

1 **Women firefighter health and well-being: An international survey**

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3 **Running heading:** Women firefighter health survey

4

5 **Word Count** (excluding abstract, citations, acknowledgments and references): 4498

6 **Abstract Word Count:** 233

1 ABSTRACT**2 *Objectives***

3 The study aimed to identify specific health and well-being issues women firefighters may experience
4 as part of their daily working practices. Issues identified from this under-represented population can
5 drive future research, education and strategy to guide safety and health practices.

6

7 *Methods*

8 A total of 840 women firefighters from 14 separate countries (255 United Kingdom & Ireland, 320
9 North America, 177 Australasia, 88 mainland Europe) completed the survey over a 4 month period.
10 Questions related to general health and well-being and role specific health concerns, gender orientated
11 issues and available exercise facilities.

12

13 *Results*

14 Women firefighters in North America reported a higher prevalence of lower back (49%) and lower limb
15 (51%) injuries, than all other groups. North America reported more heat illnesses (45%) than other
16 places (36%). Thirty-nine percent thought their menstrual cycle and menopause effected work, with
17 36% concerned for their ability to meet future job demands. Sixteen percent felt confident they could
18 complete the role after 60yrs old. Women firefighters identified a lack of strength & conditioning
19 support (50%) or lack of gym access (21%). Availability of women specific personal protective
20 equipment was greatest in the United Kingdom (66%) compared to others (42%).

21

22 *Conclusions*

23 There is a need for women specific strength & conditioning support and facilities to reduce injury and
24 illness risk and improve longevity. Research and education into gynaecological issues, heat exposure,
25 and their effects on women's fertility and cancer risk is required.

26

27 ***Key words:*** Women, heat, work, injury, illness

28

1 INTRODUCTION

2 Numbers of women firefighters (WFF) are increasing worldwide, as a result of many bodies introducing
3 women recruitment quotas and targets. Internationally, it is estimated that WFF represent roughly 6.3%
4 of firefighters (Brushlinsky, Ahrens, Solokov, & Wagner, 2017). WFF capably complete the same tasks
5 and meet the same fitness standards as men (Kirlin, Nichols, Rusk, Parker, & Rauh, 2017). While some
6 countries are just introducing women recruitment, others are experiencing an ageing population with
7 the extension of pensions and superannuation meaning some are required to work beyond 60 years of
8 age (Sluiter & Frings-Dresen, 2007). This brings about specific long-term considerations for all
9 firefighters' health and wellbeing. However, women staff have not previously been considered due to
10 their small numbers and relatively new entrance to the firefighter workforce.

11

12 Firefighters are exposed to numerous physical and chemical hazards at work (Stec et al., 2018) and
13 undertake strenuous physical activity, often under severe heat stress conditions (Horn et al., 2018;
14 Watkins, Hayes, Watt, & Richardson, 2018; Watt et al., 2016). Male firefighters have previously been
15 documented to have high alcohol intakes (Haddock et al., 2012; Poston, Haddock, Jahnke, Jitnarin, &
16 Day, 2013), increased risk of cancers (Pukkala et al., 2014; Tsai et al., 2015), high prevalence of
17 musculoskeletal injuries (Jahnke, Poston, Haddock, & Jitnarin, 2013; Lusa, Miranda, Luukkonen, &
18 Punakallio, 2015) and high rates of post-traumatic stress disorder (PTSD) and suicide (Boffa et al.,
19 2017; Martin, Tran, & Buser, 2017). Firefighters show diminishing fitness over their careers, which
20 may result in inadequate fitness standards with extended retirement ages (Davis, Jankovitz, & Rein,
21 2002; Walker, Driller, Argus, Cooke, & Rattray, 2014). However, despite a growing body of research
22 for male health in fire services, currently there is limited work on the specific health needs of women
23 (Jahnke et al., 2012; Sinden et al., 2013). Within the WFF population previous research has identified
24 high alcohol intakes (Haddock, Poston, Jahnke, & Jitnarin, 2017), high rates of depression (Centers for
25 Disease Control and Prevention, 2010), anxiety, post-traumatic stress disorder (PTSD) and suicide
26 (Stanley, Hom, Spencer-Thomas, & Joiner, 2017), as well as pregnancy complications (Jahnke, Poston,
27 Jitnarin, & Haddock, 2018). Most published women specific research originates from the USA and to
28 our knowledge there is no documentation on women's perspectives of health and wellbeing needs,
29 particularly surrounding gynaecological health. Menstrual cycle phases may alter resting core body
30 temperature, and therefore could put WFF at an increased risk of heat illness during particular phases
31 (Marsh & Jenkins, 2002). Anatomical and physiological differences of WFF also present specialised
32 requirements regarding equipment and training. Inadequate equipment and training may be associated
33 with prevalence of injury or ill-health.

34

35 The aim of this survey was to assess the health and wellbeing issues experienced by WFF worldwide
36 and to consider potential research, education and workload implications of these findings. A secondary

1 aim was to compare responses from different countries to identify areas of best practice, and to be able
2 to plan appropriate interventions that meet each country's needs.

3

4 **METHOD**

5 Operationally active women firefighters were invited to take part in an international survey
6 investigating their health and welfare concerns. All participants presenting as women and reporting to
7 be operationally active were included. The survey was designed by the authors and pilot tested by the
8 Women in the Fire Service UK, Women and Firefighting Australasia, and the Dutch Network
9 Brandweervrouwen [Female Firefighting Network], who provided feedback on questions and
10 nomenclature. Subsequently, the survey was distributed once by email via the women in firefighting
11 organisations and other national firefighters' organisations (the USA Centre for Fire, Rescue and EMS
12 Health, the UK Fire Brigades Union, the UK National Fire Chiefs Council Research and Development
13 group, in Belgium via the Brandweer Vereniging Vlaanderen [Flanders Firefighting Network]) and by
14 social media. All participants were informed that individual responses would be kept confidential and
15 therefore would not be shared with their employers. Participants were informed they could skip
16 questions that they deemed not applicable. The study was approved by the University of Brighton ethics
17 committee and conformed to the Declaration of Helsinki guidelines (2013).

18

19 **The Survey**

20 A survey was generated using an online survey tool (Google Forms). The survey consisted of 4 sections
21 and 35 questions that covered demographics, working life, personal protective equipment and health.
22 Symptoms of ill health were self-reported. Brief definitions were provided for each type of heat illness,
23 as per Casa et al., (2015) and Coris, Ramirez, & Van Durme (2004). The survey was written in English,
24 although the introductory information was also available in Dutch. The survey was live for 4 months
25 from January through to April 2018.

26

27 **Statistical Analysis**

28 Responses were grouped according to geographical location: UK & I, United Kingdom (England,
29 Wales, Scotland and Northern Ireland) and Ireland; NA, North America (USA & Canada); AUS,
30 Australasia (Australia and New Zealand) and EU, Mainland Europe (The Netherlands, Belgium,
31 Croatia, Sweden & Germany). Demographic quantitative data are displayed as Mean \pm standard
32 deviation (SD). Prevalence of categorical data responses are reported in frequencies and percentages.
33 Pearson's chi square analysis was performed to assess if the distribution of categorical variables differed
34 between geographical groups. Where significant associations were identified standardised residuals
35 were assessed for significant differences between group responses and expected counts. Subsequent
36 odds ratios and 95% confidence intervals (CI) were calculated to analyse associations. Significance

1 level was set at $p < 0.05$. Qualitative responses to open questions were categorised into key themes, with
2 respondent frequencies for each theme reported.

3

4

1 RESULTS

2 In total, 840 WFF from 14 different countries responded to the survey (age 40 ± 9 yrs, time as a
3 firefighter 13 ± 8 yrs, monthly exposure number 2 ± 3), data for geographical groups are listed in Table
4 1.

5
6 Table 1. Demographic information for each group

Group	Number of responders	Age (yrs)	Time as Firefighter (yrs)	Exposures in previous month
UK & Ireland	255	39 ± 8	12 ± 7	3 ± 3
USA & Canada	320	41 ± 9	15 ± 8	2 ± 2
AUS & NZ	177	38 ± 11	11 ± 9	3 ± 4
Mainland EU	88	39 ± 9	12 ± 7	2 ± 2

7

8

9 Health

10

11 Illnesses and Injuries

12 There was an association between how WFF felt physically (positive [great, good, OK] or negative [ill,
13 exhausted, tired]) at the end of a weekly shift block and geographical grouping, ($\chi^2 (3) = 26.629$,
14 $p < 0.001$). Specifically, WFF in the EU were more likely to feel physically positive than other regions:
15 UK & I WFF (3.22, 95% CI 1.88-5.49), NA (3.61, 95% CI 2.14-6.08) and AUS (3.18, 95% CI 1.81-
16 5.56). Furthermore, this pattern was repeated in how WFF felt mentally at the end of a week ($\chi^2 (3) =$
17 44.993 , $p < 0.001$), with EU WFF more likely to feel mentally positive at the end of the week than their
18 counterparts in UK & I (4.41, 95% CI 2.53-7.67), NA (4.44, 95% CI 2.57-7.62) and AUS (4.69, 95%
19 CI 2.62-8.38).

20

21 Participants were also asked if they suffered from a range of injuries/symptoms and if the
22 injury/symptom was possibly caused by their occupation, see Table 2. There was an association between
23 injuries possibly caused by the occupation and group for all symptoms ($p < 0.05$) other than fertility
24 issues ($\chi^2 (3) = 7.592$, $p = 0.06$). Based on standardised residual analysis, follow up odds ratios for the
25 likelihood of symptoms occurring in NA compared to the other groups can be found in Table 2.

26

27 Table 2. Number of responders suffering from each injury/symptom type and those who believe their
28 occupation is the cause of the symptom.

Injury / Symptom	UK & I	NA	AUS	EU
Lower Limb	107 (42%)	164 (51%)	61 (34%)	24 (27%)

Occupation caused	48 (19%)	102 * (32%)	20 # (11%)	8 # (9%)
OR (95% CI)	2.2 (1.48-3.26)		4 (2.58-6.21)	5.1 (2.37-10.96)
Lower Back	100 (39%)	158 (49%)	59 (33%)	25 (28%)
Occupation caused	50 (20%)	115 * (36%)	20 # (11%)	7 # (8%)
OR (95% CI)	1.95 (1.35-2.82)		4.4 (2.62-7.39)	6.49 (2.9-14.52)
Upper Back	21 (8%)	66 (21%)	16 (9%)	8 (9%)
Occupation caused	14 (5%)	49 * (15%)	7 # (4%)	6 (7%)
OR (95% CI)	3.11 (1.68-5.78)		4.39 (1.94-9.92)	2.47 (1.02-5.98)
Upper Limb	79 (31%)	122 (38%)	30 (17%)	16 (18%)
Occupation caused	48 (19%)	94 * (29%)	16 # (9%)	5 # (6%)
OR (95% CI)	1.79 (1.21-2.66)		4.19 (2.37-7.38)	6.9 (2.71, 17.57)
Coughing/ Breathing	17 (7%)	52 (16%)	15 (8%)	6 (7%)
Occupation caused	13 (5%)	37 * (12%)	8 (5%)	2 (2%)
OR (95% CI)	2.43 (1.26-4.68)		2.76 (1.26-6.07)	5.62 (1.33-23.8)
Depression/ PTSD	46 (18%)	115 (36%)	36 (20%)	12 (14%)
Occupation caused	31 (12%)	87 * (27%)	19 # (11%)	6 # (7%)
OR (95% CI)	2.7 (1.72-4.23)		3.1 (1.82-5.31)	5.1 (2.15-12.12)
Fertility Issues	22 (9%)	35 (11%)	18 (10%)	2 (2%)
Occupation caused	12 (5%)	23 (7%)	4 (2%)	2 (2%)

- 1 * denotes a significantly higher number of counts in this category than the expected number of counts,
2 p<0.05. # denotes a significantly lower number of counts in this category than the expected number of
3 counts, p<0.05. Odds ratios indicate the likelihood of each symptom/injury occurring in NA WFF
4 compared to the other country groups for symptoms where significant associations occurred.

1

2 **Heat Illnesses**

3 Altogether 36% (300/840) of WFF have suffered from a heat related illness at work: 26% (66/255) UK
 4 & I, 45% (158/350) NA, 34% (61/177) AUS, 19% (17/88) EU. There was an association between
 5 suffering from a heat illness and group (χ^2 (3) = 34.782, $p < 0.001$). WFF in NA are 2.36 (95% CI 1.66-
 6 3.35) times more likely to report suffering from a heat illness than those in the UK & I, 1.56 (95% CI
 7 1.08-2.28) times more likely than those in AUS and 3.44 (95% CI 1.94-6.07) times more likely than
 8 those in EU.

9

10 Types of heat illness experienced are detailed in Table 3. There was an association between group and
 11 heat cramps (χ^2 (3) = 45.060, $p < 0.001$) and heat exhaustion (χ^2 (3) = 13.673, $p = 0.003$), but not for heat
 12 syncope (χ^2 (3) = 4.750, $p = 0.191$) or heat stroke (χ^2 (3) = 1.454, $p = 0.693$). Follow up odds ratios indicate
 13 that NA and AUS are 4.34 (95% CI 2.45-7.67) and 3.95 (2.12-7.36) times more likely to experience
 14 heat cramps than the UK & I and 12.48 (95% CI 3-51.97) and 11.36 (95% CI 2.67-48.35) times more
 15 likely than EU, respectively. WFF in NA and AUS are also 1.94 (95% CI 1.29-2.9) and 1.78 (95% CI
 16 1.12-2.84) times more likely to experience heat exhaustion than those in UK & I and 1.96 (95% CI
 17 1.07-3.6) and 1.81 (95% CI 0.95-3.46) times more likely than those in EU.

18

19 Table 3. Types of heat illness experienced by WFF.

Heat Illness	UK & I	NA	AUS	EU
Heat Cramps	16 # (6%)	72 * (23%)	37 * (21%)	2 # (2%)
NA OR	4.34 (2.45-7.67)			12.48 (3-51.97)
AUS OR	3.95 (2.12-7.36)			11.36 (2.67-48.35)
Heat Exhaustion	44 # (17%)	92 (29%)	48 (27%)	15 (17%)
NA OR	1.94 (1.29-2.9)			1.96 (1.07-3.6)
AUS OR	1.78 (1.12-2.84)			1.81 (0.95-3.46)
Heat Syncope	9 (4%)	15 (5%)	13 (7%)	2 (2%)
Heat Stroke	11 (4%)	8 (3%)	6 (3%)	3 (3%)

20 * denotes a significantly higher number of counts in this category than the expected number of counts,
 21 $p < 0.05$. # denotes a significantly lower number of counts in this category than the expected number of
 22 counts, $p < 0.05$. Odds ratios (OR) are provided for the likelihood of the heat illness types occurring in
 23 NA and AUS compared to the UK & I and EU.

1 **Gynaecological Health**

2 Forty-five percent (369/818) of WFF were not aware that resting body temperature can change with
 3 phases of the menstrual cycle: 35% (88/251) UK & I, 47% (146/312) NA, 50% (84/169) AUS, 59%
 4 (51/86) EU. There was an association between country group and awareness, ($\chi^2(3) = 24.720, p < 0.001$).
 5 WFF in the UK are 1.63 (95% CI 1.16-2.29) times more likely to be aware than those in the NA, 2.39
 6 (95% CI 1.58-3.62) AUS and 2.7 (95% CI 1.63-4.46) EU.

7
 8 Thirty-nine percent (199/512) of WFF said their menstrual cycle affects their response to fire exposures,
 9 although this only equates to 24% (199/840) of the total participants of this study, as 39% (328/840)
 10 chose not to answer this question. Due to the low number of responses to this question, comparisons
 11 between countries have not been made. Details as to why given by those WFF who answered yes are
 12 provided in Table 4.

13

14 Table 4. WFF beliefs about the menstrual cycle and work.

Injury / Symptom	UK & I (n=61)	NA (n=73)	AUS (n=45)	EU (n=20)
Hygiene concerns	7	12	14	4
Mental Fatigue	8	9	4	2
Physical Fatigue	9	8	6	3
Pain/discomfort	5	5	5	1
Headaches/migraines	5	0	2	1
Thermal tolerance/regulation	19	0	0	1

15

16 Seventeen percent (141/840) of WFF reported that they are perimenopausal or menopausal: 20%
 17 (50/255) UK & I, 15% (47/320) NA, 15% (26/177) AUS and 20% (18/88) EU. Of those who are peri-
 18 /menopausal 39% (55/141) reported that it impacts their working life: 24% (12/50) UK & I, 45% (21/47)
 19 NA, 62% (16/26) AUS and 33% (6/18) EU. WFF were asked to detail how it affects them at work, with
 20 the themed answers shown in Table 5.

21

22 Table 5. WFF beliefs about menopause and impact on working life.

Theme	UK & I (n=50)	NA (n=47)	AUS (n=26)	EU (n=18)
Hot flushes	19	14	5	3
Fatigue	14	7	2	1
Mood swings	13	9	2	5
Dizzy spells	3	0	2	0
Heavy/irregular bleeding	10	2	0	0

Weight gain	2	2	0	1
Muscle pain	1	0	1	3
Loss of concentration	5	3	0	1
Memory loss	6	0	0	1
Night sweats	3	1	1	0
Insomnia	0	5	1	0
Strength loss	0	2	0	0
Nausea	0	1	1	0

1

2 Of those that are not yet peri-/menopausal, 36% (242/676) were worried about how menopause may
3 affect their working life in the future: 60% (124/205) UK & I, 27% (69/256) NA, 23% (33/144) AUS
4 and 23% (16/71) EU. There was an association between worry and country, (χ^2 (3) = 89.798, $p < 0.001$).
5 WFF in the UK are more likely to be worried about how menopause will affect them than those in NA
6 (4.15 95% CI 2.8-6.15), AUS (6.4, 95% CI 3.99-10.26) and EU (5.26, 95% CI 2.82-9.81). Those that
7 were worried were asked to detail their concerns, key themes included: 16% (38/242) lack of
8 knowledge, 13% (32/242) concern for the level of stress and mental health, 19% (46/242) changes in
9 temperature regulation, 14% (35/242) changes in fitness, 11% (27/242) changes in bone and muscle
10 strength, 4% (9/242) embarrassment due to male dominated environment.

11

12 **Longevity of Career**

13 Only 16% (136/828) of WFF were confident that they would be able to meet the demands of their job
14 at 60 yrs of age, 31% (256/828) reported that they think they will be able to but that it would be a
15 struggle and 53% (436/828) responded that they do not think they will be able to meet the demands.
16 There was an association between possible ability to meet demands at 60 yrs and country (χ^2 (3) =
17 47.052, $p < 0.001$). WFF in AUS were more likely to be confident they could meet the demands at 60
18 yrs, than those in the UK & I (6.78, 95% CI 3.72-12.35), NA (2.27, 95% CI 1.47-3.51) and EU (2.6,
19 95% CI 1.33-5.1). WFF that replied “no” or “yes, but it will be a struggle” were asked why they thought
20 that, themed responses are detailed in Table 6.

21

22 Table 6. WFF role concerns at age 60 yrs.

Theme	UK & I (n=192)	NA (n=240)	AUS (n=134)	EU (n=65)
Meeting fitness standards	53	14	3	7
Lack of strength	60	38	17	6
Physical demands of the job	47	56	34	12
Not mentally tough enough	7	15	4	14
Impact of Menopause	33	1	0	0

Impact of Night shifts	13	9	2	3
Injury/pain	39	51	8	6
Workload	2	3	1	0
Weight of equipment	0	6	2	0

1

2

3 **Training and Facility Availability**

4 Of 773 responders, 79% (613) reported having access to a gym at their station or base: 94% (239/253)
 5 of UK& I, 86% (275/318) of NA, 39% (44/114) of AUS and 58% (51/88) of EU. There was a significant
 6 association between country group and availability of gym facilities, $\chi^2 (3) = 181.480$, $p < 0.001$. Odds
 7 ratios indicate that WFF from the UK & I and NA are 27.16 (95% CI 14.07-52.43) and 10.17 (95% CI
 8 6.2 – 16.7), times more likely to have a gym than those from AUS, respectively and 12.39 (95% CI 6.24
 9 – 24.58) and 4.64 (95% CI 2.73 – 7.89) times more likely than those from the EU, respectively.

10

11 Of those with a gym, 79% (490 of 618 responders) reported that they used it. Of those who did not,
 12 seven key themes were identified: not enough time provided at work (36%), the gym is not fit for
 13 purpose/big enough/lacks equipment (49%), preference to train elsewhere (41%), too tired (3%),
 14 feelings of self-consciousness/intimidation (9%) or lack of interest (6%).

15

16 Only 30% (245/829) of participants had been provided with a strength and conditioning programme or
 17 support: 18% (46/251) UK & I, 44% (140/317) NA, 15% (27/176) AUS and 38% (32/85) EU. There
 18 was an association between country group and support provided $\chi^2 (3) = 66.011$, $p < 0.001$. WFF from
 19 NA are 3.52 (95% CI 2.39-5.2) times more likely to have been provided with support than WFF in the
 20 UK & I, 4.36 (95% CI 2.74-6.96) times more likely than those in AUS and 2.1 (95% CI 1.32-3.34)
 21 times more likely than those in EU.

22

23 Half of responders (51% 419/827) would like further support and guidance on fitness and training: 43%
 24 (110/253) UK & I, 47% (148/315) NA, 63% (108/172) AUS and 61% (53/87) EU. Suggestions of
 25 support included: a training plan to follow (106), strength training (105) and age/women specific
 26 training (49).

27

28 **Personal Protective Equipment**

29 Women specific PPE was available to 42% (354/834) of WFF: 66% (167/253) UK & I, 25% (78/318)
 30 from NA, 55% (97/177) of AUS and 14% (12/86) of EU. There was an association between country
 31 group and PPE availability ($\chi^2 (3) = 138.927$, $p < 0.001$). WFF in the UK are 11.97 (95% CI 6.17-23.24)
 32 times more likely to have women's PPE than those in the EU, 5.97 (95% CI 4.15-8.6) times more likely
 33 than NA and 1.6 (95% CI 1.08-2.38) times more likely than those in AUS. Of those who did have

1 women specific PPE available to them, 73% (256/349) choose to wear it: 70% (116/165) UK & I, 79%
 2 (61/77) NA, 73% (69/95) AUS and 83% (10/12) EU, although this did not include helmets. Those who
 3 used women specific PPE were given the space to provide any comment on it. Responses are detailed
 4 in Table 7.

5
 6 Table 7. PPE comments by regional group (%)

	UK & I	NA	AUS	EU
Can access women specific PPE	167(66%)	78(25%)	97(55%)	12(14%)
Content with available PPE	5	9	10	0
Difficult to access women PPE	12	15	19	10
Quality of PPE is better for men specific PPE	10	0	3	0
Wasn't aware there was women specific PPE	8	23	3	20
Ill-fitting: gloves	9	12	1	1
Ill-fitting: helmet	16	13	1	1
Ill-fitting: tunic	8	9	5	0
Ill-fitting: trousers	9	9	10	2
Ill-fitting: Breathing apparatus face mask	2	3	4	4
Ill-fitting: boots	5	5	4	0
Ill-fitting: uniform in general	10	13	14	1

7

8 **Additional Comments**

9 WFF were given the opportunity to raise any other concerns around their health and well-being. Key
 10 themes included: risk of cancer (54), fertility issues with regards to conception and full-term
 11 pregnancies (11), returning to work after pregnancy and impact on breastfeeding (17) and a perceived
 12 culture of sexism (19).

13

14 **DISCUSSION**

15 This survey represents the first comprehensive international snapshot of the issues facing WFF, a
 16 rapidly growing sector of a traditionally male dominated industry. The survey identified areas such as
 17 training support and facilities as a potential avenue to aid injury and illness prevention and career
 18 longevity. Respondents also identified WFF specific gynaecological issues that warrant further
 19 research.

20

21 **Health**

1 **Illness and Injury**

2 There is a high prevalence of injury and illness that WFF consider associated with their occupation,
3 with WFF in NA being more likely to suffer from injury and illness than any of the other country groups.
4 Musculoskeletal injuries, including work-related upper and lower limb and back injuries were reported
5 by 9-23% of WFF. This is in line with previous research which suggests that up to 44% of firefighters
6 will likely develop back pain with time in service (Lusa et al., 2015). The relatively high occurrence of
7 musculoskeletal injuries in WFF may be a consequence of heavy lifting, the weight of PPE and
8 breathing apparatus (~23kg) and wearing restrictive boots (Roy & Lopez, 2013; Vu, Walker, Ball, &
9 Spratford, 2017). Women typically have a lower muscle mass to weight ratio in comparison to men but
10 are often required to carry the same weighted PPE and breathing apparatus, which could increase the
11 occurrence of musculoskeletal injuries. Consequently, in order to minimise the physical load, and
12 reduce musculoskeletal injury rates, lighter weight, women specific clothing and alternative boots
13 should be considered.

14

15 Firefighters have previously been noted to have a higher prevalence of dyspnea, coughs and sinusitis
16 (Mustajbegovic et al., 2001). In our survey, coughing and breathing problems were reported by 7-16%
17 of respondents, reflecting previous research reporting that firefighters are 1.23 times more likely to
18 develop adult onset asthma than non-firefighters (Ribeiro, de Paula Santos, Bussacos, & Terra-Filho,
19 2009). A UK recent survey has also reported the occurrence of coughing and breathing problems
20 amongst UK firefighters and fire service instructors (Watkins et al., 2018), suggesting that this issue
21 may be universal amongst Fire and Rescue Service personnel. These issues may be caused by air
22 pollutants from combustion products and consequently smoke and particulate exposure during and after
23 fire exposure, which could be alleviated through appropriate use of breathing apparatus and proper
24 decontamination processes. The 2-6 increased likelihood of WFF in NA experiencing coughing and
25 breathing issues suggests that differences in operating procedures between services may be having an
26 impact on breathing quality. Thus, further collaboration is needed to inform all Fire and Rescue Services
27 of effective strategies to reduce smoke and particulate exposure.

28

29 Seventeen percent of WFF also report experiencing mental health issues and/or PTSD. This supports
30 previous findings that typically 10-32% of first responders experience PTSD (Berger et al., 2012;
31 Fullerton, Ursano, & Wang, 2004) and indicates that this is not an issue that is more prevalent in WFF.
32 This also supports the finding of Perrin et al. (2014) who reported that once trauma characteristics are
33 accounted for women are no more likely to experience PTSD than men. The prevalence of PTSD within
34 emergency responders, and the levels reported within this study, exceed that noted within the general
35 population (2-14%) (Lukaschek et al., 2013; Perrin et al., 2014; Walker, McKune, Ferguson, Pyne, &
36 Rattray, 2016), thus this study reinforces the importance of mental health support within Fire and
37 Rescue Services.

1

2 Heat Illness

3 This study details that 39% of WFF have previously experienced a heat related illness, with WFF in
4 NA 1.5-3.5 times more likely to experience a heat illness. When separated by type of heat illness heat
5 cramps and heat exhaustion were more likely to occur in NA, however there was no difference in
6 prevalence of heat syncope and heat stroke. The discrepancy in the prevalence of heat illnesses between
7 countries could be a consequence of climate differences. There is currently no available data on the
8 prevalence of heat illnesses amongst the general population of firefighters in the UK or in the
9 Netherlands. In the USA, 39% of fire departments reported at least one case of heat illness a year, with
10 32% of all heat illness incidents requiring hospitalisation (Bach, Maley, Minett, & Stewart, 2018). Due
11 to the serious nature of heat illnesses and the increased likelihood of experiencing repeated episodes
12 following an initial occurrence, it is clear that preventive and treatment strategies should be planned
13 and implemented, such as the use of pre and post cooling, which are currently poorly used within Fire
14 Service departments worldwide (Bach et al., 2018; Brearley, 2012; Watkins, Hayes, Watt, &
15 Richardson, 2018). This is in addition to greater consideration for PPE design and operating procedures
16 supporting operational use of clothing.

17

18 Gynaecological Health

19 The occurrence of high core temperatures may vary with menstrual cycle phases, as a consequence of
20 fluctuations in resting core temperatures (Marsh & Jenkins, 2002). However, less than half of WFF
21 were aware of this association. Furthermore, a quarter of WFF indicated that their menstrual cycle
22 affects their response to fire exposures, with key issues raised including fatigue, pain/discomfort,
23 hygiene concerns and thermotolerance. Lack of suitable toilet facilities was commonly referred to with
24 regard to hygiene concerns. Alterations in thermoregulation was also cited as a concern for women
25 regarding the onset of menopause and as a symptom that affects peri-/menopausal WFF working life.
26 To the authors knowledge there has been no previous assessment of heat tolerance changes with
27 menstrual cycle phases or with menopause. With 39% (55/141) of peri-/menopausal WFF indicating
28 that it impacts their working life, it is clear that further research and education is needed to ensure that
29 WFF can maximise their potential during this period of their working life.

30

31 From the WFF surveyed, 5% reported experiencing fertility issues that they believed were related to
32 their fire exposures. In addition, both fertility concerns regarding conception and miscarriages and
33 return to work following pregnancy and whilst breastfeeding were key themes in the additional
34 comments section. Previously, shift work, heavy lifting, high temperatures, loud noises, physical strain
35 and environmental toxins have been noted to impact reproductive health (Agnew, McDiarmid, Lees, &
36 Duffy, 1991; McDiarmid, Lees, Agnew, Midzenski, & Duffy, 1991; Nilsson, Andersen, Strandberg-
37 Larsen, & Andersen, 2014; Stillerman, Mattison, Giudice, & Woodruff, 2008). A recent survey of US

1 WFF reported that the majority of WFF were actively running emergency calls whilst pregnant (Jahnke
2 et al., 2018). Moreover, nearly a quarter of first and second pregnancies and nearly a third of third and
3 fourth pregnancies, ended in miscarriage (Jahnke et al., 2018). This is more than twice the average
4 miscarriage rates previously reported in literature (Andersen et al., 2000; Jahnke et al., 2018; Slama et
5 al., 2005). Pre term births (<37 weeks) also occurred in 12-17% of pregnancies, greater than the 10%
6 general women population average, despite a reduction of common risk factors in WFF (Jahnke et al.,
7 2018). This type of data on reproductive health is not currently available for WFF from other countries.
8 It is also unknown how working practices of WFF directly relate to reproductive health. Overall, further
9 research is needed to investigate the link between fire exposures and reproductive health.

11 **Career Longevity, Training & Facility Availability**

12 Many western countries are seeing a requirement for staff to work to and beyond 60 years of age,
13 reflecting the ageing worker paradigm currently being addressed by all workplaces. WFF were
14 concerned with their ability to meet the demands of the role by this age, with only 16% confident they
15 could cope, given the current operating procedures of their individual Fire Services. The main concerns
16 were around meeting future physical fitness standards, which could reflect the limited focus on strength
17 and conditioning programs and monitoring at work (Walker et al., 2014).

19 Training based questions demonstrated the need for improved access to gym facilities particularly in
20 AUS. The UK & I WFF were 27 times more likely to report having access than AUS personnel.
21 Seventy-nine percent of those with access used the facilities. Of those respondents who reported that
22 they did not use facilities, the facilities not being fit for purpose was cited as the main barrier. Thirty
23 percent of WFF received some kind of strength & conditioning (S&C) support, with greatest availability
24 in NA. However, half of all respondents wanted specialised women's S&C programmes. Jahnke et al.,
25 (2012) previously reported that most WFF were typically healthier than male firefighters, based on a
26 lower prevalence of overweight and obesity and with most women measuring within the women's high
27 range for strength on standardised tests. However, given the natural physiological discrepancy in
28 strength between similar sized men and women this does not necessarily equate to WFF having a greater
29 strength capacity than men. Participants highlighted the need for strength-based recommendations, as
30 they felt this area of fitness limited them in their role and the potential longevity in their career. Future
31 work should therefore aim to develop training packages, with particular consideration of ageing WFF.

33 **Personal Protective Equipment**

34 PPE availability differed between countries, with far greater provision in the UK & I (66%) than others;
35 NA had the lowered reported rate of women specific PPE (14%). Ill-fitting, male specific PPE, may
36 contribute to injuries in women (Andersen, Grimshaw, Kelso, & Bentley, 2016) based on the likely
37 biomechanical limitations stemming from inappropriate design. The finding that reported injury rates

1 were lowest in UK & I and highest in NA, where respondents reported the least access to specially
2 designed equipment, supports this hypothesis. However, it must be noted that of those that had access
3 to women's PPE, only 73% used it, as very few (2-5%) were content with what was available. Fire
4 Services should therefore be selective in procuring PPE appropriate to women's needs and consult WFF
5 in future procurement processes.

6 7 **Other Concerns Raised**

8 WFF also raised a clear concern surrounding cancer risk, specifically cancer types classically
9 considered as women's cancers, such as breast cancer. There is a lack of research into the association
10 between contaminants exposure and breast and ovarian cancer, likely as a consequence of the reduced
11 population size in comparison to male firefighters, with women previously having been excluded from
12 many cancer risk assessments (Kang, Davis, Hunt, & Kriebel, 2008; Pukkala et al., 2014; Tsai et al.,
13 2015; Zeig-Owens et al., 2011). However, with growing numbers of WFF this is an area that warrants
14 future investigation.

15
16 The presence of a culture of sexism was also raised within the additional comments section. Throughout
17 the survey many open-ended question responses gave some level of reference to lack of consideration
18 for women's needs and attitude towards WFF. This varied from not using gym facilities due to
19 intimidation and self-consciousness, to lack of hygiene facilities for women and worry about menopause
20 due to embarrassment in a male dominated environment. Whilst it is positive to note that, in relation to
21 the number of respondents to the survey, these issues are reported by a small number of WFF, the
22 permeation of this culture throughout different aspects of the occupation, and across the different
23 country groups, indicates that further work on the culture within Fire and Rescue Services with regards
24 to attitudes and provision for WFF is required.

25 26 **Limitations**

27 This study was purposefully broad in its approach, to gain an understanding of areas of concerns for
28 WFF. Consequently, in depth details on each issue/symptom discussed was not gathered. Future
29 research should develop a greater understanding of the key areas and themes this study identified.
30 Reports of health issues were subjectively collected, with verification by a medical professional not
31 obtained. In addition, response bias towards WFF with health concerns may have occurred, due to the
32 word of mouth and social media distribution of the survey. However, this method was chosen to
33 maximise participation across countries. Similarly, the study was not translated from English thus
34 precluding many from taking part, future work should expand on this and consider non-English
35 speaking perspectives.

36 37 **CONCLUSION**

1 Injury, illness and heat illness risk is high amongst WFF, yet variation between countries is indicative
2 of the different environments, activities, access to PPE and training. The study evidences a need for
3 women specific S&C support worldwide and improved access to facilities, particularly in AUS, to
4 specifically improve strength and career longevity. Findings also demonstrate a lack of research and
5 education into gynaecological issues surrounding firefighting and its potential effects on women's
6 fertility and cancer risk. This is becoming ever more important with the growing number of WFF and
7 Fire Services' desire for worker to undertake these physically strenuous roles up to and beyond 60 yrs
8 of age.

9

10 **IMPLICATIONS FOR PRACTICE AND POLICY**

11 Heat illness and injury of women firefighters was particularly prevalent in the US & Canada,
12 consequently working practices, equipment and training need consideration. All countries should make
13 women specific PPE available to staff, and include women firefighters in the consultation phase of PPE
14 procurement. There is also a need for women specific strength and conditioning support to support
15 career longevity. Services should consider their facilities, support and education of women firefighters
16 in regards to menstrual cycle phases and menopause. Finally, there is a concern from women firefighters
17 about the risk of cancer and fertility, which clearly needs greater research.

18

19 **Acknowledgements**

20 This research did not receive any specific grant from funding agencies in the public, commercial, or
21 not-for-profit sectors.

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1 List of Tables

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