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Rural Fires—Causes of Human Losses in the 2017 Fires in Portugal

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Abstract: Extreme wildfires are increasingly rising to intense and uncontrolled fires, with dimension and destructive potentials that are greater than what has been seen and dealt with. The hazards posed by these fires increase significantly when they approach the wild–urban interface, with relevant environmental and socio-economic consequences. The 2009 Victorian bushfires and the 2017 Portugal wildfires are powerful reminders, and they have demonstrated the need to better understand why mitigation plans have failed to protect the community in these events and to improve community resilience. The year 2017 is a milestone in the history of wildfires in Portugal, not only because of the vast burned area but also due to the high number of fatalities. The two occurrences were at different times (June and October) but were geographically close (region of centre of Portugal). A total of 117 deaths occurred in both events and 92% of the victims were in wild–urban interface areas. This paper analyses and discusses the characteristics and causes of death of the victims of these two events: age, place of death, distance from place of death to place of residence and last-minute choices to aim to understand the actions that people took in the face of the approaching fire, which led to their death. In both cases, most people died fleeing the fire without any information from the competent authorities. In the end, it is possible to identify risk factors that lead to the death of civilians due to wildfires, such as the increase in demand for rurality by young people from big cities with no previous contact with wildfires; on the other hand, there is the ageing of the population residing in forest areas, who were previously physically and structurally prepared to deal with fires and are currently no longer able to.

Keywords: wildfires; victims; Portugal wildfires; self-evacuation; risk factors

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1. Introduction

Rural fires with extreme and unpredictable behaviour are a growing and critical problem around villages, often requiring mass evacuations to protect people and ensure safety [1].

It is now well established that the continuous climate change across the globe exacerbates the risk of heatwaves and prolonged dry periods, more frequent thunderstorms and changes in wind patterns and severity. The probability and severity of future disasters will increase because of these extreme events, and wildfire incidents will be common not only in the areas already susceptible to wildfires but also in new areas [2].

Portugal, like other southern European countries, faces unparallel circumstances nowadays, where large and uncontrollable fires are becoming more frequent, exceeding the capabilities of existing suppression resources and increasing community exposure [3]. Sociodemographic changes in rural areas, climate change issues and vegetation changes have led to unprecedented circumstances that require the adjustment of fire use strategies and planning tools [4].

Wildfires become hazardous to the community when they spread into urban areas, the boundary of which is known as the wildland–urban interface (WUI). In Portugal, the

interface problem is also an emerging problem, with increasing importance due to the various factors associated with it: the aggravation of forest fires, the population growth on the outskirts of large cities and the frequency of extreme risk events of meteorological nature [5].

A recent study reviewed the susceptibility and danger of forest fires in Portugal, introducing new data and extending the study period [4]. This study indicates that in Portugal, about 2% of the municipalities have more than 90% of their territories classified as dangerous, while 32% of the municipalities have, on the contrary, less than 10% of classified dangerous areas.

Until 2003, rural fires in Portugal were known for the destruction of large areas of forests, causing mainly environmental and economic destruction (due to the loss of eucalyptus and pine trees) and occasionally causing property damage and loss of life (mainly the participants in fire combat). However, 2003 and 2005 were remarkable years due to the civilian losses. The loss of a high number of civilian lives as a result of forest fires is a recent reality in Portugal.

The safety of populations at risk depends on accurate risk assessments, emergency planning and emergency management.

After the fires in a 2009 event in Australia, where a high number of people died, it was concluded that, in some cases, non-prepared evacuation increased the risk of death in the population. The US and Australian governments carried out a review of public evacuations or alternative actions during rural fires and proposed measures for a rapid response of the population against rural fires [6].

Australia's Country Fire Authority (CFA) conducted a retrospective study of civilian deaths that occurred in the fires in Victoria. The investigation used the coroners' reports to determine the circumstances of each death. Many of the case studies illustrate the risk resulting from late evacuation and the poor understanding of fire behaviour. Three categories of victims were identified:

- Victims who recognised the real threat to their safety, with enough time to save their lives, but choose an ineffective survival strategy;
- Victims who do not recognised the real threat to their security in time to implement an effective survival strategy; and
- Victims who were physically unable to implement effective survival strategies [7].

In Portugal, the problems are similar. Evacuation is a recent concept, and populations are still very resistant to leaving their villages early, often resorting to escape when the fire is already inside the village. Evacuation is one of the population's security hypotheses, but it will have to be carried out in advance with the support and organisation of competent authorities. If there is no monitoring by the authorities, this evacuation may be disorganised and made at the wrong time, which could lead to the deaths of many people.

The study and discussion of the type of victims and the conditions that led to their deaths are essential for a better understanding of this phenomenon and, from there, to infer the processes of change to avoid similar situations. This paper aims to identify the factors that lead to the loss of human lives during rural fires, studying the characteristics of the victims of the 2017 fires in Portugal and trying to identify their last actions and their last choices based on an analysis of data from the Independent Technical Commission and from the Centre for Studies on Forest Fires of the University of Coimbra, from both the June and October fires of 2017.

2. Change in the Paradigm of Rural Fires in Portugal

As previously mentioned, climatic conditions related to the environment and the meteorology have proved to be of great importance in the development of fire and its propagation. Under certain optimal weather conditions, the probability of massive rural fires increases significantly, as in the case of Pedrógão Grande in 2017 in Portugal [8]. Extreme meteorological phenomena appear with increasing frequency, giving rise to this type of fire. It is known to be severe and complex, capable of reaching a very large size and high intensity, causing major environmental and socio-economic impacts.

According to the legislation of the Portuguese government in Ordinance n. 301/2020 of 24 December, it was recognised that the divestment in forestry has contributed to the emergence of a monocultural landscape with a high fuel load and fire risk potential, and "when in the presence of severe meteorological episodes, this situation has resulted in large fires, devastating extensive forest and agricultural areas, infrastructure and heritage and putting human life at risk. These episodes, in turn, feed the vicious circle of abandonment, with consequences in terms of ecosystem degradation and the social and economic vulnerability of these territories." [9]. It is assumed that the policies implemented so far have not been enough and that populations are increasingly vulnerable to both the social and economic aspects.

Additionally, Portugal is also characterised by dispersed urban agglomerations, mainly in the countryside. Thus, it is essential that rural fire risk assessments consider not only hazard and exposure but also social vulnerability [4]. Dispersed urban agglomeration is synonymous with small villages of compact construction that are isolated in the landscape. Especially in the north and centre of Portugal, there are other types of villages, called "Avulso" and "Espraiado" settlements, that also contributed to this dispersed urban agglomeration. "Espraiado" settlements are briefly characterised by being consolidated in a network of rural paths spread out in all directions and are also characterised by having a vegetable garden or farm at the back, while "Avulso" settlements are characteristically off-centre, presenting as loose buildings on a rural matrix; many of them are used as second homes, without permanent occupation [10].

In rural areas, despite the high exposure to risk, residents are used to living with rural fires and, over the years, have developed ways to protect themselves against this danger. The villages are protected by surrounding natural containment strips (agricultural fields), and in case of fire, the active population comes together to protect the distressed housing. However, with the abandonment of agricultural practices and the exodus of younger people to urban areas, this natural protection is decreasing and the inhabitants who remain do not have the physical capacity to face the fires. Quite often, the abandoned agricultural areas are replaced by trees, bringing the forest closer to their houses.

In the scope of rural fire risk, the affected people are generally in rural areas, but recent cases have shown that this is not always the case, and fires are increasingly taking on such a dimension that they cross borders, going into urban areas as well. In 2005, a fire devastated the outskirts of Coimbra, even going into the urban area due to spotting. The fire started on 19 August in Vila Nova de Poiares, but it was a re-ignition that gave rise to a new fire, which, covering several kilometres, entered the city of Coimbra on 21 August. Ten years earlier, in August 1995, a similar event also affected the same city, causing damage to an apartment and several vehicles.

These events highlight a change in the exposure of populations to danger, as fire is no longer just a problem in rural areas but also in some urban areas, where this risk has not yet been considered. People who live in urban or residential areas, among patches of forests, will hardly recognise the potential for destruction of rural fires before having experienced the situation of an approaching fire [11].

Additionally, elderly residents keep feeling that they are safe, but the context in which they live has changed. In this way, it can be considered that the inhabitants of these villages may have a false sense of security, which will make them stay close to their houses and refuse to evacuate their villages, thus increasing their exposure and vulnerability.

3. Human Losses in Rural Fires

Year after year, wildfires are killing people around the world, and some of the fires have led to the loss of a large number of people in a single occurrence.

The first recorded high number of losses of human life was in October 1871 in Wisconsin, a state in the upper Midwestern United States, when a forest fire caused between 800 and 1200 deaths, according to estimates. The fire, which had broken out in the forest a few days before, destroyed in a few hours a town of 1700 inhabitants and 16 other villages in

an area of more than 500,000 hectares [12]. This event has been recognised as the deadliest rural fire event in history.

Additionally, in Landes, France, in August 1949, 82 people were killed fighting fires. The victims-firefighters, volunteers and 23 military personnel-were caught in a "cloud of fire" caused by a sudden change in the direction and intensity of the wind.

Many other events followed, such as in Australia in 2009, where at least 173 people died in several fires that occurred in what became known as Black Saturday. In Russia in July 2010, during one of the hottest summers ever registered, wildfires killed 60 people. In Matti, Greece, in 2018, around 100 people died when they tried to fight the flames.

In Portugal, this is a recent reality, remembering the years 2003 and 2005, when, respectively, 21 and 23 people died [13], and the fateful year of 2017, with the loss of 66 casualties in June and 57 in October. The year 2017 was a milestone in history due to the high number of fatalities in two different occurrences that were geographically close by, where most deaths occurred in urban–forest interface areas. Between 2017 and 2021, there was no loss of civilians to forest fires, only the loss of firefighters.

The loss of human life due to forest fires will always be the greatest loss, regardless of the area burned by the fire or the cumulative number of fires each year.

4. Analysis of the 2017 Rural Fires in Portugal

The June and October events killed a total of 117 persons and burned more than 200,000 hectares [14]. Both fires, despite being spatially and temporally differentiated, had in common erratic behaviour and destructive potential that had never been seen before in Portugal.

The Pedrógão Grande fire will be remembered in the history of rural fires as it caused 66 fatalities (65 civilians and 1 firefighter), making it one of the most serious fire disasters in Portugal and one of the worst in Europe. It consisted of several events, the most critical being those that started in Pedrógão Grande and in Góis, which were associated with three other fires that consumed a total area of 45,328 ha [8]. This fire started on 17 June 2017 and burned for almost a week. In the first two days, almost 98% of that area was burned.

At an impressive rate of approximately 3000 ha per hour, 8700 ha of shrubs, pines, and eucalyptus were consumed in the period between 19:00 and 22:00 h on 17 June. As a result of two main fire fronts joining, a firestorm developed, resulting in several episodes of extreme fire behaviour, with many fatal accidents [14].

Following these fires, the Portuguese government created, through Law n° 49-A/2017 of 10 July, the Independent Technical Commission (ITC), with a mandate to carry out an independent assessment of those fires. At the same time, the government requested that the Centre for Studies on Forest Fires (CSFF-ADAI) of the University of Coimbra carry out a study on the conditions of the occurrence, initiation and propagation of fire, as well as the analysis of fatal accidents [8]. Both studies have similar conclusions, and they are complementary.

The reports produced after this fire showed that the Portuguese Civil Protection warning system failed to inform citizens of the severity of the fire, and no evacuation actions were carried out by the competent authorities. Additionally, the populations were unprepared to reduce their risks in order to have an effective response.

The October fire event was quite different from the one in June because of both the geographic dispersion and the dynamics of the fires. On 15 October, the meteorological fire hazard was classified as extreme for almost the entire territory of Portugal, with emphasis on the exceptionality of the wind speed component in the meteorological fire hazard system. This situation resulted from exposure to hot, dry air coming from the south, intensified by Hurricane Ophelia, combined with the severity of seasonal drought [15].

Different ignitions on 15 October produced seven burning spots in a period of few hours that affected more than two hundred thousand hectares, practically covering the entire centre of Portugal, from the coast to the border with Spain; the largest fire in memory, before that year, had started in Vilarinho, Lousã, and covered an area of 45,505 ha [15,16].

In addition to the very large burned area, this mega-fire is considered unique in Europe because it was the first one of this order of magnitude that had occurred during the autumn season. On that day, more than 500 fires were registered, exceeding the response capacity of the Portuguese Civil Protection Agencies [15]. A total of 51 people died.

4.1. Analysis of Fatalities in June 2017

The ITC report identified 64 fatalities due to the fire and carried out an exploratory analysis of the conditions and particularities of these human victims. Note that the CSFF-ADAI report counted 65 victims because this report considered an additional victim who died two days later following serious injuries. This victim was the only firefighter among the other victims, who were all civilians. It is known that one other injured person died later in the hospital, increasing the total number of fatalities to 66.

Analysing the age of the victims, most of them were between 30 and 80 years old; they were active people without limitations in the process of escape or risk perception (Figure 1). As for gender, the number of male and female victims was very similar (35 men and 31 women), so it was not considered a risk factor or characteristic related to the cause of death.

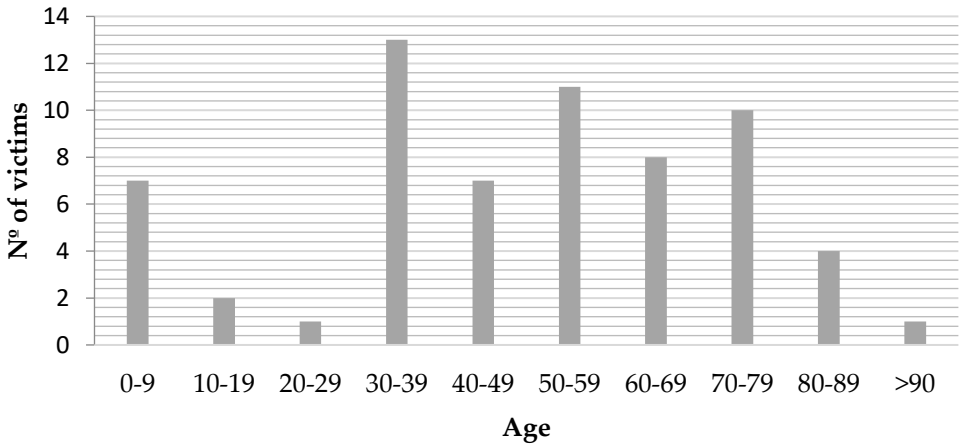

Figure 1. Distribution of the age of the dead victims-June 2017 [8].

An important factor in this analysis is the relationship of the victims with the place where they died. According to the data of the ITC report, half of the victims were residents in the villages affected by this fire. However, it is the high number of occasional visitors that needs special attention (Figure 2).

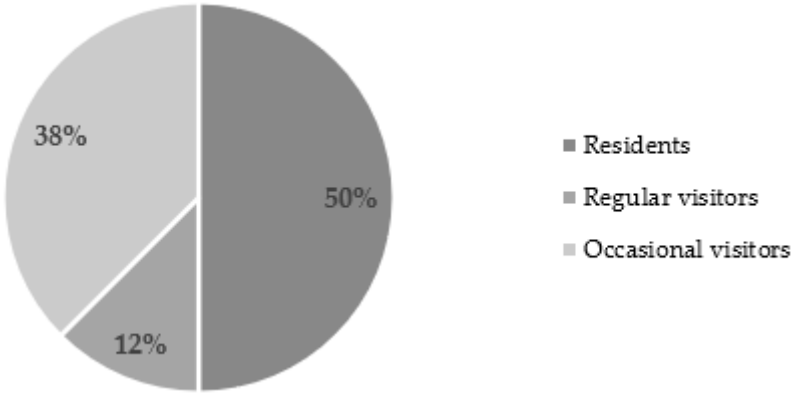

Figure 2. Relationship between the residence of the victims and the place of death-June 2017 [16].

It should be noted that this is a very popular zone in the summer, mainly due to the river beaches and leisure activities. The violence of the fire, combined with the lack of competent authorities to give indications, significantly increased the panic of these people, and looking for escape routes led them to death. Only 4 of the 66 victims died at home.

Regarding the distance from the place of death to the victims' homes, 55% of victims died at a distance higher than 5 km from home. These victims were tourists and visitors who, whether or not they had a relationship with this zone, were on an occasional visit (Figure 3).

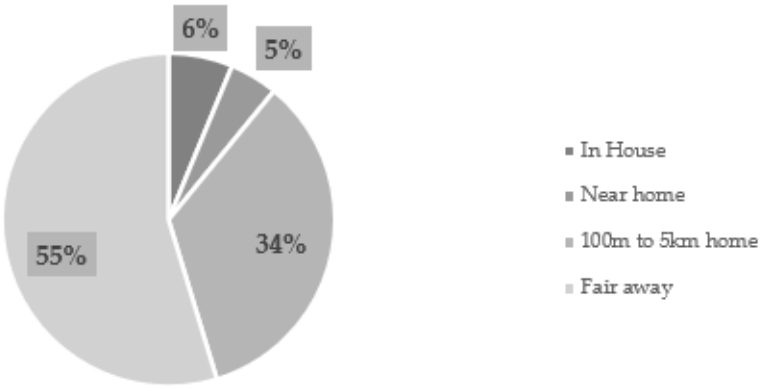

Figure 3. Relationship between the victims and the place of death-June 2017 [16].

Considering the connection of the victim with the territory, it is important to analyze only the behaviour of residents. It is possible to assume from the victims who died between 100 m and 5 km from their homes that the most of residents (76%) decided to flee their villages. This indicates that the victims tried to run away in the face of the approaching fire, thinking that they were going towards safety (Figure 4).

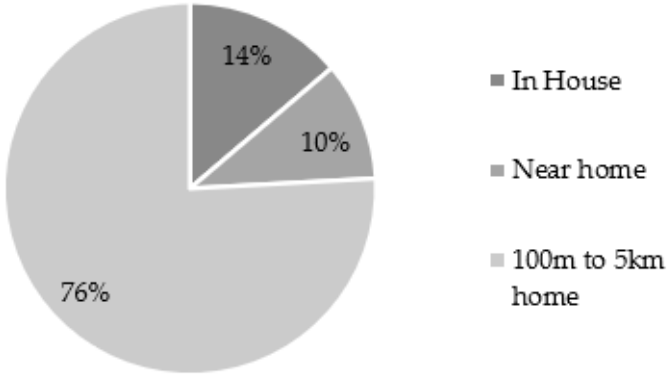

Figure 4. Distance from the place of death to the home of the inhabitants-June 2017 [16].

Additionally, regarding the circumstances of death, from the analysis of data, it is assumed that 70% of the victims were running away from the fire (Figure 5).

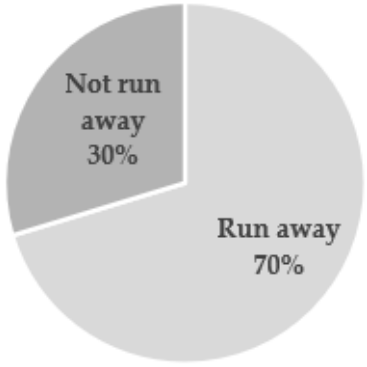

Figure 5. Circumstance of the death direction-June 2017 [16].

In the group of victims who did not run away from the fire, the report identified evidence that in addition to the four victims who remained at their homes and who were

caught by the fire there, the remaining victims who were not running away were passing through that area and returning home or to their accommodation after a day of sightseeing in the mountains. Regarding how the victims run away from the fire, the CSFF-ADAI report identifies that 89% of victims chose the car as a means of escape.

4.2. Analysis of Fatalities in October 2017

In the sequence the 15 October fires, the Portuguese government also requested the constitution of the Independent Technical Commission. Also, the Portuguese Government requested to CSFF-ADAI a study of the most relevant facts of these fires, with the country still in the aftermath of the June fires and still in shock from this new disaster.

Although both reports indicate similar findings, the number of victims identified in both is not coincident: the CSFF-ADAI report identified and analysed 51 fatalities, whereas the ICT only recognised 48 victims. This discrepancy is because the ICT report only considered the direct victims of the fire (and those investigated by the Judiciary Police), while the CSFF-ADAI report analysed victims who were directly and indirectly related to the fire, based on 40 accidents that resulted in these deaths.

In the fires of June 2017, all victims died in a short time in a limited zone, while in October 2017, the victims were dispersed in different fires. In the October fires, more than 50% of the victims were 50 years of age or older (Figure 6). This fact, important in the following analyses, shows that the victims of these fires were mostly elderly, in many cases with health problems and mobility difficulties. As for gender, in these fires, 65% of the victims were male and 35% female.

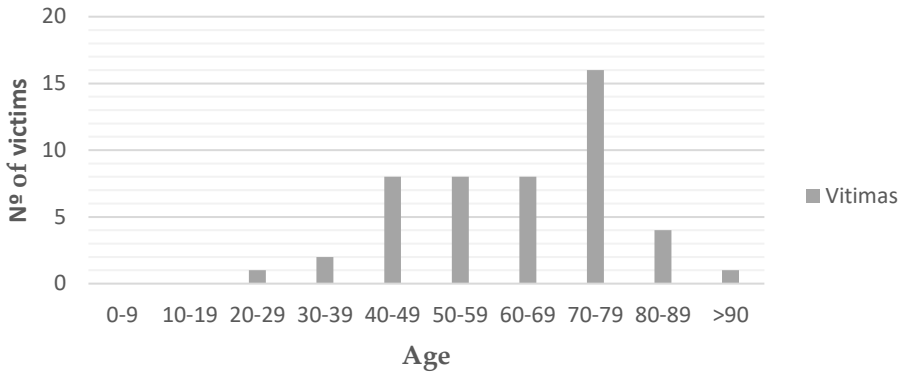

Figure 6. Distribution of the age of the dead victims-October 2017 [17].

The analysis of the relationship of the victims with the place of death shows that 86% of the victims were residents. In addition, since most victims were old people, they ended up dying either inside their homes or nearby (Figure 7).

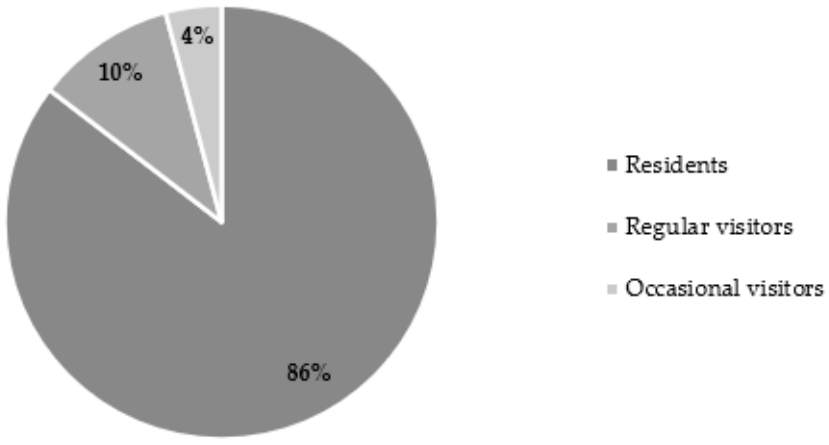

Figure 7. Relationship between the residence of the victims and the place of death-October 2017 [17].

The distribution of distances from the place of death to the home was more heterogeneous in the October fire (Figure 8), allowing us to conclude that there were different circumstances and decisions by the victims.

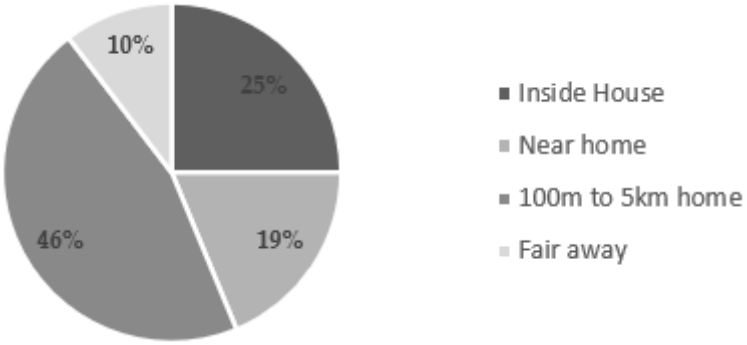

Figure 8. Distance between the residence of the victims and the place of death-October 2017 [17].

About 44% of victims died inside or near houses, but a large percentage of people, about 46%, tried to run away. It should be noted that, according to the ITC report, 60% of the houses of the victims of this fire did not burn. In this case, 63% of the people tried to run away (Figure 9).

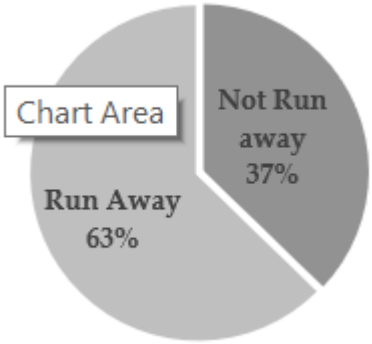

Figure 9. Circumstance of the death-October 2017 [15].

After the June fires, it was expected that people would have learned to stay in their homes and not choose to run away. Even so, a large percentage of people died while trying to run away.

5. Discussion

The analysis and discussion of the types of victims and the conditions that led to their deaths are essential tools for a better understanding of this phenomenon and, from there, to infer the processes of change to be adopted in order to avoid such disastrous events. In this study and from both the analysed fires, it was observed that the victims had very different characteristics.

The fire of June 2017 was a fire with great severity on the surface [16]; it was on a hot Saturday afternoon and gave rise to victims of all ages, where some would be enjoying a weekend of leisure activities and others were relishing family time in the mountain villages. Many of them, faced with the imminence of a major fire, decided to use their vehicles to move away, meeting the fire along the way. It should be noted that most of the victims were tourists with limited information about the zone, and they chose to follow the only path they knew. It is important to refer that, based on the analysis of official reports and other documents, there was no evacuation action by the local authorities, with only reference to the interdiction of the road where most people died at the time of the tragedy. Regarding the victims who lived in the area of the fire, it is observed that none of the houses of the victims who decided to run away were affected, and probably staying at home would have

been the best option. These people would have been safe, and the option of escape became their exposure factor, leading to their death.

From the analysis of both reports, the conclusions stated that after June 2017, the population should have been left with the idea that running away would be the most dangerous option. However, and not contradicting the validity of this thesis, it is important to understand that the typology of victims was different in the occurrence of the October 2017 fire.

The victims of the October 2017 fire were elderly people without children or young people; among the victims, some of them had limitations in their perception and reaction to danger as well as in mobility. Thus, according to the analysis of survivors' reports in the CEIF-ADAI report, a large number of victims were surprised by flames already in the vicinity of their homes or during the night. Additionally, in this event, preventive evacuation measures were not taken, even for the most vulnerable people with physical limitations and no way to escape.

It is also important to point out that, even with the change in the fire paradigm, as mentioned above, the elderly maintained their belief that they were safe in the villages, sometimes not recognising the risk situation. Adding to this idea, the lack of trust in the fire-fighting authorities made the population stay near their homes to protect them.

6. Conclusions

Rural fires are the source of many fatalities in Portugal and around the world. The analysis of the type of victims and their characteristics allowed us to identify the risk factors that led to human losses in Portugal during the rural fires in 2017.

In the October event, more people died indoors than in the June event. In Pedrógão Grande, it was an occurrence with an intensity never seen before in Portugal, on a Saturday afternoon and in a very touristy area. In the October fires, several fires with great speed and intensity caught the inhabitants by surprise without them having a chance to escape. It is also important to understand the ages of the people who died at home in this occurrence: they were mostly elderly people with mobility difficulties who should have been evacuated in advance by the authorities. The analysis of fatalities resulting from the 2017 fires in Portugal shows that people still have a poor perception of fire risk, making wrong last-minute decisions that lead to death. A lack of awareness combined with a lack of credible information means that, in the face of a fire, people make decisions based on what they know from their experience of past events.

With the analysis of the location and some characteristics of the victims, it is possible to identify the following risk factors that lead to the death of civilians due to rural fires.

- Growing demand for nature-based tourism: The change in the dynamics of fires in Portugal has taken increasing proportions and dynamics that are difficult to identify in advance. The high demand for rural and forested areas for tourism and leisure, essentially by residents of urban areas, has significantly increased the number of people dispersed in these spaces. In addition, the visitors are mostly people who are poorly prepared and unaware of the risk of rural fire, thus increasing their vulnerability.
- False feelings of inhabitants in rural areas: Inhabitants in rural areas have become used to living with fires. With the abandonment of rural areas, the forest tends to invade the villages, significantly increasing the urban–forest interface. The feeling of safety that the inhabitants had before is no longer real, and currently, the rural settlements are very vulnerable and increasingly exposed to fires, being a relevant risk for their inhabitants.
- Demand for rurality and nature-based experiences: Although there has been an exodus of permanent inhabitants from the villages in the countryside in recent decades, there is now an increasing demand for accommodation and/or housing in rural areas, essentially by foreigners. There is also an increase in the return of retired people to their origins, in search of the tranquility of the countryside. This factor has

further contributed to the fact that, in addition to the forest entering urban alleys, new construction often "enters" the forest in search of a deeper contact with nature.

- Strong exposure of vulnerable communities to risk: the villages have become increasingly aged. The sense of neighborhood has ceased to exist, and it is increasingly common for the elderly to be debilitated in their homes, cared for and often visited by employees of social solidarity institutions. In the face of a fire situation, and in addition to the difficulties associated with age and illness, indirect fire products such as smoke and gases substantially affect these people.
- Understanding the escape process: The lack of preparation and awareness makes the population wait for the fire to arrive at the houses. In the face of very intense fire phenomena, combined with poor information and the lack of competent authorities on the ground to guide their exit process, last-minute self-evacuation will increase people's exposure to the fire from which they are fleeing.

Since 2017, the Portuguese Civil Protection Authorities have begun to carry out preventive evacuations more frequently, often adjusted to the severity of the fire. From 2017 until 2021, there were no more civilian fatalities to be reported despite very dramatic years regarding rural fires. However, in August 2022, an elderly couple died while fleeing the fire that surrounded their village despite instructions from authorities and neighbours to stay inside their home.

The conclusions from this study are intended to be the stepping stone for future work on the creation of methodologies for the protection of civilians in the face of rural fires, namely, more training on safety behaviours among populations, better preparation of preventive evacuation strategies and, above all, the development of models that identify the most vulnerable people in order not to forget them in emergency situations.

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