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Mapping and characterization of fires with victims in Belo Horizonte.

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Mapeamento e caracterização dos incêndios com vítimas em Belo Horizonte

RESUMO

Objetivo - esta pesquisa investigou o perfil das vítimas de incêndio na cidade de Belo Horizonte, indicadores geográficos do local da ocorrência e as características construtivas e de uso e ocupação das edificações.

Metodologia – foram analisados, através da estatística descritiva, todos os atendimentos a incêndios urbanos na cidade de Belo Horizonte no período de 2021 e 2022. Dissecando aqueles que tiveram vítimas (feridas e fatais) e confrontando estes dados com os encontrados em estudos internacionais.

Originalidade – Os padrões de incêndios que causam vítimas no Brasil, especialmente em grandes cidades é algo pouco conhecido e debatido o atual estudo joga luz nos sinistros em Belo Horizonte, uma das maiores cidade brasileiras em uma perspectiva inédita.

Resultados -foi constatado que foram registrados 1.371 incêndios em edificações, cerca de 62,14%(852) aconteceram em edificações destinadas à habitação, dos quais 76,41%(651) foram em habitações unifamiliares. Foram registrados 133 incêndios em edificações na cidade que resultaram em pessoas feridas ou mortas. Vê-se uma prevalência dos incêndios com registro de pessoas feridas acontecendo em edificações habitacionais (unifamiliar e multifamiliar), correspondendo a 89,47%(119). Na comparação entre os registros de vítimas de incêndios do CBMMG e DATASUS, é possível perceber que se todos os feridos atendidos pelo CBMMG fossem internados na rede hospitalar, representaria cerca de 33% do total de internações registradas no DATASUS. Quanto ao gênero das vítimas, observa-se uma sutil diferença, sendo que homens foram vitimados em cerca de 53%(88) dos casos.

Contribuições teóricas/metodológicas – estabelecer um panorama de incêndios que causam mortes e feridos em Belo Horizonte, trazendo dados relevantes para as políticas públicas e o desenvolvimento das cidades, de uma forma efetiva e com capacidade de repetibilidade em outras municípios é uma das contribuições da pesquisa.

PALAVRAS-CHAVE: Incêndio e Letalidade. Incêndios em Belo Horizonte. Mortes em Incêndios. Vítimas de Incêndios.

Mapping and characterization of fires with victims in Belo Horizonte

ABSTRACT

Objective - this research investigated the profile of fire victims in the city of Belo Horizonte, geographical indicators of the location of the incident, and the construction, use, and occupancy characteristics of the buildings.

Methodology - All urban fire responses in the city of Belo Horizonte in the period from 2021 to 2022 were analyzed using descriptive statistics. Those that had victims (injured and fatal) were dissected and these data were compared with those found in international studies.

Originality – The patterns of fires that cause casualties in Brazil, especially in large cities, are little known and discussed. The current study sheds light on incidents in Belo Horizonte, one of the largest Brazilian cities, from an unprecedented perspective.

Results – It was found that 1,371 fires were recorded in buildings, about 62.14% (852) of which occurred in residential buildings, of which 76.41% (651) were in single-family homes. There were 133 fires in buildings in the city that resulted in injuries or deaths. There is a prevalence of fires with injuries occurring in residential buildings (single-family and multi-family), corresponding to 89.47% (119). When comparing the records of fire victims from CBMMG and DATASUS, it can be seen that if all those injured and treated by CBMMG were admitted to the hospital network, this would represent about 33% of the total hospitalizations recorded in DATASUS. Regarding the gender of the victims, there is a slight difference, with men accounting for about 53% (88) of the cases.

Theoretical/methodological contributions – one of the contributions of this research is to establish an overview of fires that cause deaths and injuries in Belo Horizonte, providing relevant data for public policies and urban development in an effective manner that can be replicated in other municipalities.

Social and environmental contributions – identifying the main interrelationships between fires that cause victims in large cities, such as Belo Horizonte, is an important contribution to city management and the preservation of a society's most valuable asset, the lives and integrity of its citizens.

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KEYWORDS: Fire and Lethality. Fires in Belo Horizonte. Fire Deaths. Fire Victims.

Mapeo y caracterización de incendios con víctimas en Belo Horizonte

RESUMEN

Objetivo – esta investigación tiene como propósito establecer el perfil de las víctimas de incendios en la ciudad de Belo Horizonte, los indicadores geográficos del lugar de ocurrencia y las características constructivas y de uso y ocupación de los edificios.

Metodología – se analizaron todas las respuestas a los incendios urbanos en la ciudad de Belo Horizonte durante 2021 y 2022 mediante estadística descriptiva. Se analizaron los causaron víctimas (heridos y fallecidos) y se compararon estos datos con los de estudios internacionales

Originalidad/Relevancia – Los patrones de incendios que causan victimas en Brasil, especialmente em las grandes ciudades, son poço conocidos y debatidos. El presente estúdio arroja luz sobre los incendios em Belo Horizonte, una de las ciudades más grandes de Brasil, desde uma perspectiva sin precedentes.

Resultados – Indicar brevemente losprincipales resultados alcanzados.

Se encontró que se registraron 1.371 incendios de edificios, aproximadamente el 62,14 (852) ocurrieron en edicificios destinados a vivienda de los cuales el 76,41% (651) fueron em casa unifamiliares. Se registraron 133 incendios de edificios en la ciudad que resultaron em lesiones o muertes. Existe una prevalência de incendios com registros de lesiones ocurridas em edificios residenciales (unifamiliares y multifamiliares), que corresponde al 89,47% (119). Al comparar los registros de víctimas de incendios de CBMMG y DATASUS, ES posible ver que si todos los heridos atendidos por CBMMG ingresaran em la red hospitalaria, representaría aproximadamente el 33% Del total de hospitalizaciones registradas en DATASUS. Em cuanto al gênero de las víctimas, se observa una diferencia sutil, siendo los hombres los victimizados en aproximadamente el 53% (88) de los casos.

Contribuciones Teóricas/Metodológicas – establecer um panorama de los incendios que causan muertes y heridos en Belo Horizonte, proporcionando datos relevantes para las políticas públicas y el desarrollo de las ciudades, de forma efectiva y con capacidad de repetibilidad em otros municípios es una de las contribuciones de la investigación.

Contribuciones Sociales y Ambientales – identificar las principales superposiciones entre los incendios que causan víctimas em grandes ciudades, como Belo Horizonte, es un importante aporte a la gestión urbana y a la preservación del activo más valioso de una sociedad: la vida y integridad de sus ciudadanos.

PALABRAS CLAVE: Incendio y letalidad. Incendio en Belo Horizonte. Muertes por incendios. Víctimas de incendio.

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1 INTRODUCTION

Every year, hundreds of fire-related victims are recorded in the state of Minas Gerais. Only in 2021, there were 91 fatalities with the cause of death indicated as "exposure to smoke, fire, and flames," 22 of which were in the state capital of Minas Gerais, Belo Horizonte, representing approximately 24% of the records (DATASUS, 2023).

According to the Military Fire Department of Minas Gerais – CBMMG (2023), the corporation responds to an average of 4,000 fire incidents in urban areas in the state of Minas Gerais every year, of which about 700 occur in the state capital only. The data presented indicate the responses carried out by the state emergency and emergency agency, however, it is important to note that in some of the fires, firefighters do not act to contain the flames, which results in underreporting in the fire records in Minas Gerais.

1 Figure - Fires recorded by CBMMG in Minas Gerais

Ano	janeiro	fevereiro	março	abril	maio	junho	julho	agosto	setembro	outubro	novembro	dezembro	Total
2015	468	305	229	266	296	289	339	405	366	366	269	279	3.876
2016	253	262	280	325	298	254	384	374	353	309	235	287	3.614
2017	289	295	263	281	309	323	347	404	462	426	271	318	3.988
2018	307	272	284	329	354	334	350	377	384	321	291	326	3.929
2019	410	319	326	275	302	366	389	395	367	407	314	334	4.204
2020	264	263	264	245	278	308	333	370	536	319	339	327	3.846
2021	310	247	296	296	325	359	424	392	458	320	279	292	3.998
2022	298	241	332	356	369	365	440	437	387	460	334	282	4.301
Total	2.599	2.204	2.274	2.373	2.531	2.598	3.006	3.154	3.313	2.928	2.332	2.445	31.756

Source: CINDS/CBMMG (2023).

According to World Fire Statistics No. 28, a report published by the International Association of Fire and Rescue Services - IAFRS/CTIF (2023), which compiles statistical data on fire incidents in various countries, approximately 84.6% of deaths and 73.7% of injuries in urban fires occur in residential buildings, whether single-family or multi-family. This prevalence of victims in residential buildings raises a red flag for fire departments in Brazil, since there is a regulatory gap regarding the application of fire safety measures in homes, as pointed out by Menezes and Corrêa (2022).

The Military Fire Department of Minas Gerais (CBMMG) regulates and standardizes fire and panic prevention actions in the state of Minas Gerais through Technical Instructions (TI), which indicate which safety measures should be implemented in buildings and which parameters should be followed. The purpose of the TIs is to preserve the safety of people and property, in that order, in order to reduce the risk of death in fires.

Despite the existence of regulatory instruments to reduce the risk of death in fires through preventive fire and panic safety measures, there is a gap in the technical standards applicable to single-family buildings, i.e., buildings intended for the habitation of a single family unit not located in villages or in conjunction with other dwellings. Residential fires are not covered by any of the current standards and are not the subject of public policies at the state or municipal level, highlighting an omission by th nd municipal authorities on this issue within the study perimeter of the city of Belo Horizonte, the political and administrative capital of Minas Gerais.

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Understanding the sociodemographic profile of fire victims in the city of Belo Horizonte, geographical indicators of the location of the occurrence, and the construction, use, and occupancy characteristics of buildings are necessary actions for proposing preventive measures and assertive public policies. Therefore, it is essential to understand how fires occur and under what circumstances people become victims in these events, so that measures and actions can be developed to reduce the risk of fire in cities.

2 LITERATURE REVIEW

The development experienced by human groups after the domestication and use of fire in everyday activities is unquestionable, whether to access more nutritious food, for protection in severe weather conditions, or when attacked by predatory animals (Xiong, Zhang, and Liu, 2022). Even today, fire management is present daily in most homes and is the basis of many industrial processes in the contemporary world.

Just as relevant as the benefits experienced through the conscious use and management of fire is the severity of the damage caused by uncontrolled fire: wildfires. Wildfires are part of the history of urbanization and cities. Some episodes, such as the great fires that struck London in 1666 and Chicago in 1871, have become historical landmarks due to the extensive devastation and large number of deaths caused (Lima and Neto, 2017; Mastropieri, 2016).

Currently, the risk of fire in cities is still considered a risk factor for urban life. A study conducted by Corrêa (2024) indicates that in the 2017-2019 triennium, the Brazilian Fire Department responded to more than 730,000 fires and more than 2,700 people died as a result of these incidents, about 900 deaths per year. In the state of Minas Gerais alone, there were more than 20,000 incidents and 268 lives lost, about 90 deaths each year as a result of fires.

Bispo *et al*. (2023) add that fires cause direct damage (deaths, injuries, and property loss) and indirect damage (homelessness and unemployment), which corroborates Jennings' (2013) assertion that fire is a physical and social phenomenon.

According to Xiong, Zhang, and Liu (2022), urban fires threaten public safety and the social development of communities, especially in underdeveloped and developing countries. Among the various types of fires typical of the urban environment, fires in residential buildings are the most notable due to their frequency and the number of fatalities and injuries. Studies characterizing urban fires around the globe point to the prevalence of fires in family homes as responsible for most of the fatalities or injuries.

Primo and Rodrigues (2013), for example, produced a study characterizing the risk of urban fires in the city of Porto, Portugal, by analyzing fires recorded between 1996 and 2006. The authors concluded that 86% of recorded deaths and 73% of injuries in fires occurred in residential buildings.

Although residential fires are potentially more dangerous to people, in general, residential buildings are not covered by local fire and panic prevention legislation and, in many cases, are not subject to any regulations, as pointed out by Menezes and Corrêa (2022). Santos (2016) adds that single-family buildings are more susceptible to fire risk because they generally

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lack compartmentalization measures or preventive systems when compared to multi-family buildings and industrial fires.

In addition, uncontrolled urbanization and lack of urban planning contribute to an increased risk of fire in cities. As conglomerates are formed and substandard residences are built, which in many cases do not respect minimum isolation spacing between housing units, there is a greater risk of fires spreading and causing greater potential damage. Another risk factor is related to materials commonly found in substandard housing units, such as pallets, demolition wood, cardboard, among others, which increase the fire load on site and contribute to the rapid spread of flames (Primo and Rodrigues, 2013).

According to Xiong, Zhang, and Liu (2022), fires occur on a specific spatial and temporal scale, which allows them to be characterized in time and space. In addition, further study of fires as physical and social phenomena allows for the identification of factors related to the incidence of fires in urban environments and the severity of damage in terms of economic losses and human lives.

To paraphrase Menezes and Corrêa (2022), the “cruelest face” of urban fires is the people affected by the flames or combustion gases. Understanding how fires with victims occur in territories and what factors are related to this process contributes to the characterization of fires as physical and social phenomena, as argued by Jennings (2013). It is clear, then, that studying fire records over time is essential for developing more effective fire prevention measures, improving building construction methods, and developing appropriate regulatory standards (Xiong, Zhange Liu, 2022), as well as providing first responders (firefighters) with important information for refining tactics and, consequently, increasing the effectiveness of their actions.

2.1 Focus of the study: Belo Horizonte

The locus of this study is the city of Belo Horizonte, capital of the state of Minas Gerais. Located in the Southeast region, Belo Horizonte is the sixth largest city in Brazil in terms of population and, together with 33 other municipalities, forms the Belo Horizonte Metropolitan Region (RMBH). According to the IBGE (2023), Belo Horizonte has a resident population of approximately 2.3 million people, distributed over a territorial area of 331,354 km², which represents a population density of 6,988.18 inhabitants/m², second only to Fortaleza and São Paulo.

Population density was identified by Hu *et al*. (2019) as a socioeconomic factor that directly impacts the risk of fire in cities. According to the authors, the larger the population and industrialization, the greater the risk of fire, since the origin of fire s related to people or companies. Corrêa (2024) also adds that the number of deaths in fires tends to be higher in states with larger populations and large urban agglomerations, which shows that population density is a risk factor for the occurrence of fires and their consequent higher lethality.

The founding of the capital of Minas Gerais in 1897 was the promise of a new era and coincided with the beginning of the Brazilian Republic. The urban planning of Belo Horizonte was notable for its orderly layout, known as a "chessboard," which externalized the ideals of republicanism and modernity (Simão and Gonçalves, 2019). The city was inspired by the great

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urban metropolises of the time, especially Paris and Washington, and was based on the fundamental principles of order, progress, and hygiene (Fernandes, 2021). The urban project provided for socio-spatial segregation by creating urban, suburban, and rural zones, which ultimately paved the way for Belo Horizonte to become the metropolis it is today.

According to Fernandes (2021), Belo Horizonte was initially designed to be the administrative center of the state of Minas Gerais and to house a population of about 200,000 inhabitants, including the elite and civil servants. Over the years, the policy of selling lots and providing access to housing, the poor and slow construction of basic urban services such as sanitation systems, migratory movements stimulated especially by the intense rural exodus of the time, the process of industrialization, among other factors, led to exaggerated and disorderly population growth in the then-recent capital of Minas Gerais (Brito and Souza, 2005), reaching 2 million inhabitants in the 20th century, far beyond the capacity that had been planned. As a result, there was extensive occupation of risk areas, the emergence of slums, and the favelization of crowded areas, bringing with it the obvious hallmark of these locations: precarious and substandard housing.

According to the Belo Horizonte Urban Development and Housing Company (Urbel), in 2021, about 20% of the municipality's population was distributed across 218 settlements of villages, slums, and irregular housing complexes, in about 120,000 households, with an estimated population of 480,000 people (PBH, 2021). This urban distribution in Belo Horizonte may contribute to an increase in the number of fires, according to a study by Corrêa (2024), which suggests that the number of fire deaths tends to be higher in states with larger populations and large urban agglomerations.

The city of Belo Horizonte was the first planned city in the country and was conceived as an ideal place to live. Although considered a model at the time, Belo Horizonte was inaugurated without a fire department, which would soon become evident. According to the CBMMG Centennial Book (Minas Gerais, 2013c), four months after the official inauguration of the capital of Minas Gerais, Belo Horizonte already faced its first fire, at the Police Brigade Headquarters, causing considerable economic damage at the time. In addition to the fire at the Police Brigade Headquarters, between 1898 and 1908, other major fires were recorded in the capital, such as a fire in a bar near the Station that caused two fatalities and the fire at the Grande Hotel, a very luxurious building in the city center, which was completely destroyed by the flames (Minas Gerais, 2013c). In light of these events, the population and the local press began to question the absence of a fire department in the capital, which culminated in the signing of Law 557 in 1911, creating the Fire Department, the first step towards what is now the Military Fire Department of Minas Gerais.

The creation of the Fire Department marked the beginning of the structuring of the fire service in Minas Gerais. Although the law was signed in 1911, Belo Horizonte only had firefighters effectively operating from February 1913 (Minas Gerais, 2013c). The challenges faced at the time, proportionally speaking, were similar to those faced today, such as difficulties in activating and determining when to activate the fire department, lack of water, incompatibility of materials, and insufficient equipment. In 1930, the CBMMG began the process of expanding into the interior of the state (Minas Gerais, 2013c), and by 2023, it was already present in 89 of the 853 municipalities in Minas Gerais, according to the 5th Edition of

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the Minas Gerais Military Fire Department Command Plan, a document that outlines the institution's strategic planning (Minas Gerais, 2023).

Of the various incidents handled by the corporation, fighting urban fires is one of the most noteworthy. According to the Firefighters in Numbers Panel (CINDS CBMMG, 2024), the CBMMG responded to almost 200,000 incidents related to urban fires between 2008 and February 2024, which corresponds to more than 12,000 reports each year, or about 30 fires every day.

It is interesting to note that even though there are a significant number of fires in the state of Minas Gerais and in the city of Belo Horizonte, the Urban Quality of Life Index (IQVU), established by the city government since 1990, does not account for them or give them any weight in its map of indicators. Meanwhile, 'crimes against people', 'traffic accidents' and even 'geological risks of the terrain' are observed (Santos and Gallo, 2018, p.91).

3 METHODOLOGY

To achieve the objectives proposed by the research, a survey was conducted of building fires recorded in the city of Belo Horizonte between 2021 and 2022, through the analysis of the Social Defense Event Records (REDS/DIAO) (CBMMG, 2023b) produced by the CBMMG garrisons. The data were tabulated and analyzed with Microsoft Excel® software using descriptive statistics to identify patterns and trends, especially those related to factors that contribute to people being injured or killed in urban building fires.

Like Menezes and Corrêa (2022), this study also uses the hypothetical deductive logic presented by Marconi and Lakatos (2015), as it seeks a relationship between fires with deaths and injuries and the characterization of these occurrences in time and space, through the collection of data to prove the hypotheses raised.

Two distinct databases were made available by the CBMMG, one with all incidents of fires in buildings recorded in Belo Horizonte in 2021 and 2022, and another with all incidents of fires in buildings that resulted in injuries or deaths in the same location and study period.

The database provided by CBMMG includes the types of records presented in Table 1 and specified by the Integrated Action and Operations Guideline – DIAO (Minas Gerais, 2023b). Given the scope of the work, some types belonging to Group O 02.000 – Urban Fire were excluded from the analysis, as they are not related to fires in buildings.

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Table 1 - Types of Group O 02.000 evaluated in the study

No.	Types	Status
1	O 02.001 - Fire in a single-family residence/dwelling (house)	Evaluated
2	O 02.002 - Fire in a multi-family residence/dwelling (apartment)	Evaluated
3	O 02.003 - Fire in commercial building	Evaluated
4	O 02.004 - Fire in a shopping center	Evaluated
5	O 02.005 - Fire in a bank branch / public office	Evaluated
6	O 02.006 - Fire in a school/daycare center	Evaluated
7	O 02.007 - Fire in a collective building/accommodation	Evaluated
8	O 02.008 - Fire in prison/socio-educational facilities/barracks/police stations	Evaluated
9	O 02.009 - Fire in religious/cultural/artistic locations	Evaluated
10	O 02.010 - Fire in a stadium/sports and recreation center	Evaluated
11	O 02.011 - Fire in a hospital/clinic/laboratory	Evaluated
12	O 02.012 - Fire in workshop/auto service/garage	Evaluated
13	O 02.013 - Fire in industrial building	Evaluated
14	O 02.014 - Fire in warehouses/container yard	Evaluated
15	O 02.015 - Fire in boiler room	Evaluated
16	O 02.016 - Fire in cylinders/pressure vessels	Evaluated
17	O 02.017 – Fire in storage silos	Evaluated
18	O 02.018 – Fire in a location with explosives	Evaluated
19	O 02.019 - Fire in fuel tanks/reservoirs	Not considered
20	O 02.020 - Fire in fuel/gas pipes/pipelines	Evaluated
21	O 02.021 - Fire at fuel/gas supply site	Evaluated
22	O 02.022 - Fire at passenger/cargo station/terminal	Evaluated
23	O 02.023 - Fire at waste processing site	Assessed
24	O 02.024 - Fire at power/communications center	Evaluated
25	O 02.025 - Fire in a tanker truck	Not considered
26	O 02.026 - Fire in tank car	Disregarded
27	O 02.027 - Fire in motor vehicle (except cargo tank/bus/minibus)	Disregarded
28	O 02.028 - Fire in a cash transport vehicle	Disregarded
29	O 02.029 - Fire in a railroad car (except cargo tank)	Disregarded
30	O 02.030 - Aircraft fire	Disregarded
31	O 02.031 - Fire in agricultural machinery	Disregarded
32	O 02.032 - Fire in vessels	Disregarded
33	O 02.033 - Fire in a pile of trash	Disregarded
34	O 02.034 - Fire in a dumpster / debris	Disregarded
35	O 02.035 - Fire in pile of tires	Disregarded
36	O 02.036 - Fire in a pile of wood	Disregarded
37	O 02.037 - Fire on public road / demonstrations	Disregarded
38	O 02.038 - Fire in electrical network/pole/short circuit	Disregarded
39	O 02.039 - Fire in tree trunks	Disregarded
40	O 02.040 - Fire in multiple buildings	Evaluated
41	O 02.041 - Fire in abandoned property	Evaluated
42	O 02.042 - Fire in bus/minibus	Not considered
43	O 02.999 - Other types of urban fire (specify in the history)	Evaluated

Source: Adapted from Minas Gerais (2023b)

In a similar study, Ghassempour *et al*. (2023) pointed out that the database analyzed was a limiting factor, given that many records were incomplete and inadequately coded, making it necessary to discard them. In order to avoid underreporting of fire victims due to misclassification of the nature of the incident, the histories of all records of burn victims treated by the CBMMG, coded as V 03.020 - Burn victim, were evaluated. Those related to building fires were considered in the study.

In each of the records, the type of building, time of onset of the flames, number of victims, and circumstances of the fire were noted. The victims were also characterized (age, gender, and severity of injuries) in order to identify the most vulnerable groups and possible factors that increase susceptibility to fires. The data were organized didactically into sections according to the parameters evaluated, and the results were represented graphically for better evaluation.

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According to research conducted by Ghassempour *et al*. (2023), only 27% of people hospitalized due to fires in residential buildings received care from the local fire department, which demonstrates a tendency toward underreporting when considering only emergency service data. In order to make the study more comprehensive, data was also collected from DATASUS, with the aim of identifying possible victims of building fires who were not attended to by the CBMMG and who were admitted to the hospital network.

With the records of injured or deceased individuals in hand, a geographic analysis of the incidents in which fatalities were recorded was performed by plotting the geographic coordinates on the municipality map and comparing them with the nearest CBMMG unit, thus assessing the distribution of fire department service points in the territory.

3.1 Study Limitations

The objective of the research was to characterize and analyze all building fires with deaths and injuries recorded in the city of Belo Horizonte, MG, in 2021 and 2022. It is important to note that in some cases, fire victims seek hospital care on their own or do not seek care at all, which leads to some underreporting of cases. In order to reduce underreporting, data provided by the CBMMG was cross-referenced with data provided by DATASUS.

Furthermore, even though the fire was recorded by the CBMMG, some records were incomplete or inadequate, hindering the analysis. It is important to note that the CBMMG does not yet conduct fire investigations, and the presumed cause of the fires is based on the subjective perception of the teams on site, having no legal value and limited technical and scientific value.

4 RESULTS AND DISCUSSION

This chapter presents and discusses the results obtained through the analysis of the CBMMG database on fires recorded in Belo Horizonte in 2021 and 2022.

4.1 Building Fires Recorded in Belo Horizonte in 2021 and 2022

During the period analyzed by this study, 1,371 building fires were recorded in the city of Belo Horizonte, distributed by type of building as shown in Figure 2.

The graph shows the prevalence of fires in residential buildings, with a particular focus on single-family dwellings, i.e., houses. Of the total number of fires recorded by the CBMMG (1,371), approximately 62.14% (852) occurred in residential buildings, of which 76.41% (651) were in single-family dwellings. The results are in line with the study conducted by Bispo *et al.* (2023) in Portugal, which evaluated urban fire occurrences recorded between 2013 and 2022, in which the authors concluded that 73% of the fires recorded occurred in residential buildings.

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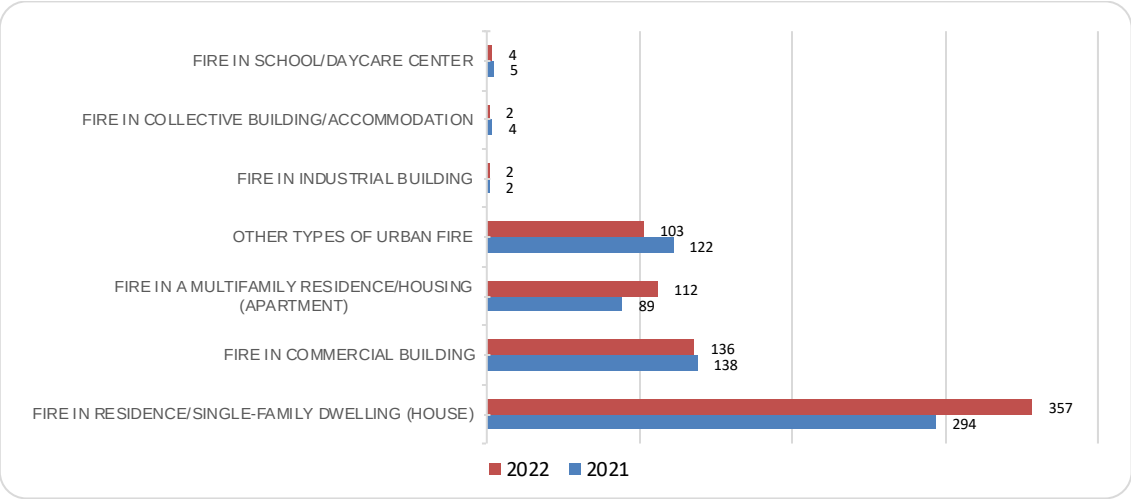
Figure 2 - Fires recorded in Belo Horizonte in 2021 and 2022



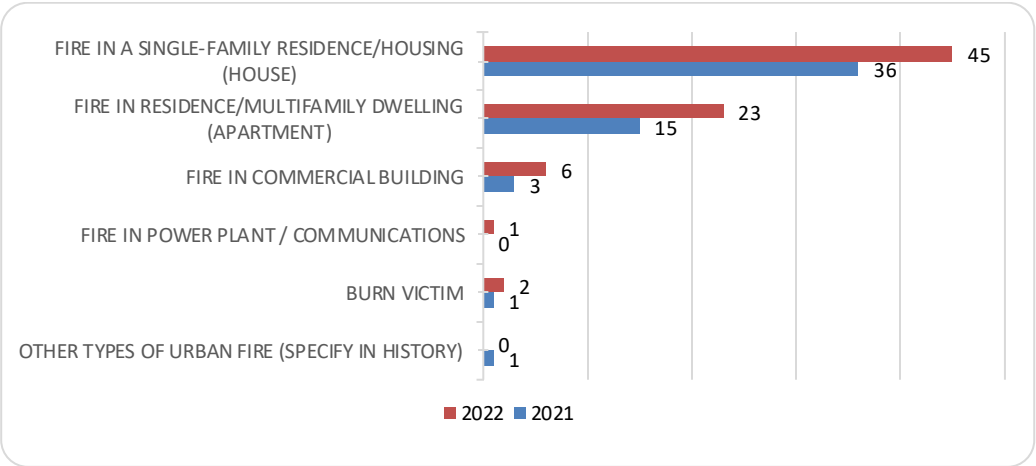
Source: Research data.

4.2 Fires in Buildings in Belo Horizonte with Deaths or Injuries

Through analysis of the database provided by CBMMG, it was found that in 2021 and 2022, there were 133 fires in buildings in the city of Belo Horizonte that resulted in injuries or deaths. Considering that the total number of fires during the period was 1,371, it can be inferred that for every 10 building fires in the city of Belo Horizonte, one resulted in injuries or deaths, which corresponds to a minimum of 10% of the incidents attended, given the likely underreporting, as already warned by Ghassempour *et al.* (2023).

Based on the sample under analysis, we evaluated which types of buildings pose the greatest risk to occupants in fire situations, as shown in Figure 3. It is possible to see the prevalence of fires with reported injuries occurring in buildings intended for housing (whether single-family or multi-family), which corresponds to 89.47% (119) of events.

Figure 3 - Types of buildings with recorded fires with victims



Source: Research data.

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4.3 Fire victims admitted to the hospital network – DATASUS

To make the study more comprehensive and assess underreporting of records when considering only one database, records of hospitalizations and deaths possibly related to fire incidents in Belo Horizonte in 2021 and 2022 were evaluated.

The DATASUS query on the number of hospitalizations and deaths used the following filters:

- By place of residence – Municipality code: 310620 Belo Horizonte
- Hospital morbidity due to external causes
- Cause group: X00-X09 Exposure to smoke, fire, and flames
- Period: 2021-2022

Table 2 - Data on hospitalizations and deaths related to exposure to smoke, fire, and flames

Criterion	Age
Hospitalizations	477
Deaths	14
Total cost	**R$ 1,505,325.32**

Source: Adapted from Ministry of Health / DATASUS (2024).

According to DATASUS, in 2021 and 2022, there were 477 hospitalizations in the Belo Horizonte hospital network and 14 deaths were recorded because of exposure to smoke, fire, and flames, conditions characteristic of victims who were injured in fire situations. The city of Belo Horizonte has hospitals that are leaders in the treatment of burn victims and receives many patients from the interior of the state for continued treatment. To consider only the residents of Belo Horizonte, the filter "by place of residence" was applied.

Table 3 - Comparison between the records of injuries and victims made by CBMMG and DATASUS

Victims	Injured	Deaths
CBMMG	158	8
DATASUS	477	14
Total	**635**	**22**

Source: Data from the 2024 survey.

Table 3 presents a comparison between the CBMMG and DATASUS records of fire victims. It can be seen that if all the injured people treated by the CBMMG were admitted to the hospital network, this would represent about 33% of the total hospitalizations recorded in DATASUS, which is in line with the findings of Ghassempour *et al.* (2023), who indicated that only 27% of people hospitalized due to residential building fires received care from the local fire department.

When evaluating the death records, the total number of deaths would be at least 22 people in two years, since deaths recorded at the scene of the incident are not recorded by the

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hospital network. In addition, it is possible that there is still underreporting if the care has already been provided by the forensic police, through the activation of forensic expertise and referral to the Medical-Legal Institute.

The death rate per million inhabitants serves as a parameter for comparing territories in relation to fire risk. Corrêa (2024) conducted a study evaluating the lethality of fires in Brazil and presented the rate of fire deaths per million inhabitants for all states, indicating that in Minas Gerais there are approximately 4.19 deaths per million inhabitants. Considering the *locus* of this study, the city of Belo Horizonte, with approximately 2.32 million inhabitants (IBGE, 2023) and that in 2021 and 2022 there were about 11 deaths per year due to fires, the death rate per million inhabitants would be around 4.78, indicating a slight increase in the risk of lethal fires in the capital when compared to the rest of the state. The result found can be justified by the increased risk of fire as population density increases, structures become more vertical, and populations become more crowded (Hu *et al.*, 2019; Corrêa, 2024).

The assessment of costs related to hospitalizations of victims who have been exposed to smoke, fire, or flames reveals that fire impacts society in many ways, proving to be a social and physical phenomenon, as pointed out by Jennings (2013). In addition to direct losses and damages resulting from the destruction of property, there is an overload of the hospital system, an impact on the labor market due to the absence of those who were injured, a social impact on the community, increased uncertainty, and urban insecurity (Hu *et al.*, 2019).

4.4 Profile of victims treated by CBMMG

In the time frame studied, the years 2021 and 2022, the CBMMG recorded 166 people injured or killed because of 133 building fires in the urban perimeter of the municipality of Belo Horizonte. It was observed that 57.83% (96) of the victims were recorded in 2022, representing an increase of approximately 37.1% (70) compared to the previous year. One hypothesis for the observed growth is the commercial recovery experienced by metropolitan areas in the post-pandemic period and the return to everyday life in cities, but it would be necessary to compare the data with the pre-pandemic period for more assertive conclusions.

4.5 Characterization of victims by gender

In analyzing the distribution of victims by gender, there was a slight difference between men and women, with men accounting for approximately 53% (88) of cases. This result corroborates the data from the National Fire Protection Association (NFPA) report Home Fire Victims by Age and Gender (Ahrens, 2021), in which 57% of fatalities and 55% of injuries were male. According to Ahrens (2021), men tend to be injured more often in fires because they take more risks than women in attempting to extinguish the flames and save others from the burning environment.

Doyle *et al.* (2019), on the other hand, studied fire-related deaths in Ireland between 2014 and 2016 and concluded that 69.65% of the victims were men and that 52% were aged

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65 or older. The authors also identified that 30% of the victims were smokers and that 73.69% were alone when the fire started, suggesting that "being a smoker" and "living alone" may be risk factors for fire deaths.

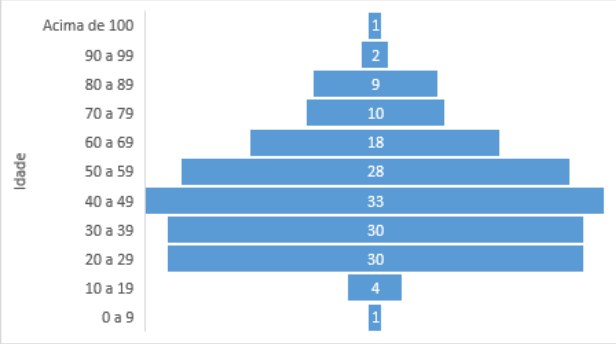
Still on the relationship between smokers and fire risk, *Diekman et al*. (2008) and Kegler *et al*. (2018) *apud* Jonsson *et al*. (2022), when analyzing records of residential fires with fatalities in Sweden between 1999 and 2018, showed that there is a correlation between the number of smokers and the risk of death in cigarette-related fires, stating that if the number of smokers decreases, the risk of death in fires will also decrease.

4.6 Characterization of victims by age group

When evaluating the age groups most affected by building fires, there is a higher concentration of victims between the ages of 20 and 60, i.e., adults, who account for 72.89% (121) of the cases recorded in the period evaluated, as shown in Figure 4.

Regarding the age groups most likely to be victims of fires, Marshall *et al*. (1998) *apud* Xiong, Bruck, and Ball (2015) indicated that children up to 5 years of age and the elderly over 64 years of age are more likely to be fatal victims in residential fires. Similarly, Doyle *et al*. (2019) indicate that in 52% of fire-related deaths in Ireland, the victims were aged 65 or older, and *Ahrens* (2021) points out that between 2015 and 2019, about 64% of fire fatalities in the United States were 65 years of age or older.

Figure 4 – Distribution of victim records by age group.



Source: Research data.

In the analyzed sample, there was some divergence from the studies cited. It is noted that 24.09% (40) of the victims injured or killed because of building fires were 60 years of age or older and that only one child was injured in the period analyzed, representing 0.6% of cases. Despite the lower number of elderly victims of fires in the period analyzed by this study, it is worth considering the study by Ghassempour *et al.* (2023), which indicates that elderly fire victims are at greater risk of dying within 30 days after the occurrence when compared to young adults with the same exposure, making it necessary to increase the level of attention to this group to reduce the risk of death from fires.

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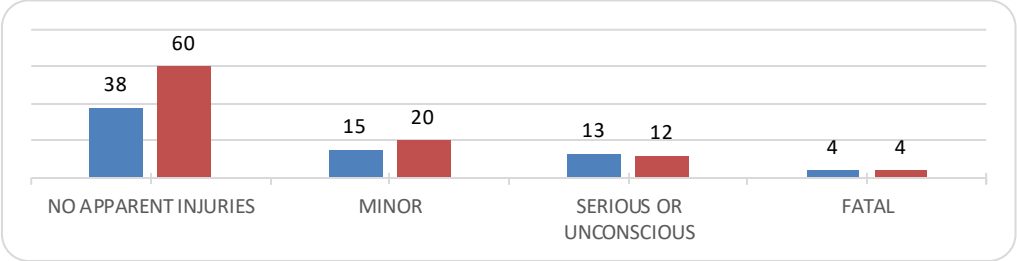
4.7 Profile of victims by degree of injury

An analysis of the profile of victims according to the degree of injury shows that there were 8 deaths among a total of 166 fire victims, representing 4.81% of cases. It is important to note that the classification of the degree of injury of victims as "Mild" or "Severe" is up to the reporter of the Social Defense Event Registry (REDS), and there is room for somewhat subjective analysis, hindering the comparative analysis between cases of mild and severe injuries. Figure 4 shows the distribution of records according to the degree of injury reported in the incident record.

In most cases, fire victims have no apparent injuries, representing 57.83% (96) of cases. The graph shows that 15.06% (25) of victims had serious injuries or were unconscious, mainly related to burns and smoke inhalation. According to Ghassempour *et al.* (2023), victims who suffer burns because of fire situations are 25% more likely to face prolonged hospitalizations for recovery, and when the injuries are associated with smoke inhalation and airway burns, this probability increases to 90%.

Figure 5 – Distribution of victim records by degree of injury



Source: Research data.

4.8 Profile of fatal victims recorded by CBMMG

During the period analyzed by the survey, four fatalities were recorded by the CBMMG each year because of building fires. The data presented in Table 4 does not include those who were injured in fires and died in health facilities, but rather cases in which death was confirmed at the scene of the accident and the CBMMG was present and recorded the event.

Table 4–Records of fatalities in fires

Occurrence	Year	Nature	Age	Gender	Time
1	2021	Fire in a single-family residence/dwelling (house)	64	M	02:58:56
2	2021	Fire in a single-family residence/dwelling (house)	48	M	11:38:09
3	2021	Fire in a single-family residence/dwelling (house)	67	F	07:33:52
4	2022	Fire in a single-family residence/dwelling (house)	49	F	04:22:24
5	2022	Fire in a single-family residence/dwelling (house)	47	M	1:50:26
6	2022	Fire in a single-family residence/dwelling (house)	45	M	3:43:13
7	2022	Fire in a single-family residence/dwelling (house)	65	M	6
8	2021	Fire in commercial building	30	M	10:28 p.m.

Source: Research data.

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The data presented in Table 4 shows the prevalence of deaths due to fires in single-family residences, representing about 87.50% of fatalities. The result is in line with the studies by Menezes and Corrêa (2022), in the Recife Metropolitan Region (RMR), and Doyle *et al*. (2019) in Ireland, which found that 94% and 97.92% of deaths recorded because of building fires occurred in single-family dwellings, respectively.

Similarly, the results indicate that 75% of fatalities were male, like the results obtained by Doyle *et al*. (2019) and Menezes and Corrêa (2022), 69.65% and 68.75%, respectively. This prevalence of men as fatal victims of fires can be explained by the tendency of men to take more risks than women in attempting to extinguish flames, as suggested by Ahrens (2021). In addition, other factors such as alcoholism were identified by Doyle *et al.* (2019) in a significant number of fatal victims of fires, most of whom were men.

Regarding the ages of the victims, Marshall *et al*. (1998) *apud* Xiong, Bruck & Ball (2015) concluded that children up to 5 years old and the elderly over 64 are more likely to be fatal victims in residential fires. This vulnerability of children and the elderly can be explained by the greater difficulty of mobility of these groups, which would make it difficult to escape quickly from uncontrolled fire situations. In this study, it was not possible to confirm the hypothesis of Xiong, Bruck, and Ball (2015) in the period analyzed in relation to children. As for the elderly, it was observed that 37.5% of fatalities were in the 64+ age group, confirming the author's hypothesis.

Corrêa, Silva, and Pires (2017) analyzed building fires that caused deaths in the city of Recife in 2011. The authors concluded that there was one death for every 135 fires recorded in the city. In the case of Belo Horizonte, there were 1,371 fires and 8 deaths, which corresponds to 1 death for every 171 fires recorded by the CBMMG, suggesting a higher risk of death in building fires in Belo Horizonte.

To deepen the understanding of the circumstances in which people are fatally injured in urban fires, the histories reported in the records of incidents with fatalities in 2021 and 2022 were analyzed. Table 5 presents a summary of the information consulted in the records and allows for some analysis.

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Table 5 – Detailed history of incidents with fatalities

Occurrence	Age	Gender	Time	Neighborhood	History
1	64	Male	02:58:56	Alto Vera Cruz	Fire in a three-story residential building, body found in the burned room (bedroom, 1st floor) during the aftermath. It was the parent of the resident of the residence.
2	48	Male	11:38:09	Jardim Guanabara	Fire in a single-family residence in one room. Upon arrival of the fire department and commencement of searches inside the residence, the victim was located inside a bathroom in the room where the fire had occurred, with burns and already in cardiac arrest.
3	67	Female	07:33:52	Imbaúbas	Fire in a single-family residence; the flames were fought by locals, and in the aftermath, a charred body was found on what appeared to be a bed.
4	49	Female	04:22:24	Jaqueline	Fire in a residence (occupied shed). Upon arrival of the fire department and control of the flames, a charred body was found in a bedroom.
5	47	Male	1:50:26	Ribeiro de Abreu	Fire in a two-story residence, victim found charred in bed in one of the rooms, where the fire started. According to family members, the victim had reduced mobility.
6	45	Male	3:43:13	Pompeia	Fire in a single-family residence, the flames were fought by locals, and in the aftermath, firefighters found a charred body on a bed in the burned room.
7	65	Male	6:19:46	Novo Glória	Fire in a single-family residence. After extinguishing the flames, a charred victim was found in the room where the fire broke out (bedroom), possibly on a bed.
8	30	Male	10:28	Downtown	Fire in a hotel room in downtown Belo Horizonte. Upon arrival of the fire department and search of the property, the victim was found inside the bathroom with burns and already in cardiac arrest.

Source: Research data.

By reading the Social Defense Event Record (REDS) for each of the incidents, it was possible to identify the neighborhood and further details described in the history reported in the record. Although there is no specific field on the REDS form to enter the room where the fire started, the histories provided made it possible to identify that in all situations the fires started in rooms used as bedrooms, which is in line with the studies by Xiong, Bruck, and Ball (2015), who indicated that fires that start in bedrooms are more likely to cause fatalities.

In addition, it was observed that, of the eight fatalities recorded, only in two cases (Incidents 2 and 8) (25%) were the fire department crews able to carry out fire rescue operations and remove them from the burning environment while still fighting the flames, finding them in the bathroom, which indicates that the victims identified the fire situation and sought shelter in the cool areas of the residence. Fire rescue operations are directly related to the response time of the crew involved and depend on several factors, such as the allocation of fire stations in the territory.

A study by Xiong, Zhang, and Liu (2022) points out that most deaths and injuries in fires occur due to delays in rescue and reduced mobility of victims. In fact, the other victims (Incidents 1, 3, 4, 5, 6, and 7) recorded in the time frame of this study were found charred and inside rooms (75%), with four of them (66.7%) found on the bed (Incidents 3, 5, 6, and 7). The way the charred victims were found may indicate that they had difficulty discerning the fire situation due to possible alcohol and other drug abuse (Doyle *et al.*, 2019) or difficulty evacuating the site due to reduced mobility (Xiong, Zhang and Liu, 2022).

In one of the cases (Occurrence 5), family members stated that the victim had reduced mobility, which may have contributed to them becoming a victim of the fire. In addition, all victims found charred were 45 years of age or older, which is in line with a study by Runefors, Jonsson, and Bonander (2021), which states that the risk of older people dying in

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fires is significantly higher than that of young people, largely due to the reduced mobility associated with older age.

Although one fatality was recorded in a fire in a commercial building (Occurrence 8), after consulting the history of the occurrence, it was noted that the dynamics of the fire were very similar to the other records, as it was also a fire that started in rooms used as bedrooms. It is important to note that, even though it was a commercial building of the "hotel" type and complied with the fire and panic safety legislation in force at the time, the protective measures in place were not sufficient to prevent the guest from becoming a victim of the fire. This can be explained by the fact that preventive measures were designed and planned for common areas, rarely covering the interior of rooms and apartments.

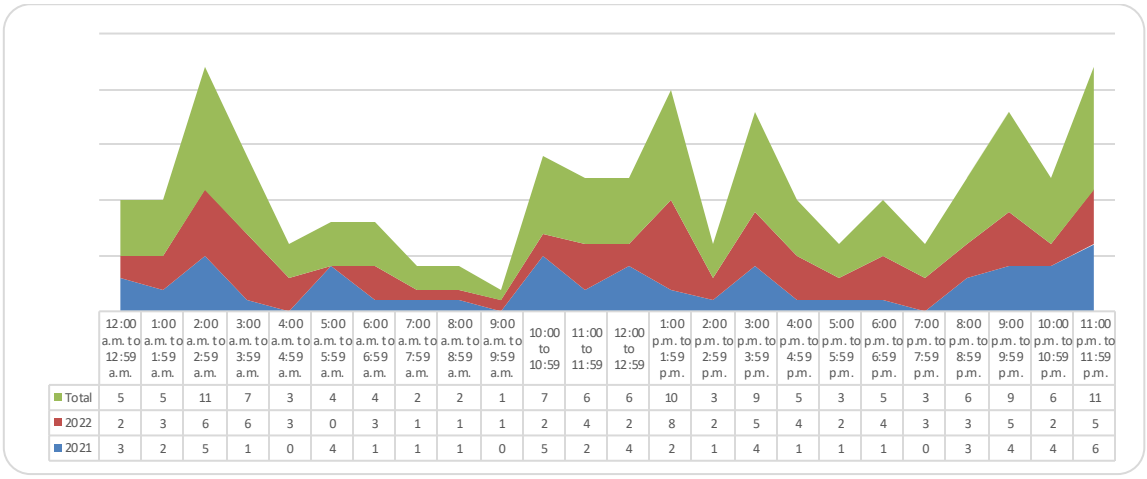
4.9 Temporal analysis of fires with victims in Belo Horizonte

According to Xiong, Zhang, and Liu (2022), fires occur on a specific spatial and temporal scale, with striking spatial and temporal characteristics. To investigate the existence of patterns or trends related to the distribution of fires with fatalities and injuries over time, the data was organized based on the time of recording, day of the week, and month of the year.

4.9.1 Distribution of fires throughout the day

The fire characterization study sought to identify temporal patterns in the occurrence of fires with victims in Belo Horizonte. To assess the times with the highest incidence of building fires, the records were distributed according to the time recorded as the “time of the incident,” corresponding to the moment when the fire started or when someone became aware of it and called the CBMMG via the three-digit number 193.

Figure 6 - Distribution of fires by time of day



	12:00 a.m. to 12:59 a.m.	1:00 a.m. to 1:59 a.m.	2:00 a.m. to 2:59 a.m.	3:00 a.m. to 3:59 a.m.	4:00 a.m. to 4:59 a.m.	5:00 a.m. to 5:59 a.m.	6:00 a.m. to 6:59 a.m.	7:00 a.m. to 7:59 a.m.	8:00 a.m. to 8:59 a.m.	9:00 a.m. to 9:59 a.m.	10:00 to 10:59	11:00 to 11:59	12:00 to 12:59	1:00 p.m. to 1:59 p.m.	2:00 p.m. to 2:59 p.m.	3:00 p.m. to 3:59 p.m.	4:00 p.m. to 4:59 p.m.	5:00 p.m. to 5:59 p.m.	6:00 p.m. to 6:59 p.m.	7:00 p.m. to 7:59 p.m.	8:00 p.m. to 8:59 p.m.	9:00 p.m. to 9:59 p.m.	10:00 p.m. to 10:59 p.m.	11:00 p.m. to 11:59 p.m.
Total	5	5	11	7	3	4	4	2	2	1	7	6	6	10	3	9	5	3	5	3	6	9	6	11
2022	2	3	6	6	3	0	3	1	1	1	2	4	2	8	2	5	4	2	4	3	3	5	2	5
2021	3	2	5	1	0	4	1	1	1	0	5	2	4	2	1	4	1	1	1	0	3	4	4	6

Source: Research data.

The data presented in Figure 5 show the distribution of fire incidents with victims in Belo Horizonte according to the time recorded as the "time of the incident." In a similar

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analysis, Menezes and Corrêa (2022) observed that 43% of fires with deaths or injuries in the Recife Metropolitan Region occur between 9:00 p.m. and 6:00 a.m. When analyzing the same period in Belo Horizonte, it is possible to verify that 61 fires were recorded between 9:00 p.m. and 6:00 a.m., which corresponds to 45.9% of the events, a result like that found by the authors in the Recife Metropolitan Region. According to the researchers, this result is to be expected, as most people are asleep or have reduced attention at night.

On the other hand, Zhang and Liu (2022) pointed out that fires occur more frequently between 10:00 a.m. and 10:00 p.m., which coincides with the period when people are most active. In this study, it was observed that about 54% of fires occurred between 10:00 a.m. and 10:00 p.m., as in the mentioned study.

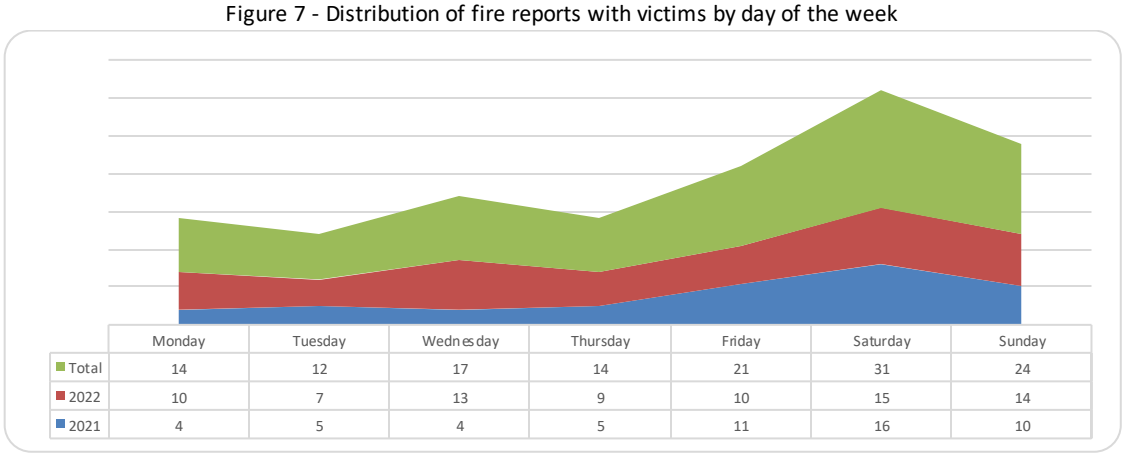
When analyzing the daytime period, considered between 6:00 a.m. and 6:00 p.m., it was observed that 43.6% of the fires with fatalities or injuries analyzed by this study occurred during the day. According to Clare, Jennings, and Garis (2018), if a fire occurs during the daytime, the probability of it spreading to other rooms falls by 64%, and material losses due to the fire fall by 41%.

According to Xiong, Zhang, and Liu (2022), fires that occur between 10:00 p.m. and 4:00 a.m. cause more economic damage and deaths/injuries, which can be explained by the late identification of the start of the fire, leading to severe fires. An effective measure to reduce the risk of people being injured or killed in residential fires could be the presence of smoke detectors in rooms, as the equipment reduces the probability of a residential fire spreading to other rooms by 71%, according to a study by Clare, Jennings, and Garis (2018).

4.9.2 Distribution of fires throughout the week

In assessing the distribution of fire incidents with victims throughout the week, a certain upward trend was observed in the number of daily records as the end of the week approached, with a peak in records on Saturday, around 31 fires, representing 23.31% of the sample, as shown in Figure 6.

Figure 7 - Distribution of fire reports with victims by day of the week



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Total	14	12	17	14	21	31	24
2022	10	7	13	9	10	15	14
2021	4	5	4	5	11	16	10

Source: Research data.

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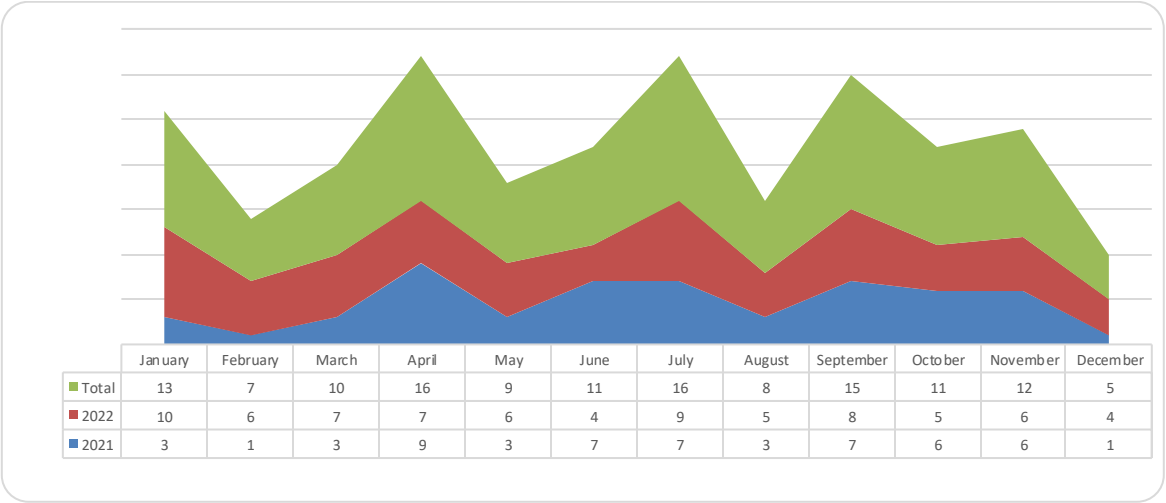
When comparing weekend records (Saturday and Sunday) and weekday records (other days), only two days account for 40% of occurrences. This discrepancy can be explained by the higher probability of people being at home and therefore ending up injured in fires, which is a preliminary hypothesis.

Another hypothesis may be that alcohol and other drug consumption tends to be higher on weekends, which is a factor that increases the risk of people being injured or killed in fires, as pointed out by Doyle *et al.* (2019).

4.9.3 Distribution of fires throughout the year

Several studies on the characterization of urban fires in buildings indicate a certain seasonality of occurrences, according to the months of the year. In the sample analyzed, it was possible to observe a higher number of records in the months of April, July, and September. Together, these months account for more than a third of the fires recorded, about 35.3% (47). On the other hand, the months of February, August, and December together account for 15.03% (20). Some hypotheses may help to interpret the results, such as the fact that February is the month with the fewest days in the year, but there is a need for more in-depth studies on the causes of fires to understand this apparent seasonality.

Figure 8 - Distribution of fire records in buildings with victims throughout the year



	January	February	March	April	May	June	July	August	September	October	November	December
Total	13	7	10	16	9	11	16	8	15	11	12	5
2022	10	6	7	7	6	4	9	5	8	5	6	4
2021	3	1	3	9	3	7	7	3	7	6	6	1

Source: Research data.

4.10 Spatial distribution of fatalities

Analyzing the occurrences of fires with fatalities in the city of Belo Horizonte, it is possible to relate urban planning to the occurrences studied. Among those that resulted in the death of people in fire situations, all occurrences in residential buildings took place in the unplanned part of the city of Belo Horizonte, that is, outside Avenida do Contorno, as shown in Figure 8.

This can be related to the disorderly urban growth experienced by Belo Horizonte throughout the 20th century, when planned areas no longer met housing demand, leading to

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the occupation of extensive areas of risk and locations unsuitable for housing (Brito and Souza, 2005). This led to the emergence of slums and the favelization of crowded areas, bringing with it the obvious hallmark of these locations: precarious and substandard housing.

In the incidents analyzed in this study, it is noted that some of the neighborhoods that recorded deaths in fires are in marginalized areas, and one of the deaths occurred in a clandestine occupation zone (Incident 4). According to the history described in REDS, the fire crews had difficulty locating the scene of the incident due to the lack of street identification and building numbering, and it was not possible for the fire truck to access the site, making it necessary to extinguish the flames using buckets of water and residential hoses.

It is important to note that the lack of urban infrastructure for firefighting impairs the quality of service and exposes firefighters to unsafe working conditions. In addition, it increases the risk of people being injured or killed in fires, as it impairs the response time of rescue teams and severely impacts the development of the fire. Clare, Jennings, and Garis (2018) estimate, for example, that for every 1-minute increase in response time, the chances of the fire spreading to other rooms increase by 17%.

Figure 8 shows the distribution of CBMMG service doors in the city of Belo Horizonte. Some areas are apparently more vulnerable, such as the North, Northeast, and Northwest regions. However, it should be noted that Belo Horizonte is surrounded by several other municipalities that make up the Belo Horizonte Metropolitan Region (RMBH) and that regions that do not have CBMMG fire stations located in are also covered by stations in neighboring municipalities, such as Contagem, Sabará, and Santa Luzia, for example.

A study by Xiong, Zhang and Liu (2022) suggests that an in-depth study should be conducted to better allocate emergency fire services, since most deaths and injuries occur due to delays in rescue and reduced mobility of victims. In addition, Clare, Jennings, and Garis (2018) indicate that the response time of emergency teams severely impacts the material losses associated with fires and estimate that for every 1 minute of additional response time, the material damage resulting from fires increases by 18%.

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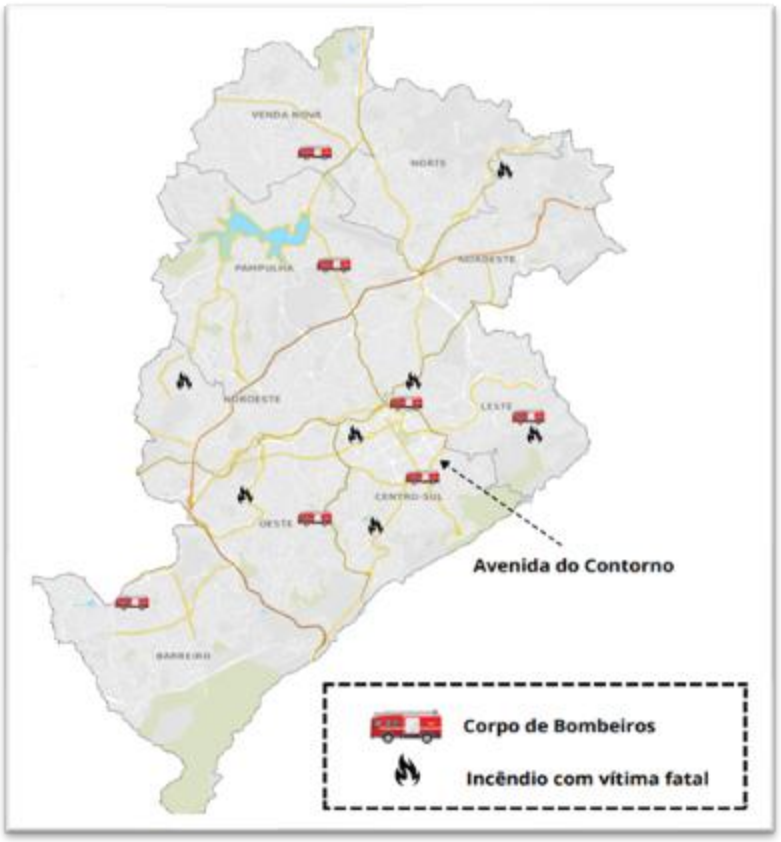
Figure 9 - Map of the city of Belo Horizonte showing the location of CBMMG fire stations and locations of fires with fatalities



Source: Research data.

5 CONCLUSIONS

This study aimed to characterize and analyze the risk of fire in the city of Belo Horizonte, based on an analysis of fire records and records of injured or fatal victims provided by the Military Fire Department of Minas Gerais for the years 2021 and 2022.

During the period analyzed, 1,371 incidents of fires in buildings were identified in the city of Belo Horizonte, with approximately 62.14% (852) occurring in residential buildings, whether single-family or multi-family. Of the fires recorded by the CBMMG, 133 resulted in fatalities and injuries, totaling 166 victims.

In terms of use and occupation, it was possible to confirm that fires with recorded injuries predominantly occurred in residential buildings (whether single-family or multi-family), accounting for 89.47% (119) of events, followed by fires in commercial buildings with 6.76% (9) of recorded victims.

The CBMMG incident records do not yet have a specific field for entering the room of origin and the dynamics of fire propagation in buildings, making more in-depth statistical analysis unfeasible. However, in relation to the recorded deaths, a detailed history of the occurrences was reviewed and it was verified that all fires that resulted in fatalities started in rooms used as bedrooms. Regarding the dynamics of flame propagation and burned materials,

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CBMMG's technical fire investigation service is still in its infancy, and it is important to further studies in this area of knowledge.

When analyzing fire records over time, the months of April, July, and September account for 35.3% (47), while February, August, and December account for 15.03% (20). Throughout the week, there is a growing trend in fire records as the weekend (Saturday and Sunday) approaches, which together account for 40% of the records. The distribution of fire reports throughout the day indicates peak times, such as from 2 a.m. to 3 a.m. and from 11 p.m. to midnight. There is also a concentration of fires with victims between 9 p.m. and 6 a.m., which accounts for 45.9% (61) of events.

By comparing the database provided by CBMMG with data available in the Ministry of Health's DATASUS system (2024), it is possible to confirm the hypothesis of underreporting of cases already pointed out by Ghassempour *et al*. (2023), who indicated that in Australia, only 27% of people hospitalized due to residential building fires received care from the local fire department. In the case of Belo Horizonte, considering that all injuries recorded by CBMMG were treated by the hospital network, only 33% of fire victims would have been treated by the fire department.

Furthermore, when the deaths recorded by the CBMMG and DATASUS are added together, there are 22 records in the analysis period, resulting in a rate of 4.78 deaths per million inhabitants each year due to fires in Belo Horizonte. Comparing the result for Belo Horizonte with the death rate per million inhabitants in Minas Gerais, indicated by Corrêa (2024) as approximately 4.19, the risk of people being victims of fires is slightly higher in the state capital than in inland cities.

Regarding fire victims, injured or killed, recorded by the CBMMG, it was found that 53% of cases were male. In terms of age groups, adults aged 20 to 60 accounted for 72.89% (121) of cases recorded in the period evaluated, while the elderly over 60 accounted for 24.09% (40) and children up to 10 years old accounted for only 0.6% (1).

When analyzing fatalities in fires, it was found that 87.5% (7) of cases were recorded outside the planned area of the city of Belo Horizonte, that is, outside the perimeter of Avenida do Contorno, suggesting that the lack of urban planning may increase the risk of people dying in fires. In addition, detailed records reveal the presence of social vulnerability, such as fires in shacks in squatter areas.

When analyzing the geographic location of incidents with fatalities and the location of fire stations, it is apparent that some areas are more vulnerable, such as the northern, northeastern, and northwestern regions of the city of Belo Horizonte, highlighting the need for more in-depth studies on the relocation of service stations and vehicles, since not all locations have adequate vehicles for fighting urban fires.

Finally, it should be noted that this study does not conclude the subject, but indicates gaps and perspectives for future research. National databases on fires still need to be consolidated, as stated by Corrêa, Silva, and Pires (2017), who recommend that national statistics on fires be implemented to build a solid and comprehensive database on this phenomenon, which is still largely unknown.

In addition, it is important that the technical fire investigation service advances so that this phenomenon can be understood in its essence, enabling the review and

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implementation of standards and procedures that increase people's safety in the face of fires, as suggested by Bispo *et al*. (2023), who state that it is crucial to understand how fires occur in order to reallocate emergency resources more efficiently.

It is worth noting that the study shows that fires with victims are more prevalent in residential buildings, which highlights the need to consider measures that can provide greater safety for residents, such as those suggested by Clare, Jennings, and Garis (2018), who state that working smoke detectors increase the chances of residents controlling fires in residential buildings before the arrival of fire crews.

Furthermore, information on fire prevention must be disseminated to reduce the number of deaths and injuries in these accidents, as stated by Xiong, Zhang, and Liu (2022). Social protection is important in preventing deaths in fires, but individuals must also be active and responsible for their own self-protection and reducing vulnerabilities (Jonsson *et al.*, 2022). Thus, with integrated action and clear communication of risks, it is possible to construct safer buildings and reduce losses and damage from uncontrolled fires.

Finally, studies that analyze the problem of fires in the city of Belo Horizonte, focusing on specific regions and even neighborhoods, as done by Bernardes and Gonçalves (2020) when studying participatory processes in the city, are understood as important steps in the debate on the issue.

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DECLARATIONS

CONTRIBUTION OF EACH AUTHOR

When describing each author's contribution to the manuscript, use the following criteria:

- **Study Conception and Design**: Jaqueline dos Santos.
- **Data Curation**: Cristiano Corrêa
- **Formal Analysis**: Jaqueline dos Santos
- **Funding Acquisition**: None
- **Investigation**: Jaqueline dos Santos
- **Methodology**: Jaqueline dos Santos and Cristiano Corrêa
- **Writing - Initial Draft**: Jaqueline dos Santos
- **Writing - Critical Review**: Cristiano Corrêa
- **Final Review and Editing**: Jaqueline dos Santos and Cristiano Corrêa
- **Supervision**: Cristiano Corrêa

DECLARATION OF CONFLICTS OF INTEREST

We, Jaqueline dos Santos and Cristiano Corrêa, declare that the manuscript entitled "**Fires with fatalities and injuries in Belo Horizonte: characterization and analysis**":

1. **Financial ties**: No institution or funding entity was involved in the development of this study.
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