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Contrasting safety attitudes, behaviors and practices in US and UK firefighters

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ABSTRACT

Firefighters across the world face hazardous work environments. While the incidents encountered by firefighters are broadly similar in the US and UK, the rate of line of duty deaths is much higher in the US than in the UK. Our research sought to characterize firefighting cultures (e.g., practices, behaviors, and attitudes) as one potential source of differences in line of duty deaths in the US and UK. 1123 incident commanders (442 from the US and 681 from the UK) completed a survey that examined five domains of incident command: Demographic and employment information; Characteristics of Fire Departments/Services; Experience, training and certification; Decision-making and practices; and Safety/Operational culture. The results revealed marked differences across these domains, with some confirming known differences in organizational structures and recruitment across US and UK, but others establishing differences in operational/safety culture, behaviors and practices that have the potential to contribute to firefighter and public safety.

1. Introduction

Occupational safety and health management traditionally focuses on making the workplace as safe as possible for the worker (Hofmann et al., 2017). However, for firefighters, the work environment during operational incidents has been regarded historically as inherently dangerous (Hardison and Gray, 2021), and the next "workplace" could be any number of locations in a fire service's response area. It is often impossible for firefighters to control or avoid all hazards at an incident scene prior to engaging in time-sensitive operations focused on preserving life, property, and the environment. Additionally, during interior structural firefighting, firefighters must rely on personal protective equipment, the least effective control in the hierarchy of hazard controls (Horn et al., 2022), such as breathing apparatus and structural firefighting ensembles. Furthermore, to accomplish strategic objectives, and in contrast to most occupations, firefighters are expected to "fight" and directly engage hazards (Kunadharaju et al., 2011).

The term "safety culture" is often used in the context of safety–critical industries such as nuclear power (Morrow et al., 2014), commercial aviation (Lawrenson and Braithwaite, 2018), and oil and gas (Iqbal et al., 2019). It was first introduced in a report on the 1986 Chornobyl nuclear power catastrophe (Orikpete and Ewim, 2024) and is also used in the context of cross cultural studies of these safety–critical industries (Liao, 2015; Noort et al., 2016). However, the term is perhaps less appropriate in the context of an expectation that firefighters will operate routinely in conditions classified as immediately dangerous to life and health (Abulhassan and DeMoulin, 2017): Given the fact that firefighting has specific characteristics (Flin, 1996), with personnel willing to place the lives of the public above their own (Scarborough, 2017), the term "operational culture" is perhaps more appropriate.

Fire and rescue services across the world, through the decisions of their personnel, attempt to balance conflicting goals of firefighter safety and operational effectiveness to provide a vital public service. Despite improved building codes, the increased prevalence of sprinkler-protected buildings, and the prospect of firefighting robots (Sanfilippo et al., 2017), firefighters throughout the world are likely to have to continue to perform manual interior structural firefighting for decades to come. This activity, described as "ultra-hazardous" by the US Occupational Safety and Health Administration (1999), sometimes results in firefighters being injured or killed. When a firefighter dies in the line of duty, a regulatory body will likely investigate to understand the circumstances that resulted in the unintended outcome, identify ways to reduce the risk of a similar occurrence from happening again, and determine if a breach of occupational safety and health law occurred (Illinois Department of Labor, 2022). Indeed a comparison of line of duty deaths across different nations suggests that they are not an inevitable

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consequence of the nature of the activities that firefighters undertake.

Given the fact that firefighters in the United States (US) and United Kingdom (UK) face broadly similar hazards, comparison of their rates of line of duty deaths is potentially informative. Moreover, line of duty deaths are recorded across these nations in a way that injuries sustained in the line of duty are less consistently recorded. The State of Illinois was chosen as a point of comparison with the UK. It has a population of 12.5 million (United States Census, 2022), a land area of 149,995 square kilometres (United States Census, 2010) and 1,082 registered fire departments with 39,231 operational firefighters (United States Fire Administration, 2022). The country of England in the United Kingdom has a population of 57.1 million (United Kingdom Office of National Statistics, 2023), a land area of 130,460 square kilometres (United Kingdom Department for Levelling Up, Housing & Communities, 2022), and 44 fire and rescue services (United Kingdom HM Government, 2022) with 31,064 operational firefighters (United Kingdom Home Office, 2022).

From 2008 through to 2023, the State of Illinois suffered 25 line of duty deaths, a rate of 6.4 deaths per 10,000 firefighters, with 16 attributed to fire incidents. During the same period, England suffered four line of duty deaths, a rate of 1.3 deaths per 10,000 firefighters, with three attributed to fire incidents. Why does the State of Illinois, as a representative state, have a firefighter line of duty death rate over four times higher than the country of England? The aim of this study is to begin to characterize differences between fire services, particularly incident commanders, in the US and UK that potentially contribute to different rates of line of duty deaths (and injuries). To do so, we developed a bespoke survey: The International Fire Service Incident Command Survey (IFSICS). This survey included an item about line of duty serious injuries and deaths: *Have you been incident commander at a structure fire where a firefighter was seriously injured (no longer able to work as a firefighter) or killed?* This type of life-changing incident has been described as a “portal experience” that can transform safety attitudes (Holgate and Clancy, 2009). Consistent with the comparison of line of duty deaths generated from analysis of archival records (see above), 41 of the final 442 US participants (i.e., 9 %) endorsed this item and only 18 of the final 681 UK participants (i.e., 3 %) did so (Fisher’s test, $p < 0.0001$). The remaining components of the survey examined the similarities and differences between Incident Commander safety attitudes, behaviors and practices between the US and UK. This is the first analysis of its kind, and while some of the organizational similarities and differences between firefighters in the US and UK are known, the nature and scale of other differences are not. These differences can function as a guide to better understand and address safety concerns in US and UK firefighters, whether or not they reflect the intertwined nature of this industry with broader cultural differences between the US and UK (see Noort et al., 2016; Reader et al., 2015; Yorio et al., 2019). As we will show, there are significant differences between safety attitudes, behaviors and practices in the US and UK, and while some reflect obvious structural and legislative differences between the two nations, others appear to reflect qualitatively different approaches to shared operational issues.

2. Methods

This study used a bespoke survey to investigate incident commander and fire service characteristics, safety-related attitudes, practices, and behaviors. It was specifically designed to function in a cross-cultural context (see Section 2.5). Participant recruitment for the study was open to fire service incident commanders from any country, but was focused on and designed for the United States and United Kingdom. To ensure participants were adequately qualified to respond to these questions, the survey introduction emphasized that participants must “serve as an incident commander at building fires involving interior/offensive firefighting.” An online survey was chosen due to the necessity to collect a large data set involving international participants. The survey could be taken using a computer or smartphone for convenience and accessibility, and was the most cost-efficient method.

Prior to data collection, participants were informed about the aim of the research, the expected time commitment to complete the survey, the requirements to participate, and how the data would be used and retained. Informed consent was obtained prior to beginning the survey and every participant could opt out of completing the survey without further explanation. No participant personal data, including internet protocol (IP) address and location, were collected, which meant that the UK General Data Protection Regulation did not apply. In the absence of identifying information, Qualtrics software assigned a unique randomly generated “responseID” to each anonymized survey response for referencing purposes. The research was approved by the School of Psychology Ethics Committee, Cardiff University.

2.1. IFSICS online survey

IFSICS was developed to obtain information about the current practices, behaviors, and attitudes of fire service incident commanders to gain further understanding cross cultural differences in safety/operational culture. It is broadly based on the Flight Management Attitudes & Safety Survey, one of the most widely used safety culture survey instruments for commercial airline pilots (FMASS; Sexton et al., 2001). FMASS has been used as the foundation for developing safety culture surveys in other domains including healthcare (Bartonickova et al., 2021). Unlike the UK fire and rescue service, which was subject to extensive restructuring and consolidation due to World War II, most US fire departments operate at the local government level and generally are much smaller than services in the UK. One difference between FMASS and IFSICS was the exclusion of items in IFSICS that involved participants rating the management in their organization, because in very small fire departments the separation between management staff and operational personnel is not distinct, rendering the items related to management ambiguous and the response subject to potential bias.

IFSICS has 70 items (see Appendix A) involving five principal domains.

1. Demographic and employment information (six items). Participants were asked about their age, gender, education, country of residence, employment status, and length of employment in the fire service

2. Characteristics of fire departments/services (17 items). Participants were asked about the type of fire department/service they worked for, the size of the department/service, if the department/service has certain written policies, the frequency of certain types of training provided by the department/service, and the frequency of evaluations for incident commanders

3. Incident commander experience, certification, training and evaluation (five items). Participants were asked about the number of years they have served as an incident commander, how many building fires they have attended as an incident commander, whether they have experienced a mayday/firefighter emergency as an incident commander, whether they have experienced a serious firefighter injury or death as an incident commander, and if they are certified as an incident commander or fire officer

4. Incident command decision-making and practices (20 items). Participants were asked to make decisions as an incident commander in three scenarios involving building fires (see Fig. 1). Another set of questions asked participants how often they perform certain practices when serving as an incident commander at a building fire

5. Operational/Safety culture (17 items). Participants were asked to provide their level of agreement with statements across four subcategories involving rule following and procedures, safety attitudes, stress and resilience, and training.

Five additional questions included an optional open-ended item, two items about familiarity with the concepts of human factors and psychological safety, one item about the perception of firefighting as an art

Fig. 1. The photograph used in the context of how the nature of the strategy deployed (fully defensive, with a very low risk to firefighters, or fully offensive, with a very high risk to firefighters) depended on whether there were known to be no occupants inside, its occupation status was unknown, or it was known to be occupied.

versus a science, and one that served as an attention check (Berinsky et al., 2013). Responses to these items will not be analysed here, but are available from the corresponding author on request.

The survey was created using Qualtrics software (2022) and was designed to be completed in approximately 10 min to increase response rate and reduce answering fatigue (Sammut et al., 2021). The development of the survey included a multifaceted approach to ensuring that the items were (equally) suitable for US and UK firefighters (cf. Boer et al., 2018; Reader et al., 2015). The survey was developed by the authors with extensive US and UK experience: One who is an active UK fire service incident commander and Chief Fire Officer (SRC-H), one who is a retired UK fire service incident commander and was a Borough Commander (PCB), and one who is a retired US fire service incident commander and was a Fire Chief (EK). In a similar way to a recent survey on health and safety management systems (Okonkwo and Wium, 2023), a draft survey was provided to senior US and UK fire service personnel for feedback on format, length, terminology, and understanding. Additionally, EK provided the draft survey to US and UK operational incident commanders in-person to generate additional feedback to ensure that their perception of the items were aligned with their intended meaning. This resulted in further refinement of the survey, including modification of some of the terms used, and the addition of side-by-side terms in a US/UK terminology format (Buil et al., 2012). For example, US fire services use the term “mayday” and UK fire services use the term “firefighter emergency” to denote a firefighter in distress, and this item was presented as “mayday/firefighter emergency” in the survey. Lastly, items that were either too complex or led to misunderstanding by review personnel were removed. The response formats to items (e.g., categorical or continuous) varied according to the nature of the information requested. Most survey questions featured Likert scales (e.g. “How often do you…” and “Express your level of agreement for…”). One optional question allowed respondents to provide a written response.

2.1.1. *Online survey sampling procedures and analysis*

Participants were recruited through non-probability volunteer, snowball, and convenience sampling. The study and the associated anonymous survey link were advertised and distributed through online platforms, social media sites, and professional networks to reach fire service incident commanders. In addition, various state and national level fire service organizations in the US were notified of the survey via e-mail for distribution to their members. The survey was also supported through distribution from the UK National Fire Chiefs Council, a non-governmental association. Significant effort was directed at obtaining participation from incident commanders with different employment types including career/wholetime, paid-on-call/retained, and volunteer, to provide a representative sample.

The survey was conducted anonymously online and was open from 13 December 2022 to 26 May 2023. A total of 2,226 responses were received from 37 countries representing every continent except Antarctica. 862 responses were incomplete and discarded. After excluding responses that failed a direct-screening instructed-item attention check (DeSimone et al., 2015), and responses from countries with a small sample size ($n < 50$), the data from 1123 respondents was processed: 442 US participants (representing 48 of 50 states) and 681 UK participants.

3. Results

3.1. *Demographic and employment information*

Table 1 provides an overview of demographic and employment information of the US and UK participants. The vast majority of participants from both the US and UK were male. The age of US participants (mean = 48.75 years), was higher than that of the UK participants (mean = 44.86; $t(1121) = 6.69$, $p < 0.001$, d = 0.409); but the distribution of ages across the ages ranges was relatively similar (see Table 1). A larger percentage of US participants than UK participants had achieved undergraduate degrees (Fisher’s test, $p < 0.00001$) or graduate/higher degrees (Fisher’s test, $p < 0.00001$). A lower percentage of US participants than UK participants were career (wholetime) firefighters (Fisher’s test, $p < 0.00001$). There was a higher percentage of participants in the US than in the UK with more than 30 years of service (Fisher’s test, $p < 0.00001$), and a correspondingly smaller percentage of US than UK participants who were from the younger age ranges.

3.2. *Characteristics of fire departments/services*

Table 2 provides information about the characteristics of the fire department/service in which the participants worked. Many of these simply confirm that the current sample is representative of the organizational structures of US and UK firefighting. The principal difference was that there was a higher percentage of US than UK participants who worked in entirely voluntary departments/services (Fisher’s test, $p < 0.00001$), and a much higher percentage of US participants (77 %) than UK participants (13 %) who worked in departments/services with 100 or fewer firefighters (Fisher’s test, $p < 0.00001$). Table 2 also shows that participants in the US were consistently less likely than those in the UK to endorse the presence of the operational policies in their fire departments/services (Fisher’s test, $ps < 0.00001$).

3.3. *Incident commander experience and certification*

Inspection of Table 3 reveals that the distributions of years of service as an incident commander in the different bandings was relatively similar across US and UK participants. However, the length of service banding in US participants (mean = 3.88, SEM = 0.09) was higher than in the UK participants (mean = 3.53, SEM = 0.06; $t(1121) = 3.43$, $p < 0.001$, d = 0.21). The distributions of building fires attended was also relatively similar across the US and UK participants, but with a greater proportion of UK firefighters reporting having attended > 250 fires as an incident commander. The mean number of building fires attended banding was higher in UK participants (mean = 2.67, SEM = 0.05) than

Table 1
Demographic and employment information.

		US (n = 442)		UK (n = 681)	
		Number	%	Number	%
Gender	Male	427	96 %	623	91 %
	Female	10	2 %	48	7 %
	Prefer not to say	5	1 %	10	2 %
Age	18–25	12	3 %	2	0 %
	26–35	54	12 %	91	13 %
	36–45	100	23 %	264	39 %
	46–55	138	31 %	269	40 %
	56–65	110	25 %	54	8 %
	>65	28	6 %	1	0 %
Highest Education	Some high school or less	0	0 %	61	9 %
	High school diploma or GED	27	6 %	95	14 %
	Some college, but no degree	99	22 %	246	36 %
	Associates or technical degree	81	18 %	97	14 %
	Undergraduate or Bachelor's degree	138	31 %	98	14 %
	Graduate degree or higher	97	22 %	84	12 %
Employment status	Career/wholetime	207	47 %	542	80 %
	Volunteer	131	30 %	1	0 %
	Paid-on-call/ retained	21	5 %	81	12 %
	Part-time	4	1 %	1	0 %
	Multiple status	79	18 %	56	8 %
Years in service	1–5	11	3 %	25	4 %
	6–10	27	6 %	78	12 %
	11–15	40	9 %	106	16 %
	16–20	61	14 %	151	22 %
	21–25	71	16 %	143	21 %
	26–30	68	15 %	113	17 %
	>30	164	37 %	65	10 %

Note: Percentages for different options within a given category do not necessarily sum to 100% due to the rounding to integer values.

Table 2
Characteristics of fire departments/services.

		US (n = 442)		UK (n = 681)	
		Number	%	Number	%
Type of department /service	All career/wholetime	160	36 %	338	50 %
	All volunteer	127	29 %	2	0 %
	All paid-on-call/retained	16	4 %	47	7 %
	All part-time	2	1 %	0	0 %
	Mixed/combination, mostly career/wholetime	84	19 %	204	30 %
	Mixed/combination, mostly volunteer, paid-on-call, retained, or part-time	53	12 %	90	13 %
Number of operational firefighters	<26	128	29 %	58	8 %
	26–100	214	48 %	32	5 %
	101–250	43	10 %	32	5 %
	251–500	17	4 %	139	20 %
	501–1000	14	3 %	221	33 %
	1001–2000	14	3 %	106	16 %
	>2000	12	3 %	93	14 %
Presence of operational policies	Accountability/ Entry Control	372	84 %	669	98 %
	Incident Command	386	87 %	675	99 %
	Mayday/Firefighter Emergency	382	86 %	652	95 %

Note: Percentages for different options within a given category do not necessarily sum to 100% due to the rounding to integer values.

US participants (mean = 2.42, SEM = 0.05; $t(1121) = 3.33$, $p < 001$, d = 0.20). As already noted, the percentage of US participants who had witnessed a firefighter seriously injured or killed was higher than in UK participants (Fisher's test, $p < 0.0001$), and US participants were also more likely to have witnessed a mayday/firefighter emergency than UK participants (Fisher's test, $p < 0.0001$). The percentage of incident commanders who were certified was lower in the US than in the UK (Fisher's test, $p < 0.0001$).

3.4. Incident commander training and evaluation

Fig. 2 depicts the frequency with which different types of training was provided by participants' departments/services: Technical training (based on a mean of 5 items); non-technical training (based on a mean of 4 items), case studies/reports (1 item) and computer simulation (1 item). There was also a single item about the frequency of performance evaluations. For each item, the scale was: 4 ("More than once per year"), 3 ("Once per year") 2 ("Less than once per year") and 1 ("Never"). Inspection of Fig. 2 shows that the US participants reported a greater

Table 3
Incident commander experience and certification data.

		US (n = 442)		UK (n = 681)	
		Number	%	Number	%
Years as an incident commander	>1	18	4 %	36	5 %
	1–5	110	25 %	167	25 %
	6–10	93	21 %	172	25 %
	11–15	71	16 %	128	19 %
	16–20	55	12 %	97	14 %
	21–25	48	11 %	53	8 %
	26–30	27	6 %	23	3 %
	>30	20	5 %	5	1 %
Number of building fires as incident commander	>10	94	21 %	117	17 %
	11–50	159	36 %	221	33 %
	51–250	127	29 %	207	30 %
	251–500	37	8 %	69	10 %
	501–1000	21	5 %	44	7 %
	1001–5000	3	1 %	19	3 %
	>5000	1	0 %	4	1 %
Firefighter seriously injured or killed as incident commander		41	9 %	18	3 %
Mayday/firefighter emergency as incident commander		102	23 %	77	11 %
Incident commander or fire officer certification		366	83 %	626	92 %

Note: Percentages for different options within a given category do not necessarily sum to 100% due to the rounding to integer values.

frequency of technical training ($t(1121) = 7.55$, $p < 0.001$, d = 0.46), non-technical training ($t(1121) = 5.42$, $p < 0.001$, d = 0.33), and the use of case studies/reports ($t(1121) = 2.38$, $p < 0.05$, d = 0.15) than their UK counterparts, but were less likely to engage in computer-based training ($t(1121) = 3.50$, $p < 0.001$, d = 0.21) and were less likely to be evaluated ($t(1121) = 7.81$, $p < 0.001$, d = 0.48).

3.5. Incident command decision-making and practices

Risk tolerance. Fig. 3 presents the selection of strategy for three operational scenarios involving a building fire for which the occupant status was either: Occupants are out of the home (i.e., unoccupied); Occupant status is unknown (i.e., unknown); and Occupants are trapped, alive, and talking to dispatch/fire control (i.e., Occupied). Given only a photo of a residential building fire (see Fig. 1) and the three scenarios, participants were asked to rate their initial strategy as an incident commander from fully defensive (0), with very low risk to firefighters to fully offensive (100), with very high risk to firefighters. Inspection of Fig. 3 reveals that across each scenario, the US participants consistently selected a more offensive strategy with higher risk to firefighters than UK participants. ANOVA with group and scenario as factors confirmed that there was a main effect of group, $F(1, 1121) = 105.531$,

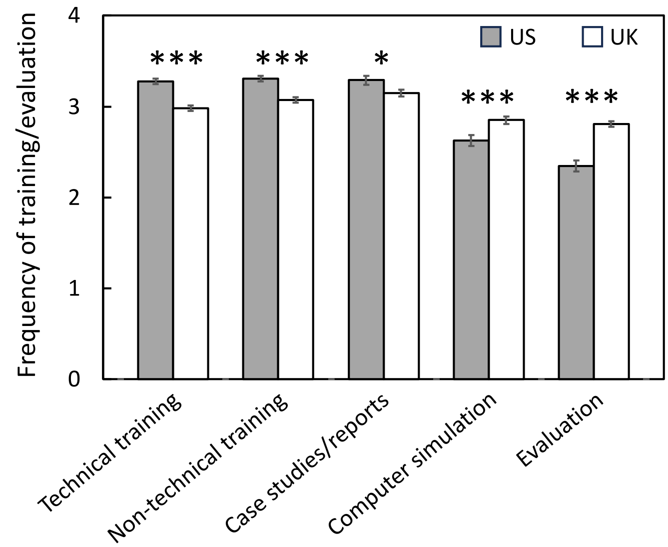

Fig. 2. The mean frequency (±SEM) of different forms of training and evaluation in US and UK participants. A score of 4 corresponds to "more than once per year" and a score of 1 corresponds to "never"; * = p < 0.05, *** = p < 0.001.

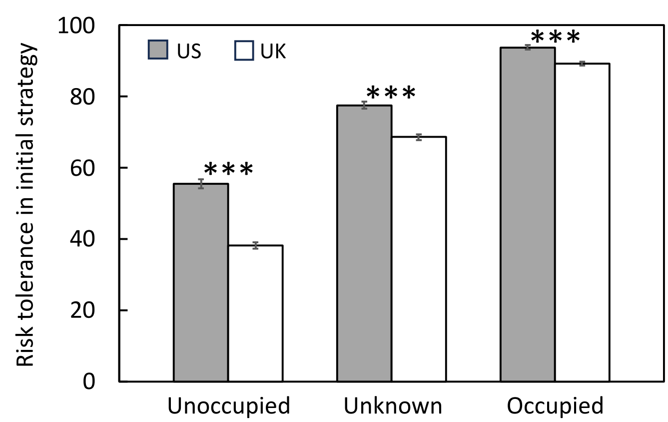

Fig. 3. The mean risk tolerance for US and UK participants in the initial strategy (±SEM) for a house fire across different occupancy conditions: occupied, unknown or occupied. A score of 0 represents fully defensive, with low risk to firefighters, and a score of 100 represents full offensive, with a very high risk to firefighters; *** = $p < 0.001$.

$p < 0.001$, η_p^2=.07, scenario, $F(2, 2242) = 2561.75$, $p < 0.001$, η_p^2=.70, and an interaction between these factors, $F(2, 2242) = 53.82$, $p < 0.001$, $\eta_p^2 = 0.046$. Subsequent tests revealed that the ratings for the US and UK groups differed for all three scenarios (smallest $t(1121) = 5.49$, $p < 0.001$, d = 0.34, for the occupied scenario). Additionally, 5 % (22/442) of US participants selected 100/100/100 (very high risk to firefighters) for all three occupancy scenarios while only 1 % (7/681) of UK participants made the same selections.

Public involvement. The likelihood of participants using members of the public to assist during an incident was assessed in the context of a scenario in which an incident commander and three firefighters are on the scene of a building fire. The team of three firefighters are performing fire suppression when a mayday/firefighter emergency call is received about one of them trapped inside. A member of the public standing nearby hears the call and offers to help, and participants rated the likelihood of accepting their offer to keep track of time, take notes, or monitor a second radio. The scale was coded as: 5 ("Very likely"), 4 ("Somewhat likely"), 3 ("Neither likely nor unlikely"), 2 ("Somewhat unlikely"), and 1 ("Very unlikely"). US participants were more likely to make use of the public to keep track of time (mean = 2.40, SEM = 0.07) and take notes (mean = 2.57, SEM = 0.06) than UK participants (means 1.99, SEM = 0.05, and 2.19, SEM = 0.05, respectively; smallest $t(1121) = 4.84$, $p < 0.001$, d = 0.29). There was no difference between the US participants (mean = 2.33, SEM = 0.07) and UK participants (mean = 2.39, SEM = 0.06) tendency to use members of the public to monitor a second radio ($t(1121) = 0.63$, p = 0.53, d = 0.38).

Operational practices. Table 4 shows the use of different practices while serving as an incident commander at a single-family building fire with an offensive/interior fire crew. The forms of support were: Incident management (six items; e.g., "how often do you use a command board or tactical worksheet (paper, dry erase, electronic)?"); technology (one item; e.g., "how often do you use a thermal imaging camera to assess the building?"); situational awareness (four items; e.g., "how often do you speak with the occupants or witnesses (if available) to gather information?"); and post-incident reviews (two items; e.g., "how often do you conduct or participate in a post-incident or after-action review with the team?"). The scale was coded as: 6 ("Always"), 5 ("Most of the time"), 4 ("About half the time"), 3 ("Sometimes"), 2 ("Rarely"), and 1 ("Never"). There was significantly more use in the UK than US of the practices of incident management ($t(1121) = 7.62$, $p < 0.001$, d = 0.47), technology ($t(1121) = 10.43$, $p < 0.001$, d = 0.63) and situational awareness ($t(1121) = 3.37$, $p < 0.001$, d = 0.21); but no differences in the use of post-incident reviews ($t(1121) = 0.11$, $p = 0.91$, d = 0.01).

3.6. Operational/safety culture

Participants provided their level of agreement (strongly agree to strongly disagree) with statements across four sub-categories: rule following and procedures (six items; e.g., "Occasionally safety rules have to be broken to save property and quickly put out the fire."); safety attitudes (six items; e.g., "You can train all of the time and try to be very safe, but 'freak' accidents sometimes happen and firefighters may get hurt."; for this and other items, strong agreement is reverse scored because it reflects tolerance of firefighter risk); stress and resilience (four items; e.g., "I am less effective when stressed or fatigued."), and training (one item; "Training on 'soft' or non-technical skills for incident commanders is very important."). Inspection of Table 5 shows that the sole marked difference between US and UK participants concerned safety attitudes, with US participants showing lower levels of endorsement of the importance of firefighter safety than their UK counterparts ($t(1121) = 10.18$, $p < 0.001$, d = 0.62). There were no differences in the remaining three sub-categories (largest $t(1121) = 1.62$, $p = 0.10$, d = 0.10; for rule following and procedures).

4. Discussion and directions for future research

US and UK firefighters face many of the same occupational safety issues, but their approaches to dealing with those issues differ in many ways, which are reflected in the demographic, employment and fire service characteristics in the US and UK participants in this study. For example, incident commanders in the US were significantly more likely than their UK counterparts to serve in small fire departments/services, to be volunteers, be older and served for longer, and to have college degrees. The fact that the size of fire departments in the US are usually smaller than those in the UK reflects a process of consolidation, from approximately 15,000 (pre-World War II) to 49 now: England has 44 fire and rescue services, Wales has three, Scotland has one, and Northern Ireland has one. Most of these services operate with a mix of career/wholetime and paid-on-call/retained firefighters. England and Wales fire services operate under joint national legislation (United Kingdom National Archives, 2004), and Scotland (United Kingdom National Archives, 2005) and Northern Ireland (United Kingdom National Archives, 2006) fire services operate under their own national legislation. Occupational safety and health law in most of the UK is enforced by the Health and Safety Executive (HSE; Northern Ireland has its own legislation and HSE). In contrast to the centralized structure found in the UK, every individual US state except Hawaii (United States Fire Administration, 2022) has more fire departments than the total number of fire services across the entire UK, and over 85 % of the approximately 27,000 fire departments in the US are all or mostly volunteer (United State Fire Administration, 2022). Under the division of power central to federalism, the US has no equivalent national-level legislation governing fire departments, instead each state determines how fire departments are established and organized with most operating at the local government (city, town, village, township, district, borough) level. Occupational safety and health legislation and enforcement is also decentralized as the federal Occupational Safety and Health Act of 1970 excludes federal jurisdiction of state and local government employers. As a result, some states have adopted and enforce standards for public workers as strict or more strict than federal law, some states enforce their own laws, and some states have no legal protections for public worker safety and health.

The organizational differences between the US and UK observed in the present study are clearly consistent with known structural and legislative differences between the US and UK, and provide internal evidence that our two samples are representative. In addition, they serve to illustrate of how organizational arrangements are intertwined with national cultural differences (see Noort et al., 2016; Reader et al., 2015; Yorio et al., 2019). The results of the survey also showed that US participants were more likely than UK participants to have witnessed firefighter deaths/injuries and maydays/firefighter emergencies, but to have attended significantly fewer fires. This pattern is consistent with the higher number of line of duty deaths in the US than the UK derived from official sources (see Introduction). It is now appropriate to consider differences between the US and UK participants in decision making, evaluation and certification, and operational/safety culture: These differences are potential contributors to firefighter safety.

US firefighters were more likely than UK firefighters to adopt an "offensive" strategy when faced with a burning building irrespective of whether the scenario involved the building being unoccupied, of unknown occupant status, or occupied. Alarmingly, almost 5 % of US respondents selected the highest risk score of 100 (fully offensive, very high risk to firefighters) for all three scenarios suggesting complete indifference to occupant status as a factor in their risk assessment. Only 1 % of UK respondents selected 100 for all three scenarios. Similarly, the safety attitudes of US participants were significantly more likely than UK participants to reflect risk acceptance and the inevitability of firefighter injury. Moreover, while the amount of training was broadly similar across the US and UK participants, US participants were less likely to use

Table 4
The use of different operational practices.

	US (n = 442)	**UK** (n = 681)
Incident Management	3.68 (0.04)	4.05 (0.03)
Technological	4.07 (0.08)	4.97 (0.05)
Situational Awareness	4.82 (0.04)	4.97 (0.03)
Post-event reviews	3.55 (0.05)	3.55 (0.03)

Note: Mean (+SEM) use of different operational practices on a scale of "never" (1) to "always" (6).

Table 5
Operational/safety culture.

	US (n = 442)	**UK** (n = 681)
Rule-following and procedures	3.84 (0.02)	3.79 (0.02)
Safety attitudes	2.82 (0.02)	3.04 (0.01)
Stress and resilience	2.84 (0.03)	2.81 (0.02)
Training	4.03 (0.04)	4.05 (0.03)

Note: Mean (+SEM) use of different components of safety culture, where higher scores indicate endorsement of importance (minimum = 1 and maximum = 5).

computer-based simulations on building fire scenarios and were also less likely to be evaluated (and certified) than UK participants. What is the origin of differences between the US and UK?

A fundamental expectation for incident commanders in the UK is to perform an initial and ongoing dynamic risk assessment (DRA) at every incident (Tissington and Flin, 2005). The DRA was introduced and distributed to the UK fire service in 1998 through a pamphlet: *The Dynamic Management of Risk at Operational Incidents;* and the importance of DRA was reinforced when the UK Health and Safety Executive required all employers in the UK to perform risk assessments (MHSWR, 1999). Briefly, the DRA is a systematic method for assessing and controlling risks at an incident with time pressure, incomplete information, and a changing environment. It is a core principle within the UK National Operational Guidance for Incident Command developed by the National Fire Chiefs Council. The process begins by evaluating the situation, deciding who might be harmed and how. Next, the incident commander must make a judgement to see if the benefits of action are proportional to the risks to those involved. If the risk/benefit is judged to be appropriate the incident commander must select a safe system of work with control measures to reduce risks. The incident commander must then declare a mode of operation for the incident, offensive or defensive. This declaration, communicated verbally, functions as confirmation of the initial risk assessment. Next the incident commander implements tactical control to ensure the incident is managed to protect personnel and implements additional or alternative control measures when possible to further reduce risk. They also ensure an ongoing review and assessment of the risks and benefits, adjust the operational mode if warranted, and continue through a DRA loop as the incident continues. While incident commanders in the US do perform some type of scene assessment upon arriving at an incident (often called a size up), the methods of assessment vary widely and lack the systematic and detailed approach found in the DRA. Consistent with the suggestion that differences in risk tolerance and assessment between the US and UK contribute to firefighter safety, Line of duty death reports by the National Institute for Occupational Safety and Health (NIOSH) consistently identify ineffective or incomplete risk/benefit analysis (risk assessment) as a major contributory factor in traumatic deaths of firefighters involving structural firefighting (NIOSH 2022, 2022, 2023 2024, 2024, 2024, 2025). However, further research is required to establish how DRA is implemented in operational contexts and how it affects firefighter safety (e.g., using simulated fire and rescue scenarios; cf. Butler et al., 2023; Cohen-Hatton and Honey, 2015), and whether such an approach could be developed for use in the US.

The results of the current comparison of US and UK firefighters is consistent with the NIOSH reports that identify risk assessment as a likely factor in firefighter safety in the US. The clear implication of our results and NIOSH reports is that greater effort should be directed towards training that involves dynamic risk assessment in the US fire service. In the UK, risk assessment has been a legal obligation in the workplace for almost 25 years, and many workers will have been introduced to the basic process before they join the fire service. Once in the fire service, prior to serving as an incident commander, rank and file firefighters are expected to perform an individual risk assessment of their own activities during an incident, especially when operating unsupervised. Additionally, UK fire services perform written risk assessments for the types of incidents they are likely to encounter. These predetermined assessments identify hazards, risks, and associated control measures that reduce the amount of novel hazards and risks that a ground level incident commander would face, reducing the possibility that an incident commander would have to develop a new, potentially untested, control measure in a high risk environment (see Butler et al., 2023).

While the UK has adopted a risk-based approach to occupational safety regulations since the 1970s, the US approach remains prescriptive in nature (Burgess et al., 2014), with state-level variations of occupational safety and health regulatory coverage of public sector firefighters. It is unlikely that the US can adopt the risk assessment ecosystem from the UK fire service. However, training efforts could be directed at the level of individual incident commanders: To teach the systematic DRA process, with the support of a pre-determined generic risk assessment for building fires that includes control measures. This program could be supported by computer-based simulation scenarios and formal evaluation, both of which were identified as aspects of training that US participants encountered less frequently than their UK peers. As we have already noted, there is a clear need for further research to better understand the implementation of DRA training and its efficacy, but also how that training could be "imported" to the US, and if risk-based occupational safety and health regulatory approaches can be adopted to enhance firefighter safety.

CRediT authorship contribution statement

Erik Kambarian: Writing – original draft, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Philip C. Butler:** Writing – review & editing, Methodology, Conceptualization. **Sabrina R. Cohen-Hatton:** Writing – review & editing, Supervision, Conceptualization. **Robert C. Honey:** Writing – original draft, Methodology, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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