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The 2017 Extreme Wildfires Events in Portugal through the Perceptions of Volunteer and Professional Firefighters

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Abstract: This study aimed to explore differences in the perceptions of professional and voluntary firefighters regarding the extreme wildfire events that occurred in Portugal in 2017. We collected a sample of 185 participants, professional and voluntary firefighters, who directly participated in suppression activities for the Pedrógão Grande and October 2017 wildfires in Portugal. They were on duty in 149 fire stations in the Central Region of Portugal. A questionnaire was sent via Google Form to participants, based mainly on close-ended and two open-ended questions. It was structured into topics concerning the characteristics of wildfire events, the problems that occurred during the suppression activity, the emotional response of participants to the events, the lessons learned, and the consequences. We found significant differences between the two groups in their perception of wildfire characteristics and their perception of the worst fires they had ever experienced. Some differences were found in their discussion of the suppression phase and their emotional response to fires. On the contrary, the two groups appear to be homogeneous when it comes to no significant changes after the deadly 2017 experience in terms of the fight against rural fires, organization, training, prevention, and careers. The results underline the inadequacy of the suppression model vs. extreme wildfire events, and also its limits from the point of view of psychological reactions and the perception of management problems occurring in extreme and complex events. There is a research gap and no examples in Portugal about the perception of firefighters of the complex flow of activities that characterize the suppression operation of extreme wildfire events. Our research fills this gap.

Keywords: EWE; Pedrógão Grande fire; October 2017 fires; perception; Likert scale; PTSD

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1. Introduction

1.1. History and Importance of Wildfires in Portugal

Many fire-prone Mediterranean countries in the last two decades registered an increase in extreme wildfire events that challenge traditional wildfire management practices, such as Portugal (2003, 2005, 2013, 2016, 2017, 2018), Spain (2006, 2009, 2012), Italy (2007, 2021), and Greece (2007, 2018, 2021). The definition of an extreme wildfire event is as follows: "a pyro-convective phenomenon overwhelming capacity of control (fireline intensity currently assumed $\geq$ 10,000 kWm^{-1}; rate of spread > 50 m/min), exhibiting spotting distance > 1 km, and erratic and unpredictable fire behavior and spread. It represents a heightened threat to crews, population, assets, and natural values, and likely causes relevant negative socio-economic and environmental impacts" [1].

In 2017, Portugal experienced the worst wildfire season on record in terms of burned area, structures affected, and fatalities when two extreme wildfire complex events occurred in June and October, affecting the Central Region. In that year, the Portuguese government reported a total of approximately 2000 wildfires, burning an area of 539,920 hectares of

forests, shrubland, and agricultural land and causing 117 deaths (116 civilians and one firefighter) [2].

On 17 June, during a period of severe heat, namely a wave with temperatures above 40 °C and a relative humidity below 20% [3,4], at the beginning of the wildfire-critical season, a series of fires, originating from natural or accidental ignitions, broke out near the municipalities of Pedrógão Grande and Góis, south-east of Coimbra. The fires extended to Castanheira de Pêra, Figueiró dos Vinhos, Pampilhosa da Serra, and Penela. A total of 45,328.6 hectares were burned [2]. The Pedrógão Grande wildfire claimed the lives of 66 individuals, the largest loss of life in Portugal's wildfire history. They were concentrated in a relatively small part of the territory; 31 (47% of them) were citizens fleeing by car from their nearby houses and being caught by smoke and flames in a short stretch of the National Road N236-1, where they were overrun and killed by the fire, inside or near their cars [3].

On 15 October and the following days, at the end of the critical season [2], very strong, dry, and hot southerly winds over the whole coastal region [3] were induced by the anomalous easternmost extra tropical Ophelia hurricane, advecting hot air from North Africa [4–6]. They fanned more than 500 agricultural fires ignited by farmers for usual and legal land cleaning practices, rapidly turning them into out-of-control fires. Most of them merged into seven complex fires, whose total area ranged from 17,005 hectares of the Seia fire to 54,407 hectares of the Lousã fire. An area of 213,830 hectares [7] was burned in less than 10 h, generating devastation in a wider area than the Pedrógão Grande fire, with a loss of 51 lives [2]. The October fires are classified as a multiple mega-fire event [4], unprecedented in Europe in terms of seasonality and the extent of area burned in a short time. Wildfires destroyed several industrial areas; damages were identified at 2480 structures, of which 768 were companies, affecting more than 4500 jobs in 30 municipalities [8].

In the critical period of the 2017 fire season (July–September), the Portuguese Special Firefighting System comprised 9740 operational staff, including the Intervention and Relief Group (GIPS) of the National Republican Guard, the Institute for Nature Conservation and Forests, and the Association of Pulp Industries, with a total of over 2300 personnel; a total of 2065 vehicles and 48 aircraft were employed. Aerial means intervened in 7457 firefighting missions, covering more than 9000 h of flight [2].

At the request of the Portuguese Government to bolster Portuguese fire-fighting capacity, the Emergency Response Coordinating Centre of the EU Directorate-General for the European Civil Protection and Humanitarian Aid Operations (ECHO), coordinated the mobilization of aerial means provided by France, Spain, and Italy, with additional Canadairs provided by Spain and Morocco. The fires were only contained when fire weather conditions eased [9]; many of them were actually considered extreme wildfire events (EWEs; [1]) due to their intensity, rate of spread, and massive fire spotting, and were regarded as well beyond the control capacity of firefighting forces, internationally accepted as being 10,000 kWm^{-1}. Values of intensity up to 60,000 kWm^{-1} were estimated in the Pedrógão Grande Fire [10]. For the October fires, estimates of maximum hourly rates of spread varied from 5 to 9 km hr^{-1}, corresponding to 50,000–90,000 kWm^{-1} for a typical fuel load of 20 tha^{-1} [4], with a maximum of 100,000 kWm^{-1} for the Sertã fire [8].

1.2. Research after the Deadly 2017 Wildfire Season

After the event, we recall the prompt appearance of official reports by appointed Commissions of Enquiry for the ex post reconstruction of events [8,10–12]. Other reports came from ICNIF [13] and IPMA [14]. Academic and scholarly research includes topics such as climatic drivers [15,16], interaction atmosphere/wildfire [6], extreme weather [17], impact on and damage to structures [18–20], fire growth patterns [4], burned and unburned patches [21], lessons learned [20], exposure to particulates and mortality [22], creative problem solving for necessary decisions [23], spot fires [24], damage to cultural heritage [25], causes [26], the climatology of extreme fires [27], and the influence of heatwaves [28,29].

However, despite this hectic level of publication activity, there is a knowledge gap because no paper investigated firefighters' work, how they coped with the 2017 wildfires, what their reactions were, and what their perceptions were regarding the organization, identification, and interpretation of sensory information to represent and understand the presented information or the environment. Almost all mentioned papers depict, from different perspectives, the physical "anatomy" of the deadly events, with details and an in-depth analysis of factors and drivers, impacts, and damages. However, the unprecedented behaviors and unheard-of intensity of the wildfire events of the 2017 spring and autumn in Portugal represented a totally new challenge for firefighters, as they were called upon to respond to a variety of situations, ranging from the usual small-scale wildfire occurrences to instances of true catastrophes; thus, this research should be receiving much more attention and scrutiny.

In general, perceptions of wildfires have been extensively researched over the past two decades, focusing on wildfires in Portugal [30], risk perception and awareness [31–35], fire hazards in WUI [24], spot fires [24], socio-ecological perceptions of wildfire management and effects [36], the perceptions of residents [37], the relationship between climate change and fire management [38], the effects of prescribed burning on communities [39], inhabitants' perceptions [40], wildfire smoke [41], the forest and fire management policy [42], residents' perception of wildfire mitigation [43], the perceptions of heat stress and fatigue [44,45], leadership's behavior [46], and pain and health [47].

With different perspectives and methodologies, the object of all the research is the wildfire perception of different social groups. Restricting our research, a more systematic search was conducted using the keywords "wildfire", "firefighters' perceptions", and "Portugal". This literature search yielded a total of only three articles [24,30,42], once again only directed toward generalities and policies, not firefighting, and have thus already been mentioned. A systematic literature review of more than 350 papers regarding firefighters' occupational exposure assessment was retrieved [48]. Here, the words "firefighters" and "perception" were also absent. From the Proceedings of the VIII International Conference on Forest Fire Research [49], held in Coimbra in 2018, a few papers referring to the 2017 wildfire season in Portugal were found and cited, but the knowledge gap in suppression activity is evident because no paper was related to firefighters' opinions.

1.3. Perspectives and Scope of the Paper

As mentioned above, despite its importance, the perceptions of firefighters in frontline activity appear to be an unexplored topic both in general and in the Portuguese context. The fact that this high-risk group has been far less investigated than other groups [50] is a relevant knowledge gap because perceptions can help to understand the dynamics and behaviors of events and improve control activities. Firefighters, as frontline witnesses, have the intrinsic capacity, related to their experience, to interpret single or collective reactions and the dynamics of wildfire events, and critically analyze the performance of suppression operations, along with their failures, weaknesses, and problems.

We strongly believe that a survey on the perceptions of the firefighters involved in the 2017 Pedrógão Grande and October wildfire events in Portugal could be of interest and of paramount importance in improving organization and the chain of control and command, especially in terms of training activity. Considering the above, we decided to fill this knowledge gap through this paper's focus on firefighters' perceptions. We considered only the 149 teams from the Center Region of Portugal, where the Pedrógão Grande and October fires occurred, and not all the firefighters that fought fires in 2017.

We emphasize our originality in investigating certain unexplored aspects, such as operational difficulties; fear for themselves, teammates, family, and the general population; doubt that they are operating in vain; discouragement and the temptation to give up; and the need for psychological support. To our knowledge, these aspects have all been considered and assessed by our research for the first time in Portugal. Furthermore, our study appears timely in terms of the ongoing process of adapting firefighting to the new

and hard challenge imposed by climate change and the multiplication of extreme fires as the "new normal" [51–55]. The object of this paper is to explore the perceptions of the firefighters regarding the behavior of extreme fire events, tactics of suppression, and personal and operational difficulties encountered by professional and volunteer firefighters' corps. The former corps are created, owned, and maintained directly by a municipal council and are exclusively composed of professional members; these have a paramilitary-style organizations with corresponding structures and rules. The volunteer corps belong to humanitarian associations, are made up of volunteer firemen and fire women, and have a minimum of one professional unit or group. Currently, there are no firefighter organizations comprising only volunteers because these are also people with permanent positions and monthly salaries, i.e., they are permanent employees. Voluntary firefighters do not receive a monthly salary, but during the fire season, they form Wildfire Fighting Teams (ECIN-Equipa de Combate a Incêndios, in Portuguese) and receive a daily allowance.

Three hypotheses were formulated:

Hypothesis 1. *There is a significant difference of perceptions—regarding fire behavior, tactics of suppression, emotional aspects and reactions, lessons learned, and possible improvements in the organization of defense against wildfires—between professional (i.e., career or paid firefighters, also including municipal teams) and voluntary firefighter teams, which represent most teams in Portugal. The hypothesis is that when facing the same event, professional and volunteer firefighters' perceptions are different.*

Hypothesis 2. *There is a significant difference between the group stating that the 2017 fires were the worst they experienced (the Pedrógão Grande and October fires) and the group that mentioned other fires that occurred in the past as their worst experienced event.*

Hypothesis 3. *The lessons learned from the 2017 wildfire season resulted in certain changes and updates in the organization and training, and other positive measures in the Portuguese wildfire defense system.*

2. Materials and Methods

2.1. Organization of the Web-Based Survey

The exploratory web-based survey was carried out in a selected group of professional (PF) and volunteer (VF) firefighters who took part in suppression operations during the Pedrógão Grande fire and/or October fires and belonged to teams operating in the Central Region of Portugal. This participation was explicitly requested as a necessary and mandatory prerequisite.

Thanks to the authorization granted by the General Command of the Fire Brigade of Portugal, 149 fire stations in the Central Region of Portugal were contacted by email explaining the scope and mode of implementation of the survey. The email provided a link to access an ad hoc questionnaire, administered online via Google Forms. The questionnaire presented the objective of the study and the authors' affiliations, ensured confidentiality, and presented the way in which the authors were going to use the information collected, assuring the absolute anonymity of the information collected. The survey was conducted during the spring of 2022 (April through June).

2.2. Building the Questionnaire: Its Structure and Content

Since no validated questionnaire is currently available in the literature for surveys similar to ours, we followed general guidelines for questionnaire building [56–58], taking our cue from previously used questionnaires, e.g., for investigating the perception of wildfire risk among Kabyle residents in Algeria [34] and perceptions on knowledge [50].

Questions in a survey questionnaire can be "close-ended" or "open-ended". The former provides the respondents with options and simply requires them to choose one or more items from a checkbox-type list. Open-ended questions allow respondents to freely

express their opinions without being restricted by options. The former type is preferred if the range of answers are well known and the options are limited; the latter is preferred if the answer options are numerous and unknown [56].

In building the questionnaire, we favored close-ended questions that demanded less involvement and time for compilation, and thus are much more accepted by respondents because they reduce the so-called LOI—Length of the Interview—and respondents' fatigue. Answering open-ended questions can be laborious for respondents and calls for more energy than the typical respondent wants to use. Thus, we limited the maximum of this type of question, with all the sections of the questionnaire being close-ended except for two. However, given the number and complexity of the responses to the two open-ended questions, the results are not presented and discussed in this paper, since they will be the subject of a separate paper that is exclusively focused on them. In building the questionnaire, we wrote it with clarity and neutrality, to keep it succinct but interesting; of course, the questionnaire was circulated in Portuguese (See File S1 in the Supplementary Materials). The order of the questions follows the logical steps of our conceptual model for a survey of firefighting crews: (i) the description of firefighters' experience with the 2017 wildfire events and extreme fire behavior; (ii) the description of suppression operations, and any difficulties they entailed; (iii) the introspective analysis of the emotional reactions of the respondents; (iv) and the initiatives taken in response to the lessons learned.

The resulting ad hoc questionnaire thus consisted of the following sections, topics, and items, and was preceded by a brief explanation of the initiative, its features, and the conditions for participation.

Section I. Generalities of respondents (age; sex; type of activity—professional or volunteer; level of instruction; seniority of service; position in the hierarchy), the worst fire experienced in general (year and place of occurrence), and the worst fire experienced in 2017 (municipality/location of the fire).

Section II. Wildfires' physical characterization from firefighters' perspectives. This section includes only Topic 1—Facing the inferno: the perception of EWEs characteristics. It includes nine items related to 2017 events, with integrative information about: (i) the maximum estimated height/length of the flames in the 2017 fires, from a checklist with six values ranging from <4 m to >15 m; (ii) what mainly impressed the respondent (this section permitted yes/no multiple answers from a check-list of 14 items); (iii) and the worst fire experienced by the respondent.

Section III. Wildfire suppression activities related to the 2017 June or/and October fires; it includes four topics and one open-ended question: Topic 2—Efficacy, difficulties, and weaknesses of wildfire operations (13 items); Topic 3—At the flame front (six items); Topic 4—Difficulties, emotions, and personal reactions faced during the June and/or October 2017 wildfire operations, in terms of feelings, fear, doubts, and hidden thoughts (eight items); and Topic 5—Psychological support (four items). The open-ended question was: *Considering your personal experience, what are the main lessons you draw from the 2017 fire season*?

Section IV. How the 2017 wildfire season changed the approach and procedures to fires. This section includes just Topic 6 and one open-ended question. Topic 6 is concerned with the lessons learned from the 2017 wildfire season and the procedure changes, if any, after the experience of the 2017 wildfire season (14 items). The open-ended question was: *In your opinion, after the experience of the 2017 fires, what changes would you like to see implemented in the organization of the Civil Protection system*?

Respondents were invited to reply to items on a five-point Likert scale. This commonly used scale provides a measure of strength for every item, of which it is possible to calculate the mean and SD of scores treated as ordinal values. For open-ended questions, the respondents had the opportunity to insert personal observations and remarks. The open-ended questions were categorized in NVivo 17 and analyzed using descriptive statistics and a chi-square test, but as already mentioned, these results are not presented in this paper. They will be presented in a separate paper.

2.3. Responses

From the 149 operational stations, we obtained 186 anonymous responses, in compliance with national and European data protection laws for scientific and statistical purposes (General Data Protection Regulation, EU GDPR Regulation 2016/679). Of these, only one was considered invalid because the respondent had not taken part in the suppression operations of the 2017 season; thus, our sample comprised 185 people.

No reminder emails were sent, considering the nature of the work performed by the respondents in a potential H24 continuous emergency. Thus, the ratio of replies was 155%, since in some cases we received more than one answer from each firefighters' station.

2.4. Statistical Analysis

In the analysis of the data, descriptive and inferential statistics were used. Descriptive statistics were calculated for each reply to items, namely the mean, SD, chi-square or $\chi 2$, and p value. As the distributions of the score values do not have the same shapes, the means and SD (parametric elements) were used to highlight the differences in the distributions of responses [50,59,60]. The general survey sample (n = 185) was grouped into two subsamples: PF (n = 62) and VF (n = 123). To establish differences in the responses between pairs of subsamples, the Kruskal–Wallis test (Kruskal and Wallis, 1952) was applied, a nonparametric test alternative to the analysis of variance (ANOVA) when heteroscedastic (i.e., with different dispersion) and non-normally distributed data are given. The use of a nonparametric test is justified by the fact that the variables examined do not have a normal distribution and the observations were represented by ordinal classifications, such as Likert scores. The test was performed using the statistics package of the R software.

2.5. Index of Agreement

In order to demonstrate the differences between responses within an entire set of items, we propose the values of the Index of agreement [61] built with the items of a five-point Likert scale. This index measures how much the sum of the positive values (Agree and Strongly Agree) is greater than the sum of the negative values plus the value of the undecided or doubtful ones:

$$I_a = \frac{(\text{Agree} + \text{Strongly agree})}{(\text{Strongly disagree} + \text{Disagree} + \text{Undecided})}$$

3. Results

3.1. Section I: Generalities: Sample Characterization

The group of respondents were made of 62 PF (33.51%) and 123 VF (66.49%). The 185 respondents (Table 1) were mainly males (n = 155) in the two groups, respectively, 29.25% of the total number for PF and 54.60% for VF; females, with a total of 29 (19.70%), were more numerous in the VF group (21 vs. 8, i.e., 11.45%). In one case, gender was not declared.

Age classes, according to Portuguese census standards, were well distributed with low numbers in the age classes up to 30–34 years, the highest number in the intermediate class of 35 to 54 years, and low numbers in the final age classes of 55 to 64 years, meaning that few very young and fairly old participants were included. In terms of percentage, the VF group showed a majority in the intermediate age classes.

The education level category was clearly dominated by the secondary school level. Low numbers appear at the lowest education level and at the highest (Bachelor's and Master's degrees). In general, the VF group exhibits the best education level (33.30% secondary school vs. 23.24% professional; 17.30% Bachelor's or license vs. 4.32% of the PF group; 4.86% Master's vs. 1.62% of the PF group).

Regarding the job start date for firefighting activities, which represents seniority, we adopted four classes. Most respondents (n = 57) started the job in 1998–2007, followed by

50 in 1988–1997 and 51 in 2008–2021; in the latter period, VF exhibited higher percentages than PF.

Table 1. Descriptive statistics considered for the analysis.

Items		PF (*n* (%))	VF (*n* (%))
Gender	Male	54 (29.20)	101 (54.59)
	Female	8 (4.32)	21 (11.35)
	Prefer not to answer	0	1 (0.54)
Age	<25	4 (2.16)	9 (4.86)
	25–29	2 (1.08)	8 (4.32)
	30–34	3 (1.62)	21 (11.35)
	35–39	10 (5.41)	17 (9.19)
	40–44	15 (8.11)	20 (10.81)
	45–49	7 (3.78)	20 (10.81)
	50–54	11 (5.95)	18 (9.73)
	55–59	5 (2.70)	6 (3.24)
	60–64	5 (2.70)	4 (2.16)
Education Level	2nd cycle (6 years of studies)	1 (0.54)	3 (1.62)
	3rd cycle (9 years of studies)	7 (3.78)	18 (9.73)
	Secondary school (12 years of studies)	43 (23.24)	61 (33.97)
	Bachelor's or license	8 (4.32)	32 (17.30)
	Master's	3 (1.62)	9 (4.86)
Job Starting Date	1973–1987	10 (5.41)	15 (8.10)
	1988–1997	18 (9.73)	32 (17.84)
	1998–2007	20 (10.81)	37 (20.00)
	2008–2021	14 (7.57)	37 (20.00)
Role in 2017	Commander	14 (7.57)	18 (9.73)
	2nd Commander	5 (2.70)	6 (3.24)
	Adjunct Commander	3 (1.62)	7 (3.78)
	1st Class Firefighter	6 (3.24)	9 (4.86)
	2nd Class Firefighter	8 (4.32)	22 (11.89)
	3rd Class Firefighter	10 (5.41)	33 (17.74)
	Chief	1 (0.51)	4 (2.16)
	Official Firefighter of 1st Class	1 (0.51)	2 (1.08)
	Official Firefighter of 2nd Class	1 (0.51)	4 (2.16)
	Principal Official Firefighter	0	1 (0.54)
	Subchief	6 (3.24)	12 (6.49)
	No Response	7 (3.78)	5 (2.70)

Regarding the position in the command hierarchy, the numbers are well distributed, but the highest number of replies came from the position of Commander (respectively, 14 and 18 for PF and VF) and from the central group of 2nd and 3rd class of firefighters, who were the most experienced.

3.2. Section II

3.2.1. Topic 1—Facing the Inferno: Perception of EWEs Characteristics

The first question group or Topic 1 (Table 2) consisted of eight questions (items) regarding the perception of the fire event, i.e., impression at first glance.

Given the breadth of wildfire scenarios, fire is observed in various situations and behavioral conditions, but despite this, except for the noise of roaring front (3.968 ± 1.13 and 3.992 ± 1.144 for PF and VF, respectively) and perceived flame size (3.935 ± 1.158 and 4.137 ± 1.023), all means are >4 in the Likert scale. Standard deviation values are reduced, which means that replies are polarized. In many cases, the SD value in the VF group was smaller than that of the PF; although, their replies on items are still more strongly concentrated on the high rates of the scale. For all eight items in the Kruskal–Wallis test,

there is a highly significant difference between the two groups (***), i.e., any *p*-value less than 0.001 was designated with three (***) asterisks

Table 2. Facing the inferno (perception of the fire event) PF vs. VF (*n* = 185).

	Items	$\bar{x}$ PF	$\bar{x}$ VF	±SD PF	±SD VF	x^2	Parameter	*p*-Value	
1	Extremeness of events	4.048	4.379	±1.234	±0.968	82.25	4	0	***
2	Rate of spread	4.226	4.573	±1.165	±0.818	185.00	4	0	***
3	Long range spotting	4.081	4.452	±1.322	±0.877	90.46	4	0	***
4	Flame size	3.935	4.137	±1.158	±1.023	65.96	4	0	***
5	Heat release	4.065	4.097	±1.054	±1.078	62.21	4	0	***
6	Roaring wildfires	3.968	3.992	±1.130	±1.144	63.76	4	0	***
7	Embers and firebrands	4.097	4.185	±1.082	±1.077	55.06	4	0	***
8	Flame length visual estimate	4.290	3.984	±1.092	±1.082	8.88	4	0.064	
9	Control capacity	4.387	4.46	±0.856	±0.83	27.13	4	0	***

Topic 1 integrates three different sets of information: (i) classes of flame length (Table 3); (ii) list of fire characteristics that particularly impressed respondents (Table 4); (iii) and the year of the worst wildfire experienced, apart from the 2017 events (Table 5).

Table 3. Flame length/height.

Classes of Flame Length (m)	PF		VF		Total	
	n	%	*n*	%	*n*	%
≤4	2	3.22	1	0.81	3	1.62
4 to ≤6	1	1.61	12	9.75	13	7.02
6 to ≤10	12	19.35	28	22.76	40	21.62
10 to ≤15	11	17.74	30	24.39	41	22.16
15 to ≤30	35	56.45	50	40.65	85	45.94
>30	0	0	2	1.62	2	1.08
No response	1	1.61	0	0	1	0.54
Total	62	100.00	123	100.00	185	100.00

Table 4. Most impressive characteristics of wildfires.

Most Impressive Characteristics of Wildfires		PF		VF		Total	
		n	%	n	%	n	%
1	Wind	0	0.0	8	6.50	8	4.32
2	Noise	2	3.22	7	5.69	9	4.86
3	Heat	2	3.22	4	3.25	6	3.24
4	Darkness	1	1.61	0	0	1	0.54
5	People in panic	6	9.67	13	10.56	19	10.27
6	Fatalities/injured people	20	32.25	29	23.57	49	26.48
7	Smoke	1	1.61	2	1.62	3	1.62
8	High rate of spread	21	33.87	50	40.65	71	38.37
9	Lack of organization	1	1.81	0	0	1	0.54
10	Flying embers	0	0	1	0.08	1	0.54
11	Spotting distance	3	4.83	5	4.06	8	4.32
12	Explosion of LPG bottles	0	0	1	0.08	1	0.54
13	Buildings burning	5	8.06	2	1.62	7	3.78
14	Other or no response	0	0	1	0.08	1	0.54
	Total	62	100.00	123	100.00	185	100.00

Classes of Flame Length

From Table 3, it is evident that more than 80% of respondents perceive a flame length > 6 m. The modal value for both groups is in class 15 to 30 m, observed more

by PF (56.45%) than VF (40.65%). The values of length > 30 m are reported only by VF, which also show higher percentage values for flames > 6 m. This table aimed to integrate the replies to item 8 (I was impressed with the length and height of the flames; 4.29 + 1.092 and 3.984 ± 1.082, for PF and VF, respectively) with the typical metrics of the flame length/height of an extreme wildfire event [1].

Table 5. Year of the worst ever experienced wildfires.

Year or Period	PF		VF		Total	
	n	%	n	%	n	%
1980–2000	4	6.45	4	3.25	8	4.32
2001–2010	10	16.12	8	6.50	18	9.72
2011–2016	5	8.06	9	7.31	14	7.56
2017	41	66.12	94	76.42	135	72.97
2018–2021	2	3.22	4	3.25	6	3.24
2005 and 2017	0	0	1	0.81	1	0.54
No response	0	0	3	1.65	3	1.62
Total	62	100.00	123	100.00	185	100.00

Fire Characteristics That Particularly Impressed Respondents

The highest number is related to a high rate of spread, followed by fatalities and injured people, and scenes of panic (Table 4). At a distance, noise, wind, and spotting distance (both <5%). All the other characteristics have values of <4%, with a maximum of 3.78% for the high number of buildings burning. The values of VF are always higher than those of PF.

Year of the Worst Wildfire Experienced, Apart from the 2017 Events

Data from this sub-section confirm that the 2017 events were the worst ever experienced by respondents, according to 73.0% of replies. The worst events experienced in other years are a maximum of 9.7% in the period 2001–2010, which includes the disastrous fires of 2003 and 2005 in Portugal, which, due to the fire regime having worsened over time, led, respectively, to the destruction of about 425,000 and 340,000 hectares [62].

In Table 6, the municipalities, parishes, and/or localities were reported where respondents assert having experienced the worst wildfires; missing responses numbered 26. Replies were reported per period and those that occurred in 2017 were particularly notable in number, involving, in decreasing order, the municipalities of Pedrógão Grande (mentioned 33 times), Arganil (6), Góis (6), Santa Comba Dão (6), Tábua (6), and Vouzela (5). All the others follow with minor values for the same year.

Table 6. Municipalities and localities where the worst wildfires were reported by respondents (n = 159).

The Worst Wildfire	Municipalities, Parishes, and Localities
1980–2000	Vila de Rei, Serra da Estrela, Águeda, Almoster-Alvaiazere, Viseu, Oleiros, Mação
2001–2010	Loriga—Seia, Vale de Estrela, Proença-a-Nova, Góis, Caselho Tondela, Famalicão da Serra, Abrantes, Sardoal, Brêscovo, Chamusca, Lisga, Pampilhosa da Serra (2), Ourém, Torre de Tavares, Benedita, São Pedro do Sul
2011–2016	Serra da Marofa, Couto Alcofra, Vouzela, Avelãs Ambom, Seia, Castro Daire, Caramulo (3), Trancoso (2), Vila Real, Nelas, Souto.
2017	Fornos de Algodres (2), Serra da Estrela (2), Mira (2), Tocha (2), Leiria (4), Pedrógão Grande (33), Santa Comba Dão (6), Vouzela (5), Carregal do Sal (4), Tarrasteira, Sabugueiro, Guarda, Nelas (2), Aveiro, Coja (2), Arganil (6), Góis (6), Oliveira de Frades, Ponte da Mucela e Adcasal, Mangualde (4), Vilarinho, Tábua (6), Vilarinho, Lousã, Mação (3), Leiria, Cabanas Viriato (4), Sobral, Travanca de São Tomé, Pardieiros, Beijos, Terras de Bouro, Chamusca, Caramulo, Tavira, Vagos, Gouveia, Pataias (3), Mealhada, Vale de Madeira, Santo André das Tojeiras, Sertã, Oliveira de Frades (2), Castanheira de Pera
2018–2021	Monchique, Salgada, Maçainhas, Bendada, Sertã (2), Oliveira de Frades
No response	No mention of any location (26)

Some municipalities were recurrent in more than one period, such as Caramulo, Chamusca, Serra da Estrela, Mação, Góis, Vouzela, Nelas, and Sertã.

3.3. Section III

3.3.1. Topic 2—Efficacy, Difficulties, and Weaknesses of Wildfire Operations

Table 7 contains 13 items regarding the efficacy of fire suppression and problems in its different phases in the complex scenario of the 2017 wildfires. Unlike the first topic, here, very scattered mean values demonstrate the different perceptions held by the two groups.

Table 7. Operational details (firefighting operations) PF vs. VF (n = 185).

	Items	$\bar{x}$ PF	$\bar{x}$ VF	±SD PF	±SD VF	x^2	Parameter	p Value	
1	Manual tools inefficacy	4.323	4.395	±0.954	±1.011	24.6	4	0	***
2	Efficacy of backfire	3.484	3.153	±1.156	±1.263	5.46	4	0.244	
3	Direct attack with hoses efficacy	3.177	3.073	±1.235	±1.289	4.51	4	0.341	
4	Aerial attack efficacy	3.371	2.952	±1.105	±1.255	7.69	4	0.104	
5	Obstacles in flight (wind)	3.839	3.903	±1.089	±0.991	12.29	4	0.015	*
6	Obstacles in flight (smoke)	3.935	4.000	±1.099	±0.979	4.16	4	0.385	
7	Indirect attack efficacy	3.871	3.726	±1.094	±1.062	3.23	4	0.521	
8	Command orders no longer adequate	3.919	4.121	±0.997	±0.812	5.34	4	0.254	
9	Communication with command post	2.661	2.024	±1.292	±1.179	13.23	4	0.01	*
10	Communication with crews	2.823	2.25	±1.30	±1.292	11.06	4	0.026	*
11	No efficacious action	3.258	3.226	±1.28	±1.299	14.44	4	0.006	**
12	Insufficient ground crews	4.129	4.323	±1.032	±1.024	21.05	4	0	***
13	Insufficient aerial resources	4.048	4.081	±1.122	±1.001	12.60	4	0.013	*

Both means <3 express disagreements related to communication with command and stations (2.661 ± 1.292 and 2.024 ± 1.179 for PF and VF, respectively) and communication with and between crews (2.823 ± 1.300 and 2.250 ± 1.292 for PF and VF, respectively).

Means >3 and >2 express disagreements regarding the efficacy of an aerial attack (3.371 ± 1.105 and 2.952 ± 1.255 or PF and VF, respectively), with no significant difference between PF and VF.

Both values of mean >3 express uncertainty/doubts or neutrality regarding the efficacy of backfire (3.484 ± 1.156 and 3.153 ± 1.263 for PF and VF, respectively) and the efficacy of a direct attack with water and hoses (3.177 ± 1.235 and 3.073 ± 1.269 for PF and VF, respectively), but also doubts concerning obstacles in flight (wind) (3.839 ± 1.089 and 3.903 ± 1.099, for PF and VF, respectively), an indirect attack (3.871 ± 1.09 and 3.726 ± 1.062 for PF and VF, respectively), and suppression operations in general (3.258 ± 1.280 and 3.226 ± 1.299 for PF and VF, respectively).

Means >3 and >4 are present in only two cases: concerning obstacles in flight (smoke) (3.935 ± 1.099 and 4.000 ± 0.979, for PF and VF, respectively) and regarding the adequacy of operational orders (3.919 ± 0.997and 4.121 ± 0.812 for PF and VF, respectively).

In only three cases, both means >4 express full agreement with the inadequacy of manual tools (4.323 ± 0.954 and 4.395 ± 1.011 for PF and VF, respectively), insufficient ground crews (4.129 ± 1.052 and 4.323 ± 1.024 for PF and VF, respectively), and insufficient aerial resources (4.048 ± 1.122 and 4.081 ± 1.001 for PF and VF, respectively).

The differences between groups are not unanimous as in Topic 1; highly significant differences (***) appear only in two items, rather significant (**) in one case, and scarcely significant (*) in four cases. No significance, marked by the absence of asterisks, exists in seven cases; that is to say, the two groups express almost the same opinions.

3.3.2. Topic 3—At the Front of Flames: Problems and Feelings

Through a set of six items, Topic 3 analyzes the first group of problems encountered at the flame front (Table 8). In the first question (felt there was a lack of orders, 2.339 ± 1.187 and 2.548 ± 1.252 for PF and VF, respectively) with a low significance difference (*), and both means <3, firefighters disagreed with feeling abandoned and not knowing what to do or where to go. This is further confirmed by the replies with a mean of <3 for both groups in the questions about feeling alone in the struggle (2.194 ± 1.341 and 2.435 ± 1.521 for PF

and VF, respectively). In all other cases, firefighters, although with different means, express the same opinion, since there is no significant difference between groups.

Table 8. At the front of flames, PF vs. VF (n = 185).

	Items	$\bar{x}$ PF	$\bar{x}$ VF	±SD PF	±SD VF	x^2	Parameter	p Value	
1	Lack of orders	2.339	2.545	±1.187	±1.256	9.78	4	0.044	*
2	No communication	3.419	4.057	±1.350	±1.066	7.39	4	0.117	
3	Sometimes I felt alone	2.194	2.431	±1.341	±1.526	3.04	4	0.55	
4	Water shortage	2.823	3.293	±1.361	±1.323	5.44	4	0.245	
5	Always used PPE	4.452	4.480	±0.899	±0.749	2.92	4	0.571	
6	Physical preparation	3.839	3.911	±1.089	±0.975	2.32	4	0.677	

Concerning the problem of the temporary failure of communication networks, the two groups express different agreements, with a mean of >4 for VF, which confirms relevant and inherent weaknesses in the general organization (3.419 ± 1.35 and 4.065 ± 1.065 for PF and VF, respectively).

Water shortage, with low means (2.823 ± 1.361 and 3.298 ± 1.319 for PF and VF, respectively), demonstrates that with some differences, although not significant, the two groups perceived some problems regarding water shortage during suppression activities.

The use of PPE (personal protective equipment) with means of >4 and no significant differences for both groups, confirms personal care for safety (4.452 ± 0.899 and 4.484 ± 0.749 for PF and VF, respectively).

With very close means of >3 and with no significant differences, the two groups state their good physical preparation (3.839 ± 1.089 and 3.911 ± 0.971 for PF and VF, respectively).

3.3.3. Topic 4—Difficulties, Emotions, and Personal Reactions

Eight very homogeneous items in Topic 4 explore the inner emotions (Table 9): feelings of helplessness; difficulties in breathing, physical (sore throat, cough, eyes and nose irritation) and otherwise (air hunger, i.e., dyspnea or breath shortness from anxiety) [63,64]; fear for safety (personal, for colleagues, for own family); feeling unable to react; fear of being caught by flames and trapped; and the temptation to give up and run. In four cases, the mean is >3 (feeling powerless, breathing difficulty, fear for one's own safety, fear for colleagues' safety); in the other four cases, the mean is >2 (fear for the safety of one's family, feeling unable to fight, fear of being caught by fire, feeling tempted to give up and run).

Table 9. Difficulties, emotions, and personal reactions, PF vs. VF firefighter (n = 185).

	Items	$\bar{x}$ PF	$\bar{x}$ VF	±SD PF	±SD VF	x^2	Parameter	p Value	
1	Feeling powerless	3.468	3.645	±0.824	±0.677	24.73	4	0.000	***
2	Breathing difficulty	3.323	3.325	±0.719	±0.659	7.79	4	0.1	*
3	Fear for my safety	3.000	3.153	±0.789	±0.929	10.66	4	0.031	**
4	Fear for colleagues' safety	3.226	3.468	±0.913	±0.966	14.97	4	0.005	*
5	Fear for my family's safety	2.435	2.815	±1 363	±1.411	12.73	4	0.013	**
6	Felt unable to fight	2.79	2.984	±0.977	±1.020	18.61	4	0.001	**
7	Fear of being caught by fire	2.532	2.895	±1 004	±0.986	15.8	4	0.003	
8	Temptation to give up and run	1.532	1.419	±0.918	±0.787	4.69	4	0.321	

In general, all replies by VF have a slightly higher mean and SD; thus, they are closer to full agreement. The highest mean value belongs to feeling powerless (3.468 ± 0.824 and 3.645 ± 0.677, for PF and VF, respectively).

Six out of eight mean values of the two groups are significantly different, with a maximum of significance for item 1 (feeling powerless ***). In three cases, the significance is **. No significance is only registered for a fear of being caught by fire and the temptation to give up and run.

A special mention must be given to item 8; the temptation to escape from danger and run to safety, abandoning the field, has the lowest score of the whole survey, <2, and with a minimum SD (1.532 ± 0.918 and 1.419 ± 0.787, for PF and VF, respectively), i.e., it expresses the maximum disagreement between the two groups. No significant difference between the two groups is found in this item (p = 0.321).

3.3.4. Topic 5—Psychological Support

Topic 5 analyses certain psychological aspects (Table 10): the need for psychological support for 2017 events; still needing psychological support; psychological state in 2017; and the willingness to remember 2017 events. Items and related comments are therefore placed here after the preceding topic where emotional aspects are treated because they are strictly connected.

Table 10. Psychological support, PF vs. VF (n = 185).

	Items	$\bar{x}$ PF	$\bar{x}$ VF	±SD PF	±SD VF	x^2	Parameter	p Value	
1	Needed psychological support	1.065	1.048	±0.248	±0.215	2.73	4	0.605	
2	Still need psychological support	1.032	1.032	±0.178	±0.177	1.02	4	0.907	
3	Willingness to remember 2017 events	2.742	2.645	±1.214	±1.351	13.06	4	0.011	*
4	Psychologically prepared	3.677	3.355	±1.212	±1.218	10.27	4	0.036	*

The replies are statistically different, although with low significance, in items 3 and 4: willingness to remember 2017 events (2.742 ± 1.214 and 2.645 ± 1351 for PF and VF, respectively) and psychological preparation (3.677 ± 1.212 and 3.355 ± 1.218 for PF and VF, respectively).

Three out of the four questions have means <3 expressing disagreement, with a high SD that marks not only polarized replies, but also the scattered values of the replies. Means are <2 in the two first items, with very a reduced SD, i.e., for the need for psychological support at the time (1.065 ± 0.248 and 1.048 ± 0.215, for PF and VF, respectively) and still feeling the need for psychological support (1.032 ± 0.178 and 1.032 ± 0.177 for PF and VF, respectively).

This means refusing to accept psychological support on the occasion of these events and still now, years after their occurrence. This seems to be partially confirmed by item 3, related to psychological preparation for the 2017 events: replies are both >3 with almost the same SD, and some significant difference (*) between the two groups.

3.4. Section IV

Topic 6—Lessons Learned (Consequences)

Through a set of 14 items, Topic 6 (Table 11) analyses initiatives, changes, and new management because of the deadly 2017 wildfire season. Items deal with safety, crew organization, training, equipment, communication, prevention, awareness raising, and career (Table 11). In this case, since the answer is just a yes/no response, in order to be consistent with other topics, we adopted a unipolar three-point Likert scale (Do not agree, i.e., NO = 1; Doubt/Uncertain/Undecided = 3; Agree, i.e., YES = 5) [65,66].

Differently to other topics, all the items here have mean values without significant differences, with the only exception being the question regarding more specialized training (2.742 ± 1.828 and 2.886 ± 1.798, p. value 0.049 *), which is to say that the two groups unanimously expressed the same opinions. Mean values are >4 for priority for firefighter safety (4.194 ± 1.377 and 4.041 ± 1.544 for PF and VF, respectively); the sharing of lessons learned (4.452 ± 1.363 and 4.593 ± 1.172 for PF and VF, respectively); and improvement in decision-making processes (PF only: 4.097 ± 1.387). Mean values are >3 for changes in firefighting acts, changes in crew organization, more efficient training, more equipment, more involvement in monitoring and prevention, more involvement in public awareness raising, more data sharing, and more institutional collaboration. Mean values are >2

for more specialized training and improved communication protocol among/with crews. The mean is only <2 in the last item, namely, firefighter career revision, where values 1.516 ± 1.083 and 1.748 ±1.316, for PF and VF, respectively, which is the least value of the whole Topic 6, indicating that no initiative has been taken regarding this very crucial point.

Table 11. Lessons learned (consequences), PF vs. VF (n = 185).

	Items	$\bar{x}$ PF	$\bar{x}$ VF	±SD PF	±SD VF	x^2	Parameter	p Value	
1	Priority to firefighter safety	4.194	4.041	±1.377	±1.544	1.82	4	0.768	
2	Changes in firefighting acts	3.516	3.553	±1.844	±1.742	3.16	4	0.532	
3	Changes in crew organization	3.097	3.244	±1.862	±1.785	2.44	4	0.655	
4	Decision-making processes	4.097	3.715	±1.387	±1.539	3.11	4	0.539	
5	More efficient training	3.581	3.293	±1.825	±1.805	8.42	4	0.077	
6	More specialized training	2.742	2.886	±1.828	±1.798	12.29	4	0.015	*
7	More equipment	3.290	3.358	±1.945	±1.967	1.52	4	0.824	
8	The sharing of lessons learned	4.452	4.593	±1.363	±1.172	3.61	4	0.461	
9	Improved communication protocol between/with crews	2.742	2.919	±1.792	±1.687	6.16	4	0.188	
10	More involvement in monitoring and prevention	3.097	3.260	±1.931	±1.828	8.33	4	0.08	
11	More involvement in public awareness raising	3.613	3.439	±1.796	±1.802	5.81	4	0.214	
12	More data sharing	3.710	3.585	±1.663	±1.531	6.58	4	0.16	
13	More institutional collaboration	3.806	3.569	±1.598	±1.569	8.94	4	0.063	
14	Firefighter career revision	1.516	1.748	±1.083	±1.316	5.54	4	0.236	

In order to demonstrate the differences between responses within the entire set of items, we created Table S1 in the Supplementary Materials, where the values of the index of agreement [61] were built with the items of a five-point Likert scale (see Section 2.5). In our case, the extreme values, respectively, related to firefighter career revision and the sharing of lessons learned, range between 0.05 and 5.89 for PF and 0.10 and 7.78 for VF. The values of the index are >1 in nine items and <1 in five cases for PF (changes in crew organization, more specialized training, improved communication protocol among/with crews, more involvement in monitoring and prevention, firefighter career revision), whereas there are six instances of >1 and eight instances of <1 in VF. This means that replies are dominated by agree/strongly agree scores. Values of <1 are registered for changes in the crew organization, more efficient training, more specialized training, improved communication protocol among/with crews, more involvement in monitoring and prevention, more data sharing, more institutional collaboration, and firefighter career revision.

Both groups report a lack of initiative regarding strategic items, such as changes in crews' organization, more specialized training, improved communication protocol among/with crews, more involvement in monitoring and prevention, and firefighter career revision.

4. Discussion

4.1. Sample Characterization

As per data, which are presented in Table 1, the group of respondents (n = 185) is made up of VF for about 67% of its consistency; the figure highlights the role and strategic importance of VF in the country's rural firefighting organizations. In actuality, VF teams represent, at a national level, the main component of the service of rural firefighting [67]. The groups of respondents are characterized by a dominant male presence at over 75%. As expected, females are mainly present in the VF group, an expression of the so-called "civil society" and, only recently, have begun appearing in the wildfire context of the country. Respondents have a good education level (secondary school, Bachelor's or License, and Master's), which is higher, as expected, in the VF—a transversal group with different social backgrounds and professions, who, in addition, engage in a risky volunteering activity

perhaps resulting from environmental commitment and sensitivity. The job start dates are recent, more so for the VF group. Positions in the hierarchy are well distributed, and the number of replies from people in apical positions are high and similar in the two groups.

4.2. Facing the Inferno

As per data, which are presented in Table 2, when facing the inferno of the 2017 wildfires, there are clear and statistically high significant differences between VF and PF, but means >4 in eight out of nine items demonstrate that respondents are impressed in the same but not contrasting way by the terrifying wildfire scenario, which triggers fear and a feeling of powerlessness. All firefighters faced completely unheard-of new events that were unexperienced before and representing a challenge for everybody. No wonder, despite some differences, they feel the same but not contrasting way about the inferno.

The group of VF always presents the highest average mean if compared to the group of PF, which means that their answer is closer to value 5 of the Likert scale, i.e., full agreement. The highest values in means are referred to the rate of spread and to the situation of fires exceeding the control capacity, which has the maximum value. This confirms that the VF group perceives fires with a significant difference from PF, arguably due to a lesser experience on the ground.

For the same reason, when dealing with EWEs, VF's perception and feelings are amplified, probably also in this case due to having less knowledge and awareness of fire characteristics.

4.2.1. Flame Length/Height Classes

As per data, which are presented in Table 3, the values observed and reported are consistent with an EWE [1]: when adopting the simple equation, $I = 300\ L^2$ [68] for the assessment of intensity (L in m, I in kWm^{-1}), flames about 6 m long (in practical terms, the height of two buses on top of each other) can produce an intensity > 10,000 kWm^{-1}, typical of an EWE [1]. High values were observed more by PF than VF, but the modal value for both groups clearly depicts a terrifying scenario of uncontrollable events, where flames of 15 to 30 m long are recorded by 45.90% of observations. VF express higher percentages than PF for the appraisal of flame length >6 m, but less for the most highly rated 15 >30 m class (40.65% vs. 56.45% by PF). We note that flames of <1.2 m in height (intensity < 346 kWm^{-1}) can generally be directly attacked at the head or flanks by persons using hand tools. With flames of 1.2 to 2.4 m in height (intensity 346–1730 kWm^{-1}), fires are too intense for a direct, head-on attack by persons using hand tools. Handlines cannot be relied on to hold fire [69]. The maximum values of intensity <500 kWm^{-1} for ground crews with hand tools and 500–2000 kWm^{-1} for water under pressure and heavy machinery are given [70]. During direct attack, personnel and resources work at, or are very close to, the burning edge of the fire; firefighters try to hit the fire aggressively by using hand tools and beaters and/or by applying water and/or retardants from knapsack sprayers. It is impossible to work near the flames of extreme fires with direct attack, due to the extreme radiation whose values can be lethal. EWEs have an intensity >10,000 kWm^{-1} [1] that is blatantly higher than the possibility of direct attack on the flames. Indeed, in "Classes of Flame Length", 58 replies out of 62 reported flame lengths of >6 m for the extreme fires of the 2017 season in Portugal, which are consistent with the intensity typical of fires exceeding the control capacity, such as extreme wildfire events. Such values are further confirmed by "Fire Characteristics That Particularly Impressed Respondents", where a high rate of spread with 71 replies (38.37%) receives most of the score.

4.2.2. Characteristics of 2017 Wildfires That Particularly Impressed

As per data, which are presented in Table 4, respondents are mainly impressed by the high rate of spread, which amplifies the fear of being trapped and the impossibility of escape, followed by fatalities and injured people, and scenes of panic. At a distance, they mention the noise of roaring flames, wind, and spotting activity (all 4%). All other charac-

teristics have values of <4.00%, with a maximum of 3.78% for the high number of buildings burning. The highest values are observed for a high rate of spread (71 observations, i.e., 38.37% of the total: 21 for PF, 33.87%, vs. 50 for VF, 40.65%) followed by the number of fatalities and injured people (49 observations, i.e., 26.48 of the total; 20 for PF, 32.25%, vs. 29 for VF, 23.57% of the total). Data confirm that EWE characteristics are well perceived as particularly impressive and dangerous.

4.2.3. Year of the Worst Event

As per data, which are presented in Tables 5 and 6, with almost 73% of replies, the extreme events that occurred in 2017 are the worst that had been experienced by respondents. With 9.72%, the fires in the period 2000–2010 followed, when disastrous fires affected Portugal, with more than 300,000 hectares burned in 2003 and 2005. More recent fires, from 2018 to 2021, represent only 3.24% of the total.

When answering the question about the worst extreme fire experienced in 2017, firefighters refer to having operated in 44 municipalities. Of these, Pedrógão Grande alone was mentioned 33 times, followed by Arganil (six times) and a few others.

In the other periods, the number of affected municipalities is lower, but some of them have a recurrent presence in more than one period.

Regarding wildfire manifestation, there is no possibility of objectively defining the term "worst", which could be interpreted in terms of burned area, burned buildings, duration, operational difficulties, etc. We cannot use frontline intensity as a factor, as this metric appeared for the first time in certain official reports concerning the 2017 extreme wildfires [8,10], but there is no information regarding preceding episodes; thus, "*worst*" could be related, among other things, to the large size of the fire (e.g., megafires) or the difficulty of suppression. However, the 2017 wildfires receive the maximum score by both groups of respondents, because among other characteristics (fatalities, extremeness of behavior, etc.) they affected more hectares than any preceding years in the recent period of 2009–2021, namely, 563,532 hectares vs. affected surfaces at always <200,000 [71].

4.3. Operational Activities and Problems

As per data, which are presented in Table 7, concerning operational activities and the problems of the efficacy of fire suppression in its different phases, the rather scattered mean values demonstrate different perceptions by the two groups. This means that both groups have similar perceptions with respect to the many weaknesses of the organization, the chain of command, control, and, above all, the operational management of suppression operations.

High values of mean, >4, arguably express a greater awareness of the situations that arise in the emergency phases of complex fires (in this case, concerning communication and the ability to effectively manage extreme fires in 2017). We can observe, in synthesis, that with some differences due to experience, both groups are somewhat critical in identifying weaknesses in the operational management, suppression activities, and operational orders by the command-and-control chain. They underline the inefficacy of manual tools, difficulties in communication, and insufficient aerial resources, confirming that extreme events largely exceed control capacity, as is well known [1].

4.4. At the Flame Front: The Feelings of Firefighters in Action

As per data, which are presented in Table 8, the six questions in Topic 3 are related to the feelings of firefighters in action. Both groups confirm that they receive orders from the command-and-control chain and thus do not feel alone in the operational context. On the other hand, they perceive problems of communication, which are well-known and have already been made public by different inquiry commissions, responsible for the ex post analysis of the 2017 wildfires [8,10].

A lack of water for suppression with a low mean value but a rather high SD (mainly for PF) with dispersed and non-polarized replies and with some differences, even if not

significant, means that the two groups perceive problems regarding water shortage during suppression operations, and thus, in direct and indirect attacks. The values of mean >4 also confirm that firefighters use PPE and care for their personal safety. Values of >3 and a low SD also confirm that firefighters in general felt physically well prepared.

For replies related to communication and lack of water, it is worth remembering that the size of operational scenarios in 2017 could have produced local differences in fire behavior and local problems that help to explain differences between groups and inside groups.

4.5. Emotions and Inner Feelings

As per data, which are presented in Table 9, the set of eight items in Topic 4 explores the inner emotional reactions of firefighters in the presence of unexpected violent and large wildfires with the highest record of fatalities for the country and for the whole EU.

No paper, to our knowledge, has ever surveyed this type of topic in Portugal: respondents express understandable and human reactions of helplessness and fear, with higher values of the mean in the VF group. The significance of the different means can certainly be interpreted as due to the higher experience of the PF group, whose means are always lesser than the VF group: thus, they appear "hardened" by experience and less impressionable.

Item 8, related to the temptation to escape from danger and run, receives the least Likert score of all the survey, without significant differences between the two groups. We highlight the importance of this item, which refers to the behavior of individuals on duty in very difficult and risky conditions. Values of <2, meaning no agreement, reveal a unanimous sense of belonging, attachment to work and assigned tasks, and an appreciable sense of pride.

4.6. Psychological Support

As per data, which are presented in Table 10, Topic 5, with four items, analyses the psychological conditions of firefighters ahead of the extraordinary events of 2017, as well as the need for psychological support immediately after the 2017 events, still needing psychological support long time after the events, their psychological conditions in 2017, and their willingness to remember 2017 events.

It seems that these type of questions have also never been examined for Portugal, and from what we can infer from the significant reference gathering, these aspects also seem to be not at all considered in other countries. The replies are statistically different, although with low significance, only in items 3 and 4 (psychological conditions in 2017, willingness to remember 2017 events). Three out of the four questions have means of <3 expressing disagreement. Means are <2 in the two first items, with a very reduced SD. The three questions should thus be interpreted in the sense that firefighters did not need psychological support at the time of the events, that they were psychologically prepared, and do not need psychological support years after the event. In our opinion, such replies with low values of means, indicating disagreement, seem rather strange, considering that the fire events in 2017 were extraordinary in size and extreme in terms of the violence of flames and the number of fatalities, as well being depicted as such in Topic 1 by the same firefighters.

We suppose that since this topic is rarely an object of discussion between firefighters, their replies could be interpreted as exactly contrary to their expressions: regarding the item referred to as little willingness (i.e., reluctance or avoidance) to remember the 2017 events, we realize that the well-known symptom of PTSD (post-traumatic stress disorder, the mental health condition that is triggered by a terrifying event, either experiencing it or witnessing it [72]) is present in both groups, where people seem not ready or available to remember or discuss events.

Avoiding reminders of the event is actually one of the symptoms of PTSD and those who seem affected are encouraged to seek professional trauma treatment [73]. This latter reply, although with a low mean (<3) but a high SD, reinforces our doubt that the results in

this topic could be read as the inverse of the statement, induced by a misunderstanding of the relative questions.

4.7. Lessons Learned (Consequences)

As per data, which are presented in Table 11, Topic 6 proposes a list of possible changes in the organization, training, safety, activities, and career of both groups. We could say that, in a transversal way, the two groups confirm the implementation of certain initiatives in their organization, safety, and training as a positive consequence of an unheard-of wildfire season.

The cold language of statistical parameters shows that, due to the tragic and deadly 2017 wildfire season and its heavy burden of fatalities, relevant changes have involved the actors of suppression activities. Lessons learned resulted in different and relevant changes in an effort to make suppression more efficient and updated in order to better cope with the evolution of the phenomenon of EWEs, which is rapidly becoming beyond the control capacity.

More relevant changes appear in the replies of the PF group and are much more limited or entirely absent in the replies by VF. Indeed, items with common similar responses are from the VF group: changes in crews' organization, more efficient training, more specialized training, improved communication protocol among/with crews, more involvement in monitoring and prevention, more data sharing, more institutional collaboration, and firefighter career revision.

In synthesis, and in response to the working hypotheses:

(i) The two groups of respondents appear to be fairly close to each other: PF and VF could be significantly different for values of means, which represent the intensity of the perception but not the sense or direction of it, because there were no contrasting values, i.e., values in the lower part of the Likert scale for one group and, conversely, values in the upper part in the other.
(ii) The wildfires of Pedrógão Grande and October in the 2017 season were confirmed to be the worst experienced by most respondents.
(iii) The lessons learned from the 2017 season translated into certain changes and updates regarding the organization, training, and other measures in the Portuguese wildfire defense apparatus, but much remains to be done.

5. Conclusions

In conclusion, we point out the originality and interest of our paper, which, for the first time, gives voice to the actors of wildfire defense on the ground, having to cope with a phenomenon of increasing complexity such as the EWEs, which are not yet well understood and are therefore still dealt with using techniques and approaches that are no longer appropriate to its seriousness, as is well known.

From the answers, it emerges that the firefighters, whether PF or VF, are emotionally involved in the suppression activities and the complex dynamics of the events taking place. Their answers, although from only a modest number (n = 185) of participants, may be a prelude to a radical update and modernization of the rural fire defense service. The results of the survey allow sharp conclusions, the first being that this research fills a knowledge gap in the country.

Voluntary firefighters are a very important and strategic presence in the complex multi-structure and parceled-out organization of rural fire control in Portugal. The groups have significant differences in several aspects, whereas there is no difference in others. The most marked difference is in the topic regarding the perceptive manifestation of the phenomenon, where scores on the Likert scale by the VF group always have a mean greater than PF and are significantly different. This means that they perceive more amplified impressions of the complex scenario of fires as a whole and in its specific components. Probably this is a result of lesser experience.

Regarding the evaluation of distinct phases of activity, the two groups only partially have significant differences in score assessment, because in more than half of the items, they have similar and not different critical opinions.

Regarding the psychological aspects of fear and impressions, the groups differ, certainly as a result of different experiences on the ground, which implies that the PF group is harder and less impressionable. An important exception is related to the thought of abandoning the fight and fleeing to safety, for which no difference exists between the lowest averages in the whole survey expressed by the two groups, that is to say, a total disagreement and rejection of what is perhaps perceived as a treacherous and insidious suggestion.

Regarding Hypothesis 2, the Pedrógão Grande and October fires in 2017 remain the worst-ever events that occurred in Portugal both in the mind and perceptions of firefighters. Mentions of other fires in the past and after 2017 until 2021 remain largely distant from events where the extremeness of fires resulted in the heaviest burden in terms of fatalities, injuries, and damages to assets in the country records. Previous worst fires in the period 2011–2010 were mainly mentioned by PF, whereas VF preferably remembered more recent episodes, also after 2017. This is certainly a consequence of different experiences on the ground and arguably also regarding the age of respondents.

Finally, regarding Hypothesis 3 across all sections, regarding lessons learned and the consequences thereof, no significant differences exist between the two groups that unanimously evaluate the implementation of certain new initiatives after the deadly 2017 events.

This is a focal point, because it means rearranging the organization of defense against rural fires in line with the Decree-Law (DL) no. 82/2021 from 13 October. This recent DL clearly announced that the dramatic impact of large rural fires in Portuguese communities (with loss of human lives, property, and thousands of hectares of forest) has determined the firm will to change the national paradigm on the prevention and fight against rural fires, which are expressed in the guidelines approved by the Resolution of the Council of Ministers No. 157-A/2017 on 27 October and the principles expressed in the Single Directive of Prevention and Control, approved by the Council of Ministers Resolution No. 20/2018 on 1 March.

This new regime introduces the integrated management of rural territories and the mobilization of the agricultural and livestock sectors to integrate prevention with suppression. The adoption of good landscape planning and management practices, including the implementation and maintenance of fuel management belts, the disposal and reuse of residues, pasture renewal, and agro-forestry-pastoral mosaics, are crucial for a more resilient, viable, and value-generating territory, accepting the principles of Fire Smart Territory [74,75].

The replies of the respondents, although with no significantly different values of means, confirm that public powers have invested in resolving many of the consequences of the 2017 wildfire season. Both groups' replies included values of no agreement in their responses, demonstrating that much is still to be done in the critical and crucial fields of changes in crew organization, more specialized training, improved communication protocol among/with crews, more involvement in monitoring and prevention, and firefighter career revision.

While this paper is clearly Portugal-centric, its approach could apply to other countries by properly adapting the questionnaire prepared in this research.

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