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Research Article

Factors Associated with Work Fatigue (Occupational Health Study) among Firefighters in City X

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Abstract: Firefighters are required to possess excellent physical capacity given that their tasks have major implications for public safety. The volume and criticality of duties often lead firefighters to work more than 12 hours per day for 14 consecutive days. Unmanaged work fatigue can reduce performance and increase occupational safety and health risks. Factors that influence work fatigue include age and Working Period. The aging process, marked by an increase in age, leads to a decrease in work ability due to changes in the functions of body organs, the cardiovascular system, and the body's hormonal system. Length of service refers to the period of time a person has been employed at a particular office, organization, or institution. A preliminary survey found that 47% of firefighters at the City X Fire and Rescue Agency (DAMKAR) felt moderately fatigued and 13% felt highly fatigued, based on the KAUPK2 instrument. This study aimed to determine factors associated with work fatigue among firefighters in City X. Methods: A cross-sectional design was employed, with data collected at a single point in time, in Mei 2025. The study subjects were firefighters employed by the City X Fire Department. Purposive sampling yielded 56 respondents. Worker Age, working period, and work fatigue were measured using questionnaires. Bivariate relationships among variables were analyzed using the chi-square test. Results: The number of respondents categorized as "not fatigued" was 2, "moderately fatigued" was 21, and "highly fatigued" was 5. Bivariate chi-square analyses indicated significant associations between age and work fatigue, and between tenure and work fatigue ($p<0.05$). Age was significantly associated with fatigue ($p=0.002$). Working Period was significantly associated with fatigue ($p=0.049$). Conclusions: Age and tenure were associated with work fatigue ($p<0.05$). Future studies were suggested to examine additional factors beyond age and Working Period.

Keywords: Age;Firefighters;Working Period;Occupational Health;Work Fatigue

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1. Introduction

Firefighting is a profession that demands high vigilance and deep technical expertise due to critical and high-risk tasks such as fire suppression, rescue and evacuation during fires, fire prevention, public education, and other emergency services (Maryono & Herbawani, 2023). The volume and importance of these tasks often cause firefighters to work for more than 12 hours per day for 14 consecutive days (Jeklin et al., 2021). Work fatigue is defined as a decline in physical and mental conditions due to job-related factors that subsequently disrupt worker performance (Alam, 2022; Amalia & Widajati, 2019). Physical fatigue, in particular, is among the most common occupational health problems in firefighters, given the demands to perform extended duty hours and tasks requiring substantial physical strength—such as lifting and maintaining heavy operational equipment, and conducting suppression and evacuation in emergencies (Izza & Martiana, 2023).

Fatigue among firefighters can impair performance, reduce productivity, and increase the risk of injury and workplace accidents (Widiyanto & Nasri, 2024). The International Labour Organization (ILO) reported that approximately 2 million workers die annually due to work-related accidents associated with fatigue(International Labour Organization, 2023). In Indonesia, in 2021 there were about 414 occupational accidents per day, with 27.8% attributed to high levels of fatigue (Imbara et al., 2023). Firefighting tasks, such as lifting hoses, carrying ladders, and operating breaking tools, impose substantial cardiovascular and neuromuscular demands, which in turn reduce physical capacity and accelerate muscle fatigue during and after duty (Games et al., 2020). Studies on operational tasks have indicated that intense physical exertion is directly associated with increased fatigue and decreased performance (Games et al., 2020). The use of heavy personal protective equipment (PPE) and exposure to hot environments (fire and smoke) among firefighters limit the body's ability to dissipate heat, thereby increasing core temperature, accelerating dehydration, and reducing work capacity, which leads to faster onset of physical fatigue (Sandsund et al., 2024). Experimental evidence and reviews on heat stress in firefighters indicate that heat strain is a major contributor to fatigue (Sandsund et al., 2024).

The City X Fire Department is responsible for fire mitigation and a range of other disasters. It operates four stations distributed across the city. Functional roles comprise three main divisions: Secretariat; Rescue and Fire Suppression; and Equipment Protection Inspection, Fire Investigation, and Community Empowerment. The total workforce is 138 personnel, all referred to as firefighters. During interviews, firefighters reported frequent fatigue and physical exhaustion—such as muscle pain, loss of energy, and reduced cognitive function—due to heavy workloads beyond their primary responsibilities. KAUPK2 measurements conducted on 13–14 February 2025 among 15 respondents showed that 40% did not feel fatigued, 47% felt moderately fatigued, and 13% felt highly fatigued. Additionally, annual records for 2025 indicated a rise in average suppression time: from 33 minutes in January to 44 minutes in February (↑33%), and to 54 minutes in March (↑22%), which was influenced by multiple factors, including work fatigue among firefighters. Based on the aforementioned background, the researcher aims to conduct a study on "Factors Associated with Work Fatigue (Occupational Health Study) among Firefighters in City X."

2. Literature Review

2.1. Work Fatigue

Work fatigue is a psychological syndrome that occurs due to excessive physical, mental, or emotional exhaustion experienced by workers, which interferes with performance and achievement in the workplace (Alam, 2022). According to (Caldwell et al., 2019), work fatigue is an unavoidable consequence in modern industrial environments due to continuous operational hours, inconsistent work schedules, and rapid time transitions in the workplace, which consistently disrupt workers' circadian rhythms.

2.2. Mechanisms of Work Fatigue

According to Ganong's Review of Medical Physiology (26th ed.), fatigue results from bombardment of neural impulses to the brain originating from muscles and a reduction in blood pH due to lactic acidosis, producing perceived tiredness typically accompanied by increased body temperature, muscle pain, dyspnea, and other discomforts (Barrett et al., 2019).

2.3 Types and Causes of Work Fatigue

Types of work fatigue (Artana et al., 2020):

1. Physical fatigue, characterized by tremors or musculoskeletal pain causing physical discomfort.
2. Mental fatigue, arising from psychological factors and marked by reduced willingness to work. Common contributors include job intensity and duration, environmental conditions, workload, worry, workplace conflict, and disease.

Causes of work fatigue (Wahyuni & Indriyani, 2019):

1. Internal factor – Age: Reaction speed and concentration decline with age due to neuromuscular slowing and degenerative changes; physical capacity peaks near age 25 and declines thereafter (Agustin et al., 2021). A person's physical capacity and muscle strength reach their peak condition at the age of 25 and decrease by

about 25% by the age of 50–60. Meanwhile, sensory-motor strength declines by approximately 60%, causing individuals over 60 years old to have only half the muscle strength of those aged 25 (Mahawati et al., 2021).

2. External factor – Tenure: Increasing experience can reduce fatigue through improved skills and efficiency; habituation may enhance physical endurance (Juliana et al., 2021; Trimala et al., 2023).

3. Proposed Method

This study used a cross-sectional design, with data collected at one time point in Mei 2025. Data were obtained using questionnaires including items on age, tenure, and work fatigue. Work fatigue was measured using the KAUPK2 questionnaire. This study employed a standardized questionnaire that has been tested for validity and reliability in numerous studies with similar contexts. The research utilized a previously validated instrument developed by Setyawati (2017) from the Faculty of Medicine, Universitas Gadjah Mada, as a subjective measurement tool to assess the level of work fatigue based on individual perceptions (Setyawati, 2017). The population comprised all 138 firefighters employed by the City X Fire Department. Purposive sampling was used to select respondents based on criteria aligned with the study objectives (Sugiyono, 2019). Inclusion criteria: (a) 12-hour shift firefighters; (b) tenure >1 year; (c) Android device users. Exclusion criteria: firefighters aged >60 years. Based on these criteria, 82 out of 138 workers did not meet eligibility, resulting in a final sample of 56 respondents.

Before data collection, respondents completed an informed consent form describing study procedures, respondent benefits, willingness to participate, and data confidentiality. Verbal explanations were provided for any unclear information. Participation was voluntary, and respondents could withdraw at any time. The data analysis technique employed in this study utilized the Chi-Square test to examine bivariate relationships. The Chi-Square test was applied to evaluate whether there is a significant relationship or association between two categorical variables. This test was selected due to its simplicity and robustness, as it enables researchers to test hypotheses by comparing the observed frequencies with the expected frequencies. In both the context of the goodness-of-fit test and the test of independence, the Chi-Square test provides valuable insights into the patterns and relationships within the data.

KAUPK2 is a standardized instrument for Indonesian workers covering three domains: reduced activity, reduced motivation, and physical symptoms. Each of the 17 items is rated 1–3 (never; yes, rarely; yes, often). Total scores categorized respondents as not fatigued (<23), moderately fatigued (23–31), and highly fatigued (>31).

4. Results and Discussion

Table 1. Percentage Distribution of Responses to KAUPK2 Items

No.	Item	Never	Yes, Rarely	Yes, Often
1	Do you find it hard to think?	60.7	21.4	17.8
2	Do you feel tired when speaking?	67.8	17.8	14.2
3	Do you feel nervous facing something?	60.7	25.0	14.2
4	Do you feel you never concentrate on tasks?	57.1	21.4	21.4
5	Do you feel you lack attention to things?	75.0	14.2	10.7
6	Do you feel a lack of self-confidence?	64.2	21.4	14.2
7	Do you tend to forget things?	60.7	25.0	14.2
8	Do you feel you are not diligent in your work?	60.7	28.5	10.7
9	Do you feel reluctant to make eye contact?	67.8	21.4	10.7

No.	Item	Never	Yes, Rarely	Yes, Often
10	Do you feel uneasy at work?	78.5	14.2	7.1
11	Do you feel tired all over your body?	50.0	32.1	17.8
12	Do you feel you act slowly?	64.2	17.8	17.8
13	Do you feel reluctant to work nimbly?	75.0	14.2	10.7
14	Do you feel unable to keep walking?	57.1	21.4	21.4
15	Do you feel tired before starting work?	64.2	17.8	17.8
16	Do you feel your mental capacity has declined?	53.5	32.1	14.2
17	Do you feel anxious about something?	78.5	10.7	10.7

The table above represents the total score of each question in the questionnaire used to measure work fatigue (KAUPK2) among the respondents.

Table 2. Descriptive Statistics of KAUPK2 Total Scores

Minimum	17
Maximum	39
Mean	25.54
Standard Deviation	6.80

The table above presents the descriptive analysis of the KAUPK2 instrument. Based on the results of the univariate analysis, the minimum value was 17, the maximum value was 39, the mean was 25.54, and the standard deviation was 6.80.

Table 3. Frequency Distribution of Work Fatigue Categories

Work Fatigue Category	n	%
Not fatigued	2	7.1
Moderately fatigued	21	75.0
Highly fatigued	5	17.9

Based on the table, the "not fatigued" category included 2 respondents, the "moderately fatigued" category included 21 respondents, and the "highly fatigued" category included 5 respondents.

Table 4. Univariate Analysis of Age and Working Period

Age (SD = 10.29; Mean = 38.78)		
Age Group	n	%
≤25 years	8	14.29
26–49 years	36	64.29
50–60 years	12	21.42
Working Period (SD = 7.18; Mean = 9.64 years)		

Working period Group	n	%
<6 years	16	28.6
6–10 years	21	37.5
>10 years	19	33.9

The respondents included in this study were firefighters aged up to 60 years, with age categorization based on the theory proposed by Mahawati (Mahawati et al., 2021). Based on Table 4, it is known that the majority of respondents were aged 26–49 years, totaling 36 respondents (64.29%). Meanwhile, the age group ≤25 years consisted of 8 respondents (14.29%), and the 50–60 years age group consisted of 12 respondents (21.42%). The standard deviation of the age variable was 10.29, and the mean value of the age variable was 38.78.

In this study, the categorization of working period was based on the theory of Robbins and Judge (Robbins et al., 2017). Table 4 shows that the majority of respondents had a working period of 6–10 years, totaling 21 respondents (37.5%). Meanwhile, 16 respondents (28.6%) had a working period of less than 6 years, and 19 respondents (33.9%) had a working period of more than 10 years. The standard deviation of the working period variable was 7.18, and the mean value was 9.64.

Factors associated with work fatigue among firefighters include age, gender, length of service, workload, and sleep quality (Widiyanto & Nasri, 2024). Shift design and call volume have a substantial impact on fatigue levels, sleep recovery, and the risk of errors or injuries; interventions such as in-shift napping and structured recovery schedules have been shown to be effective (Moreira & Lucca, 2025). Sleep Health programs (education and screening for sleep disorders) and Fatigue Risk Management Systems (FRMS) have been proven effective as comprehensive approaches. Structured napping during night shifts has been shown to reduce subjective fatigue and improve physiological functioning in prehospital and shift-work studies (Beatrice & Böckelmann, 2024).

Behavioral Education and Training (Sleep Hygiene) and Fatigue-Risk Management can be implemented through institutional policies involving regular sleep hygiene sessions and sleep strategies during off-shift periods (Sharma et al., 2025). Sleep hygiene has been shown to influence sleep duration and sleep quality when integrated with structural policies. Structural policies include the arrangement of structured naps (20–60 minutes) during night shifts and the provision of quiet room facilities. Education is delivered through brief instructional materials on sleep hygiene, online sleep hygiene modules, and support for the implementation of sleep hygiene practices. The success of the program can be assessed based on sleep hygiene knowledge scores and changes in behavior (self-reported). Age and length of service influence fatigue through several interrelated pathways, including physiological changes associated with aging (sarcopenia, reduced cardiovascular capacity, and mitochondrial dysfunction), sleep disturbances and increased prevalence of obstructive sleep apnea (OSA) with advancing age, cumulative occupational exposures (heat, smoke, and chemical agents) that trigger chronic and oxidative inflammation, decreased recovery capacity and resilience due to allostatic load, and musculoskeletal effects or chronic pain that impede recovery (Li et al., 2024).

The correlation test between respondent characteristics (age and working period) and the level of work fatigue was conducted. The results of this test are interpreted as follows:

Age (p = 0.002)			
Age Group	Not fatigued n (%)	Moderately fatigued n (%)	Highly fatigued n (%)
≤25	1 (12.5)	7 (87.5)	0 (0)
26–49	6 (16.7)	29 (80.6)	1 (2.8)
50–60	5 (41.7)	7 (58.3)	0 (0)
Working Period (p = 0.049)			

Working Period Group	Not fatigued n (%)	Moderately fatigued n (%)	Highly fatigued n (%)
<6 years	3 (18.75)	7 (43.75)	6 (37.5)
6–10 years	0 (0)	10 (47.62)	11 (52.38)
>10 years	0 (0)	13 (68.42)	6 (31.58)

4.1. Worker Age

Based on KAUPK2 measurements, higher levels of work fatigue were dominated by respondents aged ≤25 years. This may have occurred because individuals aged ≤25 years tended to appraise their fatigue more introspectively, thereby perceiving themselves as more fatigued even when objective performance remained optimal (Tzichinsky & Baret, 2024; Wu et al., 2015). Younger workers were also likely to be in an adaptation phase and more sensitive to psychosocial stressors because their coping strategies and stress management had not yet matured (Rohmadi & Cahyono, 2017). As shown by KAUPK2 responses, items related to mental fatigue were more prominent in the control group. The Spearman test indicated that age had a significant association with work fatigue measured by KAUPK2 ($p = 0.002$).

4.2. Working Period

Working Period was categorized as <6 years, 6–10 years, and >10 years (Robbins et al., 2017). In this study, higher levels of fatigue were dominated by respondents with >10 years of service in the "moderately fatigued" category, potentially reflecting cumulative physical and mental fatigue, and possible dissatisfaction with career progression (Rohmadi & Cahyono, 2017). Additionally, long tenure may foster boredom due to repetitive tasks (Robbins et al., 2017). Respondents with 6–10 years of tenure exhibited higher fatigue than those with <6 and >10 years, which may reflect reduced task variation during a transition phase from adaptation to stability. The Spearman test indicated a significant association between working period and work fatigue measured by KAUPK2 ($p = 0.049$), aligning with findings by Makara-Studzińska et al (Makara-Studzińska et al., 2020).

5. Conclusions

This study found that age and tenure were factors associated with work fatigue among firefighters in City X. A limitation of this study was the application of inclusion criteria restricting the sample to those working 12-hour shifts and with working period >1 year; therefore, the findings could not be generalized to the entire firefighter population. A fatigue-risk management–based work scheduling system can be implemented to mitigate occupational fatigue among firefighters. Behavioral education and training (sleep hygiene) may be incorporated through work schedule regulations that limit operational shifts to a maximum of 24 hours with a minimum recovery period of 48 hours, along with policies for structured naps (20–60 minutes) during night shifts and the provision of quiet room facilities. Future research was recommended to involve larger samples and to examine additional factors potentially associated with work fatigue to yield more comprehensive and generalizable results.

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