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Elderly at Home: A Case for the Systematic Collection and Analysis of Fire Statistics in Spain

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Abstract. At the present time, there is no nation-wide, systematic approach to collecting, analyzing and presenting fire loss data in Spain. This makes it very difficult to understand the fire problem in general, and more specifically with respect to vulnerable populations, such as the elderly. As first steps to overcome the lack of a nationally populated and managed fire incident database, a methodology for collecting fire data, based on information extracted from the media, was developed. This approach is modeled in part on the Fire Incident Data Organization system from the National Fire Protection Association in the United States, which identifies significant fires through a clipping service, the Internet and other sources. For the initial Spanish database, selected variables were chosen from similar statistics gathered in other countries. The variables are related to the place and moment of the fire, its causes and consequences, the building typology and state, and the fatal and non-fatal victims involved, among other factors. In the initial data set, data concerning residential fires occurred between January 2016 and December 2016 was collected, and variables were analyzed. An initial focus was to identify the risk factors for one of the most vulnerable groups in case of fire, the elderly people. The development of this first-ever nationally-representative database of fire incidents in Spain is overviewed, and analysis of elderly population in dwelling fires is presented as a study case that represents the value and need of such a national database in Spain.

Keywords: Fire data, Fire statistics, Elderly people, Residential buildings, Spain

1. Introduction

The use of a homogeneous and regulated system for the collection of fire data has demonstrated to be an essential tool in order to understand the fire problem and the identification of the key risk factors underlying major accidents. Several countries, such as the US, UK, New Zealand, Australia or Japan, have already developed a systematic collection of fire incident data [1–5].

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That data can be used for promoting changes in the codes, the enhancement of fire safety laws or the focus on a specific vulnerable group; and it allows taking more cost-efficient actions to reduce the consequences of such unwanted events. Along the last decades, several countries have promoted prevention and protection strategies relying on the statistical analysis of fire data and the effectiveness of those measures have been verified through the collection of that data. This is the case of the regulations for furnishing and upholstered furniture, self-extinguishing cigarettes [6], child-resistant lighters [7], the installation of sprinklers in high-risk buildings [8] or the installation of smoke detectors, which significantly reduce the number of fatalities in the event of a household fire [9].

The goal of this paper is to find out which elements influence the fire risk, specifically when elderly people are involved, through the use of Spanish fire statistics; as it has been done before in other countries [10–15]. In Spain, 77% of fatal fires from 2010 to 2016 were residential fires, and 60.1% of fatal victims were people over 65 years old [16–21]. Unfortunately, there is not a comprehensive national fire incident database in Spain which allows the identification of the risk factors for residential fires in dwellings occupied by elderly people, and previous research is sparse and incomplete.

Therefore, the first step for the characterization of the fire problem, and specifically residential fires involving elderly people, is necessarily the creation and assessment of a fire database.

Following that, the analysis of the collected fire data is undertaken, and recommendations based on the results are made.

1.1. Current Situation in Spain

At the present time, there is no nation-wide, systematic approach to collecting, analyzing and presenting fire loss data in Spain.

The statistic treatment of the fire departments interventions in Spain is poorly regulated, and it does not have homogeneity. In 1985, the Spanish Royal Decree 1053/1985, of 25 May, about the statistical treatment in the Fire and Rescue Services was published [22]. It establishes the need of collecting data since "fire statistics are essential, as they provide the basis for the research into fire causes and the effectiveness of the prevention measures, as well as in order to establish essential and complementary safety measures, where appropriate". The Royal Decree also indicates the convenience of centralizing the statistics elaboration, incorporating them into the General Statistic Plan of the Ministry of Interior Affairs (Sect. 1). The procedure would be as follows: The Prevention, Fire Extinction and Rescue Services (in Spanish, SPEIS) would be in charge of the data collection in each intervention (Sect. 2), by the use of a standard document called "Parte Unificado de Actuación" (P.U.A.)[1] [23] which will be sent to the General Directorate of Civil Protection (Sect. 3), and this Institution will process the information with computational tools (Sect. 4).

[1] PUA can be translated to English as "Standard Action Reports".

However, since 1994, official statistics have not been published. The last one was the 1982-1992 Report, by the General Directorate of Civil Protection. The P.U.A Document continues to be used in many but not all Fire Services. Although most of them have resources for collecting data, the lack of a uniform and standardized system, as well as the dearth of information in some cases, make the task of statistical analysis difficult.

Currently in Spain, the only existent documents about fire victims are those annually published by Mapfre Foundation in collaboration with "Asociación Profesional de Técnicos de Bomberos"[2] (APTB) since 2010. These reports (henceforth Mapfre Reports) show information about fatal victims in structural fires: fatal victims by month, day of the week, community, sex and age; leading causes of fatal fires… Since 2012, the reports include a section about fatal victims in residential fires specifically.

Mapfre Reports are developed from data detailed by fire departments. They voluntarily fill out a form answering some questions related to those fires which produce fatal victims. However, researchers do not have access to the original database used for the development of the reports, so they can only rely on the published data, which prevent the analysis of the key risk factors for specific population groups.

There is also one project developed in the Fire Brigade of Málaga; which creates a customized methodology for the investigation of fires in Spain. The results extracted of the statistical analysis of structure fires in Málaga in 2007 demonstrate the necessity of implementing a systematic collection of data in Fire Departments, since there are some risk factors that can be identified through the study of the incidents [24].

In order to fill the limitations of the previous researches made, the new database should collect incident data of all residential fire incidents, injured victims and deaths, instead of fatalities exclusively. In addition, through the new database, it will be possible to link the collected parameters and the age of the victim.

1.2. Justification of the Research

The focus on the elderly population is necessary taking into account the Spanish demographic predictions. We are currently living in an ageing society, where the favorite place for the elderly people to live in is their own dwelling instead of a nursing home or other residential alternatives [25]. The demographic statistics developed by the Spanish National Statistical Office (*Instituto Nacional de Estadística, INE*) estimate that by 2064 adults age 65 or older will comprise 38.7% of Spain; that is, they will be more than the third part of the Spanish population. By that date, life expectancy will reach 95 years old for women, and it will be 91 years old for men [26]. In 2050, Spain will become the second oldest country in the OECD, Organization for Economic Cooperation and Development, only surpassed by Japan [27].

[2] Asociación Profesional de Técnicos de Bomberos, APTB, could be translated as "Professional Association of Firefighters".

In addition to the consequences that demographic change will produce in the health and social services, we must think about the implications of an aged population when designing buildings and developing regulations and codes and how to deal with this population-group safety in risk situations, such as fires.

Although in several studies the terms risk of fire occurring, risk of injury and risk of fire fatality have been used interchangeably [28], previous analysis of fire data indicated that the risk of fire mortality is not due to a higher prevalence of fire incidents. There are certain groups, such as the elderly, that have a higher risk of mortality per residential fire [29].

The reasons why elderly people are more vulnerable in a fire than the general population have been investigated in different countries [8, 10, 13–15, 30–32], and are related to several factors such as: the decline in physical health, which can lead to a reduction in the ability to be aware of a fire or to escape [3, 15, 33–35]; the onset of some mental illness like dementia or compulsive hoarding behavior [13]; their vulnerability to burn injuries [10]; the prevalence of a low socio-economic status and pre-existing diseases; the use of old and under-standard electric appliances [31]; the social isolation; or the necessity of heating the household for more hours per day [7].

The combination of all these circumstances makes the elderly people a vulnerable group in case of fire. Since these factors are associated with the ageing process, and therefore they cannot be avoided through the building design, architects and engineers should focus on the identification of those risk factors involved in elderly dwelling fire fatalities, in order to take actions over the behaviors, conditions, and attitudes that lead to a fatal fire. Different safety strategies should be enhanced for different population groups, since a prevention or protection measure that is very effective for one group could be useless for another [6].

Previously to the development of this work, an international literature review was conducted [3–5, 7, 8, 10–15, 28, 30, 33, 36–41], and it revealed that fire scenarios involving elderly people usually have differences from those concerning younger people. In addition, they have a number of common factors that can help authorities to elaborate prevention campaigns and more effective protection strategies [3, 10, 12, 38, 41–43].

For instance, a high percentage of residential fires in the United States, Australia or the United Kingdom are related to alcohol and drugs consumption; however this factor hardly has an incidence in residential fires involving elderly people [10, 12, 30–33, 41, 42, 44]. Another interesting fact is that elder people in the US usually suffer fires which start in the kitchen, while the main cause of fires in young people´s dwellings are lit cigarettes coming into contact with textile elements or combustible furniture [38].

A research conducted in the UK revealed that older patients were significantly less likely to be smokers; and that significantly more fires killing elderly people were caused by faulty or misused electrical items [12].

A coronial study in North Ireland showed that the elderly were more likely to be involved in fires where their clothing was the seat of the fire, to have a physical illness that plays a role, and to suffer burn injuries as their primary cause of death [10].

Older adults living in a private dwelling represent a particularly vulnerable group. Those seniors that decide to live in a nursing home or a medical facility, even if they are impaired and cannot evacuate by themselves, can rely on the protection of the fire safety equipment and the trained staff that can assist the evacuation, which is a decisive factor [8, 45].

In addition, a study performed in eleven communities in Perth, Australia, demonstrated that elderly people living in private rental homes appeared to be less prepared in case of residential fire compared to those living in their own home, since the first group have a significantly lower prevalence of functioning smoke detectors installed [3].

After the verification of the relevance that similar researches have in other countries, and due to the lack of fire data in Spain, the elaboration of a whole Fire Statistic is considered necessary, in order to analyze the main risk factors for residential fires in dwellings of elderly people. Designers should have a real knowledge of the circumstances in which unwanted events occur and the frequencies [36] and it should be based on the specific social, demographic and architectural situation of each country; even more when fire data is frequently used to develop Fire Codes and Standards, and Fire Risk Assessment Methods [46, 47].

2. Methodology

Before carrying out the present study, all Fire Departments in Spain were contacted, requiring the fire data supposedly collected in the standardized document "Parte Unificado de Actuación (P.U.A)" [23]. The requirement was sent by email to 124 fire services, but only a 30% of responses were obtained. These responses indicated that either the age of the victims was not recorded or the P.U.A. document was not used for the data collection. Then, a second request was sent by email to all Fire Departments in Spain. It consisted in a survey about the methodology that they used to collect fire data. When the survey was designed, there were 134 fire departments in Spain, composed by 714 fire stations. 53 fire departments responses were obtained (39.6%), composed by 430 fire stations (60.2%). This difference between both percentages is due to the size of the departments that answered the questionnaire. For instance, in Catalonia there is one fire department, constituted by 148 fire stations; while there are some locations which only have one department and one station. Among other questions, they were asked about whether they use the P.U.A. document. Only 34.8% of the fire stations that answered the survey use the official document to collect the information after an incident. In addition, 41.9% of the stations do not collect the data about the age of the victim in their internal data-bases. Therefore, the data-bases used by the Fire Departments were discarded as the source of data for this research.

In addition, as it was mentioned above, previously to the development of this research there were a set of reports developed by Mapfre Foundation in collaboration with APTB. However, the original database used in its reports is not accessible for researchers, which prevents the development of the analysis of the risk factors by the age of the victim. Furthermore, these reports are limited, since they only show information about fatal victims in fires in 1-year periods. Data about non-fatal victims or incidents without casualties are not collected, therefore it is not possible to analyze the differences between fatal and non-fatal fires in order to find out which factors affect the survival of people in case of fire.

As first steps to overcome the lack of a nationally populated and managed fire incident database, a methodology for collecting fire data based on information extracted from the media was developed. Following personal interviews with Emergency Services workers, it was determined that it was the best option for the study of the key risk factors for the elderly. This approach is modeled in part on the Fire Incident Data Organization (FIDO) system from the National Fire Protection Association (NFPA) in the United States, which identifies significant fires through a clipping service, the Internet and other sources.

For the development of the database, the tool MyNews Hemeroteca [48] was used, and the search was done with two keywords: "Fire, dwelling". Any reference to the age of the victim is eliminated, with the purpose of collecting all fires in Spain in order to compare the risk factors of residential fires in dwellings occupied by elderly people with those affecting the rest of the population.

The tracking system was as follows: a search with the two keywords was carried out, day by day, from 1 January 2016 to 31 December 2016. Results were organized by its title, in order to discard those pieces of news which were duplicated, and then the extracted data were recorded in an Excel sheet, through a code system developed in a dictionary of variables. This process was performed from September 2016 to March 2018. The analysis of the collected data was performed from March 2018 to May 2018 at the National Fire Protection Association (NFPA).

The collected data included variables about fire incidents, injured victims and fatal victims in residential fires in Spain in 2016. It was compared to the information published in Mapfre Reports, and where it was supportable both data was combined; that is, some variables related to fatal victims in 2016. The results of the statistical analysis were used to assess fire risk to the elderly population living in their dwellings.

Table 1 shows a comparison between the two databases as well as their advantages and disadvantages.

The definition of home includes detached dwellings, duplexes, and single-family housing; apartments, tenements, and flats and other multi-family housing, regardless of ownership; and abandoned homes or poor-quality houses are also included, using the label "Poor-quality home".

Rates of death or injury per million population and relative risk of death or injury are used throughout this paper. Spanish Statistics Office (INE) estimates of resident population for years 2012 to 2016 are used to calculate average rates, by the calculation of the average of those data. Rates by a specific year use INE data for that year. Relative risk compares the risk of a specific group versus the population at large. The relative risk of fire death or injury for each age group was calculated by dividing the rate of death or injury per million population for each age group by the rate of the general population. The relative risk for all age groups combined is 1.0. A value higher than 1.0 for a specific age group means that age

Table 1
Comparison Between the Two Sources of Spanish Fire Data Used in the Present Study

Source	Author	Years analyzed	Data collected	Pros	Cons
Mapfre and APTB reports	Mapfre Foundation in collaboration with APTB	One report per year, from 2010 to 2016	Fatal victims	Data is provided by fire departments	The data-base is not accessible for researchers. Only published results can be used (they do not analyze risk factors by the age of the victim) Few variables collected
Data-base developed from the media	Researchers from University of Navarra	2016	All fires, fatal and non-fatal victims which were reported in the Spanish media in 2016	Data can be analyzed by the age of the victim New variables are collected	Data is extracted from the media

group is at higher risk of death than the general population [38]. When the results of the descriptive statistical analysis were insufficient to identify a trend, the statistical significance of proportions was compared by Chi square testing, with a p value of < 0.05 defined as significant.

Using the reports developed by the National Fire Protection Association (NFPA) "Characteristics of home fire victims" [37, 38], our own analysis was designed. Some of the variables analyzed in the US could not be studied in this report due to the lack of information in the media, such as the race and ethnicity of the victim, which rarely appears in the news. The most relevant results, that summarize how are residential fires in Spain, are shown in this paper.

2.1. Studied Variables

The selected variables for the research have been chosen from those used in the official P.U.A. Document [23] and they have been extended with more parameters from similar statistics extracted from the manuals for fire data collection conducted in UK and US [1, 2], as well as from researches performed from official data-bases of Australia, Japan or New Zealand [3–5]; since all of those countries have a strong fire data collection system.

The variables filled out with the data extracted from the media are divided in two large groups: general information of the residential fire, and information concerning fire victims specifically. In "General Information", the moment, place, cause, and consequences of the fire; the rescue services implied, and the victims

Table 2
General Variables Analyzed in the Database that Has Been Created Through Information Extracted from the Media

Category	Name of the variable	Category	Name of the variable
Fire code	Fire code	Rescue services	Fire station involved
Moment	Date		Fire Services
	Day of the week		Distance between the station and the damaged building[b]
	Starting time		Other rescue services involved[a]
	Extinction time[b]	Type of accident	Type of accident
Place	Autonomous community	Fire cause	Fire cause
	Province		Investigation of the causes[b]
	City	Fire victims	Are there elderly people in the damaged dwelling?[a]
	Number of inhabitants		Number of usual occupants of the dwelling where the fire started[a]
	Address		Number of occupants who were at the dwelling when the fire started[a]
	District[b]		Number of injured victims[b]
	Average income of the location[a]		Number of fatal victims
Housing	Type of housing		Number of rescued occupants[b]
	Number of stories		Is the building evacuated?[b]
	Fire floor		Who reports the fire to the rescue services?[a]
	General condition of the building[b]		Fire-extinguishing[a]
	Year of construction[a]	Consequences	Building damage[b]
	Room where the fire started		

[a]Indicates that the variable is not collected in Mapfre database
[b]Indicates that the variable is not published in Mapfre reports

involved are collected. Each one of these categories responses several questions, which are briefly shown in Table 2.

The variables related to the casualties specifically are briefly shown in Table 3. Firstly, the victim is identified with its fire code, and then the other variables are recorded: general information about the victim; type of injuries, and victim's behavior in fire.

3. Results

For ease of discussion, the results have been divided in categories according to those mentioned in the previous section, but in different order. Not all variables are discussed in this paper for space reasons. Trends are analyzed based on the results extracted from the media database. When it was possible, results from

Table 3
General Variables Analyzed in the Database that Has Been Created Through Information Extracted from the Media

Category	Name of the variable	Category	Name of the variable
General information	Fire code	Injuries	Does the victim need to be hospitalized? (Non-fatal victims)[b]
	Type of occupant		Does the victim died in the hospital? (Fatal victims)[b]
	Age		If this is the case, name of the hospital[b]
	Sex	Victims behavior in fire	At the moment when the fire started, was the victim in that room?[a]
	Nationality		Did the victim consume alcohol or drugs?[a]
	Country of origin (in case the victim is not Spanish)		Did the victim try to extinguish the fire?[a]
	Previous diseases		Did the victim try to rescue somebody?[a]
Injuries	Severity of the injuries[b]		Did the victim need to be rescued?[a]
	Type of injury[b]		Was the victim asleep when the fire started?[a]

[a]Indicates that the variable is not collected in Mapfre database
[b]Indicates that the variable is not published in Mapfre reports

Mapfre reports have been complied, analyzed as a whole and compared to the results extracted from the media.

The selected categories are, in the first place, the overall trends of fire fatalities in Spain in the last years. The second category is related to the demographic characteristics of the victims, age and gender. The third one is focused in the incident data; it consists of information about the place and moment: month, average income of the location and year of construction of the building. On the forth category, leading causes of residential fires in Spain are analyzed. And, in the last section, variables about the fatalities' involvement in the incident, and the human factors that could influence in the fire development, are presented.

3.1. Overall Trends

There have been 1146 fatal victims in fires in Spain, between 2010 and 2016. In that time period, home fires caused more than three out of four (76.8%, n = 882) fire deaths of the total number of fatalities in that type of accidents. This means that dwellings are the most common place where fatal fires happen, so far from the next usual scenario: 12% (n = 137) of victims who die in outdoor fires. Fires that occurred in residential buildings between 2010 and 2016 caused an estimated average of 126 civilian fire deaths and 1925 reported civilian fire injuries per year [16–21].

There are no data available about injured victims in general fires, so it is not possible to know the percentage of non-fatal victims injured in home fires.

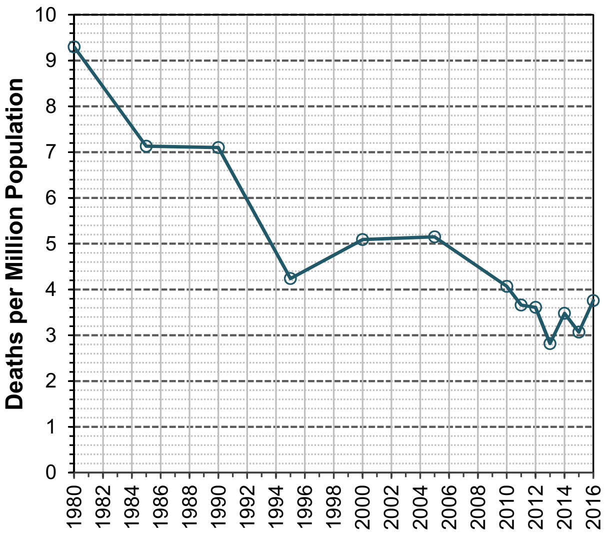

Figure 1. Fire death rate per million population in all type of fires in Spain, by year. 1980–2016 *Source*: Mapfre reports [16–21].

According to data extracted from Mapfre Reports, with increasing population, fire death rates per million population (pmp) have fallen more than the actual deaths since 1980. The fire death rate of 3.8 deaths per million population was 59.1% lower in 2016 than the rate of 9.3 in 1980, as it is shown in Fig. 1 [16–21].

Data of fatal victims in home fires is not available before 2010, and for that period, home fire fatal victims have not changed significantly, with the lowest

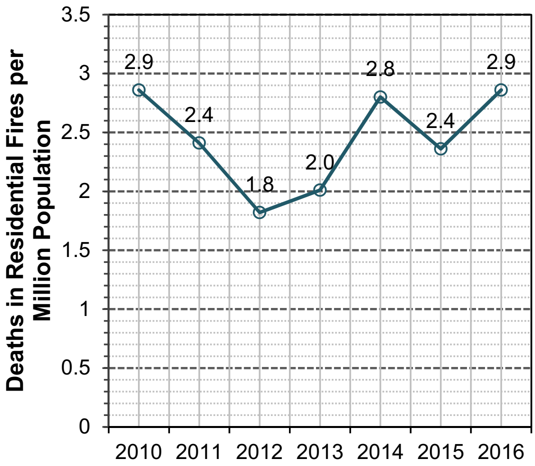

Figure 2. Home fire deaths rates per million population by year in Spain. 2010–2016 *Source*: Mapfre reports [16–21].

value in 2012, but the same deaths pmp in 2010 and 2016 (Fig. 2) [16–21]. There are no data collected of fire injuries, except for years 2010 and 2011, and 2016 in the media database.

3.2. Demographic Data

3.2.1. Age In 2016, home fires killed 80 people 65 or older. While this age group accounted for only 18.9% of the general population [26], they accounted for 60.6% of fire deaths. This means that adults 65 and over were 3.19 times as likely as the general population to die in fires and for those individuals age 85 or older, the risk was 8.48 times as high (Table 4). In other words, the risk of adults over 85 dying from a fire was approximately 750% more than that of the total population. Pearson Chi squared test confirmed that there is a significant variation in fire death rate ($\chi^2 = 320.54$, df = 9, p value < 0.01), and in fire injury rate ($\chi^2 = 149.57$, df = 9, p value < 0.01) by age group.

Results of fatal victims in residential fires by age group are consistent with those extracted from Mapfre Reports, for the 2012–2016 period, as shown in Table 5.

3.2.2. Gender Males have a higher risk of fire death and injury in home structure fires. Although Spanish Statistics Office (INE) figures show that 50.9% of the population is female [26], 57.7% of fatal home fire victims and 51.1% of injured in 2016 were male. When the relative risk of death is calculated, males have a

Table 4
Deaths and Injuries in Home Structure Fires in Spain by Age Group. 2016 *Source*: Media database, population data from Spanish Statistical Office [26]

		Number		Number per million population		Relative risk	
Age	Population	Deaths	Injuries	Deaths	Injuries	Deaths	Injuries
Under 5	2.15	4 (3.0%)	39 (4.0%)	1.86	18.13	0.66	0.87
5–9	2.46	2 (1.5%)	41 (4.2%)	0.81	16.68	0.29	0.80
10–14	2.40	2 (1.5%)	34 (3.5%)	0.83	14.19	0.29	0.68
15–19	2.22	1 (0.8%)	53 (5.5%)	0.45	23.84	0.16	1.14
20–34	7.74	5 (3.8%)	138 (14.2%)	0.65	17.83	0.23	0.86
35–49	11.42	15 (11.4%)	182 (18.8%)	1.31	15.93	0.46	0.77
50–64	9.31	23 (17.4%)	182 (18.8%)	2.47	19.54	0.87	0.94
65–74	4.43	15 (11.4%)	103 (10.6%)	3.39	23.27	1.19	1.12
75–84	2.98	31 (23.5%)	131 (13.5%)	10.39	43.91	3.66	2.11
85 and Over	1.41	34 (25.8%)	66 (6.8%)	24.07	46.71	8.48	2.24
Total	46.53	132 (100%)	969 (100%)	2.84	20.83	1.00	1.00
Selected age groups							
14 and under	7.01	8 (6.0%)	114 (11.8%)	1.14	16.27	0.40	0.78
65 and over	8.82	80 (60.6%)	300 (31.0%)	9.07	34.00	3.19	1.63

Table 5
Fire Deaths in Home Structure Fires in Spain by Age Group. 2012–2016 *Source*: Compilation based on Mapfre reports [16–21], population data from Spanish Statistical Office [26]

Age	Population (2012/2016)	Average of deaths per year	Deaths per million	Relative risk of death
Under 5	2.27	3 (2.6%)	1.32	0.54
5–9	2.47	2 (1.8%)	0.81	0.33
10–14	2.31	1 (0.9%)	0.43	0.18
15–19	2.17	1 (0.9%)	0.46	0.19
20–34	8.30	4 (3.7%)	0.51	0.21
35–49	11.52	14 (11.9%)	1.18	0.48
50–64	8.92	21 (18.2%)	2.33	0.95
65–74	4.24	15 (13.5%)	3.64	1.48
75–84	3.03	30 (26.6%)	10.05	4.09
85 and over	1.30	23 (20%)	17.52	7.14
Total	46.53	114 (100%)	2.45	1.00
Selected age groups				
14 and under	7.05	6 (5.3%)	0.85	0.35
65 and over	8.56	68 (60.1%)	8.01	3.26

Table 6
Spanish Fire Deaths in Home Structure Fires, by Age Group and Gender. 2016. *Source*: Media database, population data from Spanish Statistical Office

	Population (in millions)		Number				Number per million population				Relative risk			
			Deaths		Injuries		Deaths		Injuries		Deaths		Injuries	
Age	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Under 5	1.11	1.04	3	1	20	10	2.7	1.0	18.1	9.6	0.8	0.5	0.9	0.5
5–9	1.27	1.19	1	1	28	13	0.8	0.8	22.1	10.9	0.2	0.4	1.1	0.6
10–14	1.23	1.16	1	1	15	14	0.8	0.9	12.2	12.0	0.3	0.4	0.6	0.6
15–19	1.15	1.08	0	1	30	19	0.0	0.9	26.2	17.6	0.0	0.4	1.3	0.9
20–34	3.89	3.85	4	2	78	60	1.0	0.5	20.0	15.6	0.3	0.2	1.0	0.8
35–49	5.78	5.64	10	4	91	81	1.7	0.7	15.7	14.4	0.5	0.3	0.8	0.8
50–64	4.59	4.72	16	6	101	78	3.5	1.3	22.0	16.5	1.1	0.6	1.1	0.9
65–74	2.08	2.35	10	6	38	60	4.8	2.6	18.3	25.6	1.5	1.2	0.9	1.3
75–84	1.26	1.72	16	13	41	84	12.7	7.5	32.6	48.7	3.9	3.5	1.6	2.6
+85	0.47	0.94	14	16	31	34	29.6	17.1	65.6	36.2	9.0	7.9	3.2	1.9
Total	22.83	23.69	75	51	473	453	3.3	2.1	20.7	19.1	1.0	1.0	1.0	1.0

greater risk in all age groups, except for those people between 15 and 19 years-old (Table 6).

Chi square test was conducted to compare the proportion of population in Spain and the proportion of fatal victims of fire, by gender. The test confirmed that males were more likely to die in fires than females (χ^2 = 5.50, df = 1, $p < 0.05$). However, there is no a significant variation in the proportion of fire injury rates by gender (χ^2 = 1.49, df = 1, $p > 0.05$).

3.3. Incident Data

3.3.1. Location The most dangerous regions in Spain are not interesting by themselves in this paper. However, a relation between the deaths per million population and the percentage of elderly people has been found out after a simple correlation analysis.

As it is shown in Fig. 3, when the percentage of elderly population (over 65 years-old) in one community increases, the deaths per million population in that community also increase. The correlation coefficient has been calculated: r = 0.58, which means that there is a moderate association between both variables, but not necessarily that there is a cause-consequence relation between them.

The same analysis was conducted for the non-fatal victims. In Fig. 4 it is shown that the relation between both variables is stronger for injuries than for deaths. The value of the coefficient was r = 0.741, which means that the association is strong: when the percentage of elderly people in one community increases, the injuries in residential fires pmp in that community also increase.

3.3.2. Average Income in the Location The average gross income in Spanish locations is 25.582 euros per year [49]. However, almost 60% of injuries and 70% of

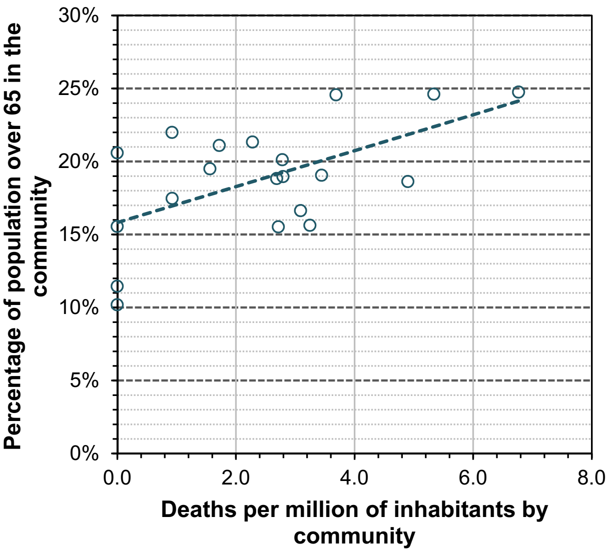

Figure 3. Relation between the percentage of population over 65 years old and the deaths per million population by community. 2016 *Source*: Media database and population data from Spanish Statistical Office [26].

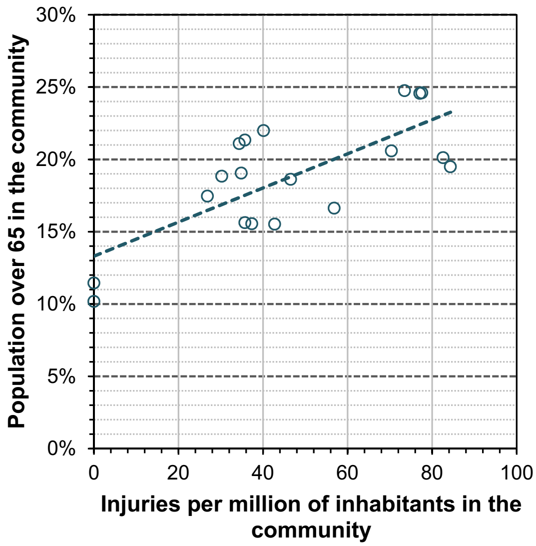

Figure 4. Relation between the percentage of population over 65 years old and the injuries per million population, by community. 2016 *Source*: Media database and population data from Spanish Statistical Office [26].

deaths were in locations where the gross income was lower than the national average. The relative risk of home fire death by the gross income of the locations has been calculated by dividing the percentage of population in each range income that had died in a home fire by the general population in that range income in Spain. The risk is multiplied by 2.7 for people living in locations with the lowest incomes in Spain, as it is shown in Table 7. Pearson Chi squared test confirmed that there is a significant variation in fire death rate (χ^2 = 320.54, df = 9, p value $<$ 0.01) by the average income in the location.

Table 7
Home Structure Fire Deaths by the Income Range of the Location, 2016. *Source*: Media database and data from the Spanish Statistical Office [26]

Income range by location	Population by location (%)	Deaths by location	R.R. deaths
10,000–15,000	3.6	12 (9.7%)	2.70
15,001–20,000	20.6	26 (21%)	1.02
20,001–25,000	30.8	49 (39.5%)	1.28
25,001–30,000	29.8	29 (23.4%)	0.79
Over 30,000	15.3	8 (6.5%)	0.42
Total	100.0	124 (100%)	
Unknown		6	

3.3.3. Month Figure 5 shows that winter was the season with the highest percentage of deaths and injuries in 2016 while there was an important decrease of victims during summer, especially fatalities. Non-parametric Chi square test confirmed that fire deaths and injuries are more likely to occur during cold months ($\chi2 = 35.41$, df = 11, $p > 0.01$ for fatal victims, $\chi2 = 251.75$, df = 11, $p < 0.01$ for non-fatal victims).

The variation of fatal fires along the year is consistent with the results showed in Mapfre Reports. Figure 6 shows that from 2012 to 2016, December and January were the months with the highest percentage of deaths, followed by November, February and March. The months with the lower percentage of deaths were August and September, followed by June, July and October.

3.3.4. Year of Construction of the Building The percentages of fatal victims in 2016 by the age of the building are shown in Fig. 7, compared to the percentage of buildings that had been built in those periods. The highest percentages of injuries and deaths in 2016 were in those houses built between 1960 and 1980, but 47% of them were built between 1940 and 1979 [26], when the development of the cities was needed due to the rural exodus. Therefore, during 2016, homes built in the last 5 years had a low risk of being the origin of a fire with victims, and those with more than 45 years had higher risk of both deaths and injuries (Fig. 8).

Further research should be focus on the influence that the introduction of the different versions of the fire safety regulations had in the reduction of residential fires. In addition, the Chi square test for trend in proportions did not demonstrate

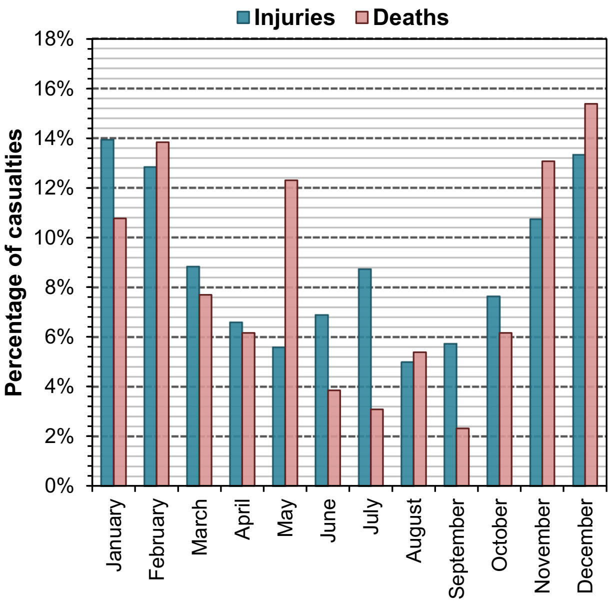

Figure 5. Percentage of fatal and non-fatal victims in residential fires by month, 2016. *Source*: Media database.

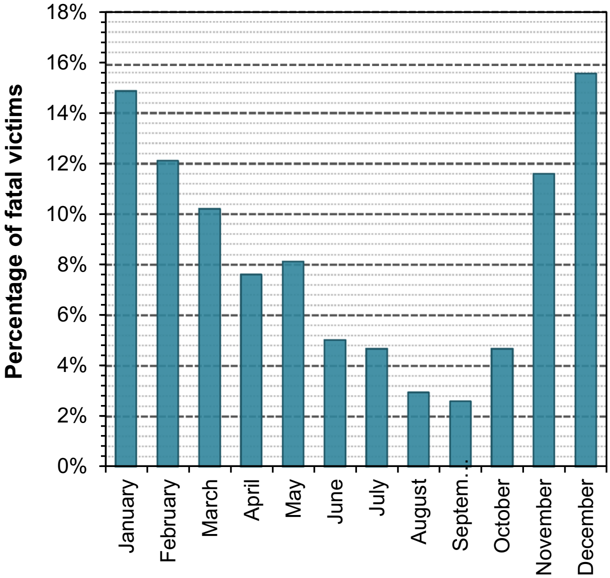

Figure 6. Percentage of fatal victims in residential fires by month, 2012–2016. Compilation based on Reports [16–21].

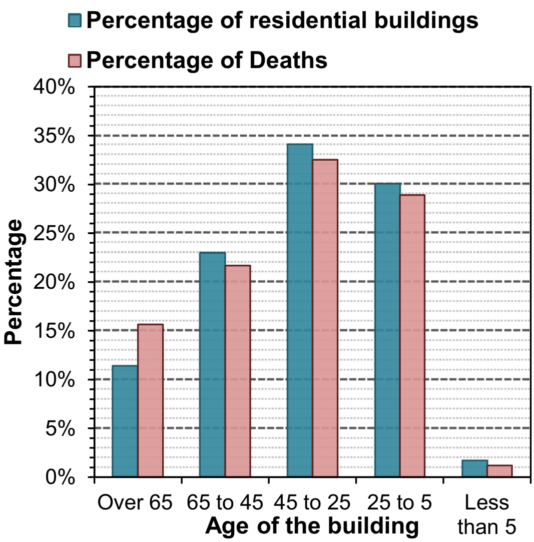

Figure 7. Percentage of residential buildings and fatal victims by the age of the building. Year 2016. *Source*: Media database and Spanish Statistical Office [26].

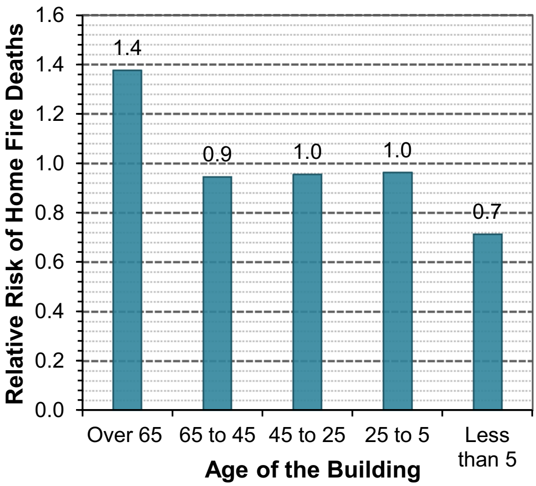

Figure 8. Relative risk of home fire deaths by the antiquity of the building, 2016. *Source*: Media database and Spanish Statistical Office [26].

that the differences of death rates by the antiquity of the building was statistically significant ($\chi2 = 0.706$, df = 1, $p > 0.05$).

3.4. Leading Causes of Fire Deaths and Injuries

During 2016, the main cause of home fire deaths was heating equipment, which means fixed or portable space heaters. Frequently in heating fire deaths the equipment was too close to something that could catch fire. The second leading cause was electrical distribution and lighting equipment, followed by smoking materials and, in the fourth position, fireplaces (Fig. 9). International studies confirm that some fire causes are more likely to result in death or injury than others [14, 38, 41]. Figure 9 also shows that during 2016, based on the information extracted from the media, only 3.4% of home structure fires were started by smoking materials. Yet these fires caused almost one in five (18.2%) home fire deaths. Something similar occurs with heating equipment: although they account 31.8% of fatal victims, they are only the cause in 18% of total incidents. Cooking equipment was involved in 29.6% of home fires, but only 6.8% of deaths resulted from these incidents. However, 25.4% of non-fatal victims were injured in this kind of fires. Therefore, it could be affirmed that the risk of fire death or injury in the event of fire varies considerably by fire cause, which is confirmed through the Chi squared test ($\chi2 = 91.62$, df = 7, $p < 0.01$ for fatal victims; $\chi2 = 120.77$, df = 7, $p < 0.01$ for non-fatal victims).

The percentage of victims by fire cause for people who were underage (less than 18 years old), elderly adults (65 and over), and all victims was also analyzed. When extracting conclusions and interpreting Figures, it must be remembered that data is only available for year 2016, and it could be influenced by different fac-

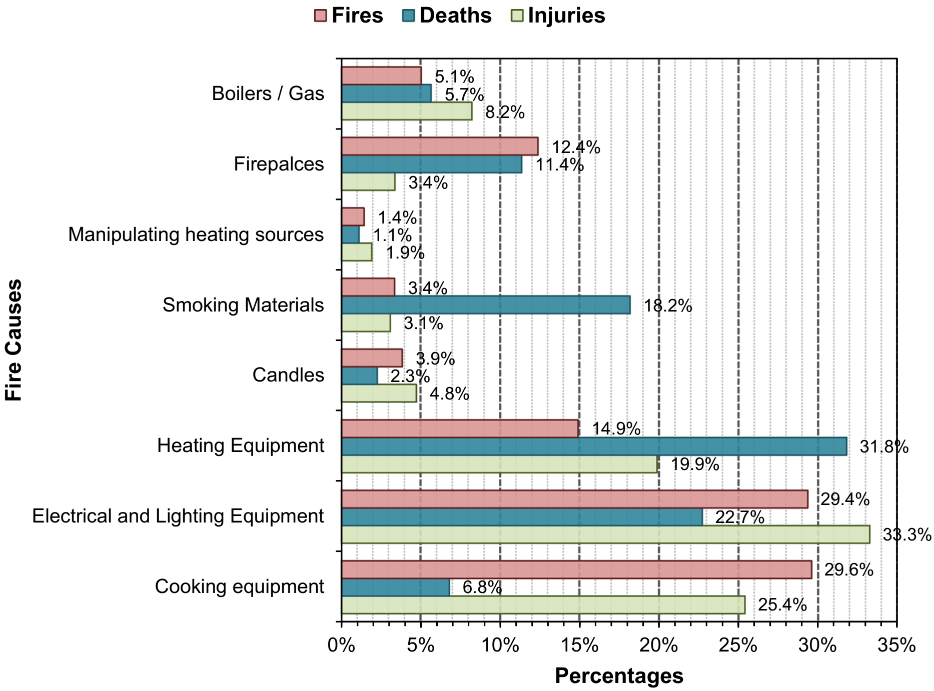

Figure 9. Percentage of fires, fatal victims and non-fatal victims in residential buildings, according to the fire cause. Year 2016. *Source*: Media database.

tors. In addition, some fire causes need to be clarified in official investigations, which do not appear in the media. Further information is needed in order to be able to give stronger conclusions.

Figure 10 shows that more than one-third (39%) of the older adult victims died in fires started by heating equipment. Almost one-half of the victims under eighteen were killed in fires involving electrical distribution and lighting equipment (44%), and roughly another quarter died in fires started by direct fire (22%). This category includes playing or manipulating the heating source, candles and fireplaces.

The leading cause of death for elderly people was heating equipment, and they accounted for 71.4% of fatal victims in this type of fires. Although 67% of deaths in cooking fires were elderly, these fires only caused 8% of the total victims in this age group. While those victims who were under 18 years old accounted for only 21.1% of the electrical fires death, these incidents accounted for 44% of the deaths to this age group. In fact, electrical fires were the leading cause of home fire deaths for victims under 18.

The second leading cause for the general population was electrical distribution. However, for the elderly people this was the third one and the second was boilers or gas explosions.

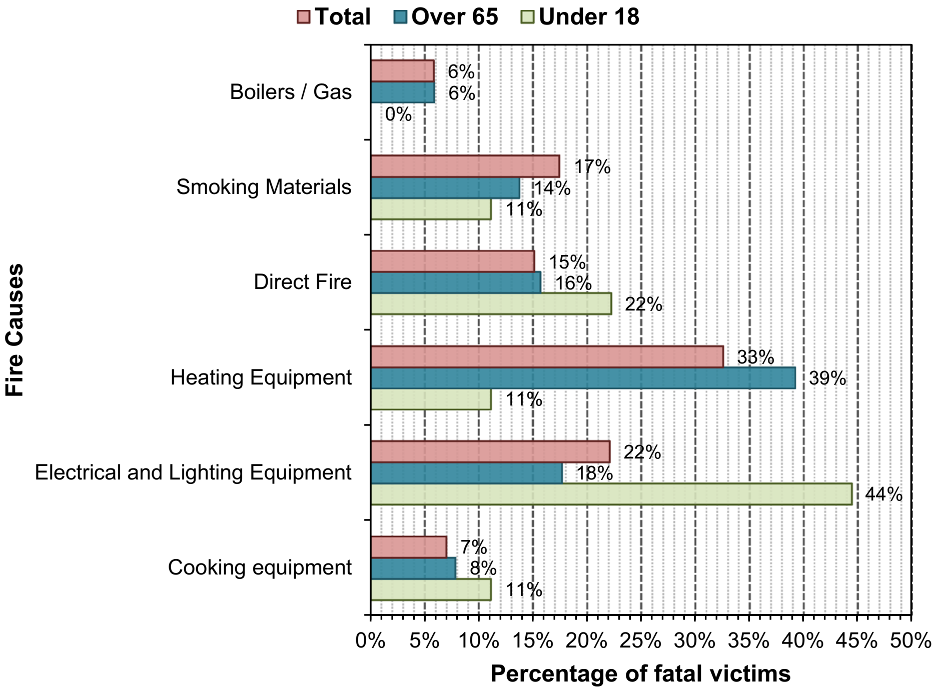

Figure 10. Percentage of fatal victims in residential fires by fire cause, for victims under 18, over 65 and total population, 2016. *Source*: Media database.

3.5. Victims' Factors

An individual's condition or circumstances can increase their risk of harm. In some incidents, a "human factor" or something about the victim, contributed to the injury. The condition may have been temporary and may or may not have been a factor in the ignition [31, 38].

For example, during 2016, almost 50% of deaths happened after a fire whose origin was in a dwelling occupied by elderly people (Fig. 11). This result indicates that elderly people are not only more vulnerable of suffering a fire, but more likely to be involved in its starting.

Table 8 shows that being asleep was a factor in, at least, 28% of the home fire deaths. More than one out of four of those killed had a physical or mental disability: 84.8% of fatal victims with disabilities in 2016 were over 65 years-old. For these fatal victims, the most frequent disability was low mobility: two thirds of fatal elderly victims were mobility impaired. 48% of the fatal victims were vulnerable people (elderly, children or disabled) who were unattended or unsupervised when the fire started, and almost one half (46.2%) were alone at home. In the case if elderly people, 93% of people over 85 years-old were unattended when the fire started: 70% of them were alone, and the rest were only accompanied by more elderly people. These percentages are calculated for the whole sample.

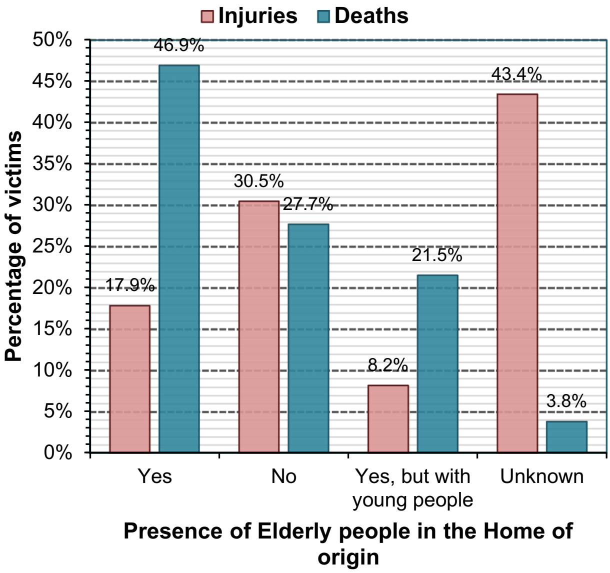

Figure 11. Percentage of fatal victims and non-fatal victims in residential fires, according to the presence of elderly people in the home of fire origin, 2016. *Source*: Media database.

Therefore, the results shown could be even larger, since a missing data does not mean a negative response, but that there is not information available.

Fatal victims among elderly people are more likely to be asleep, unattended or to have any disability when the fire starts. They have higher percentages than the rest of the population for all factors, except "Fire Control or Rescue Attempt".

4. Discussion

At the present time, there is no nation-wide, systematic approach to collecting, analyzing and presenting fire loss data in Spain. Previously to the development of this work, there was a set of reports about structural fires, but the data collection was limited and excessively basic. These reports only show information about fatal victims, leaving injured victims or incidents without casualties out. In addition, the analysis of the risk factors according to the age of the victim was not possible, since the original database is not accessible for researchers.

The new database provides information about fatal and non-fatal victims, as well as fire incidents with no casualties, instead of fatalities exclusively. The collection of new parameters allows the identification of key risk factors that influence residential fires as it was demonstrated in other countries. In addition, the new database makes it possible to link the collected variables and the age of the victim, in order to assess risk for specific groups, in this case the elderly population.

Table 8
Fatal Victims in Residential Fires According to the Human Factor Contributing to Injury Year: 2016.
***Source:* Media database**

Age	Alone	Asleep	Fire control or rescue attempt	Physically or mentally disabled	Unattended or unsupervised person (even not alone)	Total of deaths
Under 5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (33.3%)	3
5 to 9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (33.3%)	3
10 to 14	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2
15 to 19	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1
20–34	0 (0%)	1 (16.7%)	1 (16.7%)	0 (0%)	0 (0%)	6
35–49	6 (42.9%)	3 (21.4%)	2 (14.3%)	1 (7.1%)	1 (7.1%)	14
50–64	12 (54.5%)	7 (31.8%)	1 (4.8%)	4 (18.2%)	0 (0%)	22
65–74	8 (50%)	5 (31.3%)	1 (6.3%)	9 (56.3%)	7 (43.8%)	16
75–84	17 (58.6%)	12 (41.4%)	3 (10.3%)	11 (37.9%)	22 (75.9%)	29
Over 85	21 (70%)	8 (26.7%)	2 (6.7%)	8 (26.7%)	28 (93.3%)	30
Total, unknown age included	62 (49.6%)	37 (28.5%)	10 (7.8%)	34 (26.2%)	63 (48.5%)	130
Selected age groups						
< 18	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (22.2%)	9
19–64	17 (38.6%)	11 (25%)	4 (9.1%)	5 (11.4%)	2 (4.5%)	44
> 65	44 (57.9%)	25 (32.9%)	6 (7.9%)	29 (38.2%)	58 (76.3%)	76

The only tool available for the development of the new database was the search of fire incidents in the media. That search must be detailed and careful, so it takes a long time and only 1 year of incidents -2016- could be collected.

Consequently, Spanish fire safety authorities should promote further research about fire data, through a review of the current incident reporting system, and the identification of the main issues that prevent the systematic collection of data. The use of a homogeneous and regulated system for the collection of fire data has demonstrated to be an essential tool for promoting changes in the codes, the enhancement of fire safety laws, or the focus on a specific vulnerable group in other countries. Fire statistics lead to the knowledge of the factors underlying major accidents, which allows taking more cost-efficient actions to reduce the consequences of such unwanted events [50]. The potential effectiveness of the fire safety strategies can vary for different population groups, which implies that different sets of measures should be developed for different population groups [6]. The evaluation of those strategies is only possible through the study of the fire incidents, which starts with a complete collection of data.

In the present research, some key risk factors for fatal residential fires have been identified: elderly people, especially those aged over 85 years-old are more likely to die in a home fire than younger adults. Males also have a higher risk than females, regardless their age.

Those Autonomous Communities in Spain with the highest percentages of aged population are those experiencing the highest rates of fatal and non-fatal victims in residential fires per million population. In addition, those locations with lowest average per capita income have the highest relative risk of fire-related mortality in residential buildings. The number of fatal victims in domestic fires increases in cold months, from November to March. The relative risk of home fire death also increases in those dwellings built 65 years ago.

The leading cause of home fire death for the general population is the heating equipment, followed by electrical distribution and lighting equipment and smoking materials. The percentage of fatal victims due to a fire caused by a heating source is higher for victims over 65 that for the overall population, while the first cause of death for people under 18 years-old in residential fires are the electrical failures or lighting equipment malfunction.

The risk of fire death or injury in the event of fire varies considerably by fire cause: heating equipment or smoking materials cause a large number of deaths per incidents, while cooking equipment cause the lowest number of fatal victims per incident.

68% of fatal residential fires started in a dwelling where there was at least one elderly person. 76% of the elderly fatal victims were unattended or unsupervised when the fire started. 58% of them were alone at home, 33% were sleeping and 38% had a physical or cognitive disability.

The results presented in this paper have similarities and differences with studies conducted at other countries. Regarding the similitudes, as it happens in Spain residential fires are the main scenario where casualties occur, accounting for closely three out four of total fire fatalities in the United States and the United Kingdom [7, 51]. The pattern is similar in other countries as well, like China, New

Zealand or Sweden [4, 6, 42, 52, 53]. However, they are not distributed evenly through society, but there are certain sectors that experience disproportionate numbers of incidents. The elderly had a greater risk of dying in residential fires than their younger adult counterparts. The risk is higher in all age groups for males than for females; therefore the group that experiences the highest risk of fatal fire is men over 65 years-old, and it increases with age [10, 12–15, 30–32, 38, 41–44, 54, 55].

The influence that lower incomes have in the risk of home fire has been widely studied [4, 7, 13–15, 30, 31, 38, 44, 49, 56, 57]. Deprivation in basic needs, as well as living on fixed income –a typical situation among elderly people- usually lead to a bad state of the dwelling, especially if it is old, since the necessary home arrangements cannot be afforded; or in the use of older appliances that cannot be replaced, like portable heaters or heating blankets, introducing a higher risk of house fire [4, 30]. Finances can determinate where elderly people live and with whom, and if they are able to afford arrangements that include living assistance. In addition, some studies suggests that poverty may be related to a low educational level [7, 15], which can interfere with an older adult's ability to understand the details regarding fire prevention and safety. More research in this field is needed in Spain, since the results shown in this paper are extracted from only 1 year of incidents. However, they suggest that, as it happens in other countries [3, 4, 33, 37, 38, 42, 57, 58], there is a relation between deprivation and fire death rates.

Results about the role played by disabilities in the fatality of a fire are consistent with different studies [10, 12–15, 30–33, 38, 44]. In fact, the presence of people with disabilities may affect the evacuation dynamics of the building [35] and it is expected that total evacuation times will increase as populations age [34]. As people age, they are more likely to experiment physical or cognitive changes that can reduce their abilities to prevent, detect, or respond to fires. Moreover, many older adults suffer mobility impairments, which make their ability to successfully escape from fires more difficult, particularly when combined with living alone: low mobility was a factor present in two out of three elderly fire fatalities in 2016. Some studies demonstrate that substance-induced impairments, such as those caused by the side effects of prescription medication, can result in a wide range of impairments that increase older adults' risks of fire, fire fatality, and fire injury [12, 15]. In addition, stair evacuations -the traditional method to evacuate low-medium residential fires- present significant issues for people with physical disabilities [35].

The combination of all these factors is very frequent in elderly people living in their own dwelling, making them a frail group in case of fire, without appropriate safety or evacuation measures.

Some differences were also found out, such as the leading causes of home fire deaths and injuries. While in the US, Sweden, Australia, or the UK the first cause are smoking materials [7, 10, 12, 14, 15, 38, 41, 42, 44], according to both Mapfre Reports and our own database, the first cause in Spain is heating equipment [16–21]. It is coherent with the results about the relation between month and number of deaths, which show that the highest percentages of deaths were during the coldest months in Spain. In addition, the influence of low incomes and the antiquity of the building create a typical scenario of fatal home fires in Spain: if the central heating source of the dwelling does not work properly, the occupants cannot afford the cost of it or even it does not exist; people use to rely on temporary sources of heat, such as portable space heaters or fireplaces, to keep their homes warm. This situation makes heating systems the first cause of home fire deaths in Spain. In particular, they represent an elevated fire danger to older adults.

The second leading cause of home fire deaths for the general population in Spain in 2016 was electrical distribution. The information about the year of construction of the building is comparable to the one given by Boj-García and Rubio-Romero (2014) [24], which suggests the regular and detailed maintenance work in the electrical installations of those building older than 15 years, since they can go wrong over time. They also affirm that the most common source of electrical fire is indoor electric sockets, due to a faulty connection, material fatigue or overloading. Some studies in the US confirm that those electrical systems which have not been well-maintained can be compromised, since they are often outdated, inadequate or not operational. The result of that is a higher likelihood of fires caused by fraying electrical wiring, faulty heating and worn-out household appliances [13]. In Scotland, faulty or poorly maintained electrical items, were found to be the cause of one-half of fires in which elderly individuals died between 1980 and 1990, while the main cause for young people were smoking materials [12]. Results were different in Spain during 2016: electrical fires were the third cause of home fire deaths for the elderly population.

Another difference that can be discussed is the risk for children under 5 years-old. While they account a risk group in the US with a relative risk of dying in a home fire 50% higher than the risk for the general population [14, 31, 32, 38], children in Spain do not account as a vulnerable group in case of fire.

The deaths per million for the general population are lower in Spain than in other countries: while the fire death rate per million population is 5.2 in Spain, it raise 7.6 in the United Kingdom, 8.3 in New Zealand, 12.4 in the US or 16.0 in Japan, to name a few examples [59]. However, the risk for the elderly population seems to be one of the highest, above the risk for the older adults in US, UK or Japan [12, 38, 56]: In Spain, while this age group accounted for only 18.3% of the general population, they accounted for 60.1% of the fire deaths. The percentage of fatal fire victims over 65 years is similar in Japan, approximately 60% of fire fatalities. Nevertheless, the percentage of elderly population in that country is higher than in Spain (more than 25%) [8], which means that the relative risk for the older adults in Japan is lower than in Spain. Adults 65 and over were 3.3 times as likely as the general population to die in fires and for those individuals age 85 or older, the risk was 7.1 times as high. In the US the relative risk of becoming a fire fatality for those aged 65 or over, and 85 or over compared to the general population was found to be 2.7 times and 4.6 times higher, respectively [13, 31].

In Spain, only people aged 65 or older have a relative risk over 1.0. Therefore, as it happens in Sweden or Japan, the issue of fire safety is predominantly related to the elderly [8, 54].

The previous statistical reports developed in Spain do not study the variables according to the age of the victims. However, after the analysis of the media database, it has been shown that elderly people fatalities are frequently surrounded by different circumstances compared to the general population.

4.1. Limitations

As it was mentioned above, this research has several limitations, since data is only available for 1 year, and therefore it may be altered by some punctual factors. There are several variables that have never been collected before in Spain, which prevent the comparison of the results between the media database and other sets of data. That is the case of non-fatal residential fires, and injured victims. This can create a bias in the analysis, since we have only 1 year of data to grasp the factors that affected the survival of people in case of fire.

In addition, the information is extracted from the media, so its reliability is not absolute, due to the presence of sensationalism, inconsistencies between sources, lack of detail… When the reported incident is a fatal fire, it commonly appears in several news with a high degree of detail, interviews with the rescue service, the survivors, the family of the victim. However, this is not the case of non-fatal fires, when sometimes the information is excessively basic. Some collected variables, such as the ethnicity of the victim, have been discarded for the analysis, due to the high percentage of uncertain data.

But, despite these limitations, the study demonstrates the necessity of collecting fire data, in order to identify risk factors and vulnerable groups, and take actions for the reduction of the current high death rates. Moreover, a systematic methodology for the collection of data is considered necessary in order to avoid the existent uncertainties of the media database.

The assumption that the fire issue is the same in Spain than in other countries could have really bad consequences, since fire data is frequently used for the development of Codes and Standards [46, 47]; and therefore, it should be focused on the specific and unique fire situation of each country.

The analysis of fire statistics allows the identification of patterns in fires, as well as the most vulnerable groups. The results of this research indicate that fire safety in residential buildings occupied by elderly people should be a priority for the Spanish authorities, especially in old buildings in socioeconomic deprived areas. Poorer households are generally associated with lower temperatures in winter [60], which lead to the use of portable heating appliances; and faulty electrical installations [13, 24]. The combination of those factors increases the risk of fire in these dwellings.

The study of the fire statistics allows the development and assessment of prevention and protection strategies. For instance, different interventions involving a smoke-alarm distribution program reduced the incidence of injuries from residential fires in high risk areas [61–63]. However, the Spanish Building Code does not require the installation of smoke alarms in residential buildings, with the exception of those which are over 50 m height [64]. If the introduction of this requirement in the code is considered in the future, or a targeted intervention is performed, priority should be given to those groups particularly vulnerable, according to the fire data.

Further research is needed, since data from official databases is not available in Spain. Therefore, only a descriptive analysis could be conducted, based on the information from the media. Nevertheless, this work is a first step in the process of studying fire statistics in order to determine which targeted measures would be effective for vulnerable groups. Future research will focus on the description of the most typical scenarios of severe residential fires involving elderly people and, based on them, which strategies of building design would minimize the economic losses, injuries and deaths.

5. Conclusions

This research is focused on the identification of the key risk factors for fires in dwellings occupied by elderly people. Most fatal fires have their origin in residential buildings; with elderly people being the most vulnerable group. Although the death and injuries rates per million population in Spain is much lower than the rates in other countries [59], the number of fire fatalities among the elderly is not decreasing, it is even increasing for those adults over 85 years-old [16–21]. In addition, this group is also increasing day by day [26], so we can expect that the number of fires continue growing in Spain. A similar trend can be appreciated in more developed countries like the US, where great decreases have been made in lowering fire death rate during the last decade, but fewer gains have been realized among the oldest age groups [13].

Residential fires in dwellings occupied by elderly people usually have a similar pattern, and there are some risk factors that are frequently present. For this reason, an exhaustive knowledge of the risk factors for this population sector is crucial in order to develop effective prevention and protection measures; and the best tool for the enhancement of that knowledge is the collection and analysis of fire data.

Due to the lack of common criterion for the fire data treatment in Spain, a database was created on the basis of press reports. The selected variables have been chosen from those used in the official P.U.A. Document, and they have been extended with different factors found after a literature review.

The present paper confirms, as several studies did before [12, 15], that elderly fatalities differ from general population fatalities in fire. These differences may suggest that preventive strategies for the elderly population require a different emphasis from those for younger people [10, 12, 43]. In addition, there are some factors that are different in Spain than in other countries which have more experience in the fire statistical work. Both reasons support the importance of fire data collection and analysis, as an essential task to understand how home fire incidents are and the consequent development of efficient fire safety measures and Building Codes and Regulations, which will led the reduction of casualties.

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