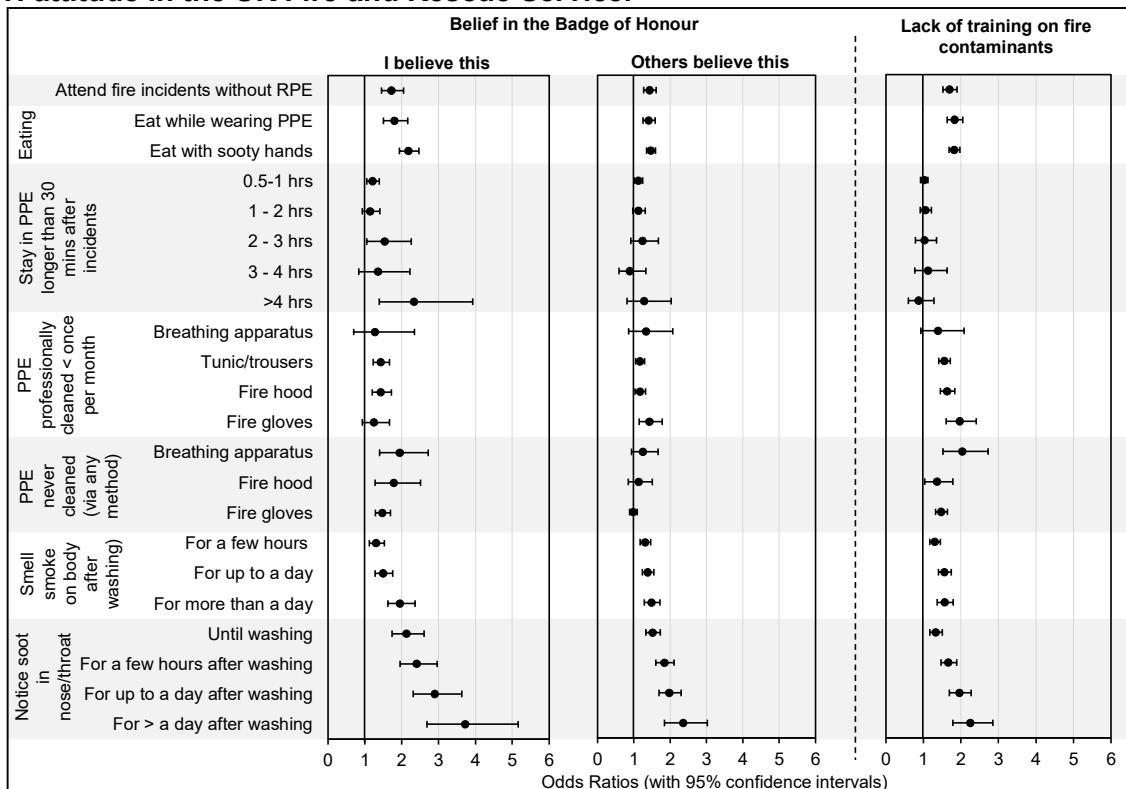
The “badge of honour” (BoH) is an attitude sometimes upheld by firefighters; whereby heavily contaminated personal protective equipment (PPE) is perceived as a mark of prestige. BoH and similar attitudes therefore have the propensity to not only increase the wearer’s exposure to fire toxins, but also that of his/her colleagues/family.

The final analysis of the UK Firefighter Contamination Survey examines the influence of cultural beliefs such as the BoH on firefighters’ exposure to contaminants and engagement in decontamination practices. Results revealed that:

- Lack of training on fire effluents and their health outcomes is strongly associated with increased fire smoke/contaminant exposure.
- Untrained firefighters were at least twice as likely to:
 - never clean personal protective equipment (PPE) (OR= 2.0, 1.5-2.7),
 - infrequently send their PPE for professional cleaning (OR=2.0, 1.6-2.4),
 - remain in the workwear (t-shirt etc.) worn while attending a fire incident (OR up to 3.6, 2.3-5.6),
 - and indicate that cleaning at fire stations is not taken seriously (OR=2.4, 2.2-2.6).
- Firefighters personally viewing contamination as a “badge of honour” (BoH) were at least twice as likely to:
 - remain in contaminated PPE after fire incidents (OR=2.3, 1.4-3.9),
 - eat with sooty hands (OR=2.2, 1.9-2.5),
 - notice soot in the nose/throat (OR=3.7, 2.7-5.2),
 - and smell fire smoke on the body for more than a day after incidents (OR=2.0, 1.6-2.4).
 - They were also more likely to indicate that cleaning at fire stations is not taken seriously (OR=2.5, 2.2-2.9) and that fire stations smell of smoke always/most of the time (OR=2.3, 2.0-2.6).
- Strong links were also found between belief in the BoH and never cleaning PPE (OR=1.9, 1.4-2.7), and eating while wearing contaminated PPE (OR=1.8, 1.5-2.2).



Training on fire contaminants and their associated health outcomes, and belief in the BoH attitude in the UK Fire and Rescue Service.



Crude odds ratios for engaging in practices/behaviours which increase contaminant exposure for firefighters who believe in the badge of honour, or who have not received training on fire contaminants and their associated health outcomes.