



Published in final edited form as:

J Occup Environ Med. 2019 May ; 61(5): e227–e231. doi:10.1097/JOM.0000000000001566.

Use of Aqueous Film-Forming Foams and Knowledge of Perfluorinated Compounds among Florida Firefighters

Alberto J. Caban-Martinez, DO, PhD, MPH^{1,4}, Natasha Schaefer Solle, RN, PhD^{2,4}, Paola Louzado Feliciano, MS¹, Kevin Griffin, BS¹, Katerina M. Santiago, MPH¹, David J. Lee, PhD^{1,3}, Sylvia Daunert, PharmD, MS, PhD^{3,4}, Sapna K. Deo, PhD^{3,4}, Kenneth Fent, PhD, CIH⁵, Miriam Calkins, PhD, MS⁵, Jefferey L. Burgess, MD, MS, MPH⁶, Erin N. Kobetz, PhD, MPH^{1,2,4}

¹Department of Public Health Sciences, University of Miami, Miller School of Medicine, Miami, FL, USA

²Department of Medicine, University of Miami, Miller School of Medicine, Miami, FL, USA

³Department of Biochemistry and Molecular Biology, University of Miami, Miller School of Medicine, Miami, FL, USA

⁴Department of Sylvester Comprehensive Cancer Center, University of Miami, Miller School of Medicine, Miami, FL, USA

⁵Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health (NIOSH), Cincinnati, OH, USA

⁶Mel and Enid Zuckerman College of Public Health, The University of Arizona, Tucson, AZ, USA.

To the Editor:

The U.S. Navy developed Aqueous Film Forming Foam (AFFF) in the 1960s containing per- and polyfluoroalkyl substances (PFAS) and synthetic foaming surfactants that allowed for improved firefighter safety, particularly for firefighters involved in liquid fuel and crash fire rescue operations and those using nozzles during structural firefighting.¹ PFAS are also commonly used to water and stain-proof specific textiles such as the materials

Corresponding Author: Alberto J. Caban-Martinez, DO, PhD, MPH, Department of Public Health Sciences, Leonard M. Miller School of Medicine, University of Miami, Miller School of Medicine, 1120 N.W. 14th Street, Room #1025, Miami, Florida 33136, Phone: (305) 243-7565 | Fax: (305) 243-3651, acaban@med.miami.edu.

Institution at which the work was performed: Department of Public Health Sciences, Leonard M. Miller School of Medicine, University of Miami, Miller School of Medicine, 1120 N.W. 14th Street, Room #1025, Miami, Florida 33136

Authors' contributions: AJCM, NSS, PLF, KG, KS, MC, JB, and EK, conceived the study, participated in its design, coordination, performed statistical analyses, and co-drafted the manuscript. AJCM, NSS, PLF, KG, and KS collected field data, entered study data, assisted in data analysis, and interpretation of stud results. AJCM, NSS, PLF, KG, KS, DJL, SD, SKD, KF, MC, JB, and EK performed statistical analysis, interpreted study results and helped with the manuscript draft. All authors read, revised, and approved the final manuscript

Institution and Ethics approval and informed consent: This study research protocol was reviewed and approved by the University's Institutional Review Board (#20170787).

Disclosures: The authors declare no potential conflicts of interest.

Publisher's Disclaimer: Disclaimers: The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention. Mention of trade names and commercial products does not constitute endorsement or recommendation for use by NIOSH.

used to construct firefighter turnout gear.^{2,3} AFFFs have evolved to include a number of different formulations (including AFFFs that meet Military Specifications (MILSPEC), alcohol-resistant aqueous film-forming foam (AR-AFFF), etc.) that often, but not always, rely on PFAS compounds for proper foam performance. AFFFs used to fight Class B petroleum fires have historically contained longer chain PFAS such as perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)^{4–6} which are associated with adverse health outcomes.^{7,8} PFOS use in new AFFFs and other products were banned in the European Union in 2011 and Canada in 2013, and major U.S. manufacturers of AFFF indicated they would no longer produce PFOA-based fluorosurfactant foams after 2015.^{9,10} However, AFFF typically have a long shelf life of up to 25 years.¹¹ Additionally, current fluorinated AFFF contain shorter chain PFAS chemicals with less information on potential toxicity. Little is known about AFFF use and knowledge of legacy and current PFOA and PFOS chemicals among firefighters.

Some PFAS are associated with cancer, such that in 2016 the International Agency for Research on Cancer (IARC) classified PFOA as Group 2B indicating they are possibly carcinogenic to humans, based on limited evidence in humans that it can cause testicular and kidney cancer, and limited evidence in lab animals.^{7,12,13} Since the IARC designation, some additional cancer studies have suggested an increased risk of testicular cancer with increased PFOA exposure, while others have suggested possible links to thyroid cancer and kidney cancer.^{14–16} Epidemiologic studies have associated firefighting with an increased risk for a variety of cancers, including testicular and kidney cancer, among others, but the exposures responsible for these increased rates have not been identified.^{17,18} To date there is limited knowledge about the use of PFOA/PFOS containing foams within the U.S. fire service. This is of greater concern in airport facilities where AFFF foams that meet the Military Specification (MILSPEC) are required for use on Federal Aviation Administration (FAA) regulated airports and military airports.

Concerns about AFFF use and PFOA/PFOS chemical exposure center around the potential negative impact on firefighter health as well as on the environment from the discharge of foam solutions generated from the combination of water and foam concentrate. When PFOA/PFOS-containing AFFF are repeatedly used in one location over an extended period of time (such as in firefighter training facilities), the PFOA/PFOS can move from the foam substance into soil and then into groundwater.^{19–21} The amount of PFOA/PFOS that enter the groundwater depends on the type and amount of AFFF used, where it was used, the type of soil and other factors. At firefighter training facilities, where AFFF is often repeated discharged onto concrete training areas, long-term release of PFAS into the surrounding soil and water from the concrete is anticipated to occur on the order of decades.²² As an initial first step to study the concern about AFFF use and PFOA/PFOS knowledge, we assess the awareness and knowledge of perfluorinated chemicals and AFFF use among Florida fire departments.

MATERIALS AND METHODS

Study Design and Participant Recruitment

A cross-sectional study design was used to collect health and safety survey information from 142 firefighters attending the Florida Fire Chiefs' Association Health and Safety Conference held on December 10–12, 2018 in Orlando, Florida. Our research team distributed paper-surveys during the conference initially by placing a blank survey at each seat in the main conference ballroom, and through distribution at a dedicated exhibitor table located in the immediate entry/egress of the main conference meeting room. The annual Florida fire chiefs meeting is open to all Florida firefighters and is largely comprised of attendees from senior-level positions within Florida fire services, including fire chiefs, assistant chiefs, fire prevention officers, shift officers, individual firefighters/paramedics, health and safety officers and fire investigators. To encourage completion of the survey, conference organizers made an announcement to attendees on the main conference stage twice a day. A t-shirt with the research team's Firefighter Cancer Initiative logo was provided to each firefighter that completed the survey. A verbal consent process was used given the anonymous nature of the survey, where the first page of the survey contained the consent information; firefighters were provided a copy upon request. A total of 11 surveys were removed from the final analytic dataset used in this study given three surveys were from firefighters outside the State of Florida and eight survey respondents indicated they did not know if their department used AFFF, the main study outcome variable.

Survey Instrument and Study Measures

We designed a 97-item survey instrument, Firefighter Assessment of Strategies Trumping Cancer (FAST-C), with the goal of documenting fire department and individual firefighter-level decontamination practices among Florida firefighters. Survey measures were adapted from previously validated or administered surveys of occupational safety and health and worksite health promotion.^{23–25} New measures assessing awareness and knowledge of PFOA/PFOS and AFFF use were adapted from other occupational health and safety measures^{26,27} and assessed for content and face validity with Florida fighters prior to survey administration.

Aqueous Film-Forming Foams (AFFF) Use and Knowledge Measures.—We asked survey respondents “Does your fire service department use Aqueous Film-Forming Foams (AFFFs)?” with response options “Yes, No, or Don't Know”. We assessed the frequency of AFFF use with the question “Approximately how many times each year does your fire department answer calls in which you need to use Aqueous Film-Forming Foams (AFFFs)?” with response options “0–1, 2–5, 6–10, 11–15, 16–20, 20+, or Don't Know”. Measures assessing AFFF brand, formulation, PFOA/PFOS components, and decontamination post-AFFF fire suppression use were assessed with the following questions all with “Yes, No, or Don't Know” response options: “Do you know the brand or manufacturer of the AFFF that your fire department currently uses?”; “If your department uses/stores AFFF, are you aware if it is the original formulation or the newest formulation?”; “Do you know if the AFFF, which you currently use, has PFOA or PFOS as a main component?”; and “After incidents where AFFF's are employed, do you and others in your

fire department exchange or wash your gear?”. Lastly, we assessed the firefighter’s interest in following current trade profession discussion on AFFF and PFOA on turnout gear with the two questions: “Do you follow the current discussion about AFFF”; and “Do you follow the current discussion about PFOA and turnout gear” with response options “Yes, No, or Don’t Know”.

Organizational Characteristics.—We evaluated four organizational characteristics of the fire department: workforce size, total health and safety officers, fire department geographic location, and employment type. Workforce size was defined as the number of active firefighters (non-administrative positions) employed within the fire department. Total health and safety officers were defined as the total number of health and safety officers employed within the fire department, where the officer is a firefighter whose job function includes the health and safety of their fire department workforce. The geographic location where the fire department is located within Florida was operationalized as rural area only, urban area only, suburban area only and mixed area (i.e., urban, suburban and rural). Employment type was a measure assessing if the fire department was comprised of career firefighters only, volunteer only, or mixed career/volunteer.

Data Analysis

Descriptives, bivariates, and correlations.—We conducted exploratory statistical data analyses for continuous variables, expressed as mean with its standard error, and for categorical variables, represented as frequency and percent of the sample. We examined the main outcome of use of AFFF stratified by workforce size, total health and safety officers, fire department geographic location, and employment type. For categorical data, we conducted chi-square analyses to compare groups, and used t-tests for continuous data. We used a Levene’s test of homogeneity of variance across groups for each variable.²⁸ We used Spearman product-moment correlation to examine the relationship between workforce size, number of health and safety officers and frequency of AFFF use. The significance level was set at 5%. All statistical analyses were done on SPSS v21 (IBM Corp, Armonk, NY). This study research protocol was reviewed and approved by the University’s Institutional Review Board.

RESULTS

A total of 131 Florida firefighters representing 67 Florida fire departments (13.7% of all Florida fire departments) completed the survey. Respondents were predominately in the 36 to 45 years old age group (36.7%), male (85.4%), career firefighters (96.9%) and current rank of chief / battalion chief / division chief (35.4%, Table 1). Over 80% of survey respondents indicated their fire departments use AFFF as part of their fire suppression activities. Fire departments using AFFF were predominately an all career workforce (93.1% vs 76.9%, $p=.015$) and had no health and safety officers on staff (7.1% vs. 0.0%, $p=.050$) compared to fire departments not using AFFF.

A third (33.3%) of fire departments using AFFF indicated that they used it on two to five calls per year and almost 17% of departments used it greater than 16 times per year (Figure 1). Departments that used AFFF greater than 16 times per year were predominately

medium-sized departments (101 to 500 firefighters, 50.0%), had one health and safety officer (60.0%), and were located in an urban area (43.8%). Among fire departments that use AFFF, there were more small- (1–100 firefighters, 48.0%) and medium-sized (101 to 500 firefighters, 43.1%) than large-sized fire departments (8.8%). Among all respondents, 24.5% knew the brand or manufacturer of the AFFF, 17.6% were aware of the original or newest formulation, 4.6% were aware that their AFFF brand had PFOA or PFOS as a main component, and 48.0% of firefighters indicated their department members wash their turnout gear after incidents where AFFF was employed. Survey respondents reported that 30.0% of them follow the current professional firefighter trade discussion about AFFF use, and 33.8% follow discussions on the presence of PFOA on turnout gear.

Among firefighters who reported on the brand of AFFF used by their department, the types include: Universal Gold 1%/3% AR-AFFF (37.5%), FireAde® Class A foam (20.8%), Ansul-A™ Municipal Class Fire (12.5%), Ansulite™ 1×3 F-601A AR-AFFF (12.5%), CHEMGUARD C3B 3% AFFF (8.3%), Fire Aide / National Gold (4.2%), and FireAde® 2000 AR-AFFF (4.2%). The annual frequency of using AFFF for fire suppression had a moderate, positive correlation to the number of active firefighters in the department ($r=.405$; $p<.001$). We also found that annual AFFF use has a small/moderate, positive correlation to the total number of health and safety officers employed in the fire department ($r=.288$; $p=.003$). A sensitivity analysis to assess agreement between firefighters responding for the same fire department (approximately 2 firefighters per department) yielded near perfect agreement ($\kappa = .98$) in the responses to the AFFF use, knowledge and organizational characteristics measures.

DISCUSSION

This is the first study to survey frequency and use of AFFF in fire departments. A large proportion of participating Florida fire departments currently use AFFF during fire suppression activities, with the most frequent use of AFFF occurring two to five calls per year for specific fire suppression calls. Fire departments with heavy AFFF use (16 or more times per years) were predominately medium-sized departments (101 to 500 firefighters) with at least one health and safety officer on staff, and located in an urban geographic area. The vast majority of firefighting foam that is currently in stock or in service in the United States is AFFF or AR-AFFF, with many AFFF products containing PFAS.^{10,27,29} We found among Florida firefighters who recalled their department's brand of AFFF, approximately 46% used contemporary AFFF products. AFFF products and other fluorinated foams are of concern because they contain PFAS. This raises the need for further research in conducting national surveillance of the types and frequency of AFFF used by U.S. fire departments, as well as to conduct continuous biomonitoring of PFAS chemical exposures in firefighters.

Firefighter respondents in our study indicated low awareness of AFFF health effects and the relationship to perfluorinated chemicals. Some PFAS pose a risk to groundwater and surface water quality, but they are also highly persistent chemicals, that may be mobile within the work environment, and bioaccumulate in organisms.²⁹ Numerous animal and human studies have evaluated both non-cancer and cancer health effects related to exposure to a limited number of PFAS, including PFOA and PFOS.^{30,31} Little to no health-effects

data are available for many PFAS. For example, Rotander et al. (2015) evaluated firefighter blood levels for eleven PFAS compounds and reported elevated concentrations for PFOS and Perfluorohexane sulfonic acid and its salts (PFHxS) compared with the general population, however they did not observe any association with studied health effects.³² One study examining PFOS and PFHxS levels in veteran firefighters working at different fire stations in San Francisco as part of a longitudinal biomonitoring program concluded that firefighters who used personal protective equipment (PPE) have lower levels of PFAS in the serum likely due to PPE use.³

Fire departments that used AFFF in this study were more likely to have no health and safety officers than departments that did not use AFFF. In addition, while it is currently not known if washing turnout gear removes PFAS compounds from gear, this study found that less than half of the departments that used AFFF in specific fire incident responses reported washing their turnout gear after using AFFF. It may be possible that health and safety officers play a unique role in educating and training their fire department's workforce on AFFF use and possible health effects. In a recent firefighter health promotion intervention, the use of an expert-led sleep program that included health and safety officers had the greatest reach and effectiveness in educating and screening firefighters.³³ Health and safety officers can play a critical role as champions within their fire service to further document the use, exposures and health effects of AFFF where there is currently limited understanding of AFFF use. Given the low knowledge and awareness of PFOA/PFOS, researchers should consider exploring how health and safety officers in a fire service could educate and train on AFFF use.

Data collected from this study was self-reported and subject to recall bias from respondent firefighters. The sample size is relatively small but included survey respondents from 67 departments which captures close to 14% of the Florida fire departments. In addition, sensitivity analyses of Florida fire departments participating in this survey were similar in geographic location (i.e., rural, suburban, urban) compared to those departments who did not participate in the survey. A similar sensitivity analysis of survey response data among firefighters from the same fire department found near perfect agreement for survey items about AFFF use, knowledge and organizational characteristics. Despite these limitations, this study sheds new light on the practice and type of AFFFs use in Florida fire departments. It is the first to document awareness of and knowledge in the types of AFFF and PFOA/PFOS chemicals associated with foam use using survey data collected largely from the leadership of various Florida fire departments. This pilot survey project also identifies a potential approach in using fire department health and safety officers as a vehicle to educate, train, and possibly surveil for AFFF use and exposures in fire departments.

This study identified relatively low awareness and knowledge of AFFF use and PFOA/PFOS chemicals in Florida fire departments. There is an urgent need to conduct national surveillance for AFFF use across U.S. fire departments. Surveillance should include point sources of AFFF exposure (i.e., fire suppression, training activities, etc.) that may be impacting firefighter health and safety. Biomonitoring activities among fire departments that use AFFF and AR-AFFF could shed further light into any acute or chronic health effects experienced by AFFF exposure. As we found low levels of awareness and knowledge of

PFOA/PFOS chemicals in our sample of Florida fighters, further education and training in the proper use of AFFF is needed. Lastly, the number of health and safety officers, regardless of fire department workforce sizes appear to be associated with AFFF use, suggesting these officers may play a unique role in educating firefighters on AFFF and PFOA/PFOS exposures.

Acknowledgements:

The authors thank Mrs. Debbie Pringle from the Coral Springs - Parkland Fire Department for her support in coordinating our research team's attendance at the Florida Fire Chiefs Health and Safety Conference. They also thank all the Florida firefighters who took the time to participate in the research study.

Funding:

This work was supported by State of Florida appropriation #2382A to the University of Miami (UM) Sylvester Comprehensive Cancer Center.

REFERENCES

1. Anderson RH, Long GC, Porter RC, Anderson JK. Occurrence of select perfluoroalkyl substances at US Air Force aqueous film-forming foam release sites other than fire-training areas: Field-validation of critical fate and transport properties. *Chemosphere* 2016;150:678–685. [PubMed: 26786021]
2. Dobraca D, Israel L, McNeel S, et al. Biomonitoring in California firefighters: Metals and perfluorinated chemicals. *Journal of occupational and environmental medicine* 2015;57(1):88. [PubMed: 25563545]
3. Shaw SD, Berger ML, Harris JH, et al. Persistent organic pollutants including polychlorinated and polybrominated dibenzo-p-dioxins and dibenzofurans in firefighters from Northern California. *Chemosphere* 2013;91(10):1386–1394. [PubMed: 23395527]
4. Giesy JP, Kannan K. Peer reviewed: perfluorochemical surfactants in the environment In: ACS Publications; 2002.
5. Moody CA, Martin JW, Kwan WC, Muir DC, Mabury SA. Monitoring perfluorinated surfactants in biota and surface water samples following an accidental release of fire-fighting foam into Etobicoke Creek. *Environmental science & technology* 2002;36(4):545–551. [PubMed: 11883418]
6. Place BJ, Field JA. Identification of novel fluorochemicals in aqueous film-forming foams used by the US military. *Environmental science & technology* 2012;46(13):7120–7127. [PubMed: 22681548]
7. IARC. IARC monographs on the evaluation of carcinogenic risks to humans. Ingested nitrate and nitrite, and cyanobacterial peptide toxins. IARC monographs on the evaluation of carcinogenic risks to humans 2010;94:v. [PubMed: 21141240]
8. ATSDR. Draft Toxicological Profile for Perfluoroalkyls 8–21-2017 2018.
9. Sontake A, Wagh S. The phase-out of perfluorooctane sulfonate (PFOS) and the global future of aqueous film forming foam (AFFF), innovations in fire Fighting foam. *Fire Engineer* 2014;39(3):19–23.
10. Seow J. Fire fighting foams with perfluorochemicals—environmental review Hemming Information Services; 2013.
11. Thalheimer A, McConney L, Kalinovich I, et al. Use and potential impacts of AFFF containing PFASs at airports. National Academies of Sciences, Engineering, and Medicine ISBN 978–0–309–44638–9.
12. Johnson PI, Sutton P, Atchley DS, et al. The Navigation Guide—evidence-based medicine meets environmental health: systematic review of human evidence for PFOA effects on fetal growth. *Environmental health perspectives* 2014;122(10):1028–1039. [PubMed: 24968388]
13. Kudo N, Kawashima Y. Toxicity and toxicokinetics of perfluorooctanoic acid in humans and animals. *The Journal of toxicological sciences* 2003;28(2):49–57. [PubMed: 12820537]

14. Barry V, Winquist A, Steenland K. Perfluorooctanoic acid (PFOA) exposures and incident cancers among adults living near a chemical plant. *Environmental health perspectives* 2013;121(11–12):1313. [PubMed: 24007715]
15. Kim MJ, Moon S, Oh B-C, et al. Association between perfluoroalkyl substances exposure and thyroid function in adults: A meta-analysis. *PloS one* 2018;13(5):e0197244. [PubMed: 29746532]
16. Biegel LB, Hurtt ME, Frame SR, O'connor JC, Cook JC. Mechanisms of extrahepatic tumor induction by peroxisome proliferators in male CD rats. *Toxicological Sciences* 2001;60(1):44–55. [PubMed: 11222872]
17. LeMasters GK, Genaidy AM, Succop P, et al. Cancer risk among firefighters: a review and meta-analysis of 32 studies. *Journal of occupational and environmental medicine* 2006;48(11):1189–1202. [PubMed: 17099456]
18. Daniels RD, Kubale TL, Yiin JH, et al. Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950–2009). *Occup Environ Med* 2014;71(6):388–397. [PubMed: 24142974]
19. Kärrman A, Elgh-Dalgreen K, Lafossas C, Møskeland T. Environmental levels and distribution of structural isomers of perfluoroalkyl acids after aqueous fire-fighting foam (AFFF) contamination. *Environ Chem* 2011;8(4):372–380.
20. Zareitalabad P, Siemens J, Hamer M, Amelung W. Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in surface waters, sediments, soils and wastewater—A review on concentrations and distribution coefficients. *Chemosphere* 2013;91(6):725–732. [PubMed: 23498059]
21. Yamashita N, Kannan K, Taniyasu S, et al. Environmental contamination by perfluorinated carboxylates and sulfonates following the use of fire-fighting foam in Tomakomai, Japan. *Organohalogen Compounds* 2004;66:4063–4068.
22. Baduel C, Paxman CJ, Mueller JF. Perfluoroalkyl substances in a firefighting training ground (FTG), distribution and potential future release. *Journal of hazardous materials* 2015;296:46–53. [PubMed: 25966923]
23. Linnan L, Bowling M, Childress J, et al. Results of the 2004 national worksite health promotion survey. *American Journal of Public Health* 2008;98(8):1503–1509. [PubMed: 18048790]
24. Barbeau E, Roelofs C, Youngstrom R, Sorensen G, Stoddard A, LaMontagne AD. Assessment of occupational safety and health programs in small businesses. *American journal of industrial medicine* 2004;45(4):371–379. [PubMed: 15029570]
25. McLellan DL, Cabán-Martinez AJ, Nelson CC, et al. Organizational characteristics influence implementation of worksite health protection and promotion programs: Evidence from smaller businesses. *Journal of occupational and environmental medicine/American College of Occupational and Environmental Medicine* 2015;57(9):1009.
26. Smith BW, Ortiz JA, Steffen LE, et al. Mindfulness is associated with fewer PTSD symptoms, depressive symptoms, physical symptoms, and alcohol problems in urban firefighters. *Journal of Consulting and Clinical Psychology* 2011;79(5):613. [PubMed: 21875175]
27. Carlson LE, Brown KW. Validation of the Mindful Attention Awareness Scale in a cancer population. *Journal of psychosomatic research* 2005;58(1):29–33. [PubMed: 15771867]
28. Rosner B. *Fundamentals of biostatistics* Nelson Education; 2015.
29. D'Agostino LA, Mabury SA. Identification of novel fluorinated surfactants in aqueous film forming foams and commercial surfactant concentrates. *Environmental science & technology* 2013;48(1):121–129. [PubMed: 24256061]
30. Exner M, Färber H. Perfluorinated surfactants in surface and drinking waters (9 pp). *Environmental Science and Pollution Research* 2006;13(5):299–307. [PubMed: 17067024]
31. Domingo JL. Health risks of dietary exposure to perfluorinated compounds. *Environment international* 2012;40:187–195. [PubMed: 21864910]
32. Rotander A, Toms L-ML, Aylward L, Kay M, Mueller JF. Elevated levels of PFOS and PFHxS in firefighters exposed to aqueous film forming foam (AFFF). *Environment international* 2015;82:28–34. [PubMed: 26001497]

33. Barger LK, O'Brien CS, Rajaratnam SM, et al. Implementing a sleep health education and sleep disorders screening program in fire departments: A comparison of methodology. *Journal of occupational and environmental medicine* 2016;58(6):601. [PubMed: 27035103]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

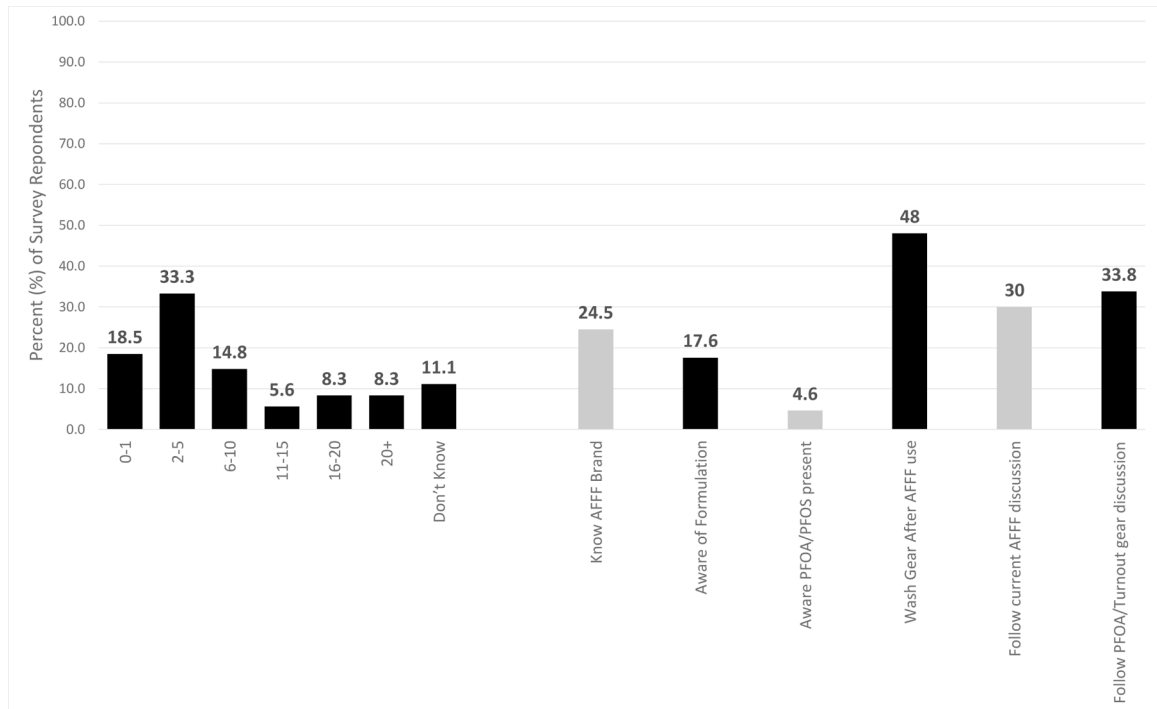


Figure 1.
Frequency of AFFF use and Knowledge/Awareness of AFFF/PFOS Issues among Florida Firefighters

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 1.

Florida firefighter and fire department characteristics stratified by Aqueous Film-Forming Foams (AFFF) use among attendees of the 2018 Florida Fire Chiefs' Association Health and Safety Conference

Characteristics	Total Sample N (%)	Use of AFFF N (%)	No Use of AFFF N (%)	p-value
Total	131 (100.0)	105 (80.2)	26 (19.8)	
Respondent Characteristics				
Age				
26–35 year olds	16 (12.5)	11 (10.8)	5 (19.2)	.227
36–45 year olds	47 (36.7)	41 (40.2)	6 (23.1)	
46–55 year olds	46 (35.9)	37 (36.3)	9 (34.6)	
55 years and older	19 (14.8)	13 (12.7)	6 (23.1)	
Gender				
Male	111 (85.4)	92 (87.6)	19 (76.0)	.139
Female	19 (14.6)	13 (12.4)	6 (24.0)	
Firefighter Type				
Volunteer	4 (3.1)	2 (1.9)	2 (7.7)	.125
Career	127(96.9)	103 (98.1)	24 (92.3)	
Current Rank				
Chief / Battalion Chief / Division Chief	45 (35.4)	34 (33.7)	11 (42.3)	.676
Fire Prevention	8 (6.3)	7 (6.9)	1 (3.8)	
Shift Officer	24 (18.9)	19 (18.8)	5 (19.2)	
Firefighter / Paramedic	24 (18.9)	18 (17.8)	6 (23.1)	
Health and Safety Officer	26 (20.5)	23 (22.8)	3 (11.5)	
Department Characteristics				
Department Workforce Size				
Small (1–100 Firefighters)	57 (44.5)	49 (48.0)	8 (30.8)	.233
Medium (101–500 Firefighters)	60 (46.9)	44 (43.1)	16 (61.5)	
Large (>500 Firefighters)	11 (8.6)	9 (8.8)	2 (7.7)	
Total Health & Safety Officers				
None	7 (5.6)	7 (7.1)	0 (0.0)	.050
One Officer	76 (60.8)	55 (55.6)	21 (80.8)	
Two or More Officers	42 (33.6)	37 (37.4)	5 (19.2)	
Department Geographic Location				
Rural Area Only	20 (15.7)	12 (11.9)	8 (30.8)	.107
Urban Area Only	38 (29.9)	33 (32.7)	5 (19.2)	
Suburban Area Only	23 (18.1)	19 (18.8)	4 (15.4)	
Mixed Area (Urban/Sub/Rural)	46 (36.2)	37 (36.6)	9 (34.6)	
Department Employment Type				
All Career	115 (89.8)	95 (93.1)	20 (76.9)	.015

Characteristics	Total Sample N (%)	Use of AFFF N (%)	No Use of AFFF N (%)	p-value
Mixed Career and Volunteer	13 (10.2)	7 (6.9)	6 (23.1)	

[†]Differences in sub-total population sample due to item non-response or missing.

*P-values are calculated from chi-square test for association for categorical variables

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript