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RESEARCH ARTICLE

Are firefighters susceptible to decision fatigue? An exploratory sequential mixed methods study of its causes and consequences

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ABSTRACT

Decision fatigue undermines the quality and effectiveness of decision-making in the challenging and life-threatening environments of firefighting. This study employed an exploratory sequential design to qualitatively identify the causes and consequences of decision fatigue in firefighting and quantify the severity of the consequences of each cause. Retrospective interviews were conducted with 19 firefighters, followed by a survey with 329 firefighters. Qualitative analysis, employing an emergent themes approach, identified 39 sub-causes and 20 sub-consequences of decision fatigue, which were eventually grouped into eight causes and five consequences. The quantitative analysis phase included univariate and multivariate regression analyses to determine significant predictors among the 39 causes, perceived stress, and occupational fatigue on the total consequence of decision fatigue. Overall, the study's findings underscore the significance of investigating fatigue in firefighting and provide the groundwork for developing training programs and coping strategies to mitigate it and improve operational efficiency.

PRACTITIONER SUMMARY: This study investigated the causes and consequences of decision fatigue among firefighters using an exploratory sequential mixed-method design. Qualitative findings identified 39 causes and 20 consequences of decision fatigue, which were further validated by the quantitative findings. These findings are vital for improving the decision-making process and safety of firefighters.

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Decision fatigue; firefighting; decision-making; exploratory sequential design

Introduction

Decision-making plays a pivotal role in firefighting (Choudhury and Saravanan 2025; Okoli and Watt 2018), as decisions made by firefighters directly impact the outcome of an incident, with any wrong decision potentially leading to severe consequences (Cadena et al. 2020; Li et al. 2014). For example, the National Transportation Safety Board (NTSB) report of the Grande Costa D'Avorio ship fire incident in 2023 highlighted that the decision errors by the fire department led to the tragic loss of two firefighters during the week-long incident (National Transportation Safety Board [NTSB], 2025). Moreover, decision-making becomes challenging during long shifts, as firefighters are always required to be prepared to respond to emergency calls (Billings, Jahnke, and Haddock 2024). They also have to be efficient decision-makers during fast-paced fire incidents (Cohen-Hatton, Butler, and Honey 2015; Waring and Hillon 2025). Prior research has shown that stress (Brown, Mulhern, and Joseph 2002; Choudhury, Bush, and Saravanan 2025; Coehoorn et al., 2020; Fraess-Phillips, Wagner, and Harris 2017), burnout (García-Iglesias et al. 2025), and physical fatigue (Roșca et al. 2021) reduce the efficiency of firefighters' decisions. Therefore, investigating how accumulated cognitive demands affect decision-making quality during fire incidents will benefit overall firefighter safety and performance. Decision fatigue (DF) is a similar form of cognitive impairment that occurs due to high cognitive and organisational demands (Choudhury and Saravanan 2024; Pignatiello, Martin, and Hickman 2020), but its influence on firefighter performance and safety remains unexplored.

Decision fatigue refers to the impaired ability to make decisions by an individual due to repeated decision-making over a prolonged period (Choudhury and Saravanan 2024; Pignatiello, Martin, and Hickman 2020). Individuals have a limited ability to regulate their cognitive behaviour, and making multiple decisions can deplete their mental resources (Baumeister et al. 1998). An individual's cognitive resources are

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limited and can be depleted during decision-making activities, such as processing information or considering multiple choices to formulate a decision (Pignatiello, Martin, and Hickman 2020). DF can be interpreted as a form of mental fatigue, but there are fundamental differences between the two. While mental fatigue can be caused by performing demanding and cognitive-load-inducing activities, high-pressure tasks, physical job fatigue, and even by non-occupational factors (Kunasegaran et al. 2023; Tanaka, Ishii, and Watanabe 2014), DF focuses solely on fatigue caused by decision-making complexity. Past research has explored DF in several domains, including healthcare (Allan et al. 2019; Fernández-Miranda et al. 2023), judiciary (Torres and Williams 2022), parenting practices (Angoff et al. 2022), and economic decision-making (Hirshleifer et al. 2019; Jiao et al. 2024). For example, Treasure et al. (2022) found that as DF accumulated later in physicians' shifts in the emergency department, their decision-making became inefficient, which contributed to less efficient patient flow. Their study revealed that the admission rate decreased from 6.18% to 3.91% and the throughput time increased from 109.9 minutes to 114.1 minutes. Linder et al. (2014) observed that physicians inappropriately prescribed antibiotics instead of conducting a proper diagnosis as the working shift progressed. Similarly, Torres and Williams (2022) highlighted that case orders and session durations in the judicial system lead to DF among judges and affect their bail decisions in the second half of the day.

Similar to healthcare and the judiciary, firefighting requires extensive cognitive efforts but with greater uncertainty (Cadena et al. 2020). Firefighters need to make life-and-death decisions while dealing with resource limitations (Avci et al. 2024), high risk of hazards and accidents (Calkin et al. 2021; Cuenca-Lozano and Ramírez-García 2023), extreme heat (Coehoorn et al., 2020), time pressure (Choudhury and Saravanan 2025; Waring and Hillon 2025), and cognitive challenges (Zare et al. 2018). These decision-making challenges can abruptly increase cognitive demands, leading to mental exhaustion and a decrease in the efficiency and quality of decisions. Such inefficient and sub-optimal decision-making can lead to life-threatening outcomes for firefighters and victims. Despite the catastrophic consequences of erroneous decision-making, the extant literature lacks an in-depth exploration of DF among firefighters. Therefore, it is critical to identify the causes and consequences of DF among firefighters, which may in turn help improve their cognitive performance.

This study aimed to identify the causes and consequences of DF in firefighting and quantify the severity of the causes. By employing a mixed-methods design, our study sought to answer two research questions.

> RQ1: What are the causes and consequences of DF among firefighters?

Addressing this question through the qualitative phase uncovers the causes and consequences of DF from past experiences of expert firefighters.

> RQ2: Which identified causes significantly predict how DF impacts firefighters' performance?

Examining this research question through quantitative analysis determines which causes are significantly associated with the total consequence of DF among firefighters.

Thus, we employed an exploratory sequential mixed-methods design to qualitatively identify the causes and consequences of DF and quantitatively measure the total consequence of the causes. The findings of the study will help develop awareness among firefighters about the negative consequences of DF and help the fire departments develop training programs and coping strategies to mitigate it.

Materials and methods

Study design

This study was approved by the Institutional Review Board (IRB) at Oklahoma State University (IRB# 24-309, IRB# 24-129). The voluntary involvement of the participants was ensured following the ethical guidelines, and their verbal and written informed consent was received prior to data collection. The objectives, procedures, and potential benefits and risks were properly explained to all the participants. This study applied an exploratory sequential, mixed-methods design (Creswell and Plano 2011). In an exploratory sequential design, a qualitative study precedes a quantitative study, and the findings from the qualitative phase inform the development of a quantitative instrument that further explores the research objectives (Onwuegbuzie, Bustamante, and Nelson 2010). In this study, we conducted semi-structured interviews with firefighters who had 15 years or more experience and used the qualitative findings to develop the survey instrument for the quantitative phase, similar to the method proposed by Fetters, Curry, and Creswell (2013). The mixed methods process of data collection and analysis is shown in Figure 1.

Qualitative data collection

In the qualitative phase, one-on-one semi-structured interviews were conducted with experienced firefighters to identify causes and consequences of DF from

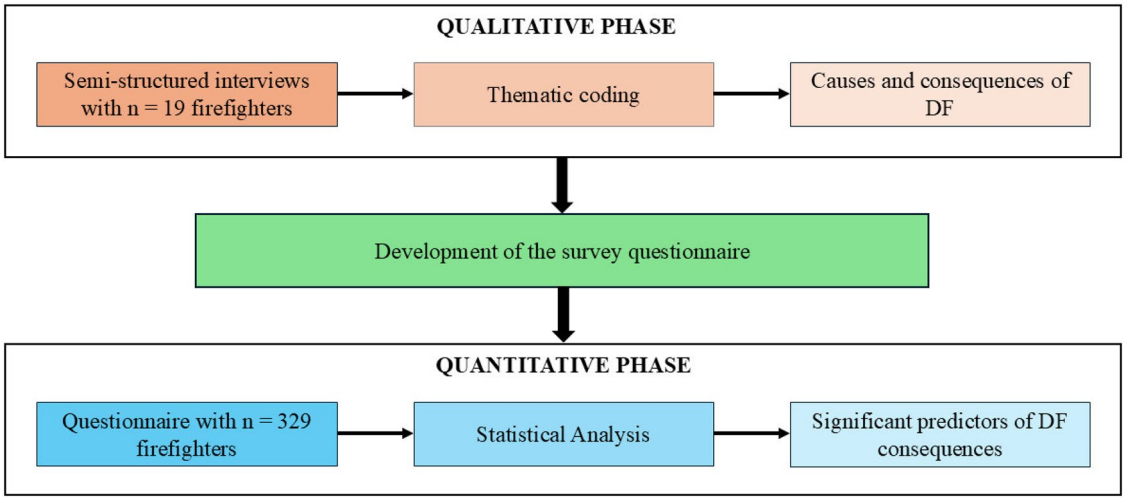

Figure 1. Exploratory sequential design. The flow diagram demonstrates the sequence of the study design starting with a qualitative phase in which semi-structured interview with n = 19 participants were conducted to identify the causes and consequences of DF, followed by the development of the survey questionnaire from the qualitative findings, and finally qualitative findings were validated through the quantitative phase in which the survey was conducted with n = 329 participants.

their years of experience. In line with existing literature (Calderwood, Crandall, and Klein 1987; Tamura, Amano, and Ota 2020), we recruited participants with a minimum of 15 years of experience in firefighting across different firefighting ranks to capture their perspectives on DF. As limited qualitative research exists on DF in firefighting, this phase aimed to identify the causes and consequences of DF from the past firefighting experiences of the participants. Participants were recruited through emails via various firefighter listservs and using snowball sampling techniques. The interviews were conducted virtually via the Microsoft Teams platform. Informed consent was obtained from each participant, who was then asked to answer a few questions about their background and professional experience. The remaining questions were developed from the findings of a prior systematic review conducted on the causes and consequences of DF by the authors (Choudhury and Saravanan 2024). The open-ended questions used in the interviews (see Appendix A) were developed based on key themes identified in the systematic review study and validated by an academic researcher, who is also a veteran firefighter with over 24 years of experience. The interviews were conducted by two interviewers (NAC and PS). Participant recruitment continued until full saturation was achieved, and no new themes emerged from the interviews. All the interviews were audio-recorded and manually transcribed verbatim for thematic analysis.

Qualitative data analysis

First, the authors (NAC and PS) familiarised themselves with the textual data by reading the interview transcripts several times, which allowed them to have an in-depth understanding of participants' perceptions about DF. Next, initial codes representing the causes and consequences of DF were generated. The coding was done by developing a codebook using an inductive approach, whereby data were coded as emergent without a priori categories (Braun and Clarke 2006). The initial coding was done in two steps using NVivo version 14 (Welsh 2002; Wong 2008). Step 1 focused on indexing and collating to draw common themes, and step 2 explored each theme by re-indexing and restructuring (Wong and Blandford, 2011). The authors independently coded in each step and collaboratively discussed to ensure that they aligned with the research objectives. These codes were then organised into potential themes, ensuring that each theme represents a pattern or relationship across similar codes (Ryan and Bernard 2003). After that, the authors reviewed and refined the themes through repeated discussion sessions to confirm the accuracy and validity of the themes. This approach guaranteed that every theme was grounded in the data and all meaningful patterns were thoroughly identified. Disagreements during the coding process were resolved by collective discussion of the authors until full consensus was achieved.

Development of survey questionnaire

Integration is a core part of an exploratory sequential design, combining qualitative and quantitative research approaches to achieve a form of synergy (Creamer 2018). Results from the qualitative phase were used to develop a survey instrument for the quantitative phase (Creamer 2018; Fetters, Curry, and Creswell 2013).

According to Creswell et al. (2011), application of an exploratory sequential mixed-method study depends on the effective utilisation of the findings from the first phase towards developing the data collection method for the second phase. A similar approach has been used in consumer assessment of healthcare providers and systems (Hammoud et al. 2012) and in developing the Illness Perception Questionnaire (Shiyanbola et al. 2021). The developed survey instrument is a Likert scale questionnaire, designed to quantitatively assess the causes and consequences of DF.

Quantitative data collection

In the quantitative phase, a survey questionnaire was distributed to firefighters to validate the causes and consequences of DF that were identified in the qualitative phase. The survey also incorporated demographic questions, the Perceived Stress Scale (PSS-10) to assess perceived stress levels (Cohen et al., 1994) and the Occupational Fatigue Exhaustion Recovery (OFER) scale to measure acute fatigue, chronic fatigue, and inter-shift recovery (Winwood et al. 2005). The survey data were used for statistical analysis.

Quantitative data analysis

Quantitative data were analysed using descriptive statistics and regression. At first, descriptive statistics were computed for all demographic variables (e.g. age, gender, experience, and ethnicity), and total scores of the Perceived Stress Scale (PSS-10), the OFER subscales (acute fatigue, chronic fatigue, and intershift recovery), and all survey items related to the causes and consequences of DF. Next, univariate linear regressions and stepwise multiple linear regression were performed to identify the most significant predictors of the DF consequences among the PSS score, OFER subscale scores, and all identified causes of DF. All the regression analyses were conducted in R version 4.3.2, with a significance level of $p < .05$.

The outcome variable of the regression analysis was the 'total consequence of DF'. It was derived by summing up the Likert scale responses of the participants for each of the consequences of DF identified as sub-themes in the thematic analysis. The responses were derived from the following question: 'Based on your experience, how severely do the following consequences of decision fatigue impact your performance as a firefighter?' The independent variables for both univariate and multivariate regression were age, experience, Perceived Stress Scale (PSS-10) score, and three subscales of Occupational Fatigue Exhaustion Recovery (OFER) scales (OFER-CF, OFER-AF, and OFER-IR), and causes of DF identified as sub-themes in the thematic analysis. Univariate linear regression analyses were conducted to examine the individual associations between each independent variable and the dependent variable. Variables that had significant associations at $p < .05$ level, were subsequently included in a multivariate linear regression model using a stepwise selection procedure to identify the most influential predictors. This method adds predictors sequentially based on the probability to enter (if ≤ .05) and removes them based on the probability to remove (if ≥ .10) (Neter et al. 1996; Wiegand 2010). R^2, adjusted R^2, and F-test values were assessed to ensure model fit.

Results

Qualitative results

Nineteen firefighters were recruited across 14 fire departments in the US to participate in this study. The demographic information of participants is shown in Table 1. From the qualitative phase of the study, initial thematic coding identified 39 causes and 20 consequences of DF. The identified causes and consequences were subsequently grouped into eight major themes of causes and five major themes of consequences.

Causes of decision fatigue

The eight major themes of DF causes were (1) environmental causes, (2) high workload, (3) sensory and cognitive overload, (4) emotional intensity, (5) time constraints, (6) resource limitations, (7) training limitations, and (8) operational complexities. The themes for the causes, along with their associated sub-themes and rationale, are presented in Table 2.

Environmental causes. Several participants noted that environmental challenges, such as *extreme weather*

Table 1. Participant demographics of the qualitative phase.

Participant characteristics	
Participants (n)	
Total	19
Male	18
Female	1
Experience (Years)	
Mean (M)	23.32
Standard deviation (SD)	7.08
Rank (n)	
Fire chief	3
Division chief	1
Battalion chief	5
General officer	2
Captain	4
Lieutenant	2
Others	2

Table 2. Summary of sub-themes, themes, and rationale of the causes of decision fatigue.

Themes	Sub-themes	Rationale
Environmental causes	Extreme weather conditions High heat	Causes related to challenging environmental conditions and high heat and working while wearing PPE and heavy gear.
High workload	Long shifts of work Long duration of fire operations Sleep deprivation Early morning fire calls Late-night fire calls Unavailability of breaks High responsibility Administrative workload Back-to-back fire calls Frequent fire calls	Causes due to high organisational workloads like long shifts and long durations, unavailability of breaks, high responsibility, time and frequency of fire calls, and individual causes like sleep deprivation.
Sensory and cognitive overload	Auditory overload Disorganised information Incomplete information Wrong information Interpretation of information Keeping track of events High frequency of decisions Uncertainty of decisions	Causes related to overwhelming amounts of information and sensory input, high frequency, and uncertainty of decisions that impair firefighters' ability to process, interpret, and respond effectively.
Emotional intensity	Fear of failure Emotional load Concern for fellow firefighters Concern for the victims Fear of injury or death	Causes in this theme include the emotional burden and intensity of firefighting, like fear of failure and injury, concern for others.
Time constraints	Time pressure Fast moving incident	Causes related to the pressure of making rapid and safe decisions within a limited time.
Resource limitations	Insufficient firefighters Insufficient firefighting equipment	Causes originating due to the lack of human resources and equipment.
Training limitations	Lack of training Learning difficulties associated with emergent technologies	Causes originating from lack of training and adaptability among firefighters.
Operational complexities	Perceptions of operation's complexity Frantic nature of operations Outside interference Miscommunication Dealing with unfamiliar resources High risk conditions Risk of structural collapse Wearing heavy protective gears	Causes related to the challenging nature of firefighting operations, including complex and frantic events, outside interference, high risk, and miscommunication, all of which makes decision-making extremely difficult.

conditions and *high heat*, make firefighting operations extremely difficult. According to them, decision-making in the presence of extreme weather conditions is not straightforward. Two participants specifically mentioned that *extreme weather conditions* involving both freezing and hot temperatures make decision-making more difficult by limiting the effectiveness of standard operating procedures.

> I feel like my decisions (would be) a lot better than times when it's freezing cold or when it's 100 degrees. [P12]

Another participant (P05) also mentioned that 'decision process becomes very muddled' under the influence of *high heat* coming from the fire. These environmental causes make decision-making extremely challenging and require high cognitive effort and mental processing. Consequently, mental resources get depleted faster, leading to DF sooner than in less environmentally challenging situations.

High workload. High workload was the most mentioned cause of DF among the participants. Nine out of the 19 participants cited *sleep deprivation* as a major reason for feeling exhausted in the fireground and ultimately suffering from DF. One participant mentioned that any 'long shifts over 24 hours' induce sleep deprivation among the firefighters. Others pointed out several other causes related to high workload, including *long shifts of work*, *long duration of fire operations*, and *unavailability of breaks*.

> There are times I'll get three or four hours of sleep, and it's terrible. Even the night before I go into the station, I lie in bed tossing and turning because I'm thinking of everything going on. [P04]

> Personally, long shift work with repetitive events, where I've been up all night or something of that nature, and I've run 10-12 calls that day (causes decision fatigue). [P18]

> You are kind of ready to mentally take a break, but you can't because you have to keep making decisions. So sometimes it gets hard to make the best decision. [P11]

A few participants also identified the unpredictable timing and frequency of fire calls as definite causes of DF. They highlighted that fire incidents are highly unpredictable, and firefighters must always be

prepared for dispatches or emergency calls at any time during their shifts. This uncertainty leads to DF if the calls arrive at unusual times, i.e. *early morning fire calls*, *late night fire calls*, *back-to-back fire calls*, or if they have to respond to *frequent fire calls*.

> It is based on the individual's ability to function and recover, and a lot of that depends on the firefighters is what they were doing before coming to the shift. [P07]

> During the day, you may run 8 or 9 calls and then some big call drops, and you've got so many other things going on. [P09]

A few participants also emphasised that *high responsibility* increases the complexity of decision-making and increases the possibility of DF. One participant mentioned the responsibility of being the first to assess and respond during emergencies as a significant source of DF. Moreover, *administrative workload* such as paperwork, report writing, and evaluations were pointed out as additional responsibilities that can mentally exhaust firefighters. These cumulative operational and administrative responsibilities can impair the decision-making ability of firefighters.

> You do get overwhelmed with that (high responsibility) because you know a lot of times you are the first arriving unit and put into action. [P12]

> We spend a lot of our day doing administrative duties, where you know you're making all these decisions administratively, they're not critical life-saving decisions, but it is still exhausting your mind [P12]

Sensory and cognitive overload. Several participants mentioned sensory and cognitive overload during fire incidents as a major cause of DF. Due to the chaotic nature of the fire incidents, auditory overload in the form of various sounds, such as fire alarms, radio communications, and loud verbal communications, were problematic for some participants. One participant particularly mentioned auditory overload as 'irritating', which interferes with concentration and smooth decision-making.

> As I got older. I am sure auditory overload was one of the most irritating things to me in terms of being able to think. [P03]

Participants were also concerned about the mental effort required to *keep track of events* during extended operations. As fast-paced incidents progress through several critical events, the accumulation of information and the need for continuous situational awareness become extremely challenging for them.

> When you are in that initial phase of that fire, it is easy to keep up with all that stuff. But once it starts getting extended, you have got to really start making sure we're taking lots of notes on stuff. [P11]

Information processing is a major cognitive function of firefighting incidents. From the dispatch call to the termination of the operation, the success of the operation largely depends on gathering and monitoring correct information. Almost every participant mentioned that difficulties in information processing create obstacles in situation assessment and decision-making. Participants identified several information-related causes of DF, including *disorganised information*, *incomplete information*, *wrong information*, and *interpretation of information*. For example, one participant mentioned that, during firefighting, he has often felt the challenges of 'missing things' and 'difficulty sorting through the variables', which made decision-making troublesome.

> In a lot of cases you have to see it to really get the full picture, because maybe the dispatcher didn't give you all the information. [P15]

> Occasionally, you do get some information, but often you walk into a house. You don't know whether fire is located in the stairs or the basement. [P16]

Uncertainty of decisions also emerged as a recurring cause of DF, particularly in unfamiliar structural fire incidents. This uncertainty is exacerbated by the potential for sudden accidents (e.g. structural collapse, explosion) and high-risk working conditions (e.g. smoke, chemical hazards). One participant noted that they faced the biggest challenges in decision-making because of 'being in situations that they were unfamiliar with'. Additionally, a *high frequency of decisions* creates mental strain throughout the incidents, as the rapid frequency and back-to-back nature of decision-making often become overwhelming and cause DF.

> Just from being overwhelmed with so many decisions at the beginning, you can be so amped up because you're making decision after decision. [P11]

Emotional intensity. A significant cause of DF was the emotional burden associated with firefighting. Participants reported that the difficult circumstances and turmoil of the events often leave the firefighters emotionally vulnerable. *Emotional load* of incorrect decisions or actions, *fear of failure*, and *fear of injury or death* disrupt smooth decision-making and require higher cognitive effort to overcome the fear, resulting in firefighters suffering from DF.

> It (decision fatigue) comes with a lot of hazards to your psychological and emotional health over time,

> and I think that the consequence of all those is the disruption of regular decision-making. [P05]

> Everybody wants to be perfect. They (firefighters) want to make the right decision no matter what, so I think sometimes they can be delayed in making decisions (because of that). [P15]

Lack of safety was also mentioned by the firefighters, as it raises high *concern for fellow firefighters* and *concern for victims*, which eventually increases pressure on the decision-maker, making it harder to stay composed and maintain focus.

> It raises stress levels just knowing you're going to this type of incident, and you have to get it right. Any incident involving children is always stressful and affects decision-making. [P15]

Time constraint. Time constraint was consistently identified as a critical cause of DF by most participants, such as *time pressure* and *fast-moving incidents*. Firefighters mentioned that the fast-paced and dynamic nature of fire incidents often left little or no time for considering alternatives and making choices. The constant awareness of *time pressure* to rescue victims also increases DF.

> The clock is running, so you always have the pressure of the clock in decision-making. [P01]

Participants also emphasised that *fast-moving incidents* demand continued focus and quick thinking, contributing to mental exhaustion quicker than routine incidents.

> It was a very fast-moving incident, and you are having to try to stay ahead of it, which can cause mental fatigue. [P08]

Resource limitations. Resource limitations cause DF when firefighters are unable to execute planned strategies due to *insufficient firefighters and insufficient firefighting equipment*. Participants mentioned how even experienced firefighters cannot make effective decisions and get fatigued because of the added mental load due to resource limitations. Furthermore, lack of firefighting equipment and reliance on outdated equipment also compound the mental strain and complexity of decision-making in the fireground.

> Anytime you have a good plan, but you do not have enough resources to implement it, that can cause fatigue. [P10]

> It is kind of a big issue for our department, but a lot of equipment failures, things breaking, and using older equipment are troublesome. [P16]

Training limitations. Participants also reported a *lack of training* and *difficulties with emergent technologies* as a cause of DF, particularly in smaller departments. One participant specifically mentioned that they lack adequate training in their smaller department compared to the well-trained firefighters in larger departments across the country. Moreover, another participant highlighted the challenges of *learning difficulties associated with emergent technologies,* causing a significant amount of DF. Particularly, they described top-down software changes that were implemented without adequate instruction.

> I think that one of the biggest challenges is that, being with a small department is the training and experience we have is not as high as other departments. [P02]

Operational complexity. Most participants highlighted the complexities of firefighting incidents as a significant cause of DF, including *perceptions of an operation's complexity, the frantic nature of fire incidents, outside interference, miscommunication, dealing with unfamiliar resources, high-risk conditions, risk of structural collapse*, and *wearing heavy protective gear*. A few participants emphasised how even seemingly simple incidents can turn unexpectedly complex in the presence of certain challenges. For instance, *perceptions of an operation's complexity* made one participant (P09) anticipate risks and hazards that were not present in reality. This perception can be caused by a lack of knowledge or awareness among inexperienced firefighters, as highlighted by another participant (P10), 'Sometimes a lack of knowledge of the incident makes them think that think a simple incident is actually complex' This anticipation is also exacerbated by the *frantic nature of the fire incidents* as the firefighters don't get time to be calm and think to make informed choices, ultimately leading to DF.

> The breathing never comes back under control from chronic hyperventilation, which has a huge effect on the ability to make effective decisions. [P07]

Firefighters also reported that *high-risk working conditions*, such as the *risk of structural collapse,* can also cause DF. One participant (P05) further cited that some fire incidents are extremely risky and even one slight mistake in decision-making can cause situations where 'chances of survival are really poor'. Moreover, the risk of structural collapse can dictate the critical decisions, including termination of operation, transition to interior/exterior attack. If firefighters are worried about the consequences of such fatal incidents, the decision-making becomes frantic and difficult.

> Part of the roof was starting to sag. That means that collapse is imminent. When that mental fatigue sets in, I may look at that roof and just simply not see the sag. [P01]

A few participants mentioned that *Outside interference* further increased the pressure to perform

flawlessly, as the presence of media personnel, neighbours, or family members of the victims can disrupt the performance and cognitive strategy-making of firefighters. One participant (P10) described the problems of outside interference as 'it does affect your decision-making because everyone's there watching'. Few participants also cited that *Miscommunication* and the need to work with *unfamiliar resources* also hinder effective decision-making.

> The concern is that what should I do with limited resources? And also another problem is to utilize unfamiliar resources. [P10]

The physical discomfort of working longer hours while *wearing heavy protective gear* was also identified as a factor contributing to DF. Both physical discomfort and thermal stress caused by wearing the heavy gear and personal protective equipment (PPE) were reported to impair the ability of critical judgement and decision-making, adding to the operational complexity of firefighting operations.

> I think the gears add additional physical weight which impacts my ability to make a decision, whereas if I could just wear my general work uniform, that would help with a lot of the decisions. [P12]

Consequences of decision fatigue

Thematic analysis of the interview transcripts identified 5 consequences of DF, including (1) decision-making inefficiency, (2) reduced cognitive performance, (3) emotional instability, (4) declining trust in leadership, and (5) communicational challenges. The themes for the consequences, along with their associated sub-themes and rationale, are presented in Table 3.

Decision-making inefficiency. According to every participant, the most severe consequence of DF is inefficiency in decision-making. They described that these inefficiencies result from a wide range of cognitive challenges faced by the firefighter after a prolonged period of decision-making. Multiple participants shared that DF led them to make *rushed decisions*. During a prolonged fire incident, where they must make multiple critical decisions, they often tend to make quick decisions without fully processing the entire situation and its consequences. A participant (P11) particularly recalled one such experience in the past where he stated, 'The problem was the rushed decision that I made. I thought both situations looked the same, and I took the wrong decision'. Others described how DF caused them to make *less effective decisions* that threatened the safety of both the victim and the firefighter.

> That (decision fatigue) can put other firefighters in jeopardy, and that can cause us to make ineffective decisions. [P10]

> If you are not making the most effective decisions, then people get hurt, fatalities, property loss, and so on. [P07]

Some participants also reported that DF causes them to operate at a *slower rate of decision-making,* which can lead to serious consequences, as firefighters must be quick in their decision-making to save lives and property during fast-paced, critical incidents. One participant (P16) specifically termed this difficulty as indecisiveness, explaining, 'It takes you longer to make

Table 3. Summary of sub-themes, themes, and rationale of the consequences of decision fatigue.

Themes	Sub-themes	Rationale
Decision-making inefficiency	Getting rushed in making decisions Making less effective decisions Wrongful decision-making Slower rate of decision making Uncertainty in the outcome of decisions Making unsafe decisions	Rationale related to slowing down of decision-making due to DF, which ultimately increases the likelihood of less effective and wrongful decisions.
Reduced cognitive performance	Mental exhaustion Losing cognitive abilities Suffering from sensory overload Unable to recognise the environment Forgetting crucial information Missing important information	Rationale related to impairment of cognitive abilities, information processing, and sensory perceptions.
Emotional instability	Lack of patience Losing empathy Fear of damage to reputation Inability to deal with failures	Rationale related to emotional instability-related effects such as losing patience, sympathy, and the ability to deal with failures and damage to reputation.
Declining trust in leadership	Lack of confidence in leadership Disrupting organisational morale	Rationale related to wrongful decision-making which eventually disrupts organisational morale and trust among firefighters.
Communicational challenges	Miscommunication between firefighters Less open to feedback	Rationale related to disruption of effective communication caused by fatigue, leading to miscommunication and reduced feedback.

decisions, it looks like indecisiveness, which doesn't build confidence in yourself'. Other participants highlighted that firefighting is an emergency response occupation, and delays in decision-making can lead to catastrophic consequences.

> Making so many decisions slows down your thought process. It's easy to get distracted by other things going on. [P11]

Moreover, DF led to increased *uncertainty in the outcome of decisions* for a few participants. Participants expressed doubt in their judgement due to exhaustion and lack of attention, even when the correct choice was made. In more severe cases, *unsafe decision-making* was regarded as a consequence of DF. For instance, a participant (P07) noted that unsafe decisions have a chain effect as one may lead to another, citing 'unsafe decisions as a result of fatigue, which is a compounding cause'. Others highlighted that their ability to evaluate risks and respond became impaired. These unsafe decisions can lead to injury to firefighters, harm to victims and property, and overall operational failures.

> I have made decisions that were the best decisions, and with mental fatigue you make a decision and you think it is the wrong decision. [P01]

> If I get that decision fatigue when I am unable to make a decision, it could really injure somebody else and hamper the mission. [P12]

Reduced cognitive performance. Several participants highlighted that the most severe consequence of DF is the impaired ability to make decisions and perform cognitive tasks. According to them, firefighting incidents largely depend on the quick and accurate decisions taken by the incident commanders and crew members. They felt they were unable to make effective decisions as the incidents progressed longer than expected. This prolonged period of firefighting led to *mental exhaustion* and *loss of cognitive abilities.* One participant (P12) notably described the condition as 'not at peak state to start that next shift' because of mental exhaustion. Consequently, they suffer from DF and continue making mistakes due to the loss of cognitive abilities, such as judgement and situational awareness.

> If you do not have the ability to rest for the next few days, then you come back to work already exhausted. You are going to be in a mental state of exhaustion, and then that affects you again. [P11]

> Once they (firefighters) have screwed up one time with one incident, they lose their competence for subsequent incidents. [P10]

Some participants mentioned that they *were unable to recognise the environment* and suffered from *sensory overload* as a result of DF. For instance, one participant (P01) cited the inability to recognise the environment as a major indicator of losing situational awareness in the fireground. Another participant felt *sensory overload* as a consequence of DF. They described becoming increasingly overwhelmed by their surroundings due to exhaustion. This included difficulty in processing simultaneous inputs such as radio communications, verbal commands, and other stimuli (e.g. smoke, smell) during an incident.

> It is very easy as (a result of) fatigue to get overwhelmed because of sensory overload and too many people talking to you. [P18]

Others also reported that information identification and processing became difficult under the influence of DF. This leads to a high likelihood of *forgetting crucial information* during firefighting operations. Participants have struggled with maintaining situational awareness and recalling essential information to make decisions and take appropriate actions during their past experiences. Participants also mentioned that another consequence of DF is *missing important information*. They described having trouble noticing key information, which is often a critical cue for making decisions. Missing those cues can lead to potential threats to both individual and team safety, and other catastrophic consequences.

> Your situational awareness, especially when you are tired. is a lot less. It is harder to do everything or remember everything on your check sheets. [P17]

> When decision fatigue comes into play, you can either miss a stimulus or indication that something is going wrong. [P18]

Declining trust in leadership. Some participants identified declining trust in leadership as a secondary consequence of DF, both at the interpersonal and organisational levels. When incident commanders make erroneous decisions, firefighters begin to show a *lack of confidence* in their leadership and often decide to make decisions on their own. Such occurrences in the fireground undermine the authority of the incident commanders. *Disrupting organisational morale* is another secondary consequence when leadership decisions go wrong. One participant (P07) particularly pointed out that disagreements between the team during firefighting can lead to 'lack of faith in the system and a very inherent negative viewpoint of the department, and that takes a long time to recover for the organization'. These reflections from the participants suggest that

DF can have ripple effects that may extend beyond individual performance and safety.

> They do not feel like they want to follow the fire chief if you make mistakes. Because sometimes they get hurt or have safety issues. [P16]

Communicational challenges. Participants also identified that DF impairs communication among firefighters, particularly in elongated and critical incidents. Mentally exhausted firefighters often suffer from a lack of situational awareness, which leads to miscommunication between themselves and incident commanders. Ineffective communication and information among the teams and individual members lead to incorrect decision-making, misinterpretation of commands, and increased risk to firefighters and victims. Another communication-related consequence mentioned by a participant (P01) was being *less open to feedback*. According to them, DF leads to reluctance to accept suggestions or feedback from other firefighters.

> Because of miscommunication, you miss a trigger. In one past incident, we missed the smoking oven. We walked right by it because we were just fatigued and didn't see that. [P18]

> I become less open to feedback with mental fatigue and as the scene lasted longer. [P01]

Emotional instability. A few participants cited that DF makes them emotionally vulnerable. Firefighters need to be physically, mentally, and emotionally strong. However, the participants mentioned that they suffer from a *lack of patience* and *a loss of empathy*. Even experienced firefighters become less focused and easily frustrated under fatigued conditions. One participant (P10) felt that DF 'slows down decision-making' and that it eventually makes them 'impatient' in their subsequent actions in the fast-paced events. Others also felt a lack of empathy under the influence of DF.

> I think if I am fatigued, I may be thinking I do not want to have much more of this conversation because I am not present in the moment. [P13]

> I have lost some aspect of empathy or sympathy due to feeling sluggish, having brain fog, and tired. [P05]

Participants also felt that they had trouble dealing with failures because of DF. It leads them to ponder over the failures and ultimately make more mistakes. Thus, they tend to have secondary consequences such as an *inability to deal with failures* and a *fear of damage to their reputation*. For instance, one participant (P19) shared their observation of fellow firefighters who 'never forget those bad decisions and never forgive themselves', and another participant (P10) cited that firefighters don't take liability for the mistakes by stating, 'but people don't really own up to that because all you turn into that personal grief'.

> It is after the operation, I think some stress is there, but as I think more, it is the embarrassment, and the reputation damage that you feel. [P10]

> Wrong decisions put an emotional load on most firefighters in general, just because of the pride and ownership we take in this job. [P18]

Quantitative results

A total of 453 firefighters initiated the survey, however, only 329 participants completed the survey, and the data from these participants were included for statistical analysis. Among them, 90% were male (n = 295) and 10% were female (n = 33). The ages of the participants ranged from 18 to 81 years ($M = 42.94$, $SD = 11.43$). The demographic information of participants is shown in Table 4.

The distribution of participant responses across the five Likert scale categories for 39 causes and 20 consequences are shown in Figures 2 and 3, respectively. The mean values of the 39 causes indicate that sleep deprivation ($M = 3.29$, $SD = 1.20$), wrong information ($M = 3.27$, $SD = 1.11$), and incomplete information ($M = 3.23$, $SD = 1.04$) are the top 3 major causes of DF. Furthermore, lack of confidence in leadership ($M = 3.09$, $SD = 1.21$), mental exhaustion ($M = 3.09$, $SD = 1.09$), and disrupting organisational morale ($M = 2.93$, $SD = 1.07$) are the 3 major consequences of DF. The descriptive analysis further revealed that the participants reported a moderate level of perceived stress ($M = 20.72$, $SD = 3.65$). Among the OFER subscales, chronic fatigue ($M = 10.67$, $SD = 7.47$) was lower among the participants compared to acute fatigue ($M = 15.59$, $SD = 3.43$). Finally,

Table 4. Participant demographics of the quantitative survey.

Participant characteristics	
Participants (n)	
Total	329
Male	295
Female	33
Preferred not to answer	1
Experience (Years)	
Mean (M)	19.49
Standard deviation (SD)	11.65
Ethnicity (n)	
White	299
White/Some other race, ethnicity, or origin	2
Black or African American	4
American Indian or Alaska Native	5
White/American Indian or Alaska Native/ Hispanic, Latino, or Spanish Origin	1
Hispanic, Latino, or Spanish Origin	3
White/American Indian or Alaska Native	8

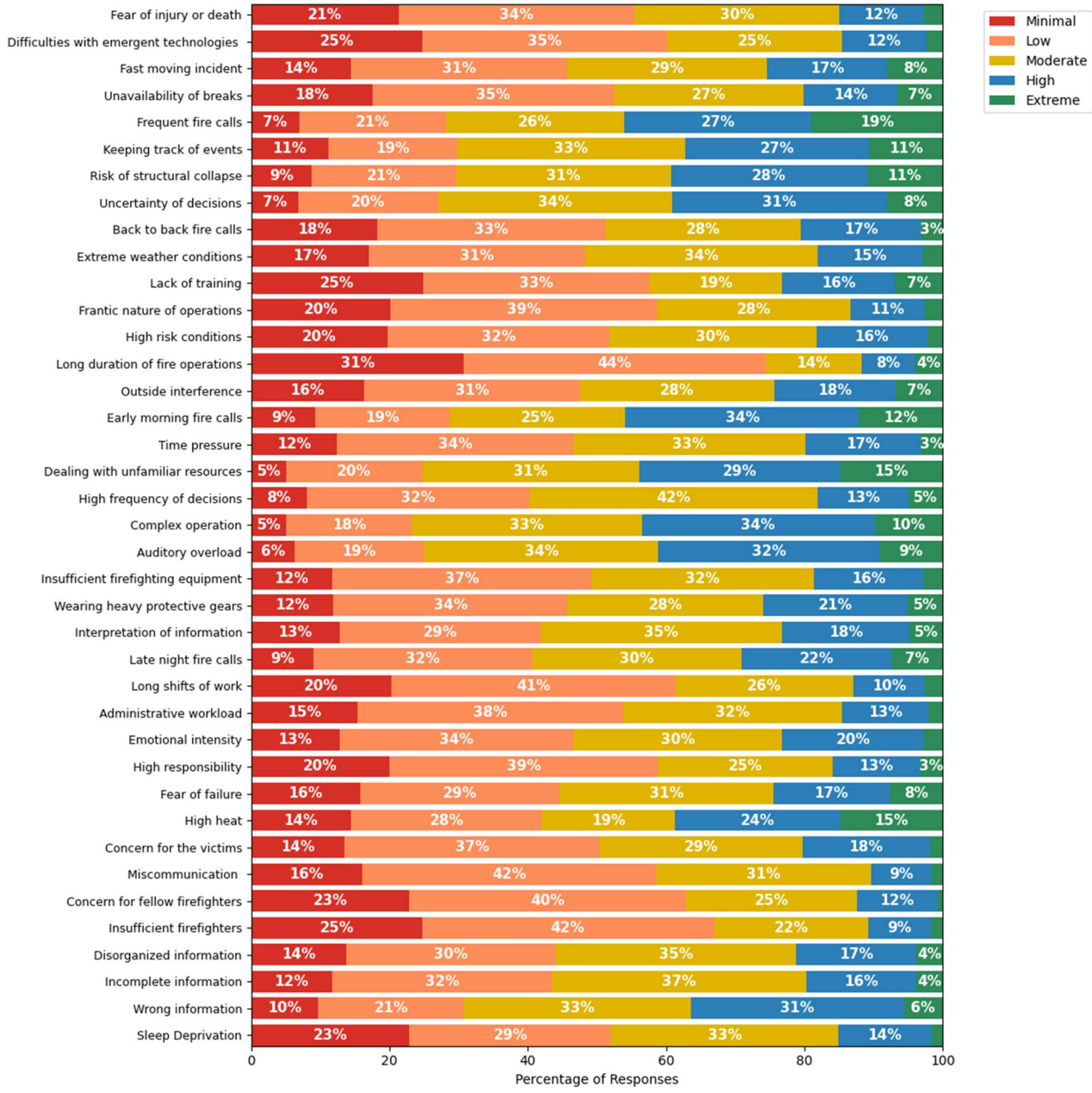

Figure 2. Distribution of participants' responses across a 5-point Likert scale for the 39 causes of DF. The stacked horizontal bars represent the percentage distribution of each cause across the 5-point Likert scale. The five coloured bars, i.e. red, orange, yellow, blue, and green represent the five scales of the survey questions, *minimal, low, moderate, high, and extreme*, respectively.

the participants reported a moderate level of recovery between shifts ($M = 14.38$, $SD = 2.78$).

Univariate regression analysis

Univariate analysis showed significant predictors of the consequences of DF, including total PSS score ($\beta = 1.22$, $t = 5.64$, $p < .001$), OFER chronic score ($\beta = 0.61$, $t = 2.58$, $p < .05$), OFER acute score ($\beta = 0.62$, $t = 5.9$, $p < .001$), OFER intershift recovery score ($\beta = 0.61$, $t = 2.58$, $p < .001$) and all the individual 39 causes of DF ($p < 0.001$). Only the demographic variables age ($B = -0.03$, $t = -0.39$, $p = .695$) and years of experience ($B = -0.08$, $t = -1.13$, $p = .258$) were not statistically significant predictors. Full results of the univariate analyses are presented in Table 5.

Multivariate linear regression analysis

The final multivariate model included 15 variables, which indicated that the eight predictors explained 63.6% of the variance in the total DF consequence score ($R^2 = 0.636$, F (15,313) = 55.53, $p < 0.001$), and among them fear of failure ($\beta = 1.42$, $t = 2.98$, $p = .003$), interpretation of information ($\beta = 2.21$, $t = 3.19$, $p = .002$), dealing with unfamiliar resources ($\beta = 1.22$, $t = 2.69$, $p = .007$), miscommunication ($\beta = 1.74$, $t = 2.61$,

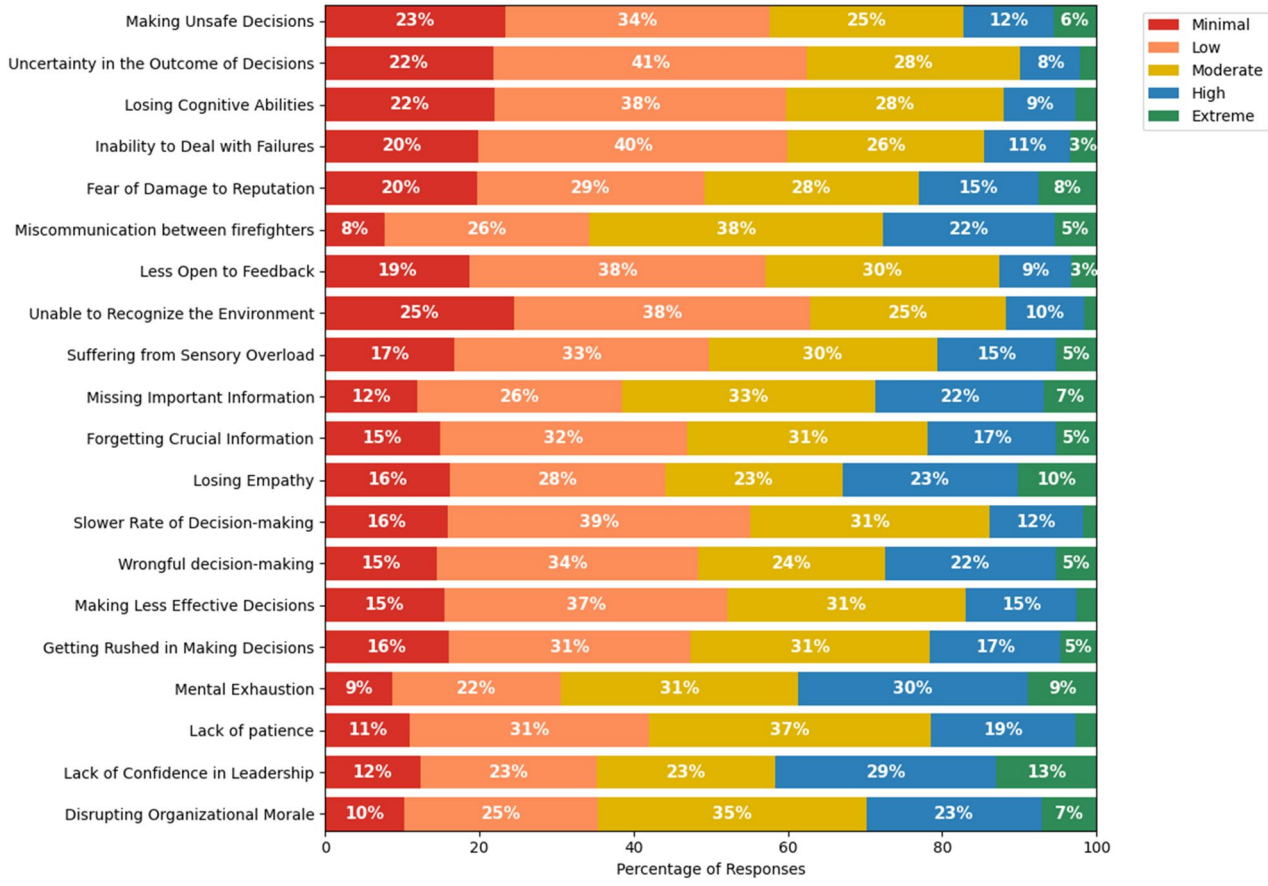

Figure 3. Distribution of participants' responses across a 5-point Likert scale for the 20 consequences of DF. The stacked horizontal bars represent the percentage distribution of each consequence across the 5-point Likert scale. The five coloured bars, i.e. red, orange, yellow, blue and, green represent the five scales of the survey questions, *minimal, low, moderate, high, and extreme*, respectively.

p = .009), uncertainty of decisions (β=1.55, t=2.22, p = .027), outside interference (β=1.37, t=2.2, p = .028), sleep deprivation (β=1.09, t=2.05, p = .041), late night fire calls (β=1.15, t=2, p = .046) were significant (Table 6). The remaining variables were not significant. The final regression model explained 63.6% of the variance in the total DF consequence score, with a large effect size according to Cohen's f^2=1.75. To assess the presence of multicollinearity among predictors, the variance inflation factor (VIF) was calculated. All VIF values were within acceptable limits (<5), indicating no serious multicollinearity issues.

Discussion

This study aimed to identify the causes and consequences of DF through an exploratory sequential analysis. The initial qualitative analysis identified 39 causes and 20 consequences of DF, which were subsequently grouped into eight and five themes, respectively. During the quantitative analysis phase, univariate and multivariate regression were applied to find the most severe causes of DF (e.g. fear of failure, miscommunication). The convergence of the qualitative and quantitative findings establishes DF as a serious threat to firefighting. All the causes identified from the qualitative phase were found significant in the univariate regression analysis (see Table 5), and 8 of them were also significant in the multivariate regression analysis (see Table 6). This methodological triangulation strengthens the validity of the findings of our study.

The findings highlight that DF is a critical challenge in firefighting, consistent with the conceptual analyses by Baumeister et al. (1998) and Pignatiello, Martin, and Hickman (2020). The ego depletion theory by Baumeister et al. (1998) proposed that any task requiring excessive cognitive effort contributes to the DF of an individual, supported by several identified causes in our study (e.g. high workload, cognitive overload). Our study also supports the findings of Pignatiello, Martin, and Hickman (2020), as our participants reported that making numerous decisions depleted their mental resources and led to erroneous decision-making. However, our findings imply that firefighting

Table 5. Univariate regression analysis of predicting decision fatigue consequences.

Predictor	β	t	p
Age	−0.03	−0.39	0.695
Years of experience	−0.08	−1.13	0.258
PSS_Total	1.22	5.64	$p < 0.001$***
OFER_Chronic_Total	0.61	2.58	$p < 0.05$*
OFER_Acute_Total	0.62	5.9	$p < 0.001$***
OFER_Recovery_Total	0.6	2.06	$p < 0.05$*
Extreme weather conditions	4.72	6.31	$p < 0.001$***
High heat	4.54	6.25	$p < 0.001$***
Wearing heavy protective gears	6.19	8.27	$p < 0.001$***
Auditory overload	5.76	7.82	$p < 0.001$***
Difficulties with emergent technologies	5.87	7.54	$p < 0.001$***
Fast moving incident	5.99	7.57	$p < 0.001$***
Keeping track of events	7.02	8.45	$p < 0.001$***
Time pressure	6.4	8.41	$p < 0.001$***
Fear of failure	5.07	8.86	$p < 0.001$***
Administrative workload	4.64	6.99	$p < 0.001$***
Back-to-back fire calls	5.83	8.15	$p < 0.001$***
Complex operation	7.69	11.22	$p < 0.001$***
Frantic nature of operations	8.82	12.65	$p < 0.001$***
Frequent fire calls	5.96	8.1	$p < 0.001$***
High responsibility	6.13	9.08	$p < 0.001$***
Long shifts of work	6.29	9.18	$p < 0.001$***
Emotional intensity	7.22	11.09	$p < 0.001$***
High frequency of decisions	8.03	11.44	$p < 0.001$***
Disorganised information	8.09	12.52	$p < 0.001$***
Incomplete information	7.82	11.81	$p < 0.001$***
Interpretation of information	9.02	12.97	$p < 0.001$***
Wrong information	7.02	11.09	$p < 0.001$***
Dealing with unfamiliar resources	8.61	12.95	$p < 0.001$***
Insufficient firefighters	4.92	7.64	$p < 0.001$***
Insufficient firefighting equipment	5.44	8.37	$p < 0.001$***
Fear of injury or death	6.29	9.02	$p < 0.001$***
High-risk conditions	6.44	9.3	$p < 0.001$***
Risk of structural collapse	6.92	9.69	$p < 0.001$***
Lack of training	5.98	10.04	$p < 0.001$***
Long duration of fire operations	7.98	12.19	$p < 0.001$***
Outside interference	7.53	11.58	$p < 0.001$***
Miscommunication	8.04	12.35	$p < 0.001$***
Concern for fellow firefighters	6.23	9.68	$p < 0.001$***
Concern for the victims	5.23	7.99	$p < 0.001$***
Sleep Deprivation	5.68	9.38	$p < 0.001$***
Early morning fire calls	6.05	9.09	$p < 0.001$***
Late night fire calls	6.46	10.34	$p < 0.001$***
Unavailability of breaks	7.25	10.69	$p < 0.001$***
Uncertainty of decisions	8.68	13.73	$p < 0.001$***

Note. β = unstandardised coefficient. Significance: *$p < .05$, **$p < .01$, ***$p < .001$.

accelerates and intensifies these consequences compared to the experimental settings of previous studies on food choice (Olsen et al. 2017) and on shoppers' self-reported degree of prior active decision-making (Vohs et al. 2008). Although past studies have associated DF with extended shifts (Allan et al. 2019; Treasure et al. 2022), our results suggest that firefighters may experience DF in incidents lasting shorter periods due to other causes, such as resource limitations, high heat, and extreme weather. Therefore, our study suggests that firefighters' cognitive resources also deplete due to operational challenges resulting from repeated decision-making within a short period, corroborating the study by Bufano et al. (2024), which highlighted the effects of shift work, occupational stress, and prolonged working hours on the cognitive functioning of firefighters.

The qualitative analysis identified eight major causes of DF (see Table 2). Previous studies on DF have primarily focused on individual causes such as high workload (Fernández-Miranda et al. 2023; Hirshleifer et al. 2019), complexity of decisions (Fernández-Miranda et al. 2023; Zheng et al. 2020), frequency of decisions (Ma, He, and Liao 2021; Natal and Saltzman 2022), and duration of the decision-making period (Natal and Saltzman 2022; Shroff and Vamvourellis 2022; Torres and Williams 2022) across several domains. However, our study shows that DF can be caused by multiple organisational, environmental, and psychological factors in firefighting, and identifying all possible causes is vital to mitigating DF. Although no studies have previously explored DF among firefighters, similar results have been observed in other domains. For example, Schweitzer et al. (2023) showed that cumulative

Table 6. Multivariate regression analysis of predicting decision fatigue consequences.

Predictor	β	SE β	t	p
Intercept	6.21	2.19	2.84	0.005**
Fear of failure	1.42	0.48	2.98	0.003**
Interpretation of information	2.21	0.69	3.19	0.002**
Dealing with unfamiliar resources	1.83	0.68	2.69	0.007**
Miscommunication	1.74	0.67	2.61	0.009**
Uncertainty of decisions	1.55	0.7	2.22	0.027*
Outside interference	1.37	0.62	2.2	0.028*
Sleep deprivation	1.09	0.53	2.05	0.041*
Late night fire calls	1.15	0.57	2	0.046*
Auditory overload	1.05	0.55	1.92	0.055
High frequency of decisions	1.36	0.76	1.8	0.073
High responsibility	−1.22	0.68	−1.78	0.075
Long duration of fire operations	1.2	0.69	1.73	0.084
Administrative workload	0.86	0.51	1.68	0.094
Lack of training	0.84	0.51	1.66	0.097
Risk of structural collapse	0.89	0.62	1.44	0.151

Note. β = unstandardised coefficient; SE β = standard error; *p*-values are rounded to three decimal places. Significance: *$p < .05$, **$p < .01$, ***$p < .001$*.

cognitive demands over time led physicians to become mentally fatigued. Similarly, Cuenca-Lozano and Ramírez-García (2023) highlighted that noise exposure, high temperatures, long shifts, and equipment-related challenges contribute to making it more difficult to select the most relevant cues amidst rapidly evolving conditions in firefighting. Our study advances beyond previous literature by categorising these factors and systematically grouping the 39 sub-causes into eight broader DF cause categories. For instance, the environmental causes identified in our study (e.g. high heat, extreme weather conditions) are unique to the context of firefighting and are notably absent in previous studies in healthcare, the judiciary, and economic decision-making. Our findings align with the articles of Abreu et al. (2017) and Duran, Woodhams, and Bishopp (2018), who identified heavy smoke and high heat as environmental stressors in firefighting. Moreover, the inclusion of emotional load further advances the concept of traditional cognitive load theory by highlighting the psychological burden firefighters face when making life-or-death decisions under challenging circumstances. For example, one participant (P15) cited emotional intensity as a major cause of DF, as he mentioned, 'incidents involving children are always stressful and affect decision-making'. Overall, most causes of DF identified in this study are aligned with past literature, while the remaining causes (i.e. miscommunication, outside interference) aim to fill gaps in the literature.

The qualitative phase of our study identified five major consequences of DF among firefighters: reduced cognitive performance, decision-making inefficiency, emotional instability, declining trust in leadership, and communication challenges (see Table 3). Participants recalled both the consequences of DF and subsequent erroneous decision-making in their past firefighting incidents. These consequences ranged from operational failures to personal and emotional trauma among firefighters. Prior literature has also shown the severity of the consequences of wrongful decisions in firefighting. For instance, Sallis et al. (2013) showed that even experienced firefighters may miss cues or misinterpret information due to the limited capability of the human brain, leading to critical errors. Moreover, previous studies have also identified several after-effects of erroneous decision-making in firefighters, including anxiety (Smith, Dyal, and DeJoy 2023), burnout (Wolkow et al. 2019), and post-traumatic stress disorder (Lebeaut et al. 2022). Our study extends the research on poor decision-making consequences by identifying and clustering these consequences under DF, establishing it as a key phenomenon that contributes to operational, emotional, and cognitive failures.

The regression analysis revealed that the most significant predictors of the consequences of DF were fear of failure, interpretation of information, dealing with unfamiliar resources, miscommunication, uncertainty of decisions, sleep deprivation, and late-night fire calls. These findings are consistent with Frost et al. (2021), who found the effect of sleep deprivation and poor recovery on the deteriorating quality of decision-making among firefighters. Similarly, Park, Moon, and Ha (2024) highlighted that organisational and psychosocial factors, such as a lack of transactional leadership ($p < 0.001$) and transformational leadership ($p < 0.001$), and poor job satisfaction ($p < 0.001$), impair the performance of firefighters. While transactional leadership may promote a more stable working environment and reduce uncertainty, our findings show that several operational challenges (e.g. the frantic nature of operations, miscommunication) and the uncertainty encountered on the fireground can limit its practical applicability. For instance, one participant (P11) in our study stated, 'radio communication broke (malfunctioned), they (firefighters) could not hear my command to evacuate', showcasing the inability of the fire chief to convey the commands to the firefighters. Moreover, the interpretation of information was significantly associated with the consequences of DF, consistent with previous studies, including the information filtering intuitive model by Okoli, Weller, and Watt (2016) and the short-term information processing model of Greenlee et al. (2014). This was also evident in the qualitative findings, where a participant (P09) highlighted that the mismatch between dispatch information and the actual information caused significant DF. Another significant predictor of the consequences of DF in our study was miscommunication, aligning with the study by Fox et al. (2017),

who found that communication is more complex in actual fire incidents than presented in training. Park et al. (2014) highlighted that reducing misconceptions and miscommunication in building fire incidents enhances the safety performance of firefighters. However, our findings demonstrate that miscommunication is not only a safety concern but also a significant predictor of DF consequences. Thus, our study provides a causal relationship between the causes and consequences of DF through the significant predictors of DF, which will help decision-makers prioritise causes based on their severity. Overall, knowledge of the most severe causes and their consequences will help decision-makers mitigate them, thereby enhancing decision-making quality, firefighter safety, and overall performance on the fireground.

Practical implications

The findings of our study suggest that firefighters must be aware of the causes of DF to reduce its occurrence. Several identified causes can be eliminated by taking appropriate measures. For example, novice firefighters can be trained to quickly assess and prioritise multiple information sources under time pressure by designing information-based training scenarios (Du et al. 2019; Hui et al. 2018) to eliminate certain causes of DF (i.e. dealing with multiple sources, interpretation of information). Past studies have also emphasised cognitive training alongside technical training for firefighters to improve cognitive performance and decision-making (Hemmatjo et al. 2020; Zare et al. 2018). Similarly, specialised training drills, such as the shadowboxing technique (Klein and Borders 2016), mindfulness training for stress reduction (Charness, Le Bihan, and Villeval 2024), and therapy sessions can be arranged to train firefighters, mitigate the causes of DF, and develop coping strategies following fire incidents. Fire departments should also consider implementing DF management strategies, similar to those previously suggested in healthcare (Maier et al. 2025; Perry et al. 2025).

Fire departments can raise awareness among firefighters about DF, maintaining that even good decisions can sometimes lead to poor consequences due to DF. The causes and consequences of DF can also be addressed in the post-scene debriefing to prevent them from occurring in future incidents (for example, see Hagemann et al. 2022). Finally, fire departments should consider implementing effective cognitive load management and risk management strategies, such as rescheduling shifts and recovery periods between fire incidents, to reduce the after-effects of DF.

Limitations and future research

This study had certain limitations that may affect the generalisability of the findings. First, the qualitative phase of the study relied on the self-reported experiences of the firefighters, which may have introduced recall bias or desirable-outcome bias. Participants may have deliberately chosen incidents that hide their inefficiencies and pretend to achieve the desirable outcome through their decision-making. Next, due to the retrospective nature of the interviews, the firefighters may not have recalled the exact causes and consequences of DF that had occurred during the real-time events. Moreover, our studies did not evaluate the potential effects of moderators (e.g. diversity of crew sizes across departments, age, and experience of firefighters) that might influence the regression results. Finally, the survey questionnaire was developed based on the qualitative findings, limiting open-ended responses from the survey participants. Therefore, there is a possibility of unexplored and latent causes and consequences of DF that can be explored in future research.

Future studies can differentiate the causes and consequences of DF between geographical areas (e.g. urban vs. wildland) or experience levels (e.g. career vs. volunteer). Moreover, physiological measurement tools (e.g. heart rate variability, EEG) can be used to objectively measure the psychophysiological consequences of DF (Katmah et al. 2021; Kim et al. 2018; Peabody et al. 2023). Finally, developing and testing mitigation strategies, such as virtual reality training (Clifford et al. 2019; Jeon et al. 2021) and decision support systems (Kadri, Chaabane, and Tahon 2014; Oh et al. 2016), will be essential to utilise the findings of our study effectively.

Conclusion

While the importance of decision-making has been addressed in past research, no studies have explored the causes and consequences of DF among firefighters. Therefore, this study employed a mixed-methods sequential design, integrating expert firefighter insights with survey-based regression analysis to identify the causes and consequences of DF. 39 sub-causes and 20 sub-consequences were initially identified, and later grouped into eight causes and five consequences, respectively. Finally, univariate regression and multivariate regression showed the severity of the causes by predicting the significance of the total consequence of each cause. Several causes stood out as significant predictors of DF consequences, including fear of

failure, interpretation of information, managing multiple resources, and miscommunication. Overall, these findings establish DF as a serious threat in firefighting, because firefighter safety and performance are highly susceptible to its adverse consequences. Future research should use real-time assessment tools to detect DF and develop mitigation strategies.

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None

Author contributions

CRediT: **Nurul Ahad Choudhury**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft; **Ed Kirtley**: Resources, Writing – review & editing; **Bryan L. Hoskins**: Resources, Writing – review & editing; **Pratima Saravanan**: Conceptualization, Funding acquisition, Investigation, Resources, Writing – review & editing.

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Data availability statement

Due to the nature of the research and due to the ethical considerations of human subject research, supporting data is not available.

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Appendix A

1. Which Fire Department are you currently working for?
2. What is your rank (or position) in your department?
3. How long have you been working as a firefighter?
4. Could you please walk us through your typical workday?
5. Do you think decision fatigue played a role in any specific way when considering or evaluating alternative options?
6. Did you feel any decision fatigue at those points that might have impacted on your decision-making? If so, what are the causes of decision fatigue?
7. Can you think of any specific ways that decision fatigue might have influenced your thinking, evaluation of options, or final choice?
8. What problems would occur if you were facing decision fatigue during the operation?
9. What were the effects on you as an individual due to decision fatigue? How did it affect your performance and decision-making?