

## TEN-YEAR HISTORY OF HIKING ACCIDENTS/INCIDENTS IN THE BUCEGI MOUNTAINS–SOUTHERN CARPATHIANS, ROMANIAN CARPATHIANS

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***Abstract:** Our study was conducted in the Bucegi Mountains from 2011 to 2020, using data from the Sinaia - Cota 1400 Mountain Rescue Public Service, which recorded a total of 800 rescue calls. These calls involved 360 incidents and 440 accidents, resulting in 419 victims injured and 21 deaths. Environmental conditions contributed to 398 events, while meteorological conditions were a factor in 402 events. Approximately 60% of all recorded events occurred during descent, while 3% were unrelated to the direction of travel (e.g., dog bites, bee stings, or bear sightings). Among the victims, 367 (45.8%) experienced accidents that resulted in sprains, fractures, and multiple injuries. Additionally, 260 victims (32.5%) faced incidents of exhaustion, fatigue, panic, or getting lost. There were also 88 cases (11% of the total) related to medical issues, including faintness, hypoglycemia, hypothermia, heart disease, stroke, and kidney colic. Notably, 67.9% of the victims did not have adequate equipment. Our results emphasize the multi-causal nature of the accidents that occurred in the Bucegi Mountains.*

***Key words:** accident history, hiking, trail, Bucegi Mountains, Romanian Carpathians*

### 1. INTRODUCTION

This paper represents a part of a broader research study on the tourist trails in the Bucegi and Făgăraș Mountains, conducted between 2018 and 2024 as part of the first author's doctoral thesis. Hiking is not only a popular sport in Alpine countries

(Faulhaber et al., 2020; Zürcher et al., 2020), but also in other mountainous areas. Approximately 100 million tourists visit high-altitude mountainous environments annually, and 40 million people visit the Alps at altitudes greater than 2000 m each year (Burtscher, 2001, 2008; Faulhaber et al., 2017). In Austria, several million hikers were registered (Burtscher et al., 2007), and approximately 2.7 million people practise hiking in Switzerland. Additionally, 300.000 foreign tourists visit the alpine ridges (Zürcher et al., 2020). Hiking involves walking great distances along a forest, mountain, or alpine track, and passing through ridges, snow patches, and scree fields, but does not include crossing glaciers or rock climbing with a rope (Gasser, 2019, p. 209). Hiking also involves walks through the countryside (Di Felice, 2014) or leisure summer walks (Svarstad, 2010) for aesthetic reasons (Mokras-Grabowska, 2016). Mountain hiking involving altitudinal differences and different lengths is considered to be a form of physical activity that lasts an average of two to three hours (Niedermeier et al., 2017; Schobersberger et al., 2010). Trails used for hiking are marked and constantly maintained routes (Ritter et al., 2012), and are developed as a network that represents a key component of tourist spaces (Boller et al., 2010). They are the most important type of infrastructure in protected areas, play a key role in preventing the uncontrolled dispersion of tourists (Tomczyk and Ewertowski, 2013a, b), and also represent pathways for visitors to access nature and recreational opportunities (Janočková et al., 2015; Marion and Leung, 2001). Generally, hiking trails are located below an altitude of 3000 m (Gatterer et al., 2019).

Evidence of accidents occurring during hiking, mountain-biking, mountaineering, or ski touring in the mountains of Great Britain (Kirkman, 1966), Cataluña (Rañe et al., 1989), and New Zealand (Johnston, 1989) were reported early by different authors. Hearn, (2003), described the wounds of victims rescued by the Scottish mountain rescue teams in 1998 and 1999, with an emphasis on major trauma. Other studies highlighted the causes of mountain accidents and provided evidence (Chamarro and Fernández-Castro, 2009; Knott, 2011; Mort and Godden, 2011), and have also reported the risk factors for several hundred mountaineering accidents (Vanpouille et al., 2017) and the socio-demographic/sports profiles of accident victims (Soulé et al., 2017). Studies have also been conducted on accidents occurring in the Alps and Mont Blanc (Lischke et al., 2001; Mourey et al., 2018), and the Mediterranean Pyrenees (Pascual and Callado, 2010). Hiking activities are highly popular among tourists (Gatterer et al., 2015; Heggie and Heggie, 2012; Zürcher et al., 2020; Windsor et al., 2009). However, only a few studies have focused on their associated risks, while the majority of these have focused on fatalities in high and very high mountains (Weinbruch and Nordby, 2010, 2013; Windsor et al., 2009), assessing the number of deaths (Heggie and Heggie, 2012) and falling-related accidents during mountain hiking (Faulhaber et al., 2020), falling-related accidents of tourists aged between 50 and 70 (Gasser, 2019), and the causes of the deaths of hikers at different altitudes (Zürcher et al., 2020).

In Romania, a few studies have examined avalanche accidents in the Făgăraș Mountains, Southern Carpathians (Gratton et al., 2015; Voiculescu, 2014). Lucaciu et al. (2021) assessed the safety of tourists in the Apuseni Mountains. Additionally, the impact of tourist activities on the Bucegi Mountains has been evaluated in several articles. For instance, Mihai et al. (2009) showed that geomorphological processes are accelerated due to tourist impact, while Voiculescu (2009) described current erosion processes in the alpine area. A comparative study by Fidelus-Orzechowska and

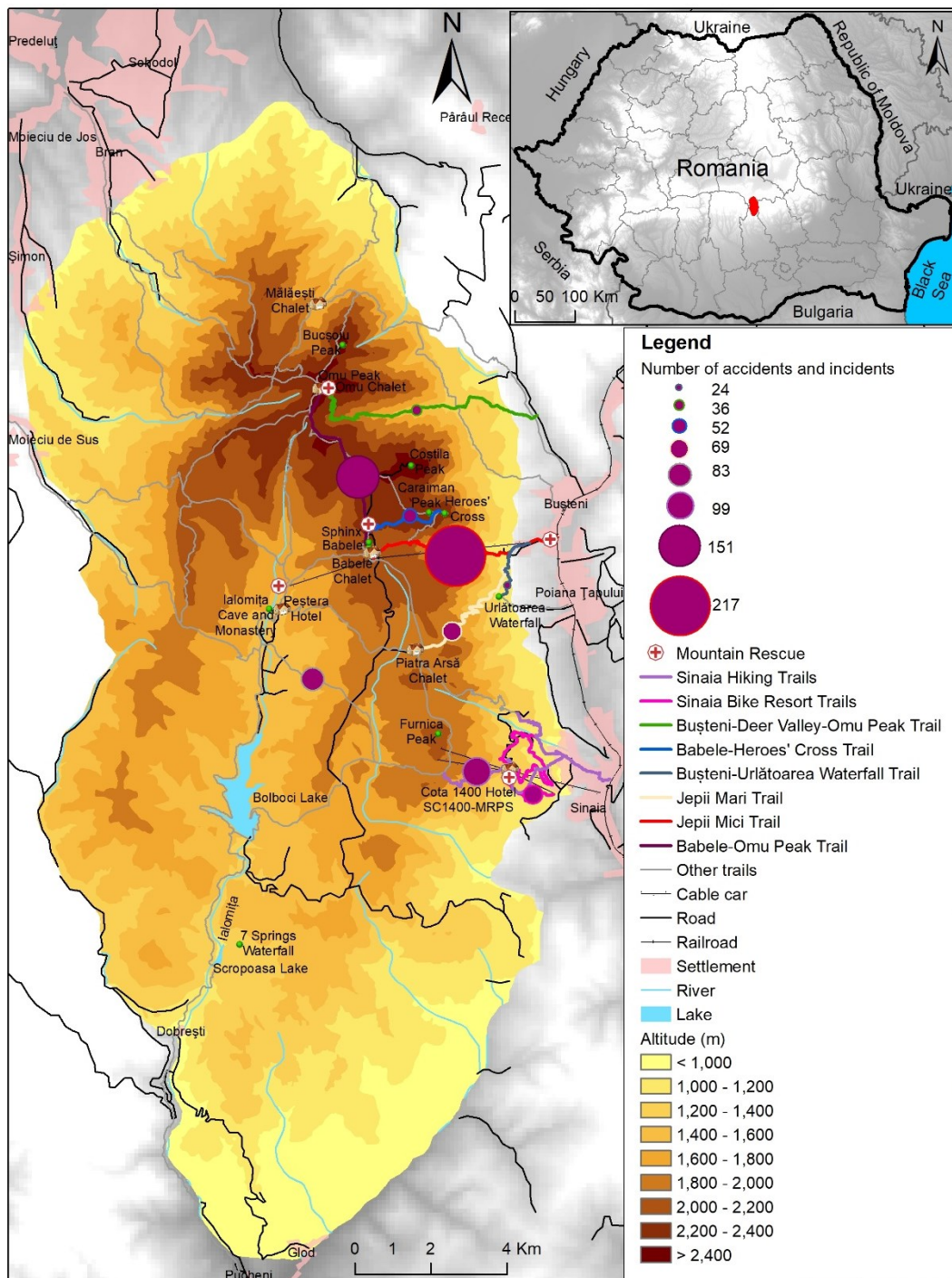
Rogowski (2012) presented the geomorphological effects of tourist traffic on the trails of the western Tatra Mountains (Poland) and the Bucegi Mountains. Also, Olariu (2019), in his PhD thesis, mapped the degraded areas on the Bucegi Plateau and analyzed the environmental impact factors, highlighting the effects of hiking. However, despite these contributions, research on accidents involving hikers and mountain bikers in Romania remains scarce. As little research has been conducted on mountain accidents (Chamarro and Fernández-Castro, 2009), our study aims to tell the ten-year story of accidents and incidents in the Bucegi Mountains and to highlight: (i) the dynamics of accidents/incidents and injured between 2011 and 2020; (ii) the role of environmental conditions in the occurrence of accidents, and (iii) the influences of the Bucegi Mountains' morphology on the characteristics of accidents and injuries.

For this purpose, the tourist trails and areas within the Bucegi Mountains where the most accidents and incidents occurred during the analyzed period have been identified, and the main factors and circumstances leading to their occurrence are presented. The study's findings include both the relationships between accidents/incidents and the factors contributing to them, as well as the main characteristics of the accidents and incidents in the Bucegi Mountains and the reasons for which the Mountain Rescue Public Service (MRPS) intervention was requested. Regarding the victims, the most common types of injuries have also been analyzed.

## 2. STUDY AREA

The Bucegi Mountains are located in the eastern extremity of the Southern Carpathians (Figure 1). The Prahova River separates them from the Eastern Carpathians. They exhibit a suspended syncline formation, with a north-south orientation in the shape of a semicircle. In the northern region of the Bucegi Mountains, the highest elevations exceed 2400-2500 m (Omu Peak - 2505 m, Bucura Peak - 2503 m and Bucșoiu Peak - 2492 m) and there are clear Quaternary glacial traces (cirques, eroded U-shaped glacial valleys and moraines). This sector is a true orographic knot with two structural cliffs, one to the east and the other to the west, with peaks exceeding 2300-2400 m, and is composed of simple and staked fronts of erosive or tectonic-erosive structures (Velcea, 1961; Velcea and Roșu, 1982). The two main escarpments have slopes greater than 45° and altitude differences of over 1000-1200 m. The eastern area is referred to as the Prahova Valley Escarpment in Romanian geographic literature (Velcea, 1961) due to its deep and narrow valleys, with waterfalls and structural thresholds, sharp ridges, and a very steep vertical profile. The central region of the Bucegi Mountains consists of a large structural plateau, with gentle slopes and altitudes that descend from north to south, ranging from 2500 to 1900-1800 m.

According to records from three long-term weather stations (Predeal, Sinaia Cota 1500 and Omu Peak), the climate is harsh in the northern region, the glacial sector, and the plateau, but moderate in the southern region. The climate of the Bucegi Mountains is dominated by humid air masses from the Atlantic Ocean and the continental influence of the Siberian anticyclone. The winter season brings cold polar air and very low temperatures (-30°C), strong winds, and snowstorms. Wet and warm air sometimes arrives from the Mediterranean, and abundant snowfalls occur (Vrânceanu, 2012).



**Figure 1.** Location of the Bucegi Mountains and the total number of accidents within specific areas

The Bucegi Mountains have been proposed as a natural park since 1938. In 1990, only their forested areas were declared a natural park by a Ministry of Waters, Forests and Environmental Protection order No. 7/27.01.1990. According to Law No. 5/2000 and government decision No. 230/2003, the Bucegi Mountains are now a fully protected area, and the national park has an area of 32,663 ha (Regia Națională a

Pădurilor, ROMSILVA 2004). The whole area is of great attractiveness in Romania for tourists interested in summer and winter sports. The first mountain chalets were constructed in 1882, and hiking, climbing, and alpine skiing activities then began. There are currently 26 chalets, 8 alpine refuges, and 7 major hiking trails in this mountainous area. There are numerous resorts popular for both summer tourism and winter sports at the periphery of the Bucegi Mountains. Additionally, the resort town of Bușteni (850 m) is located on the outskirts of the Prahova Valley Escarpment, where several hiking trails that cross the Prahova Escarpment, reach the structural plateau area, and continue to the high glacial area of the Bucegi Mountains, begin. The Bușteni resort is well known for both hiking and climbing, and is considered the “home” of mountaineering in Romania. Notably, in 2013, Romania's first bike resort serviced by a gondola lift was officially inaugurated in Sinaia. Mountain biking activities in this area began sporadically in the 1990s; however, until 2013, there were only a few temporary trails, authorized exclusively for competitions. Currently, this sport is practiced on four officially recognized trails, totaling nearly 10 kilometers. These trails have varying levels of difficulty, with some incorporating technical sections and obstacles, thus catering to multiple mountain biking styles (<https://sinaia.go.ro/bike-resort/>). Inevitably, some tourists engaging in this activity in the Bucegi Mountains fall victim to accidents, which are included in the Mountain Rescue Public Service (MRPS) statistics detailed below.

### 3. METHODOLOGY

#### 3.1. Trails and accidents

Accidents represent a considerable risk for practitioners of tourist and sports activities in mountainous areas (Chamarro and Fernández-Castro, 2009; Schad, 2000). An accident occurs when certain elements cause injury or the death of the person involved, who would require medical attention (Bentley et al., 2001; Knott, 2011). Despite all preventive measures, accidents will still occur every year, even fatal ones, during both the hot and cold seasons (Lischke et al., 2001). Accidents are the negative result of the risk of achieving an expected positive result in mountains, such as satisfying personal motivations. Therefore, risk can be considered to be a motivation for recreational activities (Johnston, 1986, 1987). The term “incident” is also used in literature, defined as *an individual or a series of mishaps that did not result in a serious accident with consequences on human life or the environment* (Mazaheri et al., 2015, p. 202), and depends on several variables, causes, and contributing factors (Knott, 2011, p. 92). Even under these conditions, incidents are reported and recorded by MRPS. A similar conceptual approach to emergencies that require an emergency call to the local MRPS by the person involved or by a person in the group who was not injured is undertaken (Faulhaber et al., 2017). Fatal accidents were found on the spot by members of both the MRPS and mountain rangers, and were then included in the statistics. All terms used, i.e., incidents, accidents, injuries, and deaths, are known as *adverse events* (Knott, 2011). Hereafter, we will employ the terms “mountain hiking” and “mountain biking”. “Mountain hiking” refers to *walking in mountainous terrain on or off tracks, usually without the need to use hands or any specific equipment to proceed* (Muhar et al., 2007, p. 8). This term is particularly appropriate for our study, as some tourist trails feature segments equipped with stairs, cables, or other safety elements that may require the use of hands and specific equipment to cling to the rocky walls. “Mountain biking”

pertains to the tourism and sports activities primarily conducted within the Bike Resort Sinaia. The accidents recorded by the MRPS, as presented hereafter, have occurred on both marked hiking and mountain biking trails as well as in off-trail areas. This study focuses on accidentology, a concept that studies accidents, their causes and characteristics, and their consequences (Mourey et al., 2018; Soulé et al., 2017; Vanpouille et al., 2017), which requires detailed knowledge of accident rates and their severity, and victim profiles (Bahr and Krosshaug, 2005; Vanpouille et al., 2017).

### 3.2. Data collection

This study was designed to tell the history of mountain accidents (injuries and death) and incidents in the Bucegi Mountains during the summer seasons (1<sup>st</sup> May to 31<sup>st</sup> October) of ten consecutive years (2011-2020) and to highlight their causes and consequences. During warmer weather, the region becomes more pleasant and tourist activity begins and intensifies. We excluded the interval between 1<sup>st</sup> November and 30<sup>th</sup> April as the hiking trails are officially closed due to snow depth, storm snows, and avalanches (Figure 2).



**Figure 2.** Display panel indicating that Jepii Mari and Jepii Mici trails are closed between 1<sup>st</sup> November and 30<sup>th</sup> April and are dedicated to well-equipped hikers (a.), and Avalanche risk (b.)

Our primary data source was the Prahova County Mountain Rescue Public Service database, with the main rescue base in Sinaia-Cota 1400 (SC1400-MRPS), from which we extracted accidents and incidents data for the analyzed time interval. The data obtained from the SC1400-MRPS covers the Prahova Valley Escarpment, the entire plateau area of the Bucegi Mountains, and some areas to the north of Omu Peak. We also acquired data from the Dâmbovița County MRPS, with the main rescue base next to Peștera cable car station, which covers the central-western part of the massif. Unfortunately, detailed data from the Dâmbovița County MRPS only covers part of the analyzed period, as it functioned as a volunteer service until 2016 when it was reorganized. Consequently, information about incidents prior to 2016, although recorded, is limited and not in a standardized format. The same applies to the northern extremity of the massif, in Brașov County, where local volunteer teams from Râșnov and Bran respond in case of emergencies. Therefore, we conducted the accident analysis

exclusively using data from the SC1400-MRPS, which has a comprehensive database over an extended observation period, well-categorized by types of accidents and incidents. As in other mountains (Gatterer et al., 2019; Lischke et al., 2001), the data in SC1400-MRPS reports are grouped by types of mountain activity (hiking, mountain biking, mountaineering, skiing, etc), location (forests, debris, rocks, ice, residual snow, etc), and whether hikers were unhurt, injured or deceased. In cases of death or disappearance, the SC1400-MRPS members are notified by a member of the group or another person arriving at the scene. We confirmed a good part of the accidents both with the original source (the SC1400-MRPS statistics) and alternative sources (local and national newspapers and TV news bulletins). We also used these elements to identify injuries, as in other cases (Faulhaber et al., 2017, 2020). We only retained the cases for which the accident date and location, cause of the accident, and identifying features of the persons involved (sex, age, and citizenship) were recorded. Thus, accidents that had brief presentations and vague or contradictory locations, were avoided.

The data utilized in this study have the advantage of being directly sourced from the Mountain Rescue Public Service (MRPS), making them the most comprehensive and complex type of data available for such situations. This direct sourcing ensures a high level of accuracy and reliability. Moreover, information concerning the location of the incidents, the reasons for the interventions, and the condition of the victims is processed by mountain rescuers who are specifically trained and possess extensive knowledge of the unique characteristics of the Bucegi Mountains. Although certain events were cross-verified with complementary sources, such as local and national media, particularly in cases of severe accidents, the specific details of accidents and incidents are comprehensively documented only within the MRPS statistics. These data are systematically organized, allowing for detailed analysis and interpretation.

### ***3.3. Personal data***

The following details for each victim were analysed: sex, age, nationality, use of adequate equipment, and whether a hiking guide was hired (yes or no).

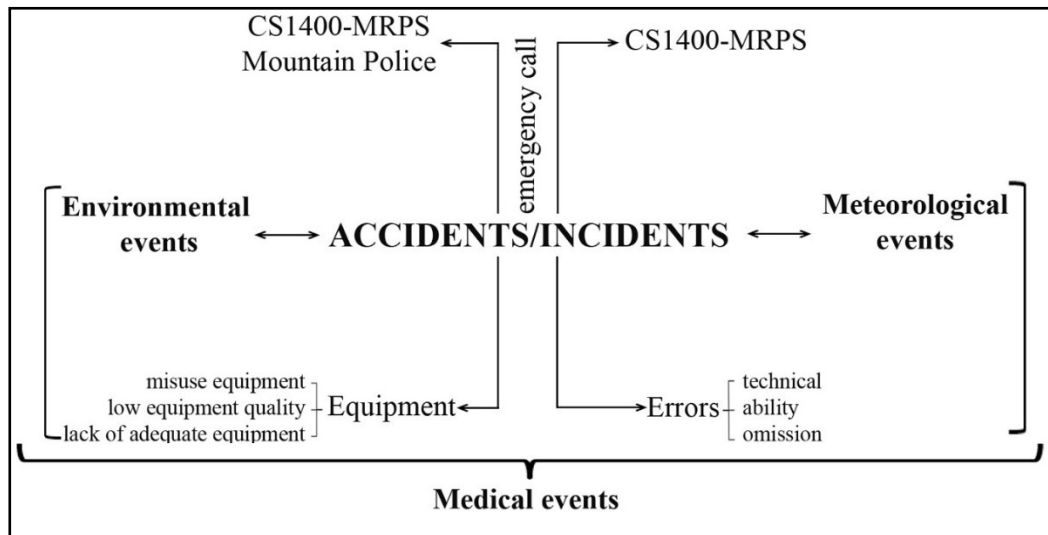
### ***3.4. Accident circumstances***

We considered the following circumstances that contribute to the onset of accidents/incidents, as described by Chamarro and Fernandez-Castro (2009); Faulhaber et al. (2017); and Zürcher et al. (2020): meteorological conditions (heavy rain, wind, fog, snowfall/sleet, snow depth), and environmental events: elements of a hiking trail (marked or outside of the hiking trail), direction (ascending or descending), day of the accident (weekday or weekend/holiday), and relief (terrain type, slippery surface, steep or high declivity, falling from rocks or grass, presence of residual snow or ice). The equipment condition was included in the SC1400-MRPS statistical file. We considered whether adequate equipment (hiking boots, backpack, sticks and clothing) was used, lacking, or of doubtful quality (used or inadequate hiking boots, such as shoes or sneakers). We also analysed some medical events for each victim, including a series of injuries (exhaustion, fatigue, panic, wandering, fractures, trauma, wounds, sprains, faintness, hypoglycaemia, hypothermia, heart disease, stroke, and kidney colic).

The method employed has the advantage of analyzing available data on accidents and incidents from multiple perspectives, capturing as many details as possible, including the terrain and weather conditions that led to rescue calls, the location and date of the events, as well as specific characteristics of the victims. This approach allows for the accurate identification of risk factors specific to hiking and mountain biking accidents in the Bucegi Mountains, enabling the adaptation of general risk-reduction measures accordingly.

#### 4. RESULTS

Most of the accidents/incidents were not due to individual factors, but to a combination of several factors, as shown in Figure 3. The multiple factors causing accidents/incidents are recorded in the SC1400-MRPS statistics for each case. In addition to environmental factors specific to the alpine mountain area of the Bucegi Mountains, we considered the lack of adequate equipment and human errors committed by hikers before and during the hike that caused accidents/incidents.



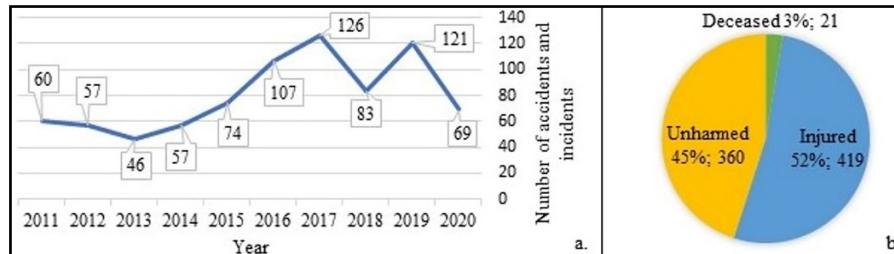
**Figure 3.** Relationship between accidents/incidents recorded by SC1400-MRPS and contributing factors

##### 4.1. Characteristics of accidents and incidents occurring between 2011 - 2020

According to the SC1400-MRPS data, 800 events occurred between 2011 and 2020 in the summer seasons. The fewest (46) occurred in 2013, while the most rescue calls were recorded in 2017 and 2019, with 126 and 121 requests, respectively. In 710 cases (88.8%), the requests came from Romanian citizens, while the remaining 90 requests were from foreign citizens from 30 countries, the majority being from the Republic of Moldova and Israel. It should be noted that in 2020, amid the pandemic, all requests came from Romanian citizens. The accidents and incidents recorded by the SC1400-MRPS are distributed by year according to Figure 4a, which shows a slight decrease at the beginning, a general upward trend, and a significant decline in 2020 during the Covid-19 pandemic. Figure 4b presents an initial classification based on the



services provided (safe escort to the base for those found wandering, stuck on the trail, and/or exhausted, medical care for the injured, and recovery of the deceased). Although requests predominantly came from injured tourists, a considerable percentage (45%) called SC1400-MRPS for other reasons (wandering, becoming stuck on the trail, or exhausted, among the most frequent).



**Figure 4.** The annual variation in the number of accidents and incidents (a.) and types of human casualties (b.)

All accidents and incidents, with the exception of a single sprain within a group of foreigners on August 19, 2016, in Deer Valley, occurred in the absence of a certified mountain guide. A considerable variation in the number of requests to SC1400-MRPS was observed depending on the days of the week, distinguishing between weekdays and non-working days (Figure 5a, b). The number of requests on non-working days (weekends and public holidays) is slightly higher than on working days (407 compared to 393). This is notable given that there are 128-129 working days each year during the analyzed period (1<sup>st</sup> May to 31<sup>st</sup> October) and only 55-56 non-working days. This indicates a significant influx of tourists on weekends and holidays compared to other days, leading to a doubling or nearly tripling of the number of requests to the SC1400-MRPS.

Regarding the distribution across vegetation zones, it can be observed that the total number of accidents and incidents during the analyzed period was equal in both forested and alpine areas (Figure 6a, b). However, the annual distribution reveals a higher incidence of rescue calls in the alpine area in recent years, which can be attributed to increased accessibility due to the paving of DJ 713 leading to the Piatra Arsă National Sports Complex. Most rescue calls (83%) occurred on tourist trails, and the number of accidents and incidents occurring off-trail remained relatively constant over the years, below 25 per year (Figure 7a, b). These cases primarily involved hikers wandering in conditions of fog or at night without a light source. Other cases include hikers frightened by the presence of bears (*Ursus arctos*), as well as rare cases of adventurers deliberately ignoring the trails. The distribution of accidents and incidents within the Bucegi Mountains stands out in Figure 1. It can be observed that over a quarter of the events (217) occurred on the most difficult marked trail of the massif, Jepii Mici, which is one of the most hazardous trails in Romania. This is followed by the area around the Babele Chalet and the trail leading from there to Omu Peak, with 151 events. Most of these accidents and incidents involved either individuals found wandering in fog - a frequent phenomenon on the plateau - or minor injuries or health issues experienced by numerous tourists lacking appropriate equipment and mountain experience, who, due to the increased accessibility of the Bucegi Plateau, underestimate the wild nature of the area. The subsequent trails in terms of number of events are Jepii Mari (69), Babele Chalet - Caraiman Peak - Heroes' Cross (52), Omu Peak - Deer

Valley - Bușteni (36), and Bușteni - Urlătoarea Waterfall (24). Noteworthy are also the 69 mountain biking accidents in the Sinaia Bike Resort area, particularly on the Happy Bear Trail, the most challenging of the resort's four trails, which reflects the increased interest in this sport. Additionally, 99 accidents and incidents, predominantly minor, occurred on hiking trails originating from Sinaia. These were particularly prevalent on the following two trails: The Royal Trail to Poiana Stănei, a paved trail with a slight slope, and the Summer Road, a forest road used for both hiking and mountain biking, which ascends from Sinaia to the alpine area at an elevation of 2000 m.

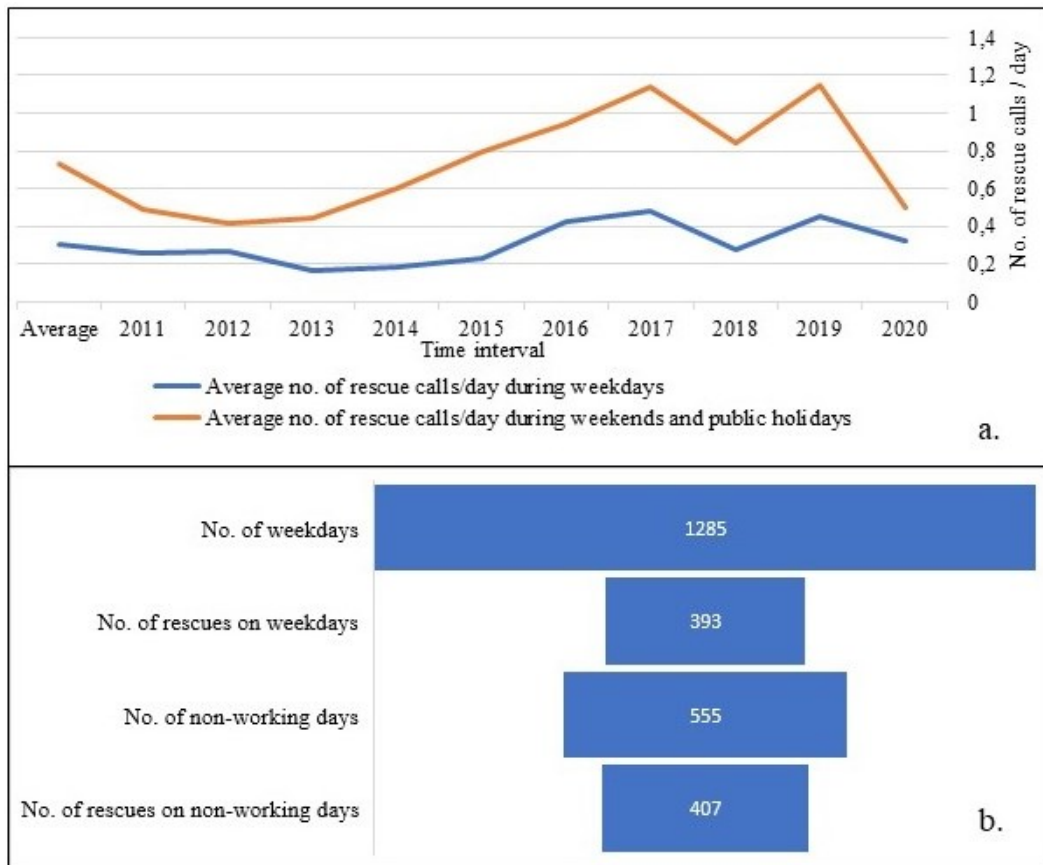


Figure 5. The average number of SC1400-MRPS requests on working and non-working days (a.), and the total number of SC1400-MRPS requests on working and non-working days (b.)

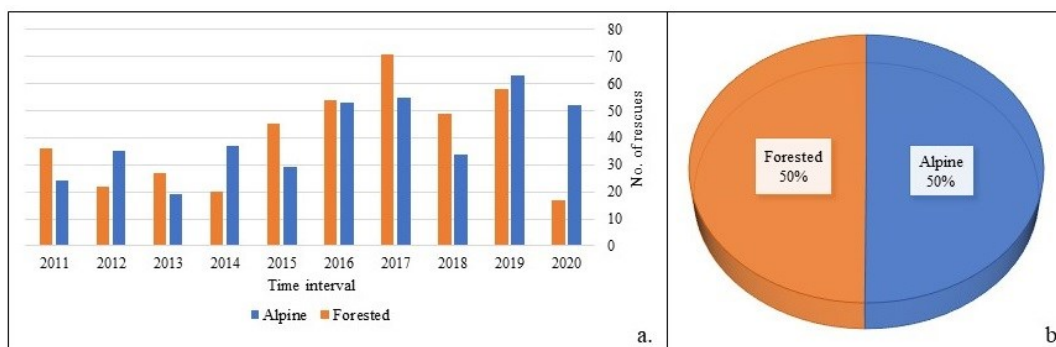
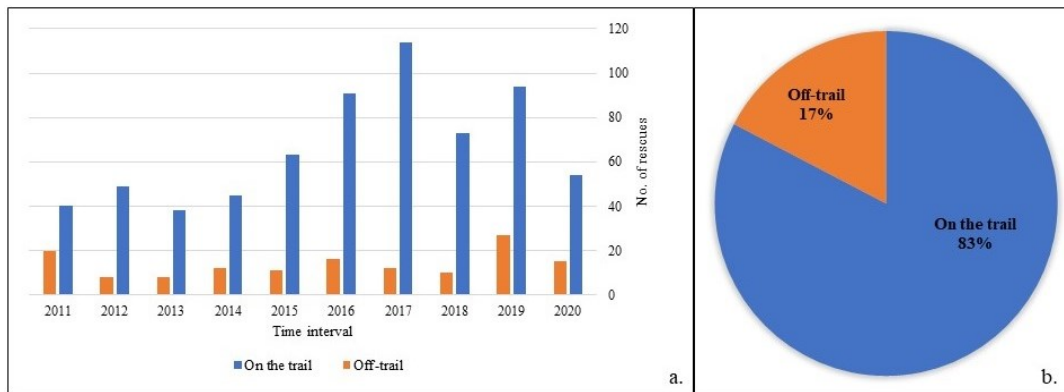
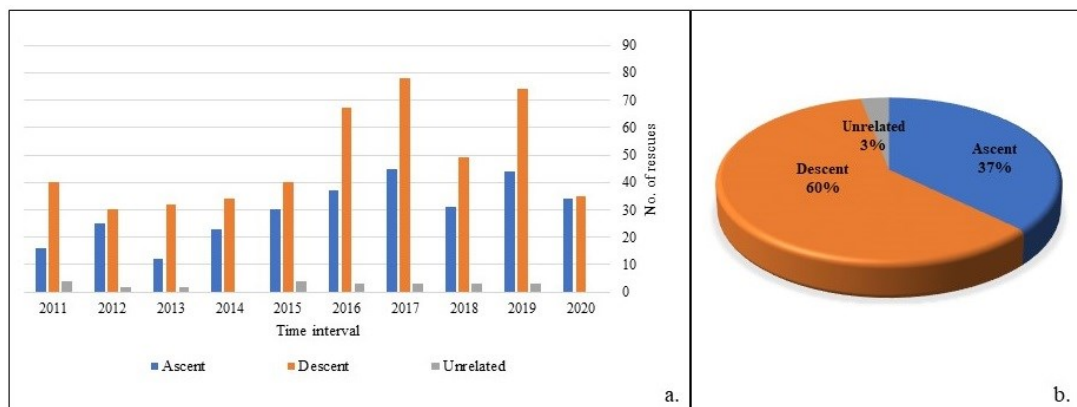


Figure 6. The annual distribution of accidents/incidents in the alpine and forestry sectors (a.) and their percentage (b.)



**Figure 7.** The annual distribution of accidents and incidents occurring on and off tourist trails (a.) and their percentage (b.)

The data analysis highlighted the real impact of the direction of travel on the incidence of events, given the well-known fact that the risk of slipping, falling, or experiencing vertigo and panic when seeing steep slopes is generally higher during descent. It was found that 60% of accidents and incidents occurred while descending (Figure 8a, b), and 3% were unrelated to the direction of travel (e.g., dog bites, bee stings, bear encounters, abdominal pain). Another particularly important aspect concerned tourists wearing specific equipment for mountain hiking. It is alarming that over two-thirds of SC1400-MRPS interventions (543 victims; 67,9%) were for tourists who were not properly equipped (hiking boots, backpacks, weatherproof clothing, and hiking sticks).

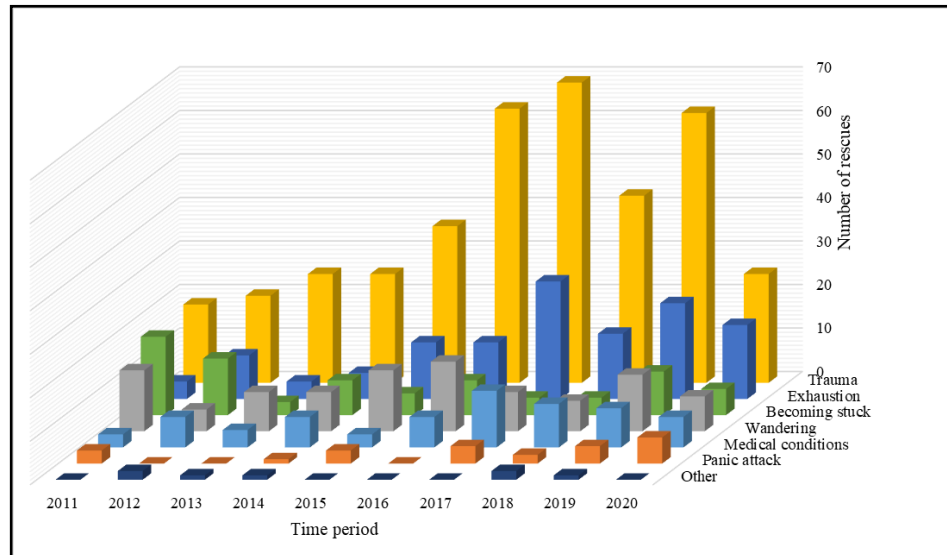


**Figure 8.** The annual evolution of events based on the direction of travel (a.) and their percentage (b.)

#### 4.2. Causes of accidents and incidents occurring between 2011 and 2020

The primary reasons for SC1400-MRPS interventions and their evolution over the past ten years are depicted in Figure 9. As expected in a high mountainous area, the main cause is trauma resulting from slips or falls, with a total of 16 fatal fall accidents. This is followed by exhaustion, wandering, becoming stuck on the trail, various medical conditions (including 3 cases of cardiac arrest resulting in the death of the victim), and

panic attacks. Considering the morphological structure of the Bucegi Mountains, significantly more injuries were recorded on the marked trails or in their immediate vicinity in the escarpment area than in the plateau or glacial areas. The cases of exhaustion, panic, or wandering, were considered incidents with the potential to cause an accident.



**Figure 9.** Main reasons for rescue calls to SC1400-MRPS and their evolution between 2011 and 2020

We classified the accidents and incidents recorded in the Bucegi Mountains according to the primary factor that led to their occurrence, as specified in the SC1400-MRPS reports: (i) Environmental conditions, represented by the difficulty of the trails due to steep structural terrain or the presence of residual snow. These factors contributed to falls and slips on medium and steep slopes or impeded the movement of hikers, sometimes becoming stuck on the trail; (ii) Adverse weather conditions (fog, torrential rain, strong winds, sleet, snow, or ice), which also caused casualties. We found that environmental conditions accounted for 398 victims (49.8%). The majority of cases involved slipping followed by becoming stuck on the trail, or simply becoming stuck at night due to lack of light, lack of experience, and inadequate equipment on steep or moderately sloped trail sections (226 cases). This was followed by falls, totalling 141 cases, resulting in multiple injuries. Unfortunately, 16 of these fall cases (11.3%) were fatal. Residual snow, which persists from the previous winter especially along narrow valleys, also led to emergency requests, although to a lesser extent, usually at the beginning and end of the tourist season. Meteorological factors caused the most casualties, totalling 402 cases (50.2%). The SC1400-MRPS reports indicated either a dominant meteorological factor at the accident site or a combination of factors. Therefore, we grouped the factors by their most significant impact on tourists. Among individual factors, fog was predominant, with 96 victims. The primary consequence was wandering due to losing trail markers, especially on the plateau area. Heavy rain resulted in 25 victims, as it led to tourists becoming stuck on the trail (due to flash floods) or slipping and falling on wet, steep ground and rocks. The group of factors including rain, snow, and sleet, combined with strong winds, low temperatures and ice, accounted for the majority of accidents and incidents in the Bucegi Mountains, totalling

281 victims. In these cases, even if the meteorological factors themselves were not the primary reason for emergency calls, their presence increased the risk of hypothermic shock, worsened the victims' condition until rescue teams arrived, and generally complicated the rescue missions. Lastly, we noted 25 emergency requests due to bear (*Ursus arctos*) presence. These averaged 1–3 per year, with the exception of 2013 and 2016, when no requests were recorded, and 2011 and 2020, which saw 6 and 7 requests, respectively. Aside from one bear attack each in 2011, 2012, 2017, and 2019, and three attacks in 2020, the other 18 situations involved tourists who were frightened by the bear, becoming stuck on the trail for this reason, or who fled and were found wandering and/or injured. None of the analysed cases were fatal.

#### ***4.3. Types of injuries suffered by the victims of hiking and mountain biking accidents***

The most common types of injuries, resulting in the highest number of casualties, were analysed: sprains, fractures, and polytraumas. Additionally, we examined incidents related to fatigue/exhaustion, panic, and wandering. Sprains, fractures, and polytraumas accounted for 367 victims (45.8%). The great number of injuries was more due to the harsh mountain terrain, especially within the abrupt area, than meteorological conditions. In the plateau area, unfavourable meteorological conditions caused more rescue calls for incidents and accidents than difficult terrain. Fatigue and exhaustion, panic, and wandering were among the most frequent incidents, representing 260 victims (32.5%). Other medical events, such as hypoglycaemia, hypocalcaemia, hypothermia, cardiac arrest, and strokes, accounted for 88 victims (11%). Additionally, unclassified medical causes numbered 85 victims (10.6%). The age of the victims is unknown in eight cases. Nonetheless, the average age was  $40.5 \pm 15.7$  years, specifically  $40.9 \pm 15.7$  years for men and  $39.9 \pm 15.8$  years for women.

### **5. DISCUSSION**

This regional study is the first analysis of accidents associated with hiking and mountain biking activities in the Bucegi Mountains and in the Romanian Carpathians during the summer season. This study covers the ten-year period between 2011 and 2020. The increasing number of mountain accidents has recently had numerous repercussions among individuals and been subjected to media attention, public opinion, and implicitly in society. The Bucegi Mountains are a popular area for hiking, mountain biking, mountaineering, and skiing activities in the Romanian Carpathians; however, a large number of accidents occur in the region. More than a quarter of the total number of mountain rescue calls registered by the SC1400-MRPS were reported by local and even national media. However, the actual number of accidents and injuries cannot be accurately quantified due to the non-transmission of the event by the injured individual or their group to the rescue services (especially for minor injuries), or the difficulty of monitoring the groups of hikers entering the trails. As in other studies (Faulhaber et al., 2017), we identified the preference of hikers for mountainous environments situated at medium-high altitudes with harsh terrain and numerous rocks and cliffs along the trails, which are characteristic of the steep areas of the Bucegi Mountains. Traversing this difficult terrain requires continuous effort and causes great physical stress, particularly muscular stress, causing accidents (Faulhaber et al., 2017; Vanpouille et al., 2017).

Hikers climbing the abrupt to reach the plateau area at approximately 2000 m are often already exhausted, and some may continue towards the highest mountain peaks in the glacial areas around Omu Peak (2507 m). Additionally, many of the tourists descending from Omu Peak continue to Bușteni, crossing the abrupt. Therefore, most accidents and incidents, and victims, were recorded in the steepest area at altitudes between 850 and 2000 m. Our data reveal that the numerous accidents occurring during descent are largely due to muscle fatigue (Zürcher et al., 2020), the lack of experience (not knowing the area and environmental events or just ignoring them), level of training, and use of inadequate equipment, considering the large difference in altitude of approximately 1200 m between Bușteni and the plateau, or the 1650 m difference in altitude between Bușteni and the highest peaks. Descents are the riskiest part of mountain hiking and mountain biking for accidents caused by falls or sliding. Approximately 60% of the accidents recorded by SC1400-MRPS occurred during descent. The situation of our case study area is comparable to other similar mountain areas. In Austria, 75% of accidents over a nine-year period (2006 to 2014) occurred while descending (Faulhaber et al., 2017), and 60.9% and 84.8% of accidents occurring over a 16-year period (2003 to 2018) in Switzerland occurred above and below 1800 m, respectively (Zürcher et al., 2020). Most accidents occurred when hiking on trails with structural thresholds (scarps), high declivity, and rocks/rubble (Chamarro and Fernandez-Castro, 2009; Faulhaber et al., 2017), confirming Pingel's statement (2013, p. 139): *moving downhill on very steep slopes is more dangerous than travelling uphill, requires more caution, and typically results in slower speeds*. The terrain conditions, quality of the rock, and the presence of fresh or residual snow as a seasonal hazard (Gasser, 2019; Vanpouille et al., 2017) contribute the number of human victims.

The variability in the climatic conditions highlights the specificity of each mountain area and the increase in the number of accidents (Chamarro and Fernández-Castro, 2009; Lischke et al., 2001; Soulé et al., 2017). In the Bucegi Mountains, half of the cases rescued by SC1400-MRPS (402; 50.2%) were affected in some way by unfavourable climatic conditions. This indicates that there is a relationship between accidents and weather conditions. Pascual and Callado (2010) also highlighted the dangers of meteorological phenomena for the Mediterranean Pyrenees. Our results also confirmed that Chamarro and Fernández-Castro's observations (2009) of the Alps were also true for the Bucegi Mountains, i.e., that tourists do not consider weather reports before beginning their journey. Owing to the growing popularity of mountain hiking and promotion of the area through the media and social media, hiking and mountain biking activities have increased considerably. This has driven the increase in accidents and injuries, as they occur in the alpine region (Faulhaber et al., 2017; Muhar et al., 2007; Soulé et al., 2017). However, the sources that have popularised tourism do not provide sufficient guidance for behaviour and rules to follow when planning hiking activities. Therefore, regardless of the cause of the accidents, they are driven by a series of errors (Chamarro and Fernandez-Castro, 2009; Vanpouille et al., 2017) and non-compliance with rules, such as ignoring bad weather reports (heavy rain, strong winds, and snowfall at high altitudes) or the instructions of the members of the mountain rescue teams when they do not recommend following the trail. Technical errors largely cause accidents, including hikers' haste to join or leave trails to reach their destination, train stations, or personal cars faster or to not be present on the trail at night. This error can be partially justified by the desire to avoid bears. Another technical error is not sufficiently utilising

the installed technical elements, especially the chains attached to the rocks, railings, or sockets. The high number of falls or slipping on the steep slopes of the Prahova Escarpment also highlights errors in the skills of the hikers. The lack of training and experience, minimal technical training, and ignorance of the area and the particularities of the terrain are represented as omission errors, as in other mountainous areas (Mort and Godden, 2011; Vanpouille et al., 2017).

## 6. CONCLUSIONS

Our study examines tourist activities and their associated risks in the Bucegi Mountains, a highly popular yet dangerous area in the Romanian Carpathians. We only considered accidents recorded by the SC1400-MRPS; however, many minor accidents or incidents were not reported by victims or witnesses and not accounted for by SC1400-MRPS members. As mentioned by Zürcher et al., (2020), and as found here, the risk is not representative of the altitude of the mountains themselves, but by the existence of general hazards in the mountainous environment. Most accidents occurred during descent due to the lack of adequate equipment, mountain experience, and inappropriate behaviour, which are well-highlighted for other mountainous areas, and to inefficient planning of travel times, according to the SC1400-MRPS data. The increase in the number of accidents and incidents observed during the warm season within the analyzed ten-year period was driven by the growing popularity of the Bucegi Mountains, as well as their attractiveness and accessibility. As this is one of the first studies of its kind conducted in Romania, it can serve as a foundation for identifying and classifying the main risk factors in the Bucegi Mountains, which is crucial for developing effective accident prevention measures. A critical self-assessment of individual capabilities and hiking skills, along with careful selection and planning of hikes, is essential for mountain hikers. However, since this study only provides information on the accidents and incidents that occurred and were recorded by mountain rescue authorities, future research should focus on identifying risk factors as the next step in accident prevention. Understanding specific internal factors (such as fatigue, fitness level, and experience) and external circumstances (such as altitude, slope, and weather conditions) is therefore vital for identifying these risk factors and developing evidence-based preventive measures. The safety of tourists must be improved and requires managerial involvement. Along the hiking trails in different mountain areas, a series of technical measures have been undertaken for restoration/development, but also maintenance. These measures include stairs, wooden supports and fixed ropes in the cliff, steps, support railings, and chains. Such measures have been undertaken in some areas of the Bucegi Mountains with steep slopes, such as Jepii Mici and Jepii Mari trails. Along these trails, work was conducted in summer 2018 to restore or complete the route with a series of safety elements in order to reduce the risk, including stairs, wooden supports, chains fixed in the rock, and the restoration of tourist signs.

### *Limitations of the study*

Our research has two main limitations. First, we only considered the injuries saved and recorded by the SC1400-MRPS. This is the most comprehensive database available in the area, but unfortunately does not include mountain rescues that involved the help of eyewitnesses or private cars, for convenience or for fear of media exposure

or repercussions, such as days of hospitalisation or house immobilisation. As these cases are numerous, they will be the subject of future analyses. Second, as the SC1400-MRPS statistic includes several risk factors that acted in combination for many of the accident cases (such as high slope, residual snow, fog, rain, or strong winds), we considered the first of these, which was likely the most important in the view of the rescue team members, as described in the field. In areas with difficult terrain and harsh climate and many natural elements, the mountain rescue teams were primarily focused on the lives of the victims and the main factor causing the accident.

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