

RESEARCH ARTICLE

A Comprehensive Profile of Volunteer Firefighters: Sociodemographic and Occupational Dimensions

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Abstract: *Introduction:* The European Union prioritizes occupational health and safety, with firefighters—particularly volunteers—facing significant risks. In Portugal, 94% of firefighters are volunteers, often balancing multiple jobs, which increases their exposure to hazards. This study investigates Portuguese firefighters' occupational risks and identifies tasks with the highest accident incidence to build a comprehensive profile of their health and work conditions. *Background:* Firefighters are exposed to extreme environments, long shifts, and high-stress situations, especially during wildfires. These conditions contribute to physical and mental health issues, including cardiovascular disease and sleep disturbances. Training and experience are key to improving risk perception and preventing accidents. Understanding firefighters' main characteristics is essential for risk reduction and improving their quality of life. *Methods:* A sociodemographic questionnaire was developed and administered to firefighters, covering three sections: General Information, Lifestyle and Clinical History, and Firefighting Activity. This enabled the collection of sociodemographic and occupational data. *Results:* A total of 220 responses were collected from Portuguese volunteer firefighters. Cardiovascular and respiratory diseases were the most commonly reported diagnoses. Wildland and urban/industrial fires were the main operational contexts linked to accidents, with 84 individuals reporting accident history in these scenarios. *Discussion/Conclusion:* The study revealed a lack of data on the profile of volunteer firefighters, a group at heightened risk due to cumulative exposures and existing health conditions. Further research is needed to support the development of regulations and health monitoring strategies that protect this workforce without compromising their operational capacity.

Keywords: firefighters, occupational exposure, health monitoring, operational context

The improvement of occupational health and safety conditions has been one of the primary objectives of the European Union (Moraes et al., 2020). Globally, approximately 2.9 million individuals face severe workplace risks daily. According to the World Health Organization (WHO, 2004), men have a higher risk, largely because they are more often assigned to hard, heavy, and dangerous tasks leading to up to five times fewer healthy life years than women due to workplace hazards.

The number of professional firefighters is increasing, with the European Union (EU) reaching its highest recorded number in 2022, totaling approximately 360,000 individuals (Eurostat, 2022). Portugal is one of the few countries where volunteer firefighters constitute the majority, representing approximately 94% of the total firefighter population in 2019 (FPS, 2023). The voluntary nature of firefighting in Portugal reflects the strong community-driven commitment of these individuals. However, volunteer firefighters may face additional occupational risks, as they often engage in other professional activities alongside their volunteer service (Pennington et al., 2022).

The main distinctions between volunteer and professional firefighters lie in the time devoted to the role and opportunities for career advancement. Despite these differences, both groups face similar occupational hazards and health risks. In this context, the following research questions (RQs) were investigated:

- RQ1:** What is the perception of firefighters regarding their exposure to occupational hazards associated with different tasks?
- RQ2:** Is there a specific firefighter task associated with a higher incidence of exposure and work-related accidents?

This study provides evidence based on background information and data collected from a sample of Portuguese

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Applying Research to Occupational Health Practice

The characterization of firefighters' sociodemographic, clinical, and occupational profiles enables a more precise and comprehensive assessment of the occupational risks to which these professionals are exposed. Individual health status constitutes a critical determinant of susceptibility and response to workplace risk agents. Considering the multifactorial and intrinsically hazardous nature of firefighting activities, the implementation of integrated, evidence-based methodologies for occupational risk assessment is imperative, along with the strengthening of surveillance, prevention, and health promotion programs in occupational health.

firefighters. The findings will help identify the tasks associated with the highest exposure and incidence of workplace accidents from the firefighters' perspective. On the other hand, this study also identifies the principal characteristics from a sample of Portuguese Firefighters.

Background

Firefighters perform a wide range of emergency response tasks, including hospital-based emergency care, vehicle accident rescue, urban, industrial, and wildfire response, as well as other specialized rescue operations, such as water rescue and confined space rescue (Ras et al., 2024). As the first responders to incidents, firefighters are frequently exposed to high-stress environments, making their profession one of the most stress-inducing occupations. Occupational stress is a major contributor to work-related diseases and workplace accidents (WHO, 2020). A well-established correlation exists between occupational stress and the prevalence of work-related illnesses (Banes, 2014; Soteriades et al., 2011).

Comparison of United States (U.S) and Portuguese Research Findings

While the focus of this paper is Portuguese firefighters, presenting studies from the U.S. and comparing them with available Portuguese research provides a relevant framework for understanding the occupational risks and operational demands that are present in Portugal, where similar firefighting structures, emergency response protocols, and rescue procedures exist. In other words, U.S. research serves as a benchmark or reference point in areas where Portuguese-specific data are limited.

The National Fire Protection Association (NFPA) estimates that firefighters in the U.S. are dispatched to a fire incident every 23 seconds. This statistic includes data on both wildland and structural fires (National Fire Protection Association, 2021).

Wildland firefighting has been the task with the highest prevalence of fatal incidents among firefighters. Between 2007 and 2016, a total of 170 firefighter deaths were recorded during wildland fire suppression (Banes, 2014; Durand et al., 2011; NIOSH, 2019; Soteriades et al., 2011; Yoo & Franke, 2009). As of September 2023, a total of 59 firefighter fatalities had been reported in the United States, with volunteer firefighters accounting for 42.4% of these deaths (U. S. Fire Administration (USFA), 2023).

Portuguese data also highlight the significant occupational risks faced by firefighters. According to the Liga dos Bombeiros Portugueses (LBP), the number of firefighter fatalities in Portugal varied over the years, with some years recording single-digit deaths and others reaching double digits. Notably, nine deaths were recorded in 1995, eight in 2007 and 2020, and several years reported between five and seven fatalities. The LBP also noted that 6 years saw particularly high numbers, exceeding 10 deaths: 16 in 1986 and 2005, 13 in 1996, and 10 in 1989, 1998, and 2013. These values illustrate that firefighting in Portugal, as elsewhere, remains a high-risk occupation. Moreover, occupational diseases related to firefighting remain difficult to identify in Portugal, which suggests that the full extent of work-related health risks may be underestimated (European Agency for Safety and Health at Work (EU-OSHA), 2023; LBP, 2022).

According to the *U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA)*, between 2012 and 2021, a total of 87 firefighter accidents were recorded, 67 of which involved wildland firefighters (USFA, 2023). The context of a wildland fire presents significant demands on those working in its vicinity. Like other work environments, wildland fires require analysis and assessment of the occupational exposure they present, which puts the safety and health of firefighters. This exposure can lead to fatal accidents or serious illnesses (Koopmans et al., 2022; NIOSH, 2023; Teixeira et al., 2021). In Portugal, several events have marked the history of wildfires due to the disastrous statistics they caused, with a high number of firefighter fatalities (Rocha, 2013; Viegas, 2013, 2017).

Contributing Medical Conditions and Environmental Exposures

In the United States (U.S.), between 1990 and 2000, approximately 14.1% of firefighter accidents occurred in men aged 61 and older. Among firefighters aged 36 to 40, one-third of fatalities were attributed to medical conditions such as heart attacks and strokes (Federal Emergency Management Agency, 2002). Between 2000 and 2021, a total of 1,096 firefighter deaths were recorded out of 2,598 fatalities occurring in the line of duty, with 90% caused by myocardial infarction (Wohlgemuth et al., 2023).

Firefighters' exposure to various emergency scenarios, extended working hours, and environmental hazards, such as extreme heat, dust, and carbon monoxide (CO), can exacerbate their psychophysiological responses and increase the likelihood of minor injuries or fatalities (Cuenca-Lozano & Ramírez-García, 2023; Horn et al., 2020; Perroni et al., 2014; Teixeira et al.,

2024). Shift work is another factor contributing to the increased incidence of occupational diseases, particularly when combined with other exposure risks (Sidossis et al., 2023). Sleep deprivation and poor sleep quality among high-risk workers may further amplify their vulnerability to occupational hazards (Allison et al., 2022; Alves et al., 2023; Khoshakhlagh et al., 2023; Lin et al., 2022). Additionally, poor sleep quality has been identified as a major factor negatively impacting firefighters' mental health (Wolffe et al., 2023).

Risk Perception

Accident investigations serve as a crucial tool for safety monitoring and analysis, enhancing firefighters' risk awareness and improving safety conditions whenever possible. Research indicates that professional firefighters tend to have a higher perception of risk compared to volunteer firefighters (Martínez-Fiestas et al., 2020). Nevertheless, studies show that 60% of firefighters consider their profession to be high-risk (Rodríguez-Garzón et al., 2016). Among the various tasks performed, structural fires are perceived as having the highest exposure risk, followed by wildland firefighting and rescue operations (Fullagar et al., 2021). Moreover, firefighters with fewer years of experience tend to have a lower risk perception regarding their tasks (Fialho et al., 2024). Accident analysis, firefighter training, and the assessment of risk perception are essential steps for identifying gaps and improving working conditions. This is important because a higher perception of risk is often associated with safer behaviors, such as adherence to safety protocols, appropriate use of personal protective equipment, and cautious decision-making during emergency operations. By systematically investigating accidents and understanding how firefighters perceive risk, organizations can identify specific areas where safety behavior may be insufficient or where additional training is needed. Consequently, these methodologies do not only enhance awareness but also provide actionable insights that guide the development of new tools, operational procedures, and training programs, ultimately reducing the likelihood of injuries and fatalities and improving overall occupational safety (EU-OSHA, 2023, 2024).

Training Effects

Training has been identified as a key factor influencing firefighters' risk perception, with higher levels of training being directly associated with increased risk awareness (Prati et al., 2013). Additionally, extensive training has been linked to a reduction in workplace accidents (Salar et al., 2017). Existing literature indicates that training is an important tool for reducing occupational accidents. Braun et al. (2022), demonstrated the implementation of immersive virtual reality scenarios for firefighter training, which is designed to improve firefighters' decision-making abilities under stress, thereby enhancing performance, as also highlighted by Oliveira et al. (2024).

Methodology

Study Design and Sampling

This was a cross-sectional study conducted between July 2021 and July 2022 in the Porto region, Portugal. The selection of the participants was made previously by visiting all the corporations in the district of Porto. A total of 26 voluntary firefighting organizations agreed to participate in this study. All participants were firefighters.

Human Subjects Protection

All participants were informed that the questionnaire was anonymous and that only the research team had access to the data. At the beginning of the questionnaire, the participants were asked to provide their ID numbers. It was clarified that this number would not be used to identify the participant, only to manage an identification code and ensure the research team that the same participant did not answer more than once. They were also informed that they could withdraw from the study at any time and request the deletion of their data. All participants signed the free and informed consent form, approved by the University of Porto ethics committee (CEUP) reference number 106/CEUP/2021.

Sociodemographic Characterization and Risk Perception

A sociodemographic questionnaire was structured and divided into three parts: General information, Lifestyle and Clinical History, and Activity as a firefighter. The questionnaire was prepared on the SurveyMonkey platform to ensure easy application and distribution of the questionnaire (Bustos et al., 2022). With the support of this platform, a web link was generated to provide participants with access to the questionnaire. The platform registered all the coded answers. After distribution of the research explanation and its purpose, the link to the sociodemographic questionnaire was provided.

The detailed description of the three areas measured by the questionnaire is included below:

General information: General information was collected to describe participants' characteristics regarding educational level, marital status, and household composition.

Lifestyle and clinical history: Lifestyle and medical history were collected through questions raised in the questionnaire and a detailed medical appointment with the participants. In this section, participants answered whether they were smokers, had alcohol consumption habits, had any illnesses, and some other information that was considered necessary.

Activity as a firefighter: The main objective of the firefighter activity was to evaluate the participants' perception of the risk of the different tasks performed. In addition, this section of the questionnaire includes questions regarding

Table 1. Sociodemographic Characteristics (n=220).

Variable	Number of cases (n)	Percentage
Sex		
Female	76	34.55
Male	144	65.45
Age (years)	34.71 ± 10.46	
Education*		
2nd cycle of elementary school	9	4.09
3rd cycle of elementary school	30	13.64
General high school	88	40.00
Technical high school	36	16.36
Post-secondary non-tertiary level qualification with credits toward further higher education studies	5	2.27
Bachelor's degree	32	14.54
Postgraduate	7	3.18
Master's degree	12	5.45
PhD	1	0.45
Years of experience as a firefighter health risk behavior's	12.94 ± 10.74	
Tobacco use	83	37.73
Alcohol consumption	62	28.18
Drugs use	12	5.45

*Levels determined by the National Qualifications Framework (Agência Nacional para a Qualificação e o Ensino Profissional, 2021).

work-related injuries and stressful episodes throughout the firefighter's career.

Data Analysis

Data were analyzed using descriptive and inferential statistics to identify trends and comparisons. Microsoft Excel and IBM SPSS Statistics (v29.0.1.0) were used. Diseases reported in the

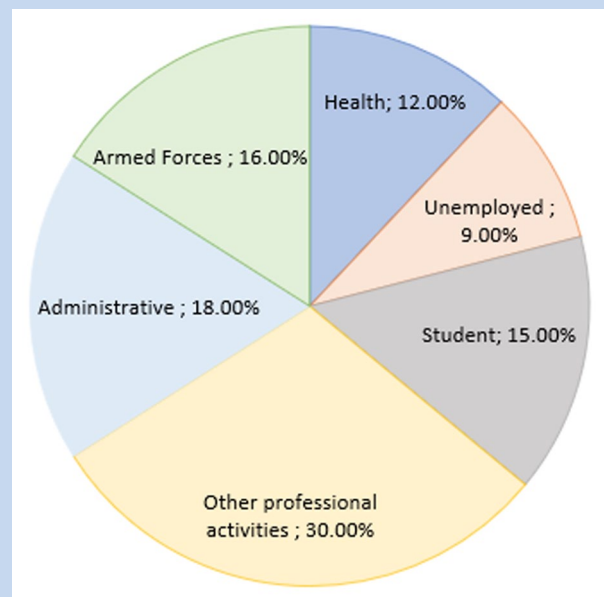


Figure 1. Professional activities (n=220).

sociodemographic questionnaire were classified per the WHO's International Classification of Diseases (WHO, 2024). The Shapiro-Wilk test ($\alpha = .05$) indicated non-normal distribution, leading to the use of a correlation matrix. Spearman's rank correlation coefficient was applied ($\alpha = .05$), with significance set at $p < 0.05$. The strength of the correlation was assessed using Spearman's rho (ρ), which ranges from -1 to 1 (Guimarães & Cabral, 2010). A value of ρ closer to -1 or 1 indicates a stronger correlation between the variables.

Results

A total of 220 responses were collected. Incomplete questionnaires were included in the statistical analysis, considering only the questions that were answered. Non-responses were considered for each question, particularly in conditional items where they were more frequent. However, all completed responses were included in the analysis, so no questionnaire was excluded due to missing answers.

General Information

This first section consisted of nine questions, with a response rate of 100%. Of the total participants, 106 were single, 85 were married, and 11 were divorced or separated as can be seen in Table 1. Regarding education, 40% of firefighters held a high school diploma, and 16% held a technical high school diploma. It was also possible to verify that 61.8% of the population were volunteer firefighters, and only 21.8% were professional firefighters, as shown in Figure 1. From this, it was possible to deduce that most of the population had more than one occupation.

Table 2. Response to the Question: “Do You Have a History of Any Medically Diagnosed Disease? If Yes, Please Specify Which One” (n=220).

Disease category	Specific conditions	n
Cardiovascular	Hypertension; Hypotension; Hypercholesterolemia; Dilated cardiomyopathy; Arrhythmias; Ventricular extrasystole	12
Respiratory	Allergic Rhinitis; Sinusitis; Asthma	10
Blood	Dyslipidemia; Hypokalemia; Anemia; Diabetes	3
Psychiatric	Depression; Anxiety	4
Gastrointestinal	Stomach cancer; Gastritis; Ulcerative colitis	6
Autoimmune	Hashimoto’s thyroiditis; Allergies; Hypothyroidism; Hypothyroidism	5
Musculoskeletal	Spine; Rheumatism; Rheumatoid arthritis	2
Urinary system	Polycystic kidney disease; Single kidney	2
Neurological	Epilepsy	2
Eating disorders	Obesity	2

Lifestyle and Clinical History

Through the assessment of participants’ pre-existing and diagnosed diseases, disease categories were established, as presented in Table 2. The results indicate a 100% response rate to the seven questions. Cardiovascular diseases (n=12) were the most prevalent, followed by respiratory diseases (n=10). Among the 220 respondents, 172 reported having no diagnosed disease.

Spearman correlation analysis revealed no significant relationship between years of service and the presence of pre-existing medical conditions. Health risk was defined as behaviors such as the use of narcotics, alcohol, tobacco, or other substances linked to increased disease incidence. In this study, no significant association was found between reported risk behaviors and disease development. However, Table 3 shows a strong correlation between diagnosed diseases, reported in the questionnaire, and tobacco and alcohol use. Tobacco was the most commonly reported risk behavior (%), and 28.2% of participants reported alcohol consumption.

Activity as a Firefighter

In this section, the response rate was 98.5% across the 11 questions. Participants reported an average of 12.94 ± 10.74 years of firefighting experience. No statistically significant correlation was found between years of service and disease onset. A total of 84 respondents reported having experienced accidents during firefighting duties, with urban/industrial firefighting and patient transport being the most frequently associated tasks. Among

Table 3. Correlation Between Diagnosed Disease Status and Risk Behaviors Among Portuguese Volunteer Firefighters (n=220).

Risk Behaviors	Diagnosed diseases (ρ)
Tobacco use	.90*
Alcohol consumption	.99*
Drugs use	.72

Note. Diagnosed disease status was coded as a dichotomous variable (0 = no diagnosed disease; 1 = at least one diagnosed disease); ρ = Spearman coefficient.

*p < .05.

these 84, 53 reported injuries, primarily fractures and sprains, as illustrated in Figure 2.

Risk Perception, Training, Exposures, and Symptoms

When asked which task they consider having the highest exposure in firefighting activities, participants indicated that the two most hazardous tasks are urban/industrial firefighting (n=63) and wildfire firefighting (n=62). Figure 3 presents the distribution of responses according to the tasks that participants consider having the highest risk exposure.

Participants identified insufficient training and damaged PPE as key factors contributing to the hazards of two specific

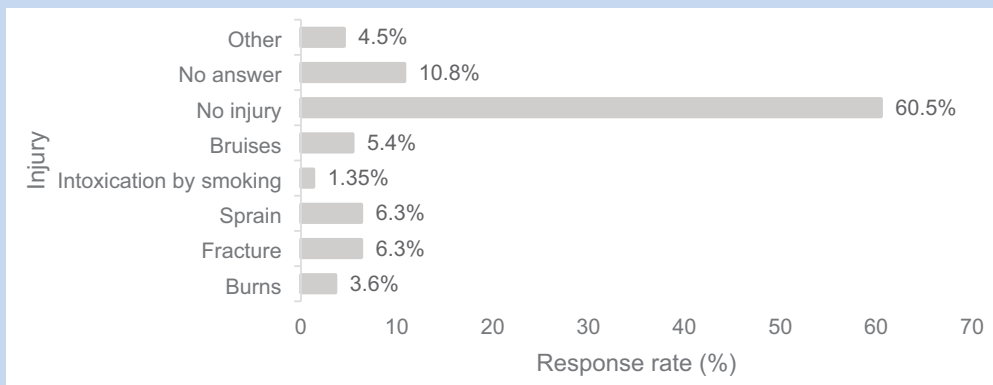


Figure 2. Type of injury reported (*n*=220).

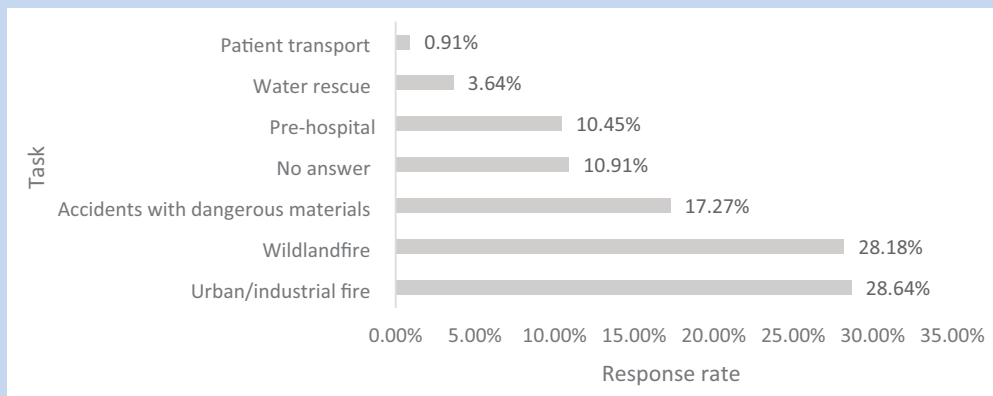


Figure 3. Reported task of greater exposure (*n*=220).

Table 4. Correlation Matrix Between Accident History and Risk Perception (*n*=220).

Accident History Risk Perception	Effectiveness of PPE	Higher exposure task	Stressful activity
Accident history	.30	.43	.43

***p* ≤ .001.

tasks: structural/industrial firefighting and wildland firefighting. Regarding stress exposure, 138 reported witnessing stressful situations, most commonly during pre-hospital care, especially involving fatalities (*n*=62) and child-related incidents (*n*=35). Additionally, tasks with greater reliance on PPE also showed a significant correlation with accident history ($\rho=0.30, p < .001; \alpha = .05$). Table 4 displays the corresponding correlation matrix.

Among the participants, 162 considered the activities of firefighters as stressful. Of these individuals, 103 have already felt symptoms such as chest palpitations, sleep disturbances, anxiety, and difficulty concentrating. The correlation analysis

confirmed a significant relationship between accident history and the perception of stressful activity, with a Spearman correlation coefficient of $\rho=0.43 < .001$.

Discussion

Few studies assess real-time exposure to occupational hazards during firefighting, hindering the development of mitigation strategies (Ferreira et al., 2011; Groot et al., 2019; Koopmans et al., 2020). Wildland firefighting remains the most concerning task of firefighters due to prolonged physical exertion and frequent sleep deprivation (Teixeira, Pratas, et al., 2024). In the U.S., 40% of firefighters sleep less than 7 hours per

night, with the profession being highly prone to sleep disturbances (Jang et al., 2020). In Portugal, report that, in a population of Portuguese volunteer firefighters, poor sleep quality was observed, likely related to shift work and the need to sleep at locations close to emergency incidents, such as during wildland fires. Furthermore, poor sleep quality in this population was found to be associated with symptoms of anxiety and depression.

Understanding firefighters' sociodemographic traits and risk perception helps evaluate health-related behaviors in the workplace (Ras & Leach, 2021). No in-depth study has yet profiled Portuguese firefighters, and such profiles can vary with ethnicity, occupation, and other personal factors (Lopes et al., 2024). Volunteer firefighting may increase exposure due to additional occupational roles, with experience, time dedicated, and training level influencing risk perception (Martínez-Fiestas et al., 2020; Rodríguez-Garzón et al., 2021).

Voluntary activity is linked to lower risk perception compared to professional roles (Martínez-Fiestas et al., 2020). Training level also impacts perception—less training leads to lower perceived risk. Traffic accidents and residential fires were deemed the most demanding tasks (Prati et al., 2013), and those with accident history showed higher risk awareness (Jafari et al., 2019). In this study, a significant correlation was found between accident history and stress symptoms ($\rho=0.43$, $p<.001$).

Structural and wildland firefighting were considered the most hazardous tasks by 62% of respondents (Fullagar et al., 2021). A weak correlation was noted between accident history and PPE effectiveness ($\rho=0.29$, $p<.001$). While PPE offers protection, it may also create a false sense of security, increasing exposure risk (Almeida et al., 2007; Prati et al., 2013; Rodrigues et al., 2018).

Smoke exposure during fires leads to respiratory inflammation and reduced lung function (Gianniou et al., 2018; Swiston et al., 2008), with risks linked to years of exposure, age, and smoking habits (Witt et al., 2017). Despite participants averaging 12.94 years of experience, no significant link was found between years of service and disease onset. This study found severe illnesses such as cardiomyopathies, asthma, and kidney disease associated with wildfire tasks. Cardiovascular disease remains the leading cause of firefighter mortality (Ras & Leach, 2021), aggravated by poor nutrition and dehydration during the fire season, which affect both physiological and cognitive performance (Cvirn et al., 2019; Marks et al., 2020).

Conclusions

The study revealed a lack of data on the profile of volunteer firefighters. In Portugal, as in many countries, firefighting is mainly voluntary, potentially increasing exposure to occupational risks, especially when combined with other professional activities. Pre-existing conditions, such as cardiovascular and respiratory diseases, further heighten vulnerability due to the job's physical and environmental demands. More research is needed to explore the link between exposure and health outcomes, supporting the creation of

regulations and surveillance programs to monitor this group and enhance their health and quality of life without compromising operational performance.

Implications for Occupational Health Nursing Practice or Implications for Occupational Health Practice

This study contributes to advancing occupational health practices by identifying health risks and proposing strategies to improve the working conditions of firefighters—a group at high risk due to the physical and environmental demands of their role. It highlights the need for a proactive, evidence-based approach to occupational health surveillance by revealing key vulnerabilities and exposures. The study also introduces a framework to guide authorities in refining recruitment, selection, and health monitoring procedures. By defining the occupational profile of volunteer firefighters, it provides a foundation for developing tailored guidelines, risk management policies, and preventive interventions aimed at reducing illness and injury while supporting the long-term wellbeing and effectiveness of this vital workforce.

Summary

Enhancing occupational health guidelines for volunteer firefighters aims to improve their quality of life and promote safer, more sustainable work practices. Defining their occupational profile supports cost reduction by helping prevent work-related injuries, illnesses, and fatalities associated with operational and individual risk factors. Effective prevention strategies require collaboration among health professionals, fire services, and policymakers to address the specific challenges faced by this high-risk group.

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Conflict of Interest

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Informed Consent

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the participants to publish this paper. This study was submitted to and approved by the ethics committee of the University of Porto (CEUP) under reference number 106/CEUP/2021. The University of Porto Ethics Committee (CEUP) submitted and approved the protocol under reference number 106/CEUP/2021.

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