



Building Resilience in Firefighters: A Systematic Review

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Abstract

Background: We aimed to identify indicators affecting firefighters' resilience through a systematic review.

Methods: International electronic databases, including Web of Science, Medline through PubMed, Scopus, Cochrane Library, and Google Scholar, were searched on Dec 23, 2018. The search strategy was developed using main words, including firefighter, resilience, and indicators. Then, the indicators related to firefighters' resilience were extracted and analyzed using a qualitative synthesis method.

Results: Overall, 7178 unique documents were identified by searching different databases. Then, by screening the title and abstract, 7104 articles were excluded, and only 74 full text papers were critically studied. Finally, 31 full text articles were selected for the analysis. Quality appraisal of included studies done by modified STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) tool. Moreover, 186 indicators and criteria were extracted from the included studies and classified into 6 domains and 15 categories.

Conclusion: This study suggests six main domains, including physical health, physical fitness, mental health, life style, job-related competencies, and demographic status, to categorize different indicators of firefighters' resilience. Building resilience in firefighters requires all these domains to be considered in the assessment, planning, and evaluation processes.

Keywords: Resilience; Safety; Firefighter; Systematic review

Introduction

Due to the nature of their job, firefighters have always been facing unknown and dynamic environments (1). Firefighting is a physically demanding job, exposing the individual to lots of hazards. There are also high injury rates among firefighters (2). This job is a high risk occupation; for instance,

80-100 firefighters die annually in the United States due to occupational risks (3). Generally, firefighters are exposed to high levels of physical and mental stress during their work (4). Therefore, it is recommended to test them for probable diseases such as musculoskeletal disorders, coronary-



artery disease, lung disease, psychological disorders and give them proactive services to identify health related problems, such as physical or mental problems as soon as possible. On the other hand, firefighting requires some specific physical and mental characteristics, such as appropriate fitness and personality to decrease occupational incidents (5). Some people have risk prone personality that lead to dangerous behaviors at workplace. Therefore, it is important at the primary stage of hiring the workers their personality to be assessed. The number of fire departments carrying out physical fitness tests to determine whether the personnel are fit for the task (6).

Firefighters' mental and physical health and welfare are important issues to help them protect themselves and communities in accidents and disasters (7). Resilience, as a way through which people deal with dangerous situations occurring in their lives, is defined as "the ability to adapt to changing conditions and to withstand and recover promptly from emergencies arising from manmade or natural disasters" (8). Resilience is a protective factor against adverse incidents for firefighters who have frequent and long-term exposure to hazardous materials and dangerous situations (9). Resilient firefighters can cope with complex situations and adapt to dangerous situations (10). To ensure the safety, health, and well-being of firefighters, increase their productivity, and to reduce occupational injuries, they need to have adequate resilience (11). Many firefighting departments use psychological exams to decide whether the firefighting candidates are truly motivated for this job. Such kinds of assessments are intended to determine the firefighters' ability to deal with severe emotional stress when facing fire and other hazardous materials (12).

In order to minimize job-related injuries among firefighters and to ensure that job duties are not beyond the capabilities of individuals, it is essential to evaluate their resilience in different aspects when hiring firefighters to ensure that they are appropriately resilient to absorb, cope with, and respond to the risks of this job. There are a variety of physical, mental, safety, and fitness examinations that evaluate firefighters' competencies. In

2014, a study suggested five dimensions, including professional skills, psychological quality, professional accomplishment, self-development, and interpersonal cooperation, to evaluate firefighters' competencies (13). Another study tried to investigate the demographic and occupational determinants of the firefighters' work ability using the Work Ability Index (WAI) (14), while this tool was not specifically developed for firefighters. The National Fire Protection Association (NFPA) has issued numerous codes and standards needed for the firefighting job (15). No comprehensive tool or model has been developed to assess firefighters' resilience. Therefore, this may endanger the lives of firefighters, and the lives of their colleagues, families, and communities (4, 7). The first step for developing a tool for resilience assessment is to identify indicators influencing the level of firefighters' resilience.

We aimed to systematically review the literature to develop a comprehensive framework, including domains and indicators, for assessing and building resilience in firefighters.

Methods

Five databases, including Scopus, Cochrane library, Web of Science, Google Scholar, and PubMed through MEDLINE, were searched to find relevant studies published in English up to search date December 23, 2018.

All the search key terms related to 'assessment' were through the PubMed (MeSH) system, and also experts' opinion in the combination with terms including 'firefighters' and 'resilience'. The search syntax, consisting of keywords and their synonyms, was searched in the title, abstract or keyword fields in the electronic databases. NNR (the Number Needed to Read) was about 13 in the Web of Science search. Databases were searched based on an evolved form of the following search syntaxes:

(Firefighter* OR fireman* OR "fire and rescue") AND (Safe* OR resilient* OR eligibility) AND (Assess* OR evaluate* OR estimate* OR appraise* OR criteria).

Study Selection

All the examined papers were transferred to a form developed by the authors, followed by removing the duplicates. Two well-informed reviewers investigated the papers briefly, and identified the relevant studies based on their titles and abstracts. Afterward, the selected papers were evaluated based on the inclusion criteria for full-text documents. Any possible disagreements between the two reviewers on inclusion or exclusion of studies was resolved by the consensus of the research team. More disagreements were discussed and resolved throughout the discussions and consensus of the group of authors. The reference list of the extracted papers was investigated by hand searching to find more relevant papers. In addition, key journals were searched using their tables of content in the Scopus database. To find the relevant documents in this field, three key journals, including Fire Engineering, Fire Prevention, and Fire Engineers Journals, and the Journal of Occupational and Environmental Medicine were searched.

Inclusion Criteria and Exclusion Criteria

The documents in scientific journals and other sources, focusing on the firefighters' resiliency and safety or the assessment of firefighters' individual characteristics were included in the study. Moreover, all papers on firefighter's resilience indicators and criteria with this research scope were also included. Furthermore, standards or guidelines that focused on firefighter's safety or resiliency were included.

Papers related to workplace safety, personal protective equipment, fire safety, and fire department, and papers in languages other than English were excluded from this study. Furthermore, those papers without full-text or those whose full texts were not available even after sending emails to their authors twice and letters to the editors were excluded.

Data Extraction and Quality Assessment

After conducting the screening, two checklists were applied for data extraction. The first checklist

consisted of the information on the selected studies, including the first author's name, publication year, location of the study, method of the study, study objectives, and the quality score. The second checklist was used to extract the indicators and domain details. The process of extracting data from the selected articles was done independently by two researchers. Indices affecting resilience were extracted then combined through group meeting. The methodological quality appraisal of the selected studies was performed using a checklist developed by the authors. Most of the selected studies were observational studies, the authors developed their checklist based on the STROBE tool (16). Two reviewers (A.H. and H.S.H.) assessed the quality of the articles based on the checklist, and in case of disagreement, the research team reexamined the results. The modified quality assessment tool had 17 questions. When considering the quality score, the authors' cutoff point for high quality studies was a score greater than 9.

Systematic Review Registration Number

PROSPERO (International Prospective Register of Systematic Reviews) Registration Number: CRD42019120555

Results

The search yielded 10,707 studies, amongst which 9,696 papers were found through searching the databases, and 1,002 papers were found by manual reviewing of Google Scholar. In the next step, 3,529 duplicate titles were excluded, and 7,178 papers remained for screening. After screening, 7,104 papers were excluded based on their titles and abstracts. Finally, 74 papers were included for full-text review, 30 of which (13, 14, 17-45) were included for data extraction. In addition, one more study (46) was found by manual searching in the reference list of included studies. To minimize the publication bias, the PRISMA checklist was followed (Fig. 1).

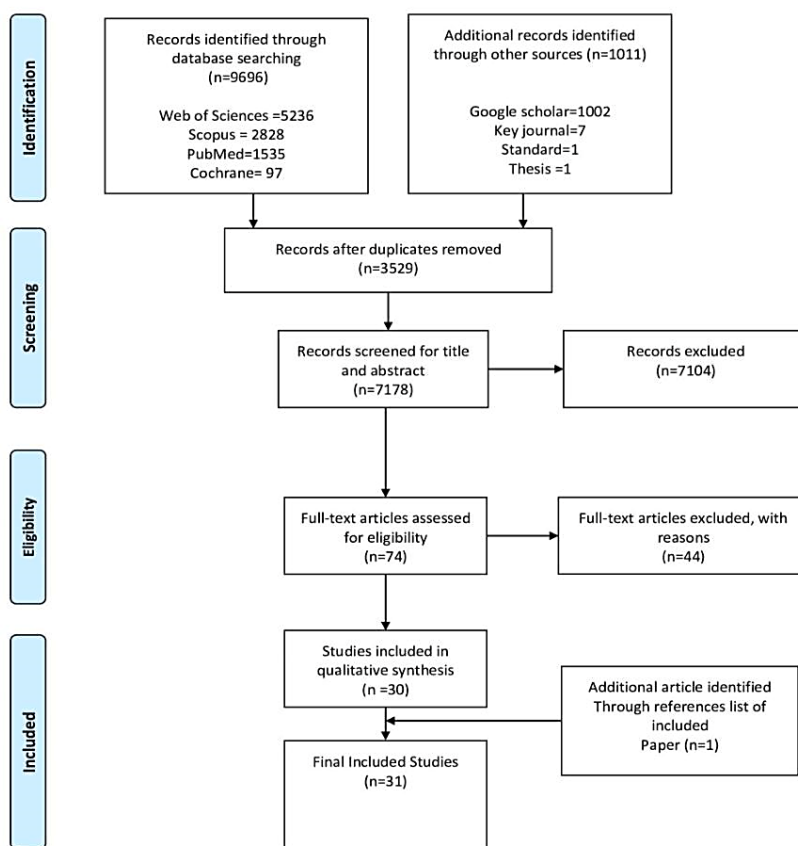


Fig. 1: Flow Diagram of the screening process of included studies of firefighter's resilience criteria and indicators

Descriptive Analysis

The number of researches about firefighter's competency assessment shows incremental growth in the last decade. Approximately two-thirds of the included studies in this research were published after 2010. This study did not find any papers that systematically reviewed criteria, methods, or models for firefighters' resilience assessment. Among the conducted research studies, 43% were from the USA (18, 19, 21, 22, 25, 26, 31, 32, 35-37, 42, 45), and others from Canada (n=5) (33, 39, 43, 44); Netherlands (n=3) (28, 29, 40); Republic of Korea (n=2) (34, 46); Malaysia (n=2) (27, 41); China (13); Iran (14), Poland (24), UK (27); Italy (30); Belgium (23), and Ghana (38). Moreover, 71% of the studies were carried out during the last decade ($n = 22$). The study designs of the included papers were

heterogeneous. Overall, 22.5% of the papers focused on physical fitness ($n=7$) (22, 25, 26, 30, 33, 35, 39), and injury determinants ($n=6$, 19.3%) (19, 24, 31, 38, 43, 46), while the remaining studies focused on demographic determinants ($n=4$, 12.9%) (14, 18, 21, 23), sleep disorders ($n=3$, 9.6%) (34, 36, 42), body composition ($n=2$, 6.4%) (32, 41), physiological determinants ($n=1$) (17), musculoskeletal disorders ($n=1$), stress and psychology ($n=1$), chronic disease ($n=1$), health requirements ($n=1$), competency model ($n=1$) (13), training ($n=1$) (37), personality ($n=1$) (40), and the occupational medical determinants ($n=1$) (45). Among the included papers, 28 were articles, one was a thesis report (38), one was a standard guideline (45), one was an official report (43), and one (13) focused on developing a competency model for firefighters. Table 1 presents the general data for the studies included in this systematic review.

Table 1: General information of included studies about firefighters' resilience assessment indicators

<i>First And Year</i>	<i>Author</i>	<i>Type</i>	<i>Study Location</i>	<i>Methodology</i>	<i>Quality score</i>
Swank, 2000		Article	USA	Field study	High
Saube, K.1991		Article	USA	Cross-sectional study	High
Kiss, P.2002		Article	Belgium	Cross-sectional study	High
Barger,2015		Article	USA	Cross-sectional	High
Firoozeh2017		Article	IRAN	Cross-sectional	High
Lim,2014		Article	KO- REA	Cross-sectional	High
STORER,2014		Article	USA	Cross-sectional	High
Jahnke,2015		Article	USA	Cross-sectional	High
Plat,2012		Article	Neth- erlands	Cross-sectional	High
Huang, 2016		Article	Neth- erlands	Cross-sectional(case study)	Low
Jahnke, 2013		Article	USA	Cross-sectional	High
Conrad1994		Article	USA	Focus groups	Low
Jahnke,2013		Article	USA	Cohort	High
Carlis,2016		Thesis	Ghana	Descriptive cross-sectional	High
Gordon,2014		Article	Can- ada	Self-administered instru- ment	High
davis,2002		Article	USA	Cross-sectional	Low
DAVIS,1987		Article	USA	Not specified	Low
Michaelides,2008		Article	USA		Low
Sullivan,2017		Article	USA	Randomized prospective trial(42)	High
Fogleman,2005		Article	USA	Cross-sectional	High
Rahimi,2017		Article	Malay- sia	Cross-sectional	Low
Lentz,2019		Article	Can- ada	Systematic review	High
MALEK,2010		Article	UK and Malay- sian	Cross-sectional	High
LI, 2014		Article	China	Cross-sectional	Low
Cheung,2016		Article	Can- ada	Review	Low
plat,2012		Article	Neth- erlands	Surveillance	High
Szubert, 2002		Article	Pol- and.	Cross-sectional	High
Yoon, 2016		Article	Korea	Cross-sectional	High
Ramsden,2018		Official report	Can- ada	Review	High
NFPA 1582, 2018		Standard	USA	Standard	Low
Caravelle, 2013		Article	Italy	Cross-sectional	Low

Thematic Content Analysis

Overall, 186 indicators were identified in the selected papers using the data extraction process. Incident-prone personality may be created due to multifactorial phenomena, and it is difficult to measure the individual's resilience score. Measurements were different in terms of physical fitness, mental health, demographic determinants, or medical examinations. As age increases, firefighters' physical status diminishes; although this decline is not solely dependent on age (18). Older workers are more prone to cardiovascular, occupational, and chronic diseases due to their long-term exposure to harmful occupational factors (14, 19, 23). However, older firefighters are more experienced and can make better decisions than younger firefighters in challenging and complex situations (14, 19, 33). Nonetheless, young firefighters are more prone to experience occupational injuries (46). The presence of chronic diseases, such as musculoskeletal, cardiovascular, and respiratory diseases, can lead to diminished workability among firefighters (22, 23, 28, 36, 43). Mental health status is another domain that can affect the safety performance of firefighters. Those who have sleep disorders, depression, stress, posttraumatic stress disorder (PTSD), anxiety, low self-confidence, low attention, and social dysfunctions

are more prone to injuries (14, 23, 27, 29, 33, 34, 36). Single firefighters have higher workability compared to their married colleagues (14). Smokers and alcohol drinkers have higher injury risk compared to others (17, 31, 46). On the other hand, aerobic fitness, muscular strength, and body composition can affect firefighters' safety performance (21-23, 29, 32, 33, 35, 41, 43, 44, 46).

Most of the papers took into account only one of the abovementioned domains, while comprehensive assessment can show the actual picture of resilience and personnel safety in order to make decisions about their presence in different job positions. Most of the studies were more focused on physical fitness, whereas fewer studies investigated the effects of psychological, demographics, lifestyle, and occupational characteristics. The firefighters who have higher age, sleep disorders, high Body Mass Index (BMI), high-risk behaviors (e.g., smoking, alcohol consumption, unhealthy eating habits, and addictions), chronic diseases (e.g., diabetes, hypertension, hypercholesterolemia, metabolic disorders, and cardiovascular and respiratory diseases), low aerobic capacity, low body strength, low experience, low length of service, musculoskeletal disorders, tumors, and those who are female are more prone to occupational injuries (28, 47-52). Table 2 presents all the indicators extracted from the selected papers.

Table 2: Indicators and variables that affect firefighters' safety extracted from the included studies

<i>Reference</i>	<i>Indicators</i>
Swank, 2000(21)	Age
Saupe, 1991(18)	Age
Kiss, P.2002 (23)	Musculoskeletal, Cardiovascular And Respiratory Disease, Age
Barger, 2015(36)	Sleep disorders, insomnia,
Firoozeh, 2017(53)	Age, job positions, BMI, educational levels, physical exercise hours, marital status, smoking
Lim, 2014(34)	sleep quality, shift work, depression, musculoskeletal pain, occupational stress, interpersonal conflict
Storer, 2014(35)	physical activity, flexibility, training, endurance, ECG abnormalities Obesity, aerobic capacity
Jahnke, 2015(37)	high-intensity training
Plat, 2012(37)	chronic disease
Huang, 2016(40)	Injury experience, personality traits

Jahnke, 2013(31)	depressive symptoms, training, Smoking, exercise
Conrad1994(19)	diet and nutrition, age, poor employee performance rating, length of employment, job dissatisfaction, job attitude
Jahnke,2013(32)	Obesity, Depression, sleepiness, Smoking, drinking, Flexibility, strength, Physical activity, Age, BMI, Obesity
Carlis,2016(38)	Age, safety training, Experience
Gordon,2014(33)	Age, personality construct, experience, Job stress, history of injury
Davis,2002(22)	Age, gender
Davis,1987(17)	Lifestyle, obesity, age, fitness, anthropometric parameter, physiologic parameters, medical evaluation, pulmonary and cardiovascular, smoking habits, hypertension, heredity, obesity,
Michael- ides,2008(26)	muscular endurance, muscular strength, Fitness, flexibility, body, composition
Sullivan,2017(42)	sleep disorders
Fogleman,2005(25)	age, weight, height, smoking, flexibility, experience, Hypertension,
Rahimi,2017(41)	BMI, aerobic fitness, anthropometric characterizes,
Lentz,2019(44)	Gender, higher physical fitness, aerobic capacity, body composition, Age
Malek,2010(27)	occupational stress, job satisfaction, sleep disturbance, job skill concerns
Li, 2014(13)	psychological adjustment ability, stress tolerance, self-protection awareness, decision-making ability, observational ability, risk-forecasting ability in the fire sites, keep learning, innovative ability, professional accomplishment, competency of team cooperation, communication and coordination,
Cheung,2016(39)	Aerobic capacity, fitness, heat acclimatization status, body composition, age, sex, and certain genetic predispositions
Plat,2012(29)	Gender, professionalism, oldest, psychological health, vision, hearing, skin, color vision
Szubert, 2002(24)	employment duration, age, Insufficient knowledge about hazards, poor physical condition, lack of physical fitness, loose conduct outside actions, too much involvement in group sport, lack of warming up before physical exercises
Yoon, 2016 (46)	regular exercise, hearing defects, females, job experience, smoking, alcohol drinking,
Ramsden,2018(43)	cancer, traumatic injury and mental health, physical exercise and cognitive weariness, Cardiovascular disease, Volunteer Status
NFPA 1582, 2018 (45)	Medical Conditions, Head and Neck, Eyes and Vision, Ears and Hearing, Dental, Nose, Oropharynx, Trachea, Esophagus, and Larynx, Lungs and Chest Wall, Heart and Vascular System, Abdominal Organs and Gastrointestinal System, Reproductive System, Urinary System, Spine and Axial Skeleton, Extremities, Neurological Disorders, Skin, Blood and Blood Forming Organs, Endocrine and Metabolic Disorders, Systemic Diseases and Miscellaneous Conditions, Tumors and Malignant Diseases, Psychiatric Conditions, Chemicals, Drugs, and Medications, Weight and Body Composition, Annual Fitness Evaluation,
Caravelle, 2013 (30)	weight, height, body fat, age, VO2max

Discussion

This systematic review was conducted to identify the indicators for assessing the firefighters' resilience level. Resilience assessment and preventive measures for ensuring personnel safety performance can be designed based on these factors. In this study, age had the highest citation in the included papers (14, 17-19, 21-25, 29, 30, 32, 33, 38, 39, 43, 44, 52), and it was recognized as an important criterion. The incidence of death among older workers was two times higher than that of the young ones, while the occurrence of non-fatal incidents was lower among older workers than younger workers (52). Based on this finding, firefighters' age is one of the important factors affecting their safety.

NFPA 1582 as "the Standard on Comprehensive Occupational Medical Program for Fire Departments" is being used in most countries to assess the health status of firefighters. Although this standard covers most of the criteria affecting occupational competence, such as medical, occupational medical, and occupational fitness evaluation (45), it is not a comprehensive framework since it does not cover other aspects of job competency, such as demographic, occupational, individual, and psychological determinants of resilience in firefighters (14, 33, 36, 39, 40). Studies introduced a competency model for firefighters consisting of five dimensions, including vocational skill, psychological quality, professional accomplishment, self-development, and interpersonal cooperation (13). While this model covers many factors, it is not complete since it does not address other important aspects, such as medical status, demographic characteristics, physical fitness, and physical health (18, 19, 22, 25, 28, 30, 33-36, 38, 42, 44, 45). Another study (14) investigated firefighters' competency using the WAI tool among Iranian firefighters. However, this tool is not specifically developed for firefighters and does not focus on job-related, fitness, and mental factors (17, 18, 22, 24, 27, 30, 36, 40). This study shows that it may be difficult to implement a special program for each aspect of human abilities.

All aspects of firefighters' competencies should be considered for assessing, planning, and building resilience in firefighters. Lack of each domain may lead the firefighters to unsafe acts. In addition, it is needed to weight and prioritize these domains and indicators to develop a tool for an actual assessment of personnel safety in different job positions, and to conduct appropriate and effective interventions for building resilience in firefighters. Consequently, these factors must be taken into account to ensure that the personnel are suitable for taking this position. Each of these domains is explored in depth as follows. Table 3 presents the classification.

Physical Health

Physical health is defined as having no acute or chronic disease or a history of chronic diseases, no infectious disease in the last two weeks, and no prescription medications in the last six months (54). The authors suggest classifying this domain into three categories, including disability, communicable diseases, and non-communicable diseases. Worse physical health can lead to more functional disability, and consequently, poorer relationships with coworkers.

Physical Fitness

Physical fitness is defined as a combination of cardiorespiratory and muscular fitness to perform occupational tasks strongly and without fatigue. The physical fitness of the firefighters is associated with positive job performance. Physical fitness consists of muscular strength, cardiovascular fitness, muscular endurance, flexibility, body composition, and aerobic capacity. Firefighters with poor physical fitness are more prone to injuries, and they need high levels of physical fitness to perform their tasks during firefighting operations (26).

Mental Health

Based on the definition, mental health is a state of psychological well-being or an absence of mental illness, and it is also defined as a level of psychological status in which people live at satisfactory levels of emotional, psychological, and social adjustment (55). Psychopathology evaluation and

management, and detecting psychological illnesses, including depression and insomnia, along with traumatic events for firefighters can prevent unpleasant consequences that can occur as a result of these mental disorders (56). People with severe mental disorders would face significant employment disadvantages.

Table 3: Suggested classification of domains, subdomains, and indicators affecting firefighters' resilience

<i>Domains</i>	<i>Sub-domain</i>	<i>Indicator</i>
Physical health	Disability	Vision defect, hearing defect, skeletal defect, muscular defect
	Communicable disease	AIDS, Hepatitis B, Hepatitis V, tuberculosis
Physical fitness	Non-Communicable disease	Coronary artery disease, respiratory disease, tumors, hypertension, diabetes, metabolic disease, digestive disease, skin disorders, hypercholesterolemia, genitourinary disease
	Aerobic fitness	Aerobic performance, aerobic capacity, lungs function, vascular system function, heart function
	Muscular strength	Muscular strength, muscular endurance
Job-related competency	Body composition	BMI, waist circumference, anthropometric, skinfold thicknesses
	Flexibility	Extent flexibility, dynamic flexibility
	Personality adjustment	Job attitude, job dissatisfaction, commitment to job, responsibility, loyalty, risk-forecasting ability, observational ability, professional dedication, enthusiasm, learning potential, innovative ability, self-protection awareness, hardship endurance ability, shift work adjustment, competency of team cooperation ¹ , communication and coordination ¹
Mental health	Occupational status	Work experience, length of service, number of weekly working hours, job position, training, history of injury, extra job, professional knowledge on firefighting, heat acclimatization, professional skills
	Anxiety disorders	Stress, PTSD, sleep disorder
	Social dysfunction	Decision-making ability, communication, self-confidence, attention
	Mood disorders	Depression, emotional preparedness, mental preparedness, psychological adjustment ability
Life Style	Psycho-Somatic disorders	Illness feeling, headache, weakness feeling
	Unhealthy habits	Alcohol consumption, smoking, unhealthy eating habits, drug addiction
Demographic status	-	Age, marital status, educational level, gender

Job-Related Competency

Job-related competency is defined as a set of measurable performance aspects, including knowledge, professional skills, job attitudes, behaviors, team workability, and organizational skills, leading to satisfactory performance (57). This finding is in line with the findings of studies which found that when individuals take jobs, they must perform all the tasks related to the job, they should be committed to do the job, and they should behave based on the job expectations (58).

Lifestyle

Lifestyle is defined as usual daily activities and relationships between the individual's behavior and his/her environment accepted by people during their lives, and these activities affect their health status (59). A similar study suggests that promoting lifestyle factors leads to a significant improvement in workability, and some factors like alcohol consumption, smoking, and drug abuse will decrease the ability to work (60).

Demographic Status

Demographic status involves the statistical data about the individuals, such as age, marital status, educational level, and gender (61). In Iran, workability was affected by factors such as age, education, and marital status (14). The results of this study are in line with another study indicating that demographic factors are important in safety performance, among which age is more effective (62). Safety status is affected by the demographic status (63).

Limitations

The full text of some studies could not be found even after sending emails to the authors; therefore, these studies were excluded from the analysis. Moreover, the authors are not fluent in other languages; therefore, several papers were excluded since they were not in English.

Conclusion

A systematic review method was used in this study to investigate firefighter's resilience indicators and criteria. This provides decision-makers with a full picture of firefighters' competency in order to administer interventions to promote resilience, and consequently safety among their personnel. The results of this study can be used to make a tool to identify deficiencies in firefighters' resilience, and to make decisions about improving their personal and professional ability. Any defect in these domains and indicators can affect the resilience and safety performance of firefighters. To reduce injuries among firefighters, people, and the community, it is required to recruit firefighters with a high level of physical and mental health. Professional resilience can lead to safe performance during search and rescue operations. This will protect the lives of firefighters, people in need of help, and the community as a whole, while it will reduce the number of casualties caused by accidents and disasters. Furthermore, assessment of firefighters' resilience is useful for managers to evaluate the eligibility of their personnel to perform relief and rescue, and to promote their ability to save the community and themselves in dangerous situations and emergencies.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflicts of interest

The authors state that they have no conflict of interest.

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