

Artículo Científico

Diagnosis of health and safety at work in a Fire Station located in Chihuahua, Mexico

Diagnóstico de salud y seguridad en el trabajo en una Estación de Bomberos ubicada en Chihuahua, México

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DOI: <https://doi.org/10.54167/tecnociencia.v15i1.754>

Recibido: 15 de enero de 2021; Aceptado: 03 de mayo de 2021

Publicado por la Universidad Autónoma de Chihuahua, a través de la Dirección de Investigación y Posgrado.

Abstract

This research presents a diagnosis of safety and health at work based on the Italian Worker's Model, for the identification of occupational risk factors of 10 firefighters from Chihuahua, Mexico. The study variables were: noise, hearing threshold (UA by its acronyms in Spanish), suspended particles, weight, and body mass index (BMI). The REBA method was employed to detect ergonomic risks in ascending-descending to the fire unit. Psychosocial demands were evaluated through DAAS 21 instrument. The level of correlation among hearing threshold (UA), seniority, age, and BMI were analyzed. The noise exceeded the Maximum Permissible Level (MPL) established by the Mexican standard. Firefighters with mild to moderate hearing loss were detected. All the firefighters except one were overweight and obese (BMI = 23 to 30). There was no correlation between BMI and UA, which indicates the condition of overweight and obese are not associated with the firefighters' hearing loss. The concentration of PM_{2.5} and PM₁₀ particles was found within the MPL. The ergonomic risk was categorized from medium to very high. The results of the DASS 21 for each worker showed the presence of moderate stress, moderate anxiety, and severe anxiety. The research provides scientific evidence that shows occupational risk factors and helps to take preventive measures.

Key words: Italian Worker's Model, firefighters, occupational risk factors, working conditions, safety and health at work.

Resumen

Esta investigación presenta un diagnóstico de seguridad y salud en el trabajo basado en el Modelo Obrero Italiano, para identificación de factores de riesgo ocupacional en 10 bomberos de Chihuahua, México. Las variables de estudio fueron: ruido, pérdida auditiva, partículas en suspensión, peso e índice de masa corporal (IMC). Se empleó el método REBA para evaluar riesgos ergonómicos. Las demandas psicosociales se valoraron mediante el DAAS 21. Se analizó el nivel de correlación entre umbral de audición (UA), antigüedad, edad e IMC. El ruido excedió el Máximo Nivel Permitido (MPL) establecido por norma mexicana. Se detectaron bomberos con hipoacusia leve a moderada. Todos los bomberos, excepto uno, tenían sobrepeso y obesidad (IMC = 23 a 30). No existió correlación entre IMC y UA, lo que indicó que la condición de sobrepeso y obesidad no está asociada a la hipoacusia de los bomberos. La concentración de PM_{2.5} y PM₁₀ estuvo dentro del MPL. El riesgo ergonómico se categorizó de medio a muy alto. Los resultados del DASS 21 para cada trabajador mostraron la presencia de estrés moderado, ansiedad moderada y severa. La investigación brinda evidencia científica que muestra factores de riesgo ocupacional y coadyuva a la toma de medidas de prevención.

Palabras clave: Modelo Obrero Italiano, bomberos, factores de riesgo ocupacional, condiciones de trabajo, seguridad y salud en el trabajo.

1. Introduction

In occupational health, firefighting is classified as a high-risk activity because it takes place in dangerous environments and conditions. It might cause a permanent disability, injuries in different parts of the body, hearing loss, burns, and muscle contractions, respiratory damages due to exposures to leaks of hazardous chemical compounds, combustion, and deadly gases (Guidotti & Clough, 1992; Díaz *et al.*, 2016; Prell *et al.*, 2020). More than 50% fire-related deaths are due to the exposure to smoke not due to burns. There are mortal accidents of firefighters caused by the collapse of architectural elements that sometimes block the possible evacuation routes during a disaster (Barr *et al.*, 2010; Yang *et al.*, 2014). The firefighter's brigade, between the general working population, frequently shows symptoms related to stress, headache, sleep disorders, fatigue, and irritability (Duran *et al.*, 2018). The working conditions of firefighters are most distinctive among the working population because of the 24-hour work shifts, the quasi-military work organization, and the pattern of generally routine firehouse-based activities interspersed with unpredictable calls for emergency medical care or to fight structural or wildland fires.

In addition to the factors mentioned above, obesity is a firefighter's risk factor, which has been linked to increased hearing thresholds. The body mass index (BMI) is a measure of body composition. Overweight and obesity are associated with an increased risk of hearing loss, and metabolically unhealthy obesity may confer additional risk (Choi *et al.*, 2011; Hu *et al.*, 2020). Hearing loss contributes to social isolation, depression, and possibly dementia risk (Croll, 2019). Firefighters are exposed to other demands such as disaster missions, rescue services, as well as firefighting in extremely hot and hostile environments (Prell *et al.*, 2020). Due to the firefighter's brigade, before the general working population, they frequently show symptoms related to stress, headache, sleep disorders, fatigue, and irritability (Duran *et al.*, 2018). The Depression, Anxiety, and Stress Scale (DASS 21), evaluates these negative effects.

Due to health and safety implications in firefighting, new research needs to be conducted to examine how firefighters' task characteristics and their work demand influence the development of work-related musculoskeletal disorders (Kodom-Wiredu, 2019). Currently, research models are used to contribute to the knowledge base about the ergonomics of firefighting, in particular to find the multi-variate demands of the job and the attributes and capabilities of operators to cope with these demands (Gentzlez, 2010). The work-related musculoskeletal disorders imply a wide range of inflammatory and degenerative conditions affecting muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels (Kodom-Wiredu, 2019). Regarding ergonomics, the method Rapid Entire Body Assessment (REBA), allows the analysis of adopted positions by upper body limbs (arm, forearm, wrist), trunk, neck, and legs.

Firefighters are exposed to a wide range of toxic chemicals due to combustion (volatile organic compounds, semi-volatile organic compounds, and metals) (Engelsman *et al.*, 2020). On the other hand, firefighters may be exposed to diesel exhaust, which is classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC) and particulate matter (PM) from vehicles and off-gas (volatile organic compounds (VOCs), formaldehyde, among others) emitted from idling vehicles and firefighting equipment, such as clothes, boots, and gloves, from the fire scene (Kim *et al.*, 2019).

Due to the complexity in the administrative organization and its work processes, it is hard to evaluate the multiple risks and demands to which firefighters are exposed. There are discrepancies between the international standard and the health and safety regulations of each country (Ehlers *et al.*, 2015; Alvarez *et al.*, 2016; Duran *et al.*, 2018; Cohen *et al.*, 2019; Prell *et al.*, 2020).

From this point of view, the objective of this research was to perform a diagnosis of safety and health at work based on the Italian Worker's Model, for risk identification and the determination of physiological and psychological demands in a fire station in Chihuahua, Mexico.

2. Materials and Methods

2.1. Subjects and design

This was an exploratory, cross-sectional study. It involved ten firefighters from a fire station located in the city of Chihuahua, Mexico. All of them aged between 27-47 years old having a traditional or rotating work schedule. The study protocol was evaluated by the Institutional Review Board of the Faculty of Nursing and Nutriology, at the Autonomous University of Chihuahua, Chihuahua, Mexico, according to the Declaration of Helsinki. The data was recollected in the year 2019.

2.2. Instruments and evaluations

2.2.1 Italian Worker's Model and the PROESSAT survey

The Italian Worker's Model, recognizes the collective intelligence of the workers as experts regarding to working conditions and it operates under three fundamental values: working experience, consensual validation and the non-delegation (Marín & Pico, 2004). The risks are studied in three groups: physical (I), chemical and biological (II), and mechanical (V); and the demands in two groups: physiological (III) and psychological (IV) (Noriega, 1995). They originate from the different compound elements that make up the process work: in work environments, objects, activity, organization, and work division (Voguel, 2016). The Italian Worker's Model has two basic instruments: I) Collective survey: it collects information, elements, and organization, through the guide for the study of the labor process and the group questionnaire; II) Risk map: it is

the visual representation through drawings, schemes, diagrams or any similar form of the results from the research (Zarate-Amador, 2013).

Its application began with the recognition of the work process and some of the places where the workforce carried out their activities. The homogeneous group was conformed. A deep interview based on the questionnaires that make up the instrument within the working hours, was conducted, using a PowerPoint presentation to visually present the questionnaires. The participations were audio recorded to ease the analysis of the information. The procedure included eight sessions of three hours each within the working day and with informed consent, being the recordings eliminated after their capture.

An epidemiological type survey such as the "Workers' Health Evaluation and Monitoring Program" in Mexico (PROESSAT by its acronyms in Spanish), was used to capture the demographic, social, risks, demands, and health issues (Balderas-López, 2019). The PROESSAT survey identifies the presence of symptoms that allow make up presumptive diagnoses of various health damages, including mental, psychic, psychosomatic disorders, and musculoskeletal. The printed form of the PROESSAT survey was given to the firefighters who voluntarily participated in its filling.

2.2.2 DASS 21 instrument

The DASS 21 instrument has the advantage of being a self-report instrument; short, easy to answer with valuable psychometric properties (alpha values from 0.87 to 0.88 for depression, between 0.72 and 0.79 for anxiety and from 0.82 to 0.83 to stress) in several studies (Elbay et al., 2020; Jian et al., 2020). It was done in writing, each item is answered according to the presence and intensity of each symptom, on a Likert-type response scale of 0 to 3 points. Each scale has seven items and its total score varies between 0 and 21 points to know the levels of stress, anxiety, and depression (Elbay et al., 2020).

2.2.3 Noise Measurements

The noise coming from the Ford Model 1982 extinguishing class was evaluated, in its different sirens; truck in moto-pump phase (in areas of the control panel and water intakes); fan noise and hydraulic tool motor. A total of 180 measurements were executed by generating source. The integrating sound level meter was used (SoundPro™ Datalogging, 3 M brand, US) following the recommendations of the Mexican regulation (NOM-011-STPS-2001).

2.2.4 Audiometry study and BMI calculations

It was carried out based on the method of American Medical Association (AMA), to know the auditory sensitivity of the firefighters. The auditory canal was examined with a stethoscope, to verify that the ducts were free and there was not any inflammation or pathology. The participant had to stay 15 minutes previous to the trial, outside of a noisy environment and without making major physical efforts. It was played only the audiometry tone in a cabin with an INVENTIS instrument (model Bell basic/plus AU1D-31, US). The data was processed by a DAISY Inventis Software computer. The firefighter responded to the auditory impulses he perceived by pressing a button. The frequencies evaluated were 250, 500, 1000, 2000, 4000, 6000, 8000 Hz. Then, it was proceeded to weigh and measure the participant's height, to calculate their body mass index (BMI).

2.2.5 Measurements of gases and suspended particles

It was performed in three different areas: machines room, out-of-room station, and the living room. In the mobile unit 871, three measurements of 15 minutes were executed, placing the environmental monitor at 1.5 meters from the exhaust of the mobile unit, simulating the distance and height at which the personnel are at the time of work. The instrument used was a 3M™ EVM-7 air and particle quality monitor, US. The density of the evaluated particles was 2.5 and 10 $\mu\text{g}\cdot\text{m}^{-3}$ and the toxic gases selected for the environmental measurements were: dioxide and monoxide carbon (CO_2

and CO), acetaldehyde, propaldehyde and volatile organic compounds (VOC), such as: chlorobenzene, formaldehyde, toluene, and benzene. Based on what is established in the Mexican regulations NOM-010-STPS-2014 and NOM-025-SSA1-2014 (NOM-025-SSA1-2014 & NOM-010-STPS-2014), the data analysis was carried out.

2.2.6 Ergonomics analysis

The REBA applications are related to preventing injury risks, which are associated with the posture, mainly of the musculoskeletal type, indicating corrective actions. It is the result of cooperative work carried out by teams of ergonomists, physiotherapists, and nurses after identifying/analyzing around 600 working postures (Hita-Gutiérrez *et al.*, 2020).

Two work activities were considered: approaching the unit and rolling hoses, which are carried out regularly for the workday and marked as potentially harmful by the worker, due to uncomfortable positions adopted and repetitiveness. It was observed the ascent-descent of the personnel to the unit and techniques of rolling hose in the ground, during 72 hours to be registered and evaluated in photos and video. The information was processed in an Excel spreadsheet, the degrees of inclination of joints, extra loads, and sudden movements were evaluated to quantify the level of risk in the adopted positions. The risk factors evaluated are: static muscular works, important postural changes, repetitive movements, obtaining punctuation, level of action, risk and required action.

2.3. Statistical analysis

Data were presented characterized in their central tendency and dispersion through the mean \pm SD (standard deviation), respectively. Additionally, and assuming the data distribution was normal the Pearson correlation between pairs of variables was obtained. The most frequently used α values are: 0.01, 0.05, and 0.10 (Wayne, 2005). The p-value or significance level of 0.1 was stipulated at the authors' discretion. The SAS 9.1 (SAS, 2006) software was used in the analysis.

3. Results and Discussion

3.1. Diagnosis of safety and health at work

In México, there is not much information available in this regard, partly because firefighters only have initial medical assistance (medical consultation) within the services allowed by the Mexican Institute of Social Security (IMSS by its acronyms in Spanish), but workplace risks and accidents are addressed by the State Health Department, as this institution is not obliged to generate statistics for occupational diseases, it is difficult to have concrete figures (Meléndez-López *et al.*, 2018).

Other relevant problems are the lack of financial resources for the payment of salaries similar to purchase and equipment, and more training. All of the above affects fire departments with very few personnel, since, in certainty, this public service becomes an altruistic endeavor rather than a job (Bárceñas-Castro & Aguilera, 2012). The subjective identification of the risks and demands through the Italian Worker's Model questionnaires, are presented in Figure 1. The application of the PROESSAT survey allowed describing the generalities of the study population and allows the calculation of a risk percentage. The age range was around 27-44 years old, with an average of 37 years. The working seniority varies around 4-23 years, 50% of the firefighters present a high domestic load index and 100% is identified and proud of their work. Both methodologies were in agreement with the individual characterization of the physical risks (sudden changes in temperature, poor lighting, and humidity), chemical risks (dusts, fumes, and gases or vapors), and physiological demands (awkward positions and musculoskeletal disorders) and psychosocial

demands (high concentration, meticulous tasks, night work, strict supervision, rescue of people in danger). Regarding worker's health it was identified damages to the musculoskeletal and respiratory system and other symptoms such as physical fatigue, depression and anxiety, sleep disorder, migraine, and low back pain were identified. Most of the activities of the firefighters are carried out outside the facilities, which makes it difficult to graphically represent the risks and demands in a static and geographically located plane. Therefore, it was not possible to design a risk map.

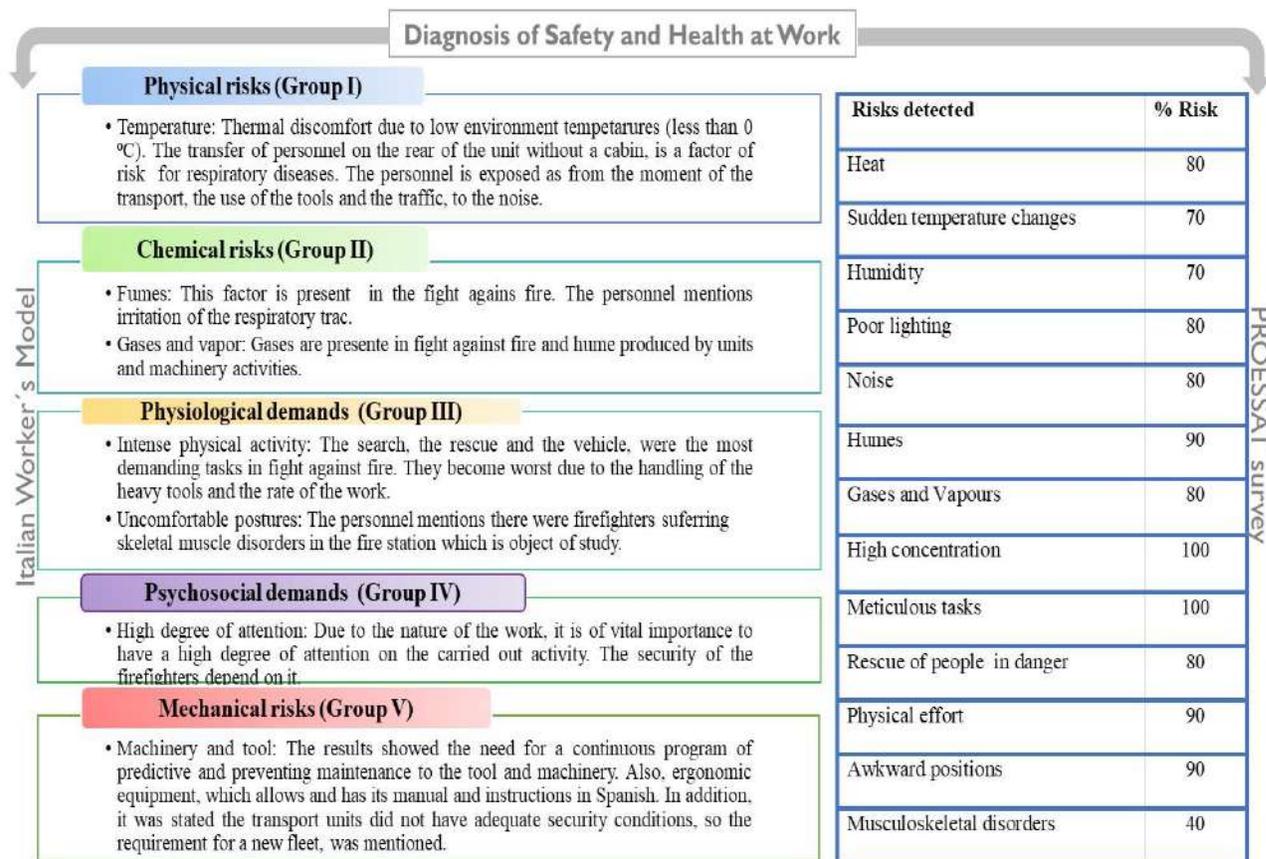


Figure 1. Subjective identification of risks and demands through the Italian Worker's Model and PROESSAT survey.

Figura 1. Identificación subjetiva de riesgos y demandas mediante el Modelo Obrero Italiano y la encuesta PROESSAT.

This research performed a diagnosis of safety and health at work based on the Italian Worker's Model and PROESSAT survey for the identification of risks at a fire station in Chihuahua, Mexico. The main risks and demands found are related to other studies, where five large risk areas for firefighters are mentioned: exposure to hazardous substances, ergonomic factors and of physical load, exposure to noise, psychosocial aspect and exposure to biological and chemical risks (Duran *et al.*, 2018; Prell *et al.*, 2020).

3.2. The DAAS 21 results

The DASS21 measurements were realized as follows: The instrument has 21 items, with four response alternatives in Likert format, which range from 0 ("It does not describe anything that happened to me or I felt during the week") to 3 ("Yes, this happened to me a lot, or almost always"). To answer, the slogan establishes to indicate to what extent the sentence describes what happened or felt the person during the last week. This instrument has the advantage of being a self-reporting scale, short, easy to administer and answer, and its interpretation is simple. The obtained results for stress (6.9-10.4), anxiety (5.3-5.4) and depression (2.5-2.8), are within the normal range for the three scales (0-14, 0-7, 0-9 for stress, anxiety, and depression, respectively) in a general analysis. However, six of the participants presented moderate stress, three mild anxieties and another one severe anxiety. These results were similar to those obtained with the PROESSAT in its section Assessment of Risk and Demands. The psychosocial risk assessment was carried out by a student with a master's degree in Occupational Health and he is not a specialist in the administration of psychological tests, which requires making recommendations that are not of such a specialized interpretation. The results must be expressed simply and clearly to the company management since psychosocial risks related to working concern aspects of work management, social and organizational contexts, with the ability to generate psychological or physical damage. Psychosocial risks cannot, analysed as environmental measurements rather than individual measurements (psychological attributes). The individual results for each worker's DASS 21 scale show the fact that six firefighters had moderate stress, three firefighters had moderate anxiety and one firefighter had severe anxiety, that is to say, these three pathologies are present even though the DASS-21 general analysis scale does not detect them. Besides, health damage analysis (PROESSAT survey) also showed physical fatigue, depression, stress, anxiety, sleep disorder, and migraine. From these points of view, it was possible to determine that psychosocial risks were present in the firefighters' sample. This fact was important due to these pathologies: stress, anxiety, and depression. Their consequences are the core point of interest for understanding psychosocial risk factors because their repercussions on both health and productivity (Vilchis-Rea & López-Hernández, 2017; Balderas-López *et al.*, 2019; Uribe *et al.*, 2020).

3.3. Noise

The results of the measurements made to unit 875 with a normal operation management, where the sound levels and the different sirens of the engine were evaluated, are shown in Table 1. The exposure time will depend on the distance of the service and the number of the emergencies required during the day. The exposure to the noise is considerable inside and outside the cabin. The noise results for the unit 871 with the revolutionized engine and the water pressure pump activated was 83.7 ± 0.2 dB (A), evaluated at the floor level in water intake area. In the control panel it was 81 ± 0.8 dB (A), areas where the machinist operator does his work. The evaluation of the noise generated by the fan, used in the cooling or extraction of air, is performed both, indoors and outdoors, the results were 95.3 ± 2.3 dB (A) and 93.2 ± 2.8 dB (A), respectively. The hydraulic tool motor for extraction generates 81.3 ± 0.7 dB (A).

Table 1. Noise measurements performed to the unit 871.**Tabla 1.** Mediciones de ruido realizadas en la unidad 871.

Measurement area	Running engine dB(A)	Sirens Wail dB(A)	Sirens Yelp dB(A)
Inside the cabin	73.8 ± 4.9	94.3 ± 1.6	94.3 ± 1.6
Outside seats	75 ± 4	94.7 ± 1.4	94.5 ± 1.1

Note: Results were expressed as the average of 180 replicas ± Standard Deviation.

The results of noise measurements are consistent with what has been reported in other researches where it is indicated firefighters are frequently exposed to high levels of noise from various sources: vehicle sirens, horns, machine and tool motors. Levels of more than 100 dB (A) can be reached in the response to emergencies (Alvarez *et al.*, 2016; Cohen *et al.*, 2019). In this research, the noise values exceeded the maximum limits allowed by the Mexican standard (NOM-011-STPS-2001). Exposure to noise at work can be harmful to health from the workers. The best-known effect of noise at work is hearing loss. However, it can also increase stress and multiply the risk of an accident.

3.4. Audiometry

Choi *et al.*, (2011) presented a theoretical framework describing the relationship between working conditions, health behaviors, and obesity in firefighters. However, the associations between working conditions of firefighters and obesity, and the relationships between working conditions and health behaviours for obesity in firefighters remain to be clarified.

There are diverse factors such as overweight, obesity, age, and time of exposure to noise appears, that influence the hearing loss. Table 2 shows the results of the audiometry (applied to nine firefighters) their age, BMI, labor seniority, the hearing threshold obtained and their categorization according to the World Health Organization (WHO). The results of the measurements showed that there is hearing loss among the studied firefighters and a low hearing of the personnel in the frequencies of 4000–6000 Hz. This phenomenon shows that the ear has a higher difficulty for a post occupational recovery. On the other hand, the level of linear association between the measured variables was analyzed, considering a significant correlation at a level of 0.1, since, the sample of firefighters is small. Table 3 shows coefficients correlation between the hearing threshold (UA), seniority, age and BMI.

Table 2. Results of the audiometry study.**Tabla 2.** Resultados del estudio de audiometría.

Firefighter	Age (years)	BMI*	Seniority (years)	UA* dB (A)	Hearing loss levels WHO
1	46	22.3	25	40	mild
2	42	32.1	18	65	severe
3	42	30.4	9	25	normal
4	40	26.8	4	15	normal
5	42	27.4	13	35	mild

6	42	29.1	13	35	mild
7	27	42.8	4	20	normal
8	35	29.7	4	20	normal
9	44	31.8	6	45	moderate

*BMI= body mass index; UA= hearing threshold.

There was a strong direct linear association ($r = 0.65$, $p = 0.0574$), between the labor seniority of firefighters and UA. It means, being firefighters as their years of service increases their auditory level decreases in a high proportion, being that their UA are increasing. Likewise, a positive correlation between the variables "Age" and "Seniority" was found ($r = 0.72$, $p = 0.074$). As firefighter's age increases, so will their seniority. Moreover, there is not enough statistical evidence, but it does exist a trend between the correlation of the variables "Age" and "UA" ($r = 0.53$, $p = 0.14$). Which suggests that for this study and under the conditions, in which the same is carried out, age can be or not, a risk factor for suffering hearing loss. A similar behaviour ($r = 0.54$, $p = 0.13$) occurs between the variables "BMI" and "seniority," that is to say, the younger firefighters with a less seniority present a higher BMI.

Table 3. Correlation Analysis.

Tabla 3. Análisis de correlación.

Ratio of Variables	Significance Level (p)	Correlation Coefficient (r)	Linear Association
Seniority-*UA	0.058	0.65	yes
Age-UA	0.14	0.53	Tendency
BMI-UA	0.76	-0.11	no
Age-Seniority	0.074	0.62	yes
BMI-Seniority	0.13	-0.54	Tendency
Age-BMI	0.0085	-0.80	yes

*BMI= body mass index; UA= hearing threshold.

Finally, it did not exist a linear correlation between the "BMI" and the "UA" ($r = 0.11$, $p = 0.76$). Which indicates that the condition of overweight and obesity (BMI) is not associated with the firefighters' hearing loss.

The firefighters show hearing loss and low hearing at frequencies of 4000 and 6000 Hz. Researchers agree on the fact there is a greater hearing loss after the sixth year of exposure and a loss in hearing acuity at the highest frequencies between 3000 Hz and 6000 Hz, in particular, around 4000 Hz (Bufano, 2013), that is, as firefighters increases their years of service, their hearing level decreases.

In this study and under the conditions in which it takes place, age can be or not a factor of risk for suffering hearing loss (there was a trend between age and UA variables). Despite this, the natural aging of the ear by age must be taken into account, which will affect each individual in a different way (Hong *et al.*, 2013), because, the hearing loss related to aging is a biological phenomenon of the ear which no one can escape, beginning around 20 to 30 years of age and it appears symptoms at 50 to 60 years of age. Therefore, it could be considered as a natural condition that increases its prevalence with age (Díaz *et al.*, 2016).

The BMI was calculated and used as an indicator for obese and overweight, conditions can affect the metabolism of glucose in the body causing internal ear dysfunction with damage to hearing and

balance (Fernández *et al.*, 2011). Due to obesity has a significant effect on vascular function, and this may have an impact on highly vascular organs such as the auditory system (Dhanda and Taheri, 2017). According to the results, all the firefighters in the study, except one, were overweight (BMI=23) and obese (BMI=30). However, the correlation analysis showed for this study, the variable of BMI and auditory threshold, does not correlate, which indicates the condition of overweight and obesity are not associated with the firefighters' hearing loss. However, in order to prevent the obesity risk factor a nutritional intervention program for firefighters was recommended. These programs often include personal diet, hereditary factors, psychological evaluations, and physical activation (Choi *et al.*, 2011). Nutritional Intervention Program is considered to improve the variables of BMI and weight. Reduction of overweight and obese in firefighters is promoted. Besides, these two conditions are strongly associated with other non-communicable diseases such as diabetes and high blood pressure.

3.5. Measurements of gases and suspended particles

At the scene of a fire, firefighters are frequently exposed to CO, CO₂ and VOC, among others (Guidotti & Clough, 1992). The values found for benzene, VOC, propaldehyde, acetaldehyde, were 3.7, 4.2, 7.7, 24.2 ppm, respectively (Table 4 and Figure 2). The concentration of benzene (3.7 ppm) exceeds the MPL established by NOM-010-STPS-2014 (2.5 ppm). Acetaldehyde was found near the MPL (25 ppm). The same regulation establishes an MPL of 30,000 ppm for CO₂. The values found (912.5 ppm), are within the MPL (working day of eight hours a day and a working week of forty hours). The CO was found at a concentration of 19.44 ppm, a value below the 200 ppm for CO, established by the Institute of Occupational Health and Safety (NIOSH) (Ehlers *et al.*, 2015).

Table 4. Comparison between VOCs obtained values and MPL's by the NOM-010-STPS-2014.

Tabla 4. Comparación entre los valores obtenidos y los MPL permitidos por la NOM-010-STPS-2014

VOCs	^a Obtained values (ppm)	MPL's by NOM-010 (ppm)
VOCs (total)	4.2 ± 0.3	*
Benzene	37 ± 0.5	25
Propaldehyde	7.7 ± 0.1	20
Acetaldehyde	24.2 ± 0.5	25

^a*Results were expressed as the average of 3 replicas ± Standard Deviation.

*Value not found.

In this research, measurement of gases and particles were carried out in the transport unit, where it was found benzene concentrations were higher than the MPL by the regulation consulted. These compounds represent a chemical risk, especially due to combustion fumes and the difficulty of analyzing them, since their concentration varies depending on the stage of the fire, and their emission continues even after the fire extinguishes (Vilchis-Rea, 2017). This implies the firefighters' exposure to these chemical substances, which cause effects such as deterioration and affectation of the lung tissue some pass into the bloodstream and other parts of the body, preventing the red blood cells from carrying oxygen. Besides, breathing them can cause loss of consciousness, suffocation, poisoning, even death. The symptoms will depend on the dose and the time of exposure.

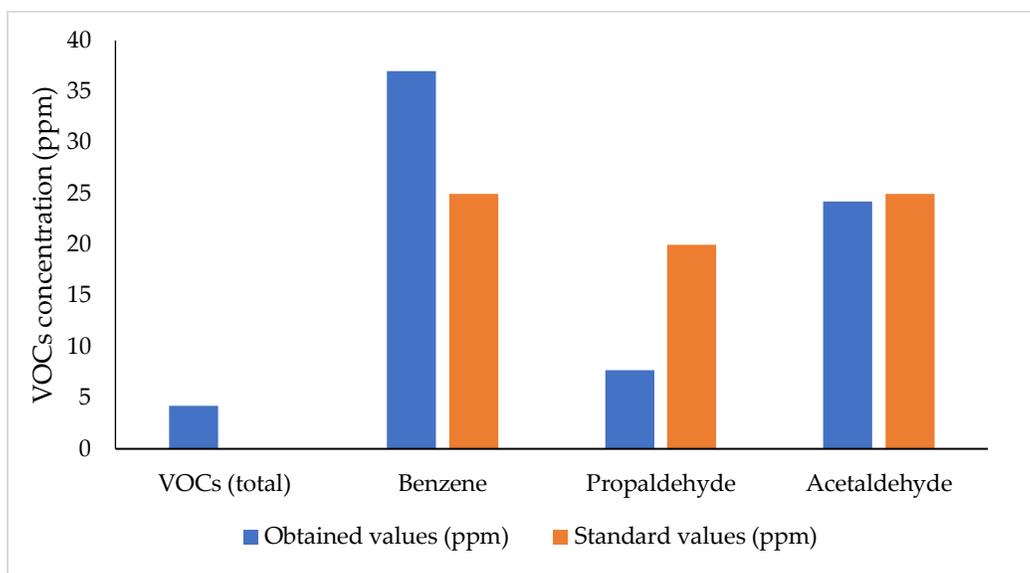


Figure 2. Comparison between VOCs obtained values and MPL's by the NOM-010-STPS-2014.

Source: Table 4.

Figura 2. Comparación entre los valores obtenidos y los MPL permitidos por la NOM-010-STPS-2014.

Fuente: Tabla 4.

The measurements obtained for PM_{10} and $PM_{2.5}$, were of a density of $4.13 \mu\text{g}\cdot\text{m}^{-3}$ and $1.88 \mu\text{g}\cdot\text{m}^{-3}$, respectively. Values that were within the corresponding normativity (NOM-025-SSA1-2014). $PM_{2.5}$ and PM_{10} particles are associated with health problems (respiratory and cancer) (Prell *et al.*, 2020), however, in this investigation, the concentration of these particles was within the MPL by NOM-025-SSA1-2014, the USEPA ($35 \mu\text{g}\cdot\text{m}^{-3}$ and $150 \mu\text{g}\cdot\text{m}^{-3}$ for PM_{10} and $PM_{2.5}$, respectively) and WHO regulation ($50 \mu\text{g}\cdot\text{m}^{-3}$ and $25 \mu\text{g}\cdot\text{m}^{-3}$ for PM_{10} and $PM_{2.5}$, respectively) (Kim *et al.*, 2018).

3.6. Ergonomic analysis

The analysis carried out through REBA method showed a very high risk in the ascending and descending activity to the fire unit, as it does not have any stirrup. The punctuation calculated for this activity was 13, with a "very high" level of risk, which suggest immediate action. On the other hand, hose winding activity had a punctuation of 7, with a "medium" level of risk, indicating that it is necessary to implement the action. Due to this, it is possible that some back injuries, muscular strains and injuries caused by falls are shown.

The results of the ergonomic measurements through the REBA, showed a categorization of risk between "very high" and "medium" in the analyzed postures. The risk was high enough for these tasks to warrant modification and changes. The suggested recommendations given included creating new mechanical and technical devices, modifying existing devices, and making workers aware of associated risks to reduce the threat of injury (Hita-Gutiérrez *et al.*, 2020). Then carry out a re-evaluation using the REBA to obtain elements would make the authorities aware of the investment in infrastructure and equipment of fire stations.

4. Conclusions

Occupational health in firefighters is a subject studied insufficiently at an international level. In this research work was possible to realize a diagnosis of safety and health at work based on the Italian Worker's Model, for risk identification and the determination of physiological, and psychological demands in a fire station in Chihuahua, Mexico. The methodology employed included the Italian Worker's Model and PROESSAT survey, both are widely used to diagnose occupational health in our country. Exposure to noise is unavoidable, difficult to assess and prevent, so the following measures are necessary to adopt such as: the elimination of risk, acquisition of more closed cabin transport units with air conditioning system so that personnel can be transported with closed windows, pneumatic and modern hydraulic tool, engineering measures, implement established predictive and preventive maintenance programs, the application of a hearing conservation program, audiometry studies on a regular basis (at least once a year), personal protective equipment. Future biomonitoring studies recognizing and assessing the range of firefighter's chemical exposure would be beneficial. This study provided some data to understand the relationship between obesity and hearing loss in the firefighters' sample. The individual results for each worker's DASS 21 scale show the fact that six firefighters had moderate stress, three firefighters had moderate anxiety and one firefighter had severe anxiety, that is to say, these three pathologies are present even though the DASS-21 general analysis scale does not detect them. The correlation analysis showed for this study that the variable of BMI and auditory threshold were not correlated, which indicates the condition of overweight and obese is not associated with the firefighters' hearing loss. The results of the ergonomic measurements through the REBA, showed a categorization of risk between "very high" and "medium" in the analysed postures. The risk was high enough for these tasks to warrant modification and changes. Firefighters knew the risk factors. However, they not knew the magnitude of negative health effects. The main contribution of this research was the evaluation of risk factors and the dissemination of its results in the firefighting community. Changes in the transport unit and personal protective equipment, a calisthenics program to improve firefighters' physical strength, agility, coordination, and flexibility, were made.

Acknowledgements

Sergio Gonzalez thanks to the Council of Science and Technology (CONACYT) and to the Autonomous University of Chihuahua (UACH), for the grant awarded to obtain a Master's Degree in Health in the Workplace. The authors would like to thank Firefighters department and Civil Protection of the city of Chihuahua, México for offering raw dates to fill the IWM's questionnaires and PROESSAT survey.

Conflicts of interest

All authors have no conflicts of interest to declare.

5. References

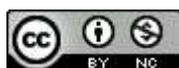
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