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Firefighter perception of risk: A multinational analysis

Myriam Martínez-Fiestas (PhD)[a], Ignacio Rodríguez-Garzón (PhD)[b,*], Antonio Delgado-Padial (PhD)[c]

[a] University of Granada, Facultad de CC. Económicas y Empresariales, Campus Universitario de Cartuja, C.P: 18071 Granada, Spain
[b] Universidad ESAN, Alonso de Molina 1652, Surco, Lima, Peru
[c] University of Granada, C/Rector López Argüeta s/n, CP: 1807, Granada, Spain

ABSTRACT

This study addresses the question of risk perception among firefighters of four Spanish-speaking countries (Argentina, Chile, Ecuador and Spain). It identifies (i) the conditions that generate high and low risk perception. Moreover, the study analyses (ii) the impact of the type of labor system (volunteer vs. professional) on the risk perception. From the methodological point of view, the study applies the *psychometric paradigm* to a large sample of firefighters (N = 690) and resorts to a statistical analysis applying data mining, and bivariate and multivariate parametric techniques. The findings reveal for the first time that risk perception among firefighters can be discerned through the dimension known as *delay of consequences* (risks that may arise in the long-term). In addition, the dimension of *personal vulnerability*, as well as that of *catastrophic potential*, can contribute to a more accurate understanding of this perception in certain situations. Secondly, the study reveals that professional firefighters tend to have a greater risk perception than their volunteer counterparts. Nationality, by contrast, does not play a determining role in the formation of a high/low risk perception. The findings represent an advance for both academia and management, in particular for security managers.

1. Introduction

1.1. Risk and risk perception

Risk is a highly interdisciplinary concept (Bodemer and Gaissmaier, 2014) and has emerged in recent decades as a far-reaching factor in a number of different fields (Micic, 2016). Moreover, the objectivity or subjectivity of the notion of risk is the object of a long debate (Slovic, 1992). In fact, how individuals judge levels of risk is complex (Knuth et al., 2015) and difficult to pinpoint. Analyses of objective risk have been carried out by a number of experts with findings based on both statistics and judgments. Yet these findings are disparate and appear to depend on the type of risk and a number of sociodemographic factors (Knuth et al., 2015).

It is therefore essential to study both the objective risk of actions as well as to determine how stakeholders involved in the process perceive risk (Micic, 2016). This is the only way to advance in risk communication. Subjective risk, that is, how risk is perceived by part of the population and the elements that influence it, is an important factor pertaining to its study (Knuth et al., 2015). This is a very compelling area of research as, to some extent, it is clearly a reflection of objective risk, especially in the cases where the hazards are well known (Sjöberg, 2000). The study of risk perception in the workplace is in fact a crucial issue as it can play a major role in putting protective actions into place (Lindell & Perry, 2012).

1.2. Risk perception in the workplace

Everybody is subject everyday to different types of risk (Burns & Slovic, 2012; Fox-Glassman & Weber, 2016). From the moment individuals wake until they go to bed they undertake a number of different activities that entail risk. The workplace is not exempt. One in three European workers, in fact, considers that they are exposed to occupational hazards (Leoni, 2010).

According to Namian et al. (2018), workplace accident reduction requires recognition of both work hazards and risk. Knuth et al. (2015), along the same lines, argue that recognizing risks and how to react to them is fundamental in improving safety systems. Moreover, research has specifically demonstrated the positive relationship between worker risk perception and safe behavior (Rundmo, 1996; Oliver et al., 2002; Mullen, 2004; Seo, 2005; Arezes & Bizarro, 2011) and risk perception and behavior linked to self-protection (Brewer et al., 2004; Mullen, 2004). Moreover, it is possible to influence individual perception of risk (Starren et al., 2013). This process, although not exclusively dependent on reception of information (Larraín & Simpson-Housley, 1994), appears to be greater among individuals with a higher level of training (Rodríguez-Garzón et al., 2016). However, despite the importance of this notion, worker perception of occupational risks has been the object of relatively little research (Leoni, 2010).

* Corresponding author.
E-mail addresses: mmfiestas@ugr.es (M. Martínez-Fiestas), tecnicoignacio@gmail.com (I. Rodríguez-Garzón), adpadial@ugr.es (A. Delgado-Padial).

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1.3. Risk perception among firefighters

Injury and damage around the world to both people and property provoked by fires is huge (Brushlinsky et al., 2012). Fire is a global fact and firefighters are among its main actors. Firefighting is an extremely dangerous occupation and there are many demands to apply fundamental changes in the way fire services address the question of safety (DeJoy, et al., 2017). However, astonishingly, few studies have focused on the perception of risk among firefighters.

According to Gomez (2008), although firefighters are individuals who tend to seek new experiences, few take disproportionate risks. Furthermore, more experienced firefighters are less conservative and are inclined to take greater risks. In any case, all firefighters carry out their tasks in a changing environment (Gomez, 2008; Flin, 1996) and are required in emergency situations to come to rapid decisions that can lead to severe consequences (Mondragon-Gilmore, 2014).

It is a profession that generates the view that assuming risks can benefit others. Risks taken in the name of public safety can, in fact, be considered heroic and a justification for greater recognition or compensation. Hence certain individuals are predisposed to accept a certain amount of risk. It is likely that differences of acceptance of risk depend on the degree of vocational factors such as occupational status, job safety, peer support, monetary compensation or public image (Bellrose and Pilisuk, 1991). However, an opinion is emerging within fire departments that effective firefighting no longer involves assuming so much risk (DeJoy et al., 2017).

Fighting fires implies confronting situations that are in constant flux resulting in the need to constantly evaluate and reassess risks (Kunadharaju et al., 2011). It is in these situations that constructs such as risk perception play a more definitive role due to the fact that firefighters can manifest too much autonomy when reaching decisions. This can lead to the premise that the end justifies the means, and the acceptance of risk for themselves and their colleagues (Crawford, 2007). The findings of Rodríguez-Garzón et al. (2016) reveal the importance of studying risk perception among firefighters and the modulating factors that serve to achieve a change of attitude. Among these factors is training and the notion that a high level of training leads to an increase of risk perception (Rodríguez-Garzón et al., 2016).

It is also widely acknowledged that firefighters are currently exposed to harmful substances. The findings of a review of the existing literature by Crawford and Graveling (2012) point to a link between firefighting and cancer. The same study does not identify, nonetheless, any significant increase of other types of maladies such as hearing loss, respiratory problems, or hip and knee osteoarthritis (Crawford and Graveling, 2012). Firefighters are also exposed to high levels of noise that can turn out to be long-term hazards (Hong et al., 2008). A part of the previous research suggests that the perception of risk among firefighters has not been widely studied (Schaefer Solle et al., 2018) in spite of recognizing that altering risk perception can lead to a change in behavior toward issues of health (Ferrer and Klein, 2015).

Certain occupational safety and health studies have also measured risk perception among workers in relation to specific tasks, while others have measured it from a more global perspective (Taylor and Snyder, 2017). In line with this second outlook, the main objective of the current study is to attempt to identify a global view of firefighter risk perception.

1.4. Voluntary and involuntary exposure to risk

Another aspect that has been taken into account in risk perception research is whether the exposure to hazards is voluntary or not. According to Starr (1969), an individual is willing to accept much greater risks if they are voluntary. This issue has spread to the realm of unhealthy activities such as smoking, taking part in high-risk sports, and even taking up residence in an area prone to flooding (Machlis and Rosa, 1990; Breakwell, 2007; Zimolong et al., 1998).

Furthermore, labor is organized in different manners in the firefighting sector. In certain countries firefighters are full-time professionals while in others they are volunteers. The repercussion to date of the relation between the type of labor system and levels of risk perception has not been studied. Although a number of specialists reveal certain repercussions regarding the type of labor system, none has specifically addressed the subject of risk perception. Prati et al. (2013), for example, delved into the notion of how more information regarding risks can exert a positive or negative influence depending on whether the risk is voluntarily or not.

2. Objectives

The main intention of this paper, given the scarcity of this type of study, is to analyze the subject of firefighter risk perception (Bourque et al., 2013). This scarcity is astounding as firefighting is a dangerous activity and studies have recognized that an increase in risk perception in the workplace can lead to more compliance with safety standards (Taylor and Snyder, 2017). Perception of risk, in fact, can play an important role in generating a safe workplace environment (Gucer et al., 2003; Seo, 2005; Mullen, 2004). Moreover, understanding this phenomenon can lead to the design of strategies that reduce occupational risk (Arezes and Bizarro, 2011). This general objective is specified through the following two specific goals.

The first aims to analyze how high or low risk perception is generated among firefighters so as to identify the path to follow to increase of risk perception and thus avoid risky behavior. This would, presumably, lead to a reduction in accidents (Namian et al., 2018), a greater awareness of the steps to carry out to assure work safety (Knuth et al., 2015), an increase of self-protection (Brewer et al., 2004; Mullen, 2004), and, ultimately, an improvement in safe behavior (Rundmo, 1996; Oliver et al., 2002; Mullen, 2004; Seo, 2005; Arezes and Bizarro, 2011).

The second is to reflect on whether the type of labor system plays a decisive role in risk perception. As mentioned in the literature review, risk perception and the adoption of risky behavior may depend on whether the risk is assumed voluntarily or involuntarily (Machlis and Rosa, 1990; Breakwell, 2007; Zimolong et al., 1998; Prati et al., 2013).

Although, the type of analysis advanced in this paper has not been carried out within the sector of firefighters, it appears that perception of danger may be greater or smaller depending on the way a subject is exposed to it. Understanding the impact that the type of labor system has on the risk perception supposes both an important theoretical contribution to academia (offering a greater knowledge of the phenomenon) and to management (allowing to act strategically at the level of risk perception).

3. Method

3.1. Participants

The sample population of the four countries totaled 690 firefighters. This number is greater than that required for an infinite population, benefits from a sampling error of 5% and a confidence level of 95%, and differs from that of simple random sampling conditions. The sample can be broken down into 149 firefighters from Spain, 205 from Ecuador, 199 from Argentina and 137 from Chile. The total can be further broken down into 354 professional and 336 volunteer firefighters. The reasons behind the choice of these four countries are laid out in section 3.1.1. The final valid sample was nonetheless reduced to 675 given the loss of certain data. All of the individuals participating in the study were firefighters, that is, individuals in the front line of emergency operations and not auxiliary personnel such as office workers. The sample's sociodemographic characteristics (global and by country) are listed in Table 1.

Table 1
Sociodemographic characteristics of the sample.

Descriptive variables	Average/percentage of the total sample	Firefighters from Ecuador	Firefighters from Argentina	Firefighters from Spain	Firefighters from Chile
Age	35	34	32	44	33
Gender (male/women)	84%/16%	75%/25%	84%/16%	99%/1%	79%/21%
Level of studies (non-university/university)	68%/32%	61%/39%	79%/21%	72%/18%	49%/51%
Marital status (without partner/with partner*)	41%/59%	35%/65%	50%/50%	23%/77%	61%/39%
Years in the position	10	9	9	17	9

* Without partner: single, divorced and/or widowed." With partner: "casado o con pareja de hecho."

3.1.1. Choice of countries

Four countries were chosen for the study. Their selection was conditioned by the three criteria described below.

The first relates to the labor system. Given that one of the objectives was to analyze the impact of the type of work system on risk perception, countries were chosen in function of their different means of engaging firefighters. Hence, two countries were chosen for their respective professional and volunteer systems. The second and third criteria were adopted to eliminate the potential biases of cross-cultural studies. Thus, the second criterion, that of potential linguistic barriers, led to the choice of countries sharing the same language (Brislin, 1983; Weber and Hsee, 1999). The third criterion carefully considered the potential cultural repercussion on the sample. The perceived risk of an individual takes place in a specific social and cultural context (Bodemer and Gaissmaier, 2014). In general, each society, according to Hofstede et al. (2010), offers different patterns of response to events, and cultural influences can serve as predictors of behavior (Carpenter et al., 2016). Moreover, authors such as Park (2011) and Starren et al. (2013) have warned that perceived risk may be affected by the national culture.

Therefore, in order to address the objectives of this study, two conditions were put in place to identify the impact of national culture on the results. These consisted of applying Hofstede's four classic national culture dimensions (individualism, collectivism, power distance and uncertainty avoidance) as well as the individual values of the National Norm Data (Hofstede, et al., 2010). The values run from 0 to 100, with 50 as a mid-level.

The first condition concerns the value of uncertainty avoidance, that is, aversion to risk. Of the four dimensions, this potentially has the most effect on perceived risk since it directly spells out how a group of individuals face the risks of their social environment (Hofstede et al., 2010). Furthermore, studies such as Reader et al. (2015) advance that this dimension generates the strongest link to the culture of safety as this construct is closely related to perceived risk (e.g. Oliver et al., 2002; Will and Geller, 2004; Seo, 2005). For these reasons, the choice of countries for the sampling was carried out based on their resemblance to this dimension. This led to a choice of those with a moderate to high level of uncertainty avoidance.

The second condition, serving to compare the results of the different pairs of countries, concerned the degree of cultural diversity among the other dimensions. Following the procedure applied in the analysis of Reader et al. (2015), this study adopted pairs of countries that combine volunteer and professional systems that, although culturally different, possess weighted arithmetic means for each dimension that are analogous to their counterparts (see Table 2).

Thus, the final selection of countries was narrowed down to Spain, Ecuador, Argentina and Chile, nations that all share the Spanish language. Furthermore, two (Spain and Ecuador) incorporate professional firefighters while the profession of other two (Argentina and Chile) is occupied by volunteers. All also attain very high scores for the dimension of uncertainty avoidance (> 50) (Hofstede, et al., 2010) and the weighted arithmetic means of each of the pairs for the other cultural Hofstede's dimensions are practically similar. The characteristics of these countries are detailed in Table 2.

3.2. Measurement tools

The current study resorted to the so-called *psychometric paradigm* to quantify risk perception. This paradigm addresses risk as a multidimensional construct that is troublesome to define. It defines the origin of the different dimensions of risk based on the premise that risk is subjective and can be quantified (Slovic, 1992).

This model was chosen for various reasons. On the one hand, it is one of the first and most influential due to its ease of use in measuring perceived risk and its multidimensionality (Bodemer and Gaissmaier, 2014). On the other hand, it is an ideal means to measure risk perception (Bourque et al., 2013) as it serves for different facets of

Table 2
Characteristics of the countries serving for the study.

Countries/Weighted arithmetic means according to Hofstede's cultural dimensions*	Power distance	Individualism	Masculinity	Uncertainty avoidance
Countries with volunteer firefighters(Chile and Argentina)	56	34.5	42	86
Countries with professional firefighters (Ecuador and Spain)	67.5	29.5	52.5	76.5
Classification	Means	Low	Medium	High

* The weighted arithmetic means were gleaned from the individual values of the National Norm Data (Hofstede, et al., 2010).

quantification (Kellen et al., 2013). Moreover, it was recently tested, with positive results, to verify its current relevance (Fox-Glassman and Weber, 2016). Previous research applied it workplace studies (Forcael et al., 2018; Portell et al., 2014) and even specifically to that of firefighters (Rodríguez-Garzón et al., 2016). Finally, the *psychometric paradigm* also serves to compare perception of risk among individuals of different countries (Boholm, 2003; Kellens et al., 2013).

It offers, in the framework of analyses of the workplace, a broad view of perceived risk beyond the possibility and consequences that the risk could occur. This last aspect is compelling because a debate exists as to whether these two dimensions are the sole that throw light on risk perception (Ferrer and Klein, 2015).

The approach to firefighter risk perception in this study is also analyzed through the nine attributes advanced by Fischhoff et al. (1978) with their corresponding adaptations to the profession (Portell and Solé, 2001).

Fig. 1 depicts a brief description of each attribute that form part of firefighter risk perception

From the practical viewpoint, the data were collected by means of questionnaires on paper and always in the presence of one of the researchers. Sjöberg (1998) recommends the use of the questionnaire as it is the most common tool in perceived risk research. Given the requirement of a single common measurement tool for the four different countries, different tests were carried out in order to arrive at a unified questionnaire. This initially consisted of a preliminary interview with a fire department officer in each country so as to confer a general overview of the project and agree upon a plan of action to collect the data. A pre-test was also carried out by five members of the fire departments in each country in order to determine if the questionnaire's language was comprehensible. The results clearly indicate that the language was clear and did not require modification.

Ultimately the questionnaire was structured in two blocks. The first

Fig. 1. Scheme of the *psychometric paradigm* model serving to measure perceived risk.

collected the values of the different dimensions of the *psychometric paradigm* described in the previous section. A total of nine items were included to evaluate the nine attributes or dimensions of risk (A1-A9), as well as the proposals of Siegrist et al. (2005) and Portell et al. (2014). This first block was completed by a final question ("Overall, what is your perception of the risk of your work?") serving to explore the global quantitative dimension of risk perception (GRP). This item is identical to that advanced in the article by Rodriguez-Garzón et al. (2015). All the results were then evaluated following the findings of Fischhoff et al. (1978) and their adaptation by Portell and Solé (2001). Each of these qualitative attributes was quantified in the questionnaire by means of a semantic differential scale of 7 points, as specified in Table 3. GRP was measured by a scale ranging from 0 to 100 (from lower to higher risk perception) with intervals of 5 (21 possible answers).

The second block contained data of sociodemographic order and variables specific to the sector. The data were collected exclusively in the presence of the researchers with the survey taking place at the fire stations. These centers were only accessed after receiving official authorization and only those who freely agreed to fill in the questionnaire were surveyed. So as to obtain data of quality, the entire process was administered by the same individuals who traveled to each country, contacted the different parties, conducted the interviews and controlled the completion of the questionnaires.

3.3. Statistical analysis

This study then, in order to respond to the research objective, carried out a series of different statistical analyses. A decision tree regression was initiated to address the first specific objective. Decision trees are one of the most commonly used data mining techniques to solve classification and prediction problems (Bakir et al., 2006). A decision tree is a predictive data mining technique serving to identify and describe structural patterns. To attain this goal it builds regression models in the form of a tree structure that serve to predict the value of a target variable based on several input variables (Perez and Santín, 2007).

The main purpose of using the decision tree is to achieve a more concise visualization of the relationship between an objective variable (GPR: global of risk) and explanatory variables (A1 to A9: the nine qualitative dimensions). This technique involves partitioning the data into subsets that contain instances with similar or homogenous values. It uses standard deviation to calculate the homogeneity of a numerical sample and searches for criteria and attributes that offer the highest standard deviation reduction standard. Hence, in what regards the first specific objective, this technique allows identifying the model that predicts the value of global risk perception (target variable) based on the different qualitative attributes of the risk (input variable). Specifically, it allows identifying, predicting and categorizing the conditions that must successively take place in order to determine different levels of risk perception. That is, this allows to visualize all the possible situations that may arise from the different values reported by firefighters associated with their global risk perception. This will determine the routes to follow to ensure that firefighters attain a high risk perception from a probabilistic point of view.

Hence, this method generates probabilistic rules to predict in what situations, and under what circumstances, a firefighter will display a

Table 3
Scales serving to measure each of the attributes of risk.

Explored Factor	Semantic differential scale	Items
Worker's personal knowledge	1 = not known; 7 = precisely known	"Do you think you have enough knowledge as to safety issues?"
Safety and health manager's knowledge	1 = not known; 7 = precisely known	"Do you think safety officials at you company are aware of the risk in your daily work?"
Fear	1 = low dread; 7 = high dread	"How concerned are you about being hurt at work?"
Personal vulnerability	1 = not probable; 7 = probable	"What is the likelihood you might get hurt at work?"
Seriousness of consequences	1 = low degree of severity; 7 = high degree of severity	"If a risk situation occurs at work, how could you be hurt?"
Preventive action (fatality control)	1 = I cannot do anything; 7 = I can do many things	"What can you do to prevent a problem that could create a situation of risk ?"
Protective action (damage control)	1 = uncontrollable; 7 = controllable	"In an eventual situation of risk, how likely is it you might intervene to control it?"
Catastrophe potential	1 = not probable; 7 = probable	"Are there possible risk situations that could involve a large number of individuals?"
Delayed consequences	1 = none at all; 7 = a great deal	"Do you think your work can impair your health in the long run?"

greater or lower perception of risk.

This technique of data mining is considered adequate in this case given the large sample. All qualitative dimensions of risk perception (A1 to A9) were included as independent or input variables of the model with the dependent or target variable being the global risk perception (GPR). All were considered continuous variables as they were measured by a semantic differential scale of 7 points (A1 to A9) or from 0 to 100 (GPR).

The decision tree regression was carried out following two cross-validated analyses: Decision tree growth CHAID (Chi-square Automatic Interaction Detector) and exhaustive CHAID. These two cross-validated types of analyses are the most commonly used algorithms in the specialized literature. At least two algorithms served to verify with greater robustness of the resulting models. 10-fold cross-validation procedure was put to use to test the models, as is often the case (Blockeel & Struyf, 2002), allowing verification of the precision of the results (Berlanga Silvente et al., 2013). The analyses were carried out resorting to both of these methods so as to assure a higher level of robustness and to evaluate the goodness of the tree structure in case it were to be generalized or extrapolated to a larger population.

The criteria for the growth of the tree are the following: its maximum depth was 3 and the minimum number of cases was 100 per parental node and 50 per filial node. These decisions derive from the choice of the selected growth methods and the study's sample size. This method of calculation applied the Snedecor F statistic. Likewise, the multiple comparisons and significance values serving for the division and fusion criteria were corrected by means of the Bonferroni method. The level of significance was set at 0.05 for all the analyses.

Finally, and prior to carrying out the examination, the study corroborated that the data lost in the independent variables did not exceed 5%, the requirement to validate the predictive categories identified in the model.

Chi Square and ANOVA tests were then carried out to address the second specific objective and analyze the influence of the volunteer system. This was undertaken by grouping the nodes obtained in the classification tree by degree of risk perception (low, medium or high). The role of the variable labor system was analyzed grouping Chile and Argentina, countries with volunteers, and Spain and Ecuador, countries with professionals. An analysis of variance (ANOVA) was then carried out together with a Bonferroni test for all countries and pairs to ascertain whether the resulting influence was due to the labor system or/and the national culture.

The coding of the surveys, the treatment of the data and the statistical analyses were conducted by means of IBM SPSS Statistics 24 software.

4. Results

4.1. Specific objective 1: Analyze how higher or lower risk perception is generated among firefighters so as to identify the path to follow to increase a greater risk perception.

The classification trees obtained using the CHAID and exhaustive CHAID growth methods led to robust results. Both methods yielded eight final nodes. In each case, the predictive variables, the size of the nodes and the characteristics of each node were identical. The estimation of the model, the deviation of error of each model, and the cross-validation yielded analogous values (Table 4). Furthermore, the tests indicate that the subjects of the sample assigned to the nodes by the two methods did not disagree (Table 5).

Fig. 2 illustrates the resulting model. It specifically offers a break down of the information on the variables that play a significant role in the future prediction of global risk perception, as well as the values of the variables with significant GRP changes. In addition, it reveals the size of each node and the percentage they represent in the global sample, as well as a prediction of the value of global risk perception and its standard deviation. It also indicates that the nodes are configured at two levels. An analysis of the tiered model is presented in the discussion section. Moreover, the study discusses the resulting routes that identify the best model to achieve an increase in perceived risk.

The nodes are configured at two levels. The first level comprises the variable related A9. A9 is therefore the most discriminating variable for GPR prediction. Four parent nodes were generated from the values of variable A9. These are differentiated by A4 and A8 as predictive variables of the model of second order. These correspond to the maximum and minimum values that can be obtained from the GPR according to the values gleaned from the classification tree that are illustrated in Fig. 3.

Table 4
Estimation of the model.

Growing Method:	Validation	Estimate	Std. Error
EXHAUSTIVE CHAID	Resubstitution	346.017	22.746
	Cross-Validation	385.136	24.408
CHAID	Resubstitution	346.017	22.746
	Cross-Validation	386.315	26.025

Dependent Variable: GPR.

Table 5
Cross-tabulation of the size of the final nodes of the two estimation models.

Count: Terminal Node Identifier		CHAID method								Total
		5	6	7	8	9	10	11	12	
Chaid Exhaustive Method	5	55	0	0	0	0	0	0	0	55
	6	0	81	0	0	0	0	0	0	81
	7	0	0	61	0	0	0	0	0	61
	8	0	0	0	56	0	0	0	0	56
	9	0	0	0	0	76	0	0	0	76
	10	0	0	0	0	0	67	0	0	67
	11	0	0	0	0	0	0	70	0	70
	12	0	0	0	0	0	0	0	224	224
Total		55	81	61	56	76	67	70	224	690

4.2. Specific objective 2: To reflect on whether the type of labor system plays a decisive role in risk perception

To address the second specific objective, the nodes were assembled into comparable groups according to their degree of risk perception (low, medium and high). Nodes 5, 6 and 7 were grouped in the "low risk perception" set as their scores are less than or equal to 60 out of 100. Nodes 8 and 9 were grouped in the "medium risk perception" set because they average 70 (> 60 and < 80) out of 100. Finally, nodes 10, 11 and 12 were grouped in the "high risk perception" set because their scores surpass 80 points.

A Chi Square test was carried out subsequent to the groupings so as to determine whether the labor system variables and the GPR level were independent. As noted in section 3.1.1, Ecuador and Spain employ professional firefighters while in Argentina and Chile they are volunteers. The analysis confirms the statistical non-independence of the two factors (Chi Square = 49.216, $p < 0.001$). As illustrated in Fig. 4, the number of professional firefighters among the low risk perception group is less than 20% while that of volunteer firefighters in this group is about 40%. The pattern among the subjects of the high risk perception groups, in turn, is reversed, with professional firefighters at more than 60% compared to 40% for volunteers. Both types of fire department labor systems appear to have the same percentage of subjects among the medium risk perception group.

Likewise, the study examined (by means of three ANOVA tests) the question if the value of the GPR differed according to each group's labor system (low, medium and high risk perception). The first served to measure the value among the low risk perception group granted to the GPR by volunteers and professionals. Similarly, the second test was applied to the medium risk perception group, and the third to the high risk perception group.

All the tests yielded statistically significant differences ($F_{low\_risk} = 4.956$, $p = 0.027$; $F_{medium\ risk} = 12.806$; $p < 0.001$; $F_{high\_risk} = 13.422$, $p < 0.001$). As indicated in Fig. 5, professional firefighters tend toward a greater risk perception, regardless of the cluster to which they belong.

4.2.1. Impact of nationality on the findings

A series of analyses were carried out to ensure that it was not the factor of nationality that determines the similarity between countries with identical firefighter labor systems and the difference in the case of opposite systems.

The study thus resorted to a Table of contingencies and a Chi Square analysis where the independence of the nationality of the firefighter variable was addressed in function of each of the clusters. These analyses, based on Hofstede's four cultural dimensions, focused individually on the differences of each of the pairs of countries and determined the pairs and combination of labor systems that share the same level of differences (see Table 6).

Six contingency tables and six Chi Square tests were carried out so as to determine the impact of the national culture on each sector. As depicted in Table 7, there is no sign that nationality affects perceived risk. Moreover, there are no significant statistical differences for the pairs of countries with identical labor systems (Ecuador-Spain and Argentina-Chile), whereas there are great differences among the other pairings (Ecuador-Argentina, Ecuador-Chile, Spain-Argentina, Spain-Chile).

The graphic representation of the percentage of individuals in each group of nodes by country is specified in Fig. 6.

5. Discussion

5.1. Specific objective 1: Analyze how high/low risk perception is generated among firefighters so as to identify the path to follow to increase risk perception.

As illustrated in Fig. 2, the predictive model of global risk perception is characterized by two levels. The first level comprises the variable related to the delay of consequences (A9). This is the model's most discriminating variable ($F = 94.986$, p-value < 0.001) that, therefore, is best suited to predict the GPR. The greater the perception of a risk of the delay of the consequences, the higher the level of GPR prediction. Hence, in order for firefighters to become aware of a high global risk, they must clearly perceive that the activities they carry out can lead to negative consequences.

It is a fact that firefighters are exposed to risks that may only become manifest in the long-term (Hong et al., 2008; LeMasters et al., 2006). These can be linked to concepts such as hygiene (Holmes et al., 1999), ergonomics or psychosocial risks.

Research on the perception and weight afforded by workers to these risks, nonetheless, has yielded contradictory findings. According to the studies of Harrell (1990) and Mullen (2004), firefighters tend to pay less heed to the long-term consequences and prioritize immediate effects. Likewise, Bellrose and Pilisuk (1991) suggest that firefighters do not perceive that their occupational risks might have greater long-term effects than those that might affect them if they had chosen a different profession. However, more recent findings tend to reflect the opposite. Joyce et al. (2006) state that firefighters are very concerned about eventual long-term occupational consequences, in particular those linked to extinguishing chemical fires. Along these lines, Hong et al. (2008) suggest similar concerns regarding potential loss of hearing. Schaefer Solle et al., (2018), in fact, conclude that firefighters currently report more concern about long-term occupational risks than those that they suffer in the act of service.

The findings of the current paper are therefore not only in line with the conclusions of this latest research, but reveal that besides being perceived as significant, the effects on health over the long-term is the factor that best serves to predict high GPR in the firefighting sector.

Fig. 2 also indicates that the first level is branched into four additional levels when considering the attributes of *Probability of occurrence* (A4) and *catastrophic potential* (A8). Therefore each of these dimensions serve as predictive variables for the model. Yet it is the first of these (A4) that appears to assume a more significant role as its predictive capacity is almost constant which modifies the upwards or downwards GPR fluctuations predicted by A9 (*delay of consequences*). Specifically, nodes 2, 3 and 4 are subdivided by the variable A4 (Node 2: $4 < A9 \leq 5$; A4: $F = 10750$; $p < 0.05$; Node 3: $5 < A9 \leq 6$; A4: $F = 9.929$; $p < 0.05$ and Node 4: $A9 > 6$; A4: $F = 9.641$; $p < 0.05$).

Fig. 3, in turn, indicates a high risk perception of the *probability of occurrence* by firefighters that can positively enhance the GPR level, although this value initially depends on the perception of the *delay of consequences* (A9). Yet firefighters who believe that an unpleasant event is unlikely to affect them only yield a GPR that is even lower than that of their perception of the *delay of the consequences*.

The attribute A4 (*probability of occurrence* or personal vulnerability) most often forms part, along with A5 (*severity of the consequences*), of risk management systems (McNeill et al., 2013) and is relevant to the

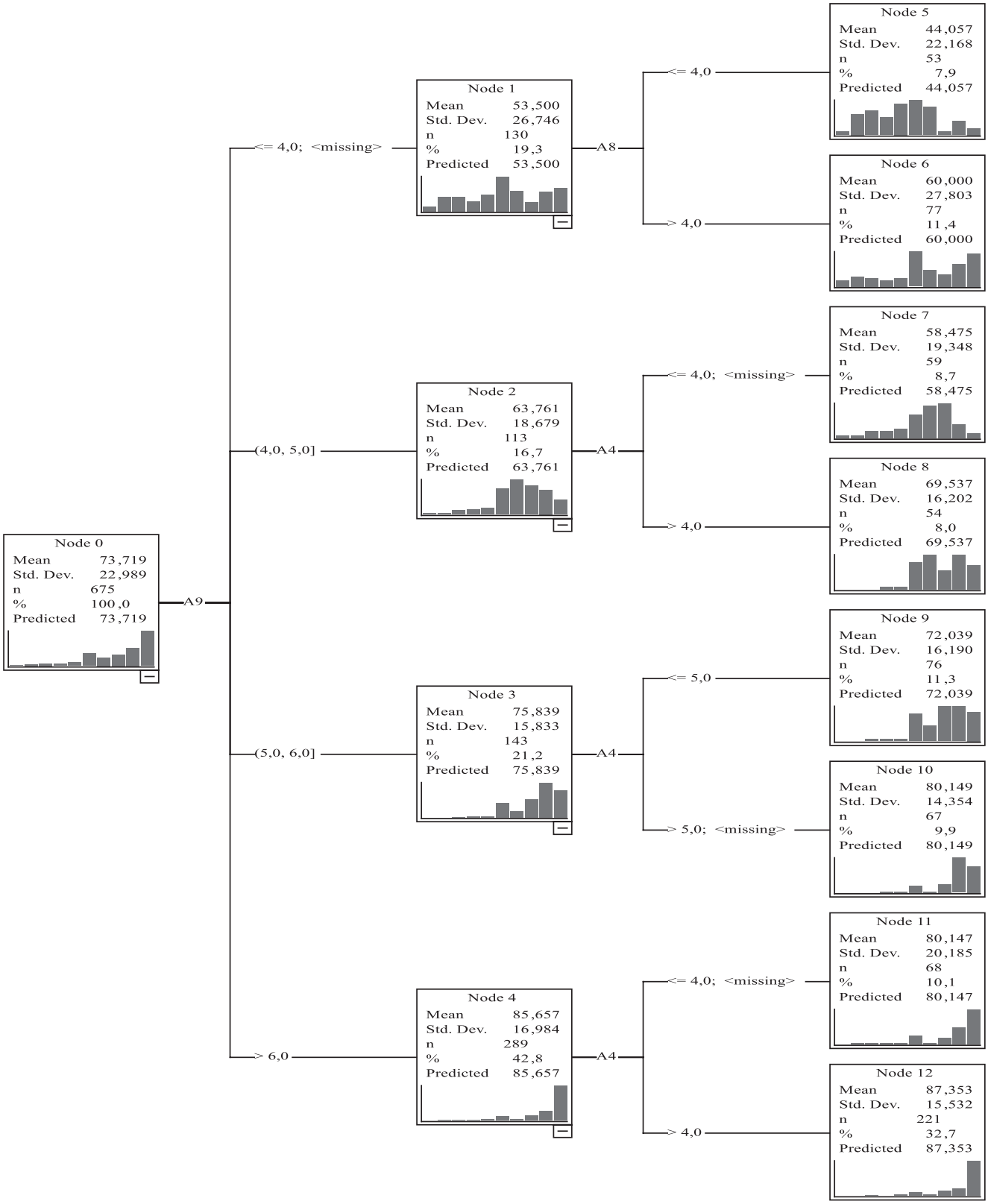

Fig. 2. Decision tree model representing the perception of risk of firefighters.

notion of perceived risk (Lin et al., 2008; Martin et al., 2009). Previous research in other sectors suggests that workers place more weight on the severity of the consequences than on the probability of a risk ever taking place (Bohm and Harris; 2010, Rundmo, 1992). However, according to Aven (2007), risk can be described by identifying personal vulnerabilities. Along the same lines, DeJoy (1996) states that personal vulnerability is particularly relevant as an individual will not take measures of protection when not perceiving his/her vulnerability.

As noted above, firefighters are often required to act independently, improvise, and adapt to changing scenarios (Flin, 1996; Kunadharaju

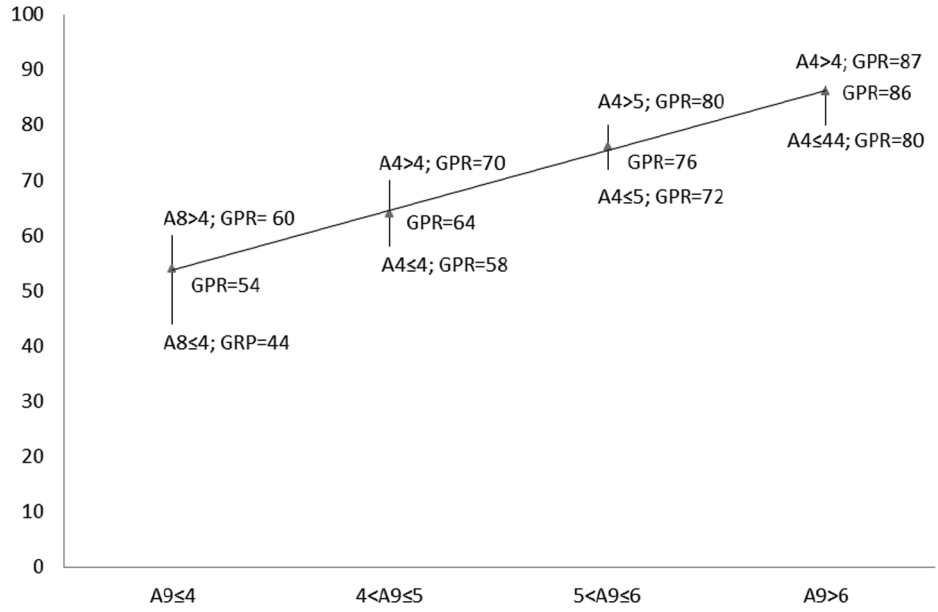

Fig. 3. GPR prediction according to the A9, A4 and A8 values.

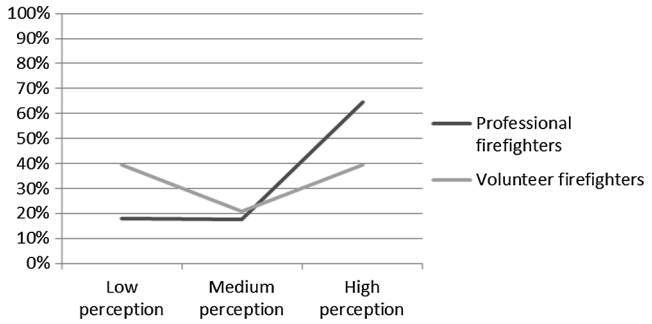

Fig. 4. Percentage of firefighters of each cluster according to labor type (professional or voluntary).

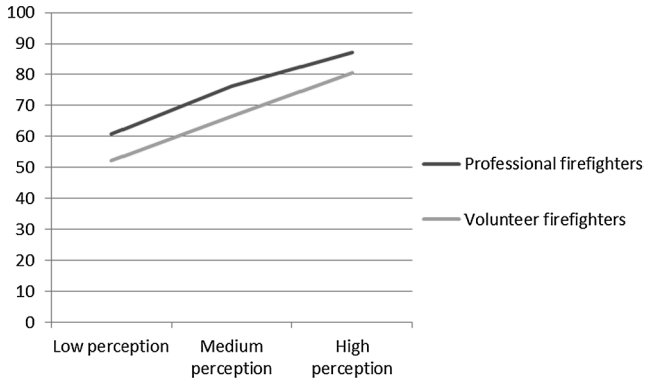

Fig. 5. Level of GPR according to the type of labor system.

et al., 2011) leading to an increase in risk (Bigley and Roberts, 2001). It is essential during these cases that firefighters perceive their vulnerability, that is, recognize that an accident can be imminent.

Moreover, taking actions in the firefighting sector that go beyond those defined by the regulations are sometimes warranted. One must often react in accordance with the circumstances (Klaene and Sanders, 2007). This is especially vital since it is possible to interpret that a disproportionate heroic action favoring the community can be warranted (Bellrose and Pilisuk, 1991). Hence firefighters, in these situations, if unaware of their vulnerability, could make decisions leading to actions that entail a type of risk beyond the levels defined as the maximum in the regulations and standards.

The last predictive variable of the model is the A8. As indicated in Fig. 3, high risk perception of the *catastrophic potential* could lead to an increase or decrease in the level of GPR when the perception of the *delay of consequences* is very low (Node 1: A9 ≤ 4, A8: F = 12.116, p <0 0 5).

The potential that a large number of individuals be affected, according to certain authors, can be a vital dimension in determining risk (Mullet et al., 1993). Along this line, it is noteworthy that firefighters can take part in collective high-risk scenarios. They can also operate under conditions entailing great material, environmental and/or economic losses. Certain authors even refer to blazes in buildings in terms of their catastrophic potential (Wolski et al., 2000). For all these reasons, it is logical that this dimension plays a relevant role in the model.

To conclude the discussion of the analyses related to the first specific objective, the study turned to the different patterns that allow predicting and categorizing the conditions that must occur successively so as to identify the different levels of risk perception. The union of all the conditions that can be generated to obtain different levels of GRP are labelled *routes*.

Three routes that yield a high GPR can be gleaned from the model. Each possesses values that are higher than the arithmetic mean (80 points) of the sample (see Fig. 7), and each yields great implications for safety management indicating the manner to achieve safer behaviors by means of individual risk perception. Moreover, the three routes are situated where the sample is characterized by a more uniform, less dispersed, distribution.

The importance of possessing a high risk perception and its relation to occupational safety is manifested in the specialized literature. High risk perception bolsters safe behavior (Rundmo, 1996; Oliver et al., 2002; Mullen, 2004; Seo, 2005; Arezes and Bizarro, 2011), improves self-protective behavior (Brewer et al., 2004; Mullen, 2004), improves the climate of climate safety (Gucer et al., 2003; Seo, 2005; Mullen, 2004) and reduces the number of accidents (Namian et al., 2018).

Arezes and Bizarro (2011) go further and argue that identifying perceived risk can lead to designing strategies that reduce occupational hazards. In this line, the the routes designated in Fig. 7 can serve as a sort of advance. They indicate how certain strategies can be developed to increase perceived risk, and therefore, reduce occupational threats. Specifically, security managers stress attributes A9 (delay of

Table 6
Differences in the values of the cultural dimensions defined by Hofstede by pairs of countries.

Classification of the pairs of countries	Cultural differences by pairs of countries	Power distance	Individualism	Masculinity	Uncertainty avoidance
Pairs of countries sharing the same working system	Argentina/Chile (*Pair 1.1*: Volunteers)	14*	23*	28*	0*
	Spain/Ecuador (*Pair 1.2*: Professionals)	21^{+}	43^{+}	21^{+}	19^{+}
Pairs of countries sharing the different working systems	Ecuador/Chile (*Pair 2.1*: Volunteers and Professionals)	15*	28*	35*	19^{+}
	Ecuador/Argentina (*Pair 2.2*: Volunteers and Professionals)	29^{+}	38^{+}	7	19
	Spain/Chile (*Pair 2.3*: Volunteers and Professionals)	6	28	14^{+}	0*
	Spain/Argentina (*Pair 2.4*: Volunteers and Professionals)	8	5	14	0
Choice of pairings	Comparison (differences < 10 points)	Pair 1.1 and Pair 2.1 Pair 1.2 and Pair 2.2	Pair 1.1 and Pair 2.1 Pair 1.2 and Pair 2.2	Pair 1.1 and Pair 2.1 Pair 1.2 and Pair 2.3	Pair 1.1 and Pair 2.3 Pair 1.2 and Pair 2.1

Notes.
(1) The differences were calculated from individual values of The National Norm Data.
(2) * and +: pairs of countries with similar differences in each of Hofstede's cultural dimensions.

Table 7
Values of Chi Square tests for each pair of countries.

Country groupings	Chi Square	p-value
4 countries	55.295	0.000
Countries with Volunteer systems (Pair 1.1)	**4.884**	**0.087**
Countries with Professional systems (Pair 1.2)	**1.734**	**0.420**
Pair 2.1	31.557	0.000
Pair 2.2	42.378	0.000
Pair 2.3	10.696	0.000
Pair 2.4	15.285	0.000

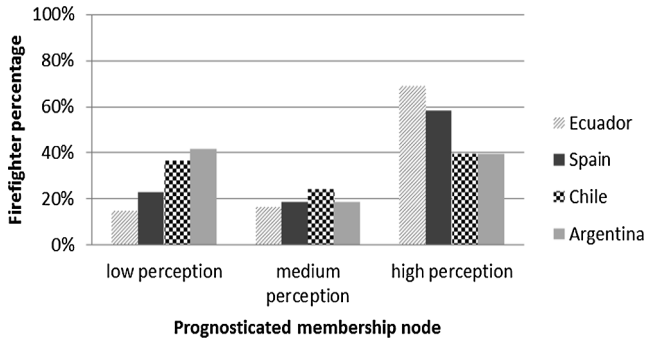

Fig. 6. Histogram indicating the percentage of firefighters with high, medium and low GPR by country.

consequences) and A4 (probability of occurrence). The higher their scores, the greater the perceived risk. Therefore, an increase of these scores of these attributes is essential. This could be achieved, for example, through specialized training.

It is clearly demonstrated that the greater the level of training of the firefighter sector, the greater the perceived risk (Rodríguez-Garzón et al., 2016). According to the routes identified in this study, this training should have an impact, firstly, on raising awareness of the risks that could materialize in the long term such those of ergonomic type or those related to exposure to toxic substances. Secondly, such training should have an influence the subject's sense of vulnerability, to become aware of the real probability of a dangerous event.

Likewise, there are three routes which require urgent action to reduce their size as they yield a low GPR, below the first sample percentile (percentile1 = 60) (see Fig. 8). The model predicts that about 30% of firefighters encounter these situations. However as indicated, this situation does not enhance safe behavior.

5.2. Specific objective 2: Reflect on whether the type of labor system plays a decisive role in risk perception.

5.2.1. The role of the type of firefighter labor system in determining GRP

It has traditionally been assumed that the more involuntary a risk, the more benefit is perceived (e.g. Fox-Glassman and Weber, 2016). However, there is no indication that this notion has been the object of research from the perspective of professional or volunteers. In this study, the activity was considered invariable ('to be' a firefighter) with

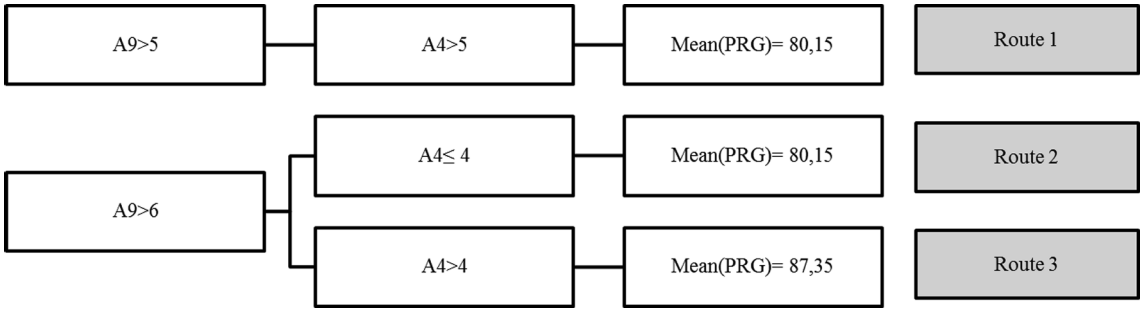

Fig. 7. Routes that yield a high level of GPR among firefighters.

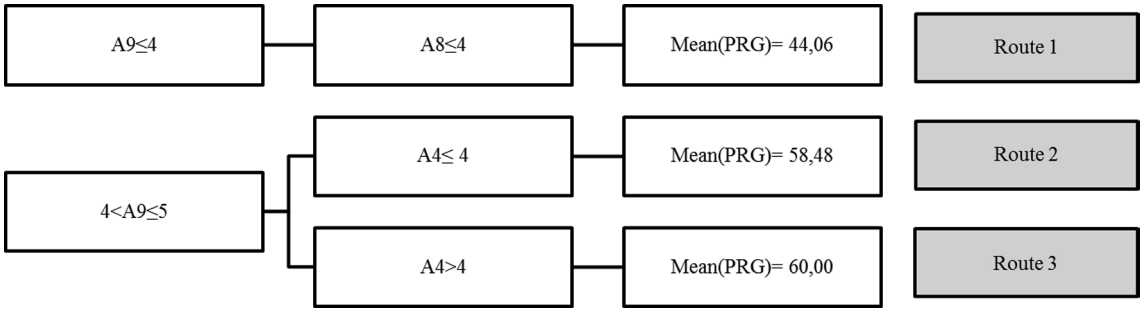

Fig. 8. Routes that yield a low level of GPR among firefighters.

an approach from two different perspectives: professional and voluntary or altruistic. This study therefore represents a significant empirical contribution to the literature of safety management.

The findings of this study therefore indicate that volunteer firefighters, due to lower risk perception, are more willing to accept higher risks than their professional counterparts (see Figs. 4 and 5).

The relevance of the current project therefore is the scarcity of research on this question as analogous current research (e.g. Starr, 1969; Sandman, 1988; Barnett and Breakwell, 2001; Machlis and Rosa, 1990) has focused only on the population in general and not a specific occupation, on issues of health (i.e. smoking) and on high risk sports (i.e. mountaineering).

5.2.2. Impact of the factor of nationality on the findings

The findings of this paper could be invalidated, at least in part, if the reasons behind the differences were provoked by the factor of nationality. Certain research has delved into the question, with mixed results, of whether nationality affects risk perception (Weber and Hsee, 1999; Park, 2011; Starren et al., 2013; Martínez-Fiestas et al., 2017). It must be borne in mind that none of the earlier studies focused directly on firefighting and that there are few that compare the perception of risk between individuals of differing nations (Starren et al., 2013).

It is of interest to note, as indicated in Table 7, that the two nations with professional firefighter systems (Ecuador and Spain) bear significant differences when compared to the two manned by volunteers (Argentina and Chile). However, no significant differences can be observed between the two countries with volunteers or between the two with professionals. Moreover, as illustrated in Fig. 6, nations relying on professionals (Ecuador and Spain) reveal a greater number of subjects with a high risk perception than those resorting to volunteers. An opposite pattern is observed for the low risk perception group represented by Argentina and Chile, countries with the highest percentage of volunteers.

These findings allow rejecting the notion of a bias provoked by national culture and that only the type of labor system (professional vs. volunteer) has an influence on risk perception. This is consistent with studies that reveal that the factor of the workplace can bear more weight than that of culture (Mearns et al., 2004) or that training can moderate the role of national culture (Klein and Steele-Johnson, 2007; Sutton et al., 2006).

6. Conclusions

This study analyzes the factors that lead to risk perception among firefighters. The analysis is founded on a large sample (N = 690) from four Spanish-speaking countries (Argentina, Chile, Ecuador and Spain), two of which (Spain and Ecuador) employ professional firefighters while the other two rely on volunteers (Chile and Argentina).

The method of quantification put to use is that of the *psychometric paradigm* which is characterized by nine attributes or qualitative dimensions of risk perception. The statistical analysis was carried out by means of data mining and specifically by generating a decision tree.

To address the general objective of the study, that is, identify firefighter risk perception, two specific objectives were defined. The first delves into how high or low risk perception are generated while the second analyzes the role played by the type of labor system (professional vs. volunteer) in determining perceived risk.

Concerning the first objective, the regression tree offers relevant information to come to decisions on safety at work and therefore serves as a basis to improve firefighter risk perception.

The findings indicate that to understand and predict firefighter risk perception it is necessary to first identify the weight they place on the dimensions of *delay of consequences* and *personal vulnerability* (or probability of occurrence) and to a lesser extent on *catastrophic potential*.

The study also identified three routes to follow in order to increase perceived risk. The routes signal that the attributes A9 (delay of consequences) and A4 (probability of occurrence) must be acted upon. The higher their scores, the greater a subject's perception of risk. Moreover, achieving higher scores can be attained by specific training programs.

Given the positive relationship between perceived risk and occupational safety demonstrated in the previous research, the three routes can have a relevant impact on the reduction of accidents, in raising awareness as to the necessity of workplace safety, in generating more self-protective actions and in improving safe behavior.

From the point of view of management, the study's findings yield numerous implications for those responsible for safety. They define the points that serve as a base of action of a profession such as that of firefighters that is characterized by so many particularities, and lead to the development of strategies to increase the risk perception either collectively or individually.

From the viewpoint of academia, the findings also represent an advance in risk perception research that can serve other specialists in their quest to move forward in understanding this construct.

The findings linked to the second objective reveal that the system of organization of fire services is essential to understanding the structure of perceived risk. Thus, professional firefighters appear to have a greater perception of risk than volunteers.

These results, together with those of previous research, offer organizations the possibility to act strategically on the question of risk perception. In addition, they reveal the urgency of developing strategies of training for volunteer firefighting services.

Understanding the impact that the type of labor system has on risk perception also offers data to academics. The findings indicate the lack of effect of national culture. Therefore, at the theoretical level, this study can assist researchers investigating which international factors, besides that of national culture, have an effect on risk perception and the culture of safety. From the managerial viewpoint, the findings allow designing geocentric strategies independent from national culture.

In spite of its cross-cultural nature, this study is hindered by its limitation to Spanish-speaking countries. It would be of interest to replicate it in countries with other languages. In addition, the four countries selected each possess a high level of *uncertainty avoidance*, one of Hofstede's cultural dimensions. Hence this study's findings require validation through future research in countries with low levels of this

dimension. It would also be of great interest to generalize the research to other professions. All these future lines of research could contribute external validity to the current findings.

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