Accidentology of mountain sports
Situation review & diagnosis

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A study produced by a research group

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SOURCES USED

The references of the data and surveys used in the study are provided in the appendix (pages 44-45).

A numbered reference system, (1) etc. is implemented to identify the relevant sources in their context.

TECHNICAL GLOSSARY

Certain terms are relatively uncommon or are used in a specific context; these are defined in the glossary (page 47).
Summary

The prevention of risks related to mountain sports requires detailed knowledge of the accident mechanisms.

The situation review presented herein results from the collection and cross-referencing of existing data, in France and abroad, concerning sporting accidents in the mountains. It intends to improve our knowledge of the scope of the phenomenon, victim profiles, and the explanatory factors and contexts that favour accident occurrence.

This report corresponds to the first phase of a much larger project. The summary produced suggests various areas for improvement in the field of accidentology.

The second phase will implement a regular analysis methodology of accident data in order to identify the recurrent causes of accidents and enable the reconstruction of “standard” scenarios.

We hope that this improved knowledge of how sporting accidents occur in the mountains will enable us to make progress in terms of preventive measures, information and practices.
Origin and objectives of the project

With support from the Petzl Foundation, a multi-disciplinary research group was formed to conduct a large scale survey of accidents related to sporting activities in the mountains (excluding downhill and cross-country resort ski areas). There are several reasons justifying this study. Firstly, the supposed importance of mountain sport accidentality. This accidentality, sometimes the subject of rather alarmist interpretations, must be analysed meticulously, since the implications are many, both in terms of public health, prevention and the treatment of victims of accidents resulting from the practice of mountain sports.

Secondly, in spite of numerous initiatives, or perhaps because of the fragmentation of sources, there appears to be room for improvement regarding the study of sporting accidents in the mountains; a multitude of data exists, providing interesting framing elements, but current knowledge remains dispersed and sometimes incomplete, due in particular to heterogeneous methodologies that do not always provide an overall vision.

Finally, our strong belief, shared by the Petzl Foundation and many mountain institutions, that prevention should be based on detailed knowledge of the frequency of accidents, their circumstances and risk factors, which represent the pillars of accidentology, in the sense of the scientific study of accidents.

The initial goal was to identify as accurately as possible the actual dangerousness and accident mechanisms of three activities: mountaineering, canyoning and ski touring. As our investigations progressed, it became clear that we would have to extend our study to include other sports (hiking, rock climbing and MTB to a lesser extent) because of the popularity of these activities and their similarity with the activities sports selected initially.

As well as the number and rates of accidents, which are not easy to estimate, we had to identify “standard” danger scenarios for each of these activities (explanatory factors and recurrent precursor events, conditions/circumstances particularly prone to accident occurrence) and specific contexts that amplify or attenuate bodily impact, to enable preliminary modelling of the dangers inherent to each activity. Although the number of incidents is important, identifying the origins of the accident sequences is equally essential in terms of prevention efforts.

A study in several phases, starting with a situation review

This report corresponds to the first phase of the survey, which consisted of:

1 / requesting and collecting as much data as possible from various identified sources, as well as identifying the data production method;

2 / summarising, re-processing, interpreting and crossing the information obtained.

This situation review aims to get as much as possible from the existing data, while identifying any shady areas that may constitute improvement areas for accidentology (possible progress areas for the second project phase).
Focus on trauma risks

Although the health risks are far from negligible in the mountains (AMS, oedema, cardio-vascular disorders, etc.), and particularly during hiking, this study is mainly focussed on the risks of body trauma specific to mountain activities. The proposed accident study differs from epidemiology, which focuses on the medical consequences suffered by the victims. However, the pathologies caused by these accidents will be discussed briefly to enable identification of the most frequent and/or serious incidents that preventive measures should target as a priority.

Methodology: a participative, collective approach

In order to understand the construction of existing reports, to align the information collected then provide estimations based on the reasoned crossing of these secondary data, we consulted and summarised all the databases that we knew of: rescue team intervention reports, aggregated statistics from the SNOSM (France’s national observatory of mountain safety), sporting federation accident declarations, accident/incident reports, etc.

Only the sources considered to be the most reliable and representative were used to compile this report owing to the number of cases processed, the exhaustive nature of data collection, the level of information detail available, etc. We had to be prudent in our interpretations to ensure we did not confer more meaning than the data actually inferred.

Our work also included consultation of all the parties playing an active role in prevention, training and mountain rescue, thus ensuring a participative, co-constructive approach to the study with the people that have the best knowledge of sporting accidents in the mountains. Around fifty such parties were interviewed on the methods implemented, the benefits and limits of current data, and the main expectations in terms of accidentology progress, thus further enhancing the credibility of the study proposed in this document.

Finally, a preliminary analysis was presented during a seminar, to which all the consulted parties were invited in order to ensure our good understanding of the information provided concerning accidents and the rescue services provided. Additional information was obtained during this event. Our seminar presentations were accompanied by round table events to confront the various expert opinions and encourage the development of collective intelligence by initiating dialogue and by networking and structuring the existing information. Aside from presenting what we had understood from the existing information, the aim was to identify the areas to develop further.

Our contribution

Our independence as university researchers gives us a freedom of tone that does not exempt us from taking into account, in a responsible manner, the stakes, constraints and institutional logic that surrounds the issues at hand. The situation review therefore contains no value judgement or apparent ideal, à priori.

We have no concern other than an intellectual interest in the sensitive subject of sporting accidents in the mountains, therefore our vision is that of a neutral observer, with a scientific approach aimed at developing knowledge. As such, our contribution has no technical content; we simply aim to provide the mountain community with our skills and perspective.

2. According to SNOSM 2012 data, more than 43% of deaths during hikes registered by the public rescue service were due to health reasons or non-trauma causes. This is also true for 4 out of 5 of the deaths reported during mountain biking.

3. The list of sources used, along with a few elements concerning their origin, are included in the appendix of this report.

4. The list of the parties interviewed can be found in the appendix.

5. Accidentologie et prévention des risques liés à la pratique des sports de montagne seminar (accidentology and prevention of risks related to mountain sports), co-organised by Coordination Montagne and the Petzl Foundation, Toulouse, CREPS Midi-Pyrénées, February 13-14 2014.
Finally, aside from offering a certain perspective, we have also played a mediating role since the aforementioned seminar. This is important since the mountain community only rarely considers the issues of risk and safety in the mountain environment according to a collective and collegial approach.

**Information of different kinds**

Information corresponding to different levels of additional reading has also been included in the synthesis compiled. This includes national counts ("macro" scale of aggregated rescue intervention reports, for example) as well as detailed accident and incident reports (the "micro" or clinical scale of detailed accident feedback), not forgetting intermediary level data ("meso" scale) taken from intervention notifications or telegrams, brief descriptions of accident circumstances (federal data), etc.

**An international dimension**

Initiatives in other leading mountain sports countries (in particular, Switzerland, Austria, Canada, USA and Japan) have also been taken into consideration, with a view to comparing the methods implemented and, if applicable, to draw inspiration from them. These elements will act as a counterpoint to avoid an overly French tendency.
The mountains represent a specific environment in which death is a regular occurrence, particularly during or resulting from sporting activities. The media is keen to focus on this death rate, which justifies this introduction. This first part therefore aims to bring some objectivity to the situation. Fatality figures from various sources are proposed first, then a few comparisons and statistical interpretations.

1 / Data in absolute values

In France, the national authorities collect data on deaths registered after intervention of mountain rescue services with a relatively good level of accuracy. Since 2012, full statistics are available for the departments concerned: 172 deaths and 33 disappearances (as well as 3,385 injured) were reported (excluding resort ski areas) (7)².

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Number of trauma-related deaths</th>
<th>Number of non-trauma-related deaths</th>
<th>Number of disappearances</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIKING</td>
<td>38</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>MOUNTAINEERING</td>
<td>35</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>SKI TOURING</td>
<td>11</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>PARAGLIDING/ HANGGLIDING</td>
<td>10</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>SNOWSHOES</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>ROCK/CLIFF CLIMBING</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>MTB</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>CANYONING</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>POTHOLING</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VIA FERRATA</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ICE WATERFALL CLIMBING</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other sporting activities</td>
<td>16</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>127</strong></td>
<td><strong>45</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

Table 1 / 2012 figures for rescue interventions in France.
Extract showing deaths and disappearances (excluding resort ski areas).

1. Since 2009, the SNOSM produces annualised summaries of the interventions conducted in France. However, it was not until 2012 that full statistics were provided by all departments.

2. This coded referencing system enables identification of the source used; consult the “list of sources used” in the appendix to identify the origin of the information cited.
This type of annual “snapshot” should be viewed with a certain degree of caution, since weather and snow conditions influence these reports every year.

It should be noted that the Mont-Blanc mountain range (French side) alone accounts for more than 30% of deaths related to a mountain sport in France [10], almost half of which occur during mountaineering (26 deaths per year on average for the period 2003-2012).

Death due to avalanche, which is a particularly feared event and very present in the representation of mountain risks, accounts for less than 20% of deaths (Sagues & Manteaux, 2007). For the past 30 years, there is an average of 30 deaths per year due to avalanche for 20 fatal accidents [2]*. This figure has remained remarkably stable for a number of years, in spite of a strong (but difficult to quantify) growth in the number of people participating in ski touring and off-piste ski and snowboard activities, which are particularly exposed to this risk.

2 / Comparison with the death rate of other sports

Comparison with other sporting activities enhances the informative value of this situation review. According to InVS [1], for 246 sporting accidents* causing a trauma-related death in France during 2010, 99 are related to mountain activities: 29 in mountaineering, 23 in ski touring and 16 in hiking. As a basis for comparison, ULM, diving and land motor sports each account for 23 trauma-related deaths, while no accidental deaths were reported for team sports (rugby) (Rigou & al., 2013).

In spite of its various methodological biases, this study identifies the fatal risk as a specific trait of mountain sports.

On the basis of a more rigorous survey conducted in Switzerland, crossing multiple sources over a period of more than 10 years*, BPA [21] also identified a clear over-representation of mountain sports (and to a lesser extent, winter sports) among death-generating activities.

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Number of accidental deaths per year</th>
<th>% of all accidental sporting deaths (not restricted to mountain sports)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIKING</td>
<td>45</td>
<td>25%</td>
</tr>
<tr>
<td>MOUNTAINEERING</td>
<td>32</td>
<td>17%</td>
</tr>
<tr>
<td>SKI TOURING</td>
<td>16</td>
<td>8%</td>
</tr>
<tr>
<td>OFF-PISTE SKIING</td>
<td>9</td>
<td>5%</td>
</tr>
<tr>
<td>DOWNHILL SKIING (ON PISTE)</td>
<td>6.7</td>
<td>3.6%</td>
</tr>
<tr>
<td>PARAGLIDING</td>
<td>6.6</td>
<td>3.5%</td>
</tr>
<tr>
<td>ROCK CLIMBING</td>
<td>5</td>
<td>2.7%</td>
</tr>
<tr>
<td>SNOWBOARDING</td>
<td>4.8</td>
<td>2.6%</td>
</tr>
<tr>
<td>BASE JUMP</td>
<td>3.3</td>
<td>1.8%</td>
</tr>
<tr>
<td>SNOW SHOES</td>
<td>2.3</td>
<td>1.2%</td>
</tr>
<tr>
<td>MTB</td>
<td>1.2</td>
<td>0.6%</td>
</tr>
<tr>
<td>ICE CLIMBING</td>
<td>0.8</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Table 2 / Mountain sports death rates in Switzerland (2000-2012)

3. The same ratio of 1:5 between the number of deaths due to avalanche and the number of deaths is also observed in Canada [27].

4. Excluding drownings and cycling accidents.

5. Including intra-hospital deaths within 30 days.
Football and ice hockey represent just 0.27% and 0.1% respectively of accidental sporting deaths in Switzerland (21) which provides a basis for our comparison. It is somewhat surprising that the total number of fatal accidents recorded during hiking, mountaineering and ski touring represents half of all accidental deaths recorded in Switzerland during the practice of sports in the broader sense*. Unfortunately, we do not currently have data to enable comparison with the situation in France.

The assessment is relatively clear: although drownings and cycling accidents have been excluded from the InVS survey, thus contributing to the rather alarmist interpretation of the situation, it is still true that sporting fatalities are more concentrated in the mountains in both France and Switzerland.

### 3/ Calculation of the mortality index

For each mountain sports activity, the information available enables calculation of the percentage of deaths among all accident victims (i.e. total of injuries + deaths) recorded by the rescue services [4] [7].

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Accident mortality index</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASE JUMP</td>
<td>47%</td>
</tr>
<tr>
<td>ULM</td>
<td>38%</td>
</tr>
<tr>
<td>WHITE WATER SPORTS</td>
<td>35%</td>
</tr>
<tr>
<td>POTHOLING</td>
<td>33%</td>
</tr>
<tr>
<td>HUNTING – FISHING – MUSHROOM GATHERING</td>
<td>23%</td>
</tr>
<tr>
<td>MOUNTAINEERING ON SNOWY TERRAIN</td>
<td>20%</td>
</tr>
<tr>
<td>HIKING (OFF TRAILS)</td>
<td>15%</td>
</tr>
<tr>
<td>ICE WATERFALL CLIMBING</td>
<td>15%</td>
</tr>
<tr>
<td>SNOW SHOES</td>
<td>13%</td>
</tr>
<tr>
<td>MOUNTAINEERING ON MIXED TERRAIN</td>
<td>13%</td>
</tr>
<tr>
<td>HANG GLIDING</td>
<td>12%</td>
</tr>
<tr>
<td>MOUNTAINEERING ON ROCKY TERRAIN</td>
<td>10%</td>
</tr>
<tr>
<td>VIA FERRATA</td>
<td>10%</td>
</tr>
<tr>
<td>MOUNTAINEERING ON SNOWY/ICY TERRAIN</td>
<td>10%</td>
</tr>
<tr>
<td>SKI TOURING</td>
<td>8%</td>
</tr>
<tr>
<td>ROCK CLIMBING ON CLIFFS</td>
<td>8%</td>
</tr>
<tr>
<td>PARAGLIDING</td>
<td>8%</td>
</tr>
<tr>
<td>CANYONING</td>
<td>6%</td>
</tr>
<tr>
<td>HIKING ON TRAILS</td>
<td>4%</td>
</tr>
<tr>
<td>ROCK CLIMBING (IN PRACTICE AREAS)</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Table 3 / Proportion of deaths / accident victims (excluding disappearances and unharmed) for each activity**

This table indicates that for 100 people suffering a base jump accident (excluding illnesses, disappearances and unharmed) resulting in intervention by the mountain rescue squad, 47 deaths were recorded. This gives a first idea of the seriousness of the bodily impact generated by each activity.

6. This is a relatively high proportion, but must be relativized since the Swiss are particularly active in these sports (Lamprecht, Fischer & Stamm, 2014).

7. For comparison, Lack & al. (2012) report the proportion of deaths among climbing accidents involving rescue operations in Boulder County (Colorado, USA) at 10%.
4 / Integration of secondary mortality

Until now, we have mainly considered the question of primary mortality resulting from the practice of a mountain sport. This accounts for the large majority of cases. However, secondary mortality, also known as intra-hospital mortality (death resulting from critical injuries), is far from negligible, occurring in 6-11% of very serious accidents (Injury Severity Score above 15, see glossary) resulting in medical treatment (Jacquot & al., 2011) (20). This secondary mortality occurs quickly in 77% of cases: within 24 hours of medical intervention. Mortality during transfer (generally by helicopter) to a healthcare facility is almost non-existent (accounting for only 1.8% of very serious accidents).

We do not yet have enough data (except for downhill skiing) to describe in detail and differentiate between cases of secondary mortality according to the activity at the origin of the accident. However, with approximately 300 cases of serious trauma due to mountain sports resulting in medical care and analysed annually by the TRENAU (emergency service network for the Northern Alps) since 2011, it will soon be possible to refine our knowledge in this area (20).

Limits of the data on trauma-related mortality

Being focussed only on trauma-related deaths, this information only concerns a small proportion of the accidents occurring mountain sports. Moreover, the data available provide no information on the death rate in relation to the number of people actually practicing the sport, since the number of participants at risk and the frequency and duration of exposure are unknown (Bianchi & Brügger, 2013). Finally, there is a certain ambiguity concerning the origin of so-called trauma-related deaths; in certain cases, they may have been caused by a health problem (e.g. loss of consciousness resulting in a fall).
Having focussed initially on deaths, this second part proposes to extend the study to include quantification of all sporting accidents occurring in the mountains. The goal is to go beyond the reporting of absolute values and to propose accident rate elements whenever possible (accidentality with respect to a variable, which may be the population of participants, hourly volume of sporting practice, etc.).

1 / How many sporting accidents occur each year in the mountains?

As for deaths, the number of accidents is generally estimated based on the rescue interventions carried out. In France, SNOSM (7) thus recorded 5,389 interventions following accidents in the mountains in 2012 (excluding winter sports), some 80% of which resulted in a helicopter evacuation, for a total number of 6,362 victims (an average of 1.2 victims per intervention¹).

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Intervention involving helicopter</th>
<th>Ground intervention</th>
<th>Total</th>
<th>Including search operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIKING</td>
<td>1,842</td>
<td>413</td>
<td>2,255</td>
<td>15</td>
</tr>
<tr>
<td>MTB</td>
<td>251</td>
<td>377</td>
<td>628</td>
<td>0</td>
</tr>
<tr>
<td>MOUNTAINEERING</td>
<td>478</td>
<td>39</td>
<td>517</td>
<td>8</td>
</tr>
<tr>
<td>PARAGLIDING/HANG GLIDING</td>
<td>202</td>
<td>107</td>
<td>309</td>
<td>1</td>
</tr>
<tr>
<td>SKI TOURING</td>
<td>206</td>
<td>24</td>
<td>230</td>
<td>0</td>
</tr>
<tr>
<td>CANYONING</td>
<td>125</td>
<td>31</td>
<td>156</td>
<td>0</td>
</tr>
<tr>
<td>SNOWSHOES</td>
<td>87</td>
<td>33</td>
<td>120</td>
<td>0</td>
</tr>
<tr>
<td>ROCK CLIMBING ON CLIFFS</td>
<td>87</td>
<td>20</td>
<td>107</td>
<td>1</td>
</tr>
<tr>
<td>VIA FERRATA</td>
<td>40</td>
<td>23</td>
<td>63</td>
<td>0</td>
</tr>
<tr>
<td>ICE WATERFALL</td>
<td>19</td>
<td>7</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>POTHOLING</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>OTHER SPORTS</td>
<td>848</td>
<td>125</td>
<td>973</td>
<td>8</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4,186</strong></td>
<td><strong>1,203</strong></td>
<td><strong>5,389</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

¹ Similarly, Lack & al. (2012) report 1.24 victims per accident requiring rescue intervention in Boulder County, Colorado (USA).
The same call for prudence regarding interpretation applies here as for the number of deaths (see first part): this type of annual report must be regarded with caution since weather and snow conditions induce a high level of variability from one year to another.

This information, based on mountain rescue intervention team reports, often underestimates accident reality. A certain number of accidents inevitably escape this type of statistical report (e.g., injured persons returning home under their own means, or with the help of third parties, regardless of whether or not they then obtain medical care). For example, 56% of patients consulting the emergency services of the Mont-Blanc hospitals after a sporting accident occurring in the mountains arrive under their own means and 25% arrive by non-SMUR (mobile intensive care unit) ambulance (Nay, 2013) [18]. An exploratory survey conducted among just over 600 participants (non-representative sample) reveals that just 21% of ski touring injuries receive assistance from state mountain rescue teams (42% go directly to the emergency department at the hospital or to a doctor’s surgery, and 36% do not require medical treatment) [36]. Finally, between 1984 and 1987, of the 220 patients treated at the Yosemite National Park medical centre, just 27% were assisted by rescue teams (Bowie & al., 1988).

The number of unharmed accident victims should also be taken into account since it represents a little more than a third (36%) of those rescued [7]: a rescue intervention does not necessarily mean a dead or injured person. To assess the number of accidents resulting bodily impact, we must therefore be aware not only of those cases that escape the rescue intervention statistics, but also of the many situations in which the victim is not actually harmed. Rescue teams report an increasing number of interventions to provide assistance for “technical blockage” situations.

We have no knowledge of any information source to overcome the first of the two aforementioned limits, making it impossible at present to know how many accidents actually occur as a result of mountains sports. However, a large number of rescue interventions are recorded, offering a large set of quantitative data, particularly within SNOSM [7] and, even more so, DGGN [4] databases.
2 / What are the particularities of each mountain sport?

One of the advantages of the data compiled by BSM (mountain rescue police team) lies in the possibility of crossing the activities specified with six victim “states” for 30,000 victims rescued between 2008 and 2012 [4]: trauma-related death, non-trauma-related death, injury, illness, unharmed, disappeared. This enables the calculation of a number of ratios.

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Unharmed / rescued</th>
<th>III / rescued</th>
<th>Injured / rescued</th>
<th>Dead / rescued</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTB</td>
<td>5%</td>
<td>1%</td>
<td>92%*</td>
<td>1%</td>
</tr>
<tr>
<td>CLIMBING ON WALLS</td>
<td>7%</td>
<td>0%</td>
<td>91%</td>
<td>2%</td>
</tr>
<tr>
<td>PARAGLIDING</td>
<td>36%</td>
<td>0%</td>
<td>58%</td>
<td>5%</td>
</tr>
<tr>
<td>HANG GLIDING</td>
<td>35%</td>
<td>0%</td>
<td>58%</td>
<td>8%</td>
</tr>
<tr>
<td>CANYONING</td>
<td>38%</td>
<td>1%</td>
<td>57%</td>
<td>4%</td>
</tr>
<tr>
<td>HIKING ON TRAILS</td>
<td>27%</td>
<td>14%</td>
<td>56%</td>
<td>3%</td>
</tr>
<tr>
<td>ICE WATERFALL</td>
<td>42%</td>
<td>0%</td>
<td>50%</td>
<td>9%</td>
</tr>
<tr>
<td>BASE JUMP</td>
<td>24%</td>
<td>0%</td>
<td>40%</td>
<td>36%</td>
</tr>
<tr>
<td>MOUNTAINEERING (SNOWY TERRAIN)</td>
<td>35%</td>
<td>14%</td>
<td>38%</td>
<td>13%</td>
</tr>
<tr>
<td>ROCK CLIMBING ON CLIFFS</td>
<td>57%</td>
<td>1%</td>
<td>38%</td>
<td>3%</td>
</tr>
<tr>
<td>MOUNTAINEERING (SNOWY/ICY TERRAIN)</td>
<td>41%</td>
<td>15%</td>
<td>37%</td>
<td>6%</td>
</tr>
<tr>
<td>MOUNTAINEERING (ROCKY TERRAIN)</td>
<td>66%</td>
<td>2%</td>
<td>29%</td>
<td>4%</td>
</tr>
<tr>
<td>MOUNTAINEERING (MIXED TERRAIN)</td>
<td>60%</td>
<td>5%</td>
<td>29%</td>
<td>5%</td>
</tr>
<tr>
<td>SNOWSHOES</td>
<td>56%</td>
<td>9%</td>
<td>29%</td>
<td>6%</td>
</tr>
<tr>
<td>HIKING OFF TRAILS</td>
<td>68%</td>
<td>3%</td>
<td>24%</td>
<td>5%</td>
</tr>
<tr>
<td>VIA FERRATA</td>
<td>70%</td>
<td>4%</td>
<td>22%</td>
<td>3%</td>
</tr>
<tr>
<td>POTHOLING</td>
<td>49%</td>
<td>15%</td>
<td>19%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Table 5 / Ratios between the states observed by the rescue teams

This table can be read as follows: on average, of 100 people rescued by the mountain police team during interventions on MTB incidents, 92 were injured (although no indication of seriousness is given), 5 were unharmed (lost, blocked, major equipment failure, etc.), 1 was ill and 1 died. The low ratio of injuries/interventions may be explained by the high proportion of unharmed victims (also true for Via Ferrata, off-trail hiking or mountaineering in rocky terrain) and/or deaths (the case of potholing, and even mountaineering in snowy/icy terrain).

Another way of presenting this type of information is to highlight the intensity of the relationship between the various states observed and each activity. This type of reasoning (relative value) is a means of overcoming the somewhat deceptive but inevitable influence of the figures alone. This intensity varies between -100% (obvious under-representation of the state for the activity) to +100% (obvious over-representation).

See Table 6.
Interpretation: the typical state of a rescued mountain biker is “injured”; for hikers, “non trauma-related death” and “illness” are slightly ahead of the other categories; “unharmed” is much more common in potholing and Via Ferrata. At the other end of the scale from these over-representations (positive values), there are a number of major under-representations (negative values), sometimes even paradoxical with respect to absolute values. Thus, the “trauma-related death” state is slightly under-represented among the population of rescued hikers, largely under-represented among canyoning participants and very largely under-represented among mountain bikers.

3 / Evolution of the mountain rescue service structure

The figures show a certain stability in the interventions carried out by mountain rescue teams and the national aggregations calculated by SNOSM. The increase in rescue operations related to MTB accidents is considerable. This figure has been increasing continuously since the end of the 1990s [7, 8, 6], to the extent that this activity has joined mountaineering and hiking among the top three activities generating rescue interventions. MTB incidents have even overtaken mountaineering incidents, which resulted in approximately 16% of rescue operations (French court of auditors, 2011)³.

This indicates a gradual change in the structure of rescue interventions, obviously echoing the changes occurring in sporting practice in France (for both residents, French holiday-makers and foreign visitors). The same trend also applies in other alpine countries, as well as in the UK, where the increase in interventions, number of injured and deaths (to a lesser extent) has been marked and constant since 2004 [25]⁴. Aside from MTB (7% of interventions), the growing popularity of hiking is the main reason for the increasing number of rescue operations in the UK (more than 70% of interventions) [25].

Hindsight means that such quantitative evolutions, provided they are properly detected and interpreted, may influence preventive efforts.
4/What are the real possibilities for accidentality calculations?

In view of the huge disparities (particularly difficult to assess objectively) in terms of number of participants, the above observations do not enable us to draw any real conclusions as to the respective risks of each activity (Lefèvre & al., 2005). The advantage of the notion of accidentality is to enable an à priori realistic statement of the more or less accident-generating nature of an activity, a site or a period in time, overcoming the problems of often deceptive interpretations based on absolute values. These values are essential (numerator), but the main difficulty of accidentality calculations lies in measuring the parent population (denominator). How to quantify the number of participants and/or estimate the duration of their exposure (time spent practising the sport)? A little trip to the Himalayas in Nepal offers an interesting perspective.

Accidentality of expeditions in Nepal: the lessons learned from the Himalayan Database

Since the ascension of mountain summits in Nepal requires the purchase of an ascension permit, exact figures exist for the number and composition of expedition teams. Furthermore, journalist E. Hawley and her team make the most of the expedition teams’ return passage via Kathmandu to produce a number of circumstantial reports.

Since 2004, these data have been compiled by R. Salisbury in the Himalayan Database (HDB). But what can we learn from this statistical objectivation? Between 1951 and 2010, 18,479 people (10,668 mountaineers and 7,811 sherpas) took part in expeditions on Everest. 213 people died (142 mountaineers and 71 sherpas). On average, fatal accidentality is 1.15%, confirming that the ascent of Mount Everest really is a dangerous enterprise. However, this figure has dropped significantly. Since the 1980s, the actual number of deaths has remained stable (an average of almost 6 deaths per year), but the number of people setting out has increased almost four-fold. The table below shows these trends (in 5-year periods to smooth certain random seasonal effects), showing a gradual distancing between the number of expedition participants and the number of deaths.

5. www.himalayandatabase.com
6. Sherpas are locally employed Nepalese guides to ensure the logistical aspects of expeditions and sometimes advise the mountaineers.

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of expedition participants recorded</th>
<th>Number of deaths</th>
<th>Fatal accidentality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951-1955</td>
<td>184</td>
<td>1</td>
<td>0.54%</td>
</tr>
<tr>
<td>1956-1960</td>
<td>222</td>
<td>1</td>
<td>0.45%</td>
</tr>
<tr>
<td>1961-1965</td>
<td>268</td>
<td>3</td>
<td>1.12%</td>
</tr>
<tr>
<td>1966-1970</td>
<td>241</td>
<td>10</td>
<td>4.15%</td>
</tr>
<tr>
<td>1971-1975</td>
<td>789</td>
<td>12</td>
<td>1.52%</td>
</tr>
<tr>
<td>1976-1980</td>
<td>734</td>
<td>13</td>
<td>1.77%</td>
</tr>
<tr>
<td>1981-1985</td>
<td>1,184</td>
<td>30</td>
<td>2.53%</td>
</tr>
<tr>
<td>1986-1990</td>
<td>1,974</td>
<td>31</td>
<td>1.57%</td>
</tr>
<tr>
<td>1991-1995</td>
<td>2,503</td>
<td>26</td>
<td>1.04%</td>
</tr>
<tr>
<td>1996-2000</td>
<td>2,505</td>
<td>34</td>
<td>1.36%</td>
</tr>
<tr>
<td>2001-2005</td>
<td>3,424</td>
<td>25</td>
<td>0.73%</td>
</tr>
<tr>
<td>2006-2010</td>
<td>4,451</td>
<td>27</td>
<td>0.60%</td>
</tr>
</tbody>
</table>

Table 7 / Fatal accidentality on Mount Everest (extracted from HDB)
This drop in accidentality probably results from innovations (improved weather predictions), equipment (fixed ropes, oxygen canisters), increased assistance (1 sherpa per 1.4 mountaineers since 1986) and the concentration on the “Normal” route, the controversial nature of which lies beyond the scope of this report.

The avalanche on April 18 2014, which resulted in the death of 16 Nepalese mountain professionals, was a cruel reminder of the high level of their exposure during the preparation of expedition itineraries. In spite of this, concerning the period observed for Mount Everest (not including 2014), the fatal accidentality of Nepalese employees (0.91%) is significantly lower than that of mountaineers (1.33%)\(^7\), which incites to prudence in interpretation following the occurrence of particularly dramatic accidents. However, the Nepalese professionals pay a heavy tribute to their presence during Everest ascension attempts (71 deaths between 1951 and 2010, i.e. 33% of deaths occurring on this mountain).

Accidentality calculations also enable comparison of the dangerousness of certain sites. For example, Annapurna I (a “mere” 8,091m), and significantly less frequently climbed than Mount Everest, is characterised by a much higher fatal accidental- ity than the latter (although figures have been in decline since 1986\(^8\)): oscillating between 2.1% (2001-2005) and 5.6% (1976-1985). Thus, fatality is not necessarily related to altitude. On Cho Oyu (8,201m), between 1951 and 2010, fatal accidentality was 0.58%; on Pumori (7,161m), it was four times higher (2.35%).

Unfortunately, the HDB initiative only appears to be transposable to a small number of mountain ranges.

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7. The trend has intensified since 1996: during the period 1996–2000 the fatal accident rate of sherpas was 0.65% (compared with 1.78% for mountaineers); then 0.14% in 2001 – 2005 (compared with 1.16% for mountaineers); finally, 0.34% in 2006 – 2010 (compared with 0.83% for mountaineers).

8. The drop in the fatal accidentality on the Himalayan summits has been significant and generalised over the past twenty years (Westhoff & al., 2012).
**A few international markers:**
the need to know the parent population

The Aconcagua (Argentina, 6,962m), the highest summit of the American continent, attracts more than 3,000 mountaineers per year, with a vast majority opting for its "normal", relatively untechnical route (more like altitude hiking than mountaineering). Servicio Medico Aconcagua data enables us to propose a mortality analysis (Westensee & al., 2013): between 2001 and 2012, there were 33 deaths for 42,731 ascent attempts, representing a fatal accident rate of 0.077%, far lower than that of Mount Everest.

In the Grand Teton National Park (USA), everyone planning an ascent must register, providing details of the summit, the proposed itinerary, etc. The data thus collected provides a very reliable image of actual activity in terms of mountain sports. Between 1981 and 1986, there were 108 accidents, resulting in 25 deaths. The accident rate per participant is estimated at 0.25%, and appears to have remained stable in comparison with the previous decade (1971-1980). The study goes further, assessing the volume of the sporting activity: with a total of 192,800 hours of sporting activity, exposure is therefore calculated at 5.6 accidents for every 10,000 hours (Schussmann & al., 1990).

Other indicators can be taken into account to relativise the absolute figures regarding accidents. Federation data are of interest in this respect.

**Accident rate based on federation accident declarations:**
FFCAM (French federation of mountain and alpine clubs)

The incidents reported by FFCAM license holders to the sporting federation insurance company give some idea of the number of accidents affecting this sub-population. The FFCAM also has provisional declarations (completed upon license application/renewal) regarding the activities practised. While this indicator provides figures for practice, it is not sufficiently reliable to be considered as a parent population (denominator)*.

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Number of participants declared among FFCAM members</th>
<th>Number of accidents reported</th>
<th>Number of fatal accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIKING</td>
<td>51,244</td>
<td>97</td>
<td>2</td>
</tr>
<tr>
<td>ROCK CLIMBING</td>
<td>41,058</td>
<td>132</td>
<td>3</td>
</tr>
<tr>
<td>DOWNHILL SKIING</td>
<td>34,174</td>
<td>220</td>
<td>2</td>
</tr>
<tr>
<td>SKI TOURING</td>
<td>30,158</td>
<td>97</td>
<td>3</td>
</tr>
<tr>
<td>MOUNTAINEERING</td>
<td>28,072</td>
<td>79</td>
<td>7</td>
</tr>
<tr>
<td>SNOWSHOES</td>
<td>23,262</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>CROSS-COUNTRY SKIING</td>
<td>13,797</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>CYCLING</td>
<td>13,636</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>CANYONING</td>
<td>6,988</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>ICE WATERFALL</td>
<td>6,350</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>SNOWBOARDING</td>
<td>4,965</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>PARA GLIDING</td>
<td>4,361</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>POTHOLING</td>
<td>3,247</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>SLACKLINE</td>
<td>1,834</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

*Table 8 / Accident rates for supervised FFCAM excursions in 2013

With no indication of volume, it is difficult to qualify the exposure related to the practice of mountain sports. However, based on the activity reports of its clubs,
FFCAM can calculate a consolidated assessment of the volume of supervised activity for each sport. Taking into account only the accidents reported in a supervised situation, it is therefore possible to calculate the exposure of this type of excursion for each sport.

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Number of dates supervised activity</th>
<th>Number of accidents reported during supervised excursions</th>
<th>Accidentality per day of supervised activity</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNOWBOARDING</td>
<td>802</td>
<td>2</td>
<td>11%</td>
<td>0.25</td>
</tr>
<tr>
<td>ICE WATERFALL</td>
<td>3,772</td>
<td>8</td>
<td>62%</td>
<td>0.21</td>
</tr>
<tr>
<td>PARAGLIDING</td>
<td>907</td>
<td>1</td>
<td>3%</td>
<td>0.11</td>
</tr>
<tr>
<td>MOUNTAINEERING</td>
<td>21,624</td>
<td>21</td>
<td>27%</td>
<td>0.10</td>
</tr>
<tr>
<td>CROSS-COUNTRY SKIING</td>
<td>5,114</td>
<td>4</td>
<td>31%</td>
<td>0.08</td>
</tr>
<tr>
<td>CANYONING</td>
<td>7,723</td>
<td>6</td>
<td>33%</td>
<td>0.08</td>
</tr>
<tr>
<td>DOWNHILL SKIING</td>
<td>12,987</td>
<td>10</td>
<td>5%</td>
<td>0.08</td>
</tr>
<tr>
<td>SKI TOURING</td>
<td>42,846</td>
<td>27</td>
<td>28%</td>
<td>0.06</td>
</tr>
<tr>
<td>SNOWSHOES</td>
<td>18,502</td>
<td>5</td>
<td>31%</td>
<td>0.03</td>
</tr>
<tr>
<td>POTHOLING</td>
<td>8,144</td>
<td>2</td>
<td>67%</td>
<td>0.02</td>
</tr>
<tr>
<td>ROCK CLIMBING</td>
<td>255,785</td>
<td>52</td>
<td>39%</td>
<td>0.02</td>
</tr>
<tr>
<td>CYCLING</td>
<td>9,857</td>
<td>2</td>
<td>8%</td>
<td>0.02</td>
</tr>
<tr>
<td>HIKING</td>
<td>134,140</td>
<td>27</td>
<td>28%</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 9 / Classification of sports according to their accidentality per day of supervised activity in 2013

The accident rates calculated above are almost zero for snowboarding, paragliding and downhill skiing since the vast majority of accidents result from unsupervised practice. In other cases, the figures are more informative. First observation: the exposure of supervised participants must be relativised since there is generally a very low risk of having an accident during a supervised outing. The previous classification is therefore modified. Accidentality is very low for rock climbing and hiking\(^{10}\); but supervised ice waterfall and mountaineering expeditions have a much higher level of exposure.

Caution: these exposure calculations do not take into account the volume (which can be very high) of unsupervised activities enjoyed by FFCAM license-holders. While suggestive, this image therefore remains highly fragmented.

10. Similar results are recorded by the French hiking federation: a very low rate of accidents during organised excursions.

The perspectives offered in terms of accidentality

In terms of accidentology, while qualitative progress has its importance, establishing the relationship between a reliable number of accidents and an accurate parent population (or better still, a participation volume) is difficult to envisage.

The calculation of exposure for non-license holder participants and/or the accidentality of places in which there is no form of regulations, remains a challenge for the time being. However, this part aims to highlight the perspectives offered by this type of information, without underestimating its limits in terms of feasibility.
Profiles of victims
of mountain sport accidents

This part summarises our knowledge of the social-demographic and sporting profiles of mountain accident victims. The huge range of sports and contexts of practice make it impossible to draw up a standard profile for accident victims for each sporting activity, but certain elements are recurrent in terms of victim characteristics (age, gender, experience, equipment, etc.), which can be of use in accidentology.

We have structured this part according to type of practice, after making a more general introduction. This third part paves the way for the later evocation of the main mechanisms and circumstances of accidents (fourth part), while providing tangible indicators for targeting prevention actions.

1 / Introduction: comments from professionals concerning the profiles of victims of mountain accidents

Beyond the often abstract statistics of accident reports (rescue interventions, avalanches, etc.), rescue professionals and avalanche prevention managers have useful practical knowledge when it comes to establishing the profile of accident victims.

“The victims of fatal accidents during hiking or rock climbing are mostly men, from Grenoble or the Isère region, aged over 40, participating regularly in mountain sports (...). This means they are our friends, neighbours, even work colleagues. We have observed that these victims are mostly people who love the mountains with a passion and have enjoyed their sports for many years without ever having an accident (...). The combination of their passion and need means that they are perhaps no longer as conscious of the risks they take during often accessible excursions. Many comments from the families of the victims mention a prudent husband, a cautious brother or a sensible child”.

Sébastien Rigault, Commander of Isère PGHM
“It is time to put a stop to the belief that serious accidents only happen to beginners or ill-shod tourists. (…) Accident statistics state the exact opposite”.

PGHM rescue team member

“It is not true that the people caught in avalanches are tourists. We have a very large proportion of local people among the accident victims”.

Frédéric Jarry, ANENA

These interview excerpts, which are obviously tinted with a certain subjectivity related to the professional implication of the speakers concerned, mainly refer to serious and/or fatal accidents. At first glance, most such accidents seem to involve “locals”, who would be expected to have sufficient knowledge, technical skills and experience to analyse the risks adequately; however, they are particularly exposed due the large number of mountain excursions they undertake. In Austria, the typical accident victim is also increasingly presented as a man aged over 40 with a long experience of mountain sports [24]. These observations push into the background the image of tourists without suitable equipment and/or adequate technical skills.

The data that we collected mostly confirm this trend, identified by numerous experts. Obviously, there is no question of hastily concluding that massively publicised and easily accessible activities (including hiking and more recently MTB) do not come without their share of sometimes very serious accidents. It is more a question of relativising a very popular idea, even dominant until the noughties, that inexperience, inadequate technical competence and ignorance of potential danger, represent the main causes of mountain accidents.

Although some accidents are related to inaptitude (physical, technical, etc.), the reality is obviously more complex, and our descriptions must therefore be qualified accordingly. Alongside the most popular activities, which generate large numbers of victims but a relatively low trauma-related death rate (e.g. hiking on trails, Via Ferrata, rock climbing and MTB), there are certain more restricted activities that are more technically demanding (mountaineering, ice waterfall) or activities that are slowly gaining in popularity (e.g. ski touring) which result in incidents involving mostly experienced or even expert participants with no fundamental technical inadequacy and most of whom have been enjoying sporting activities in the mountains for many years.

There is also another notable trait: the overall over-exposure of men. Among the victims rescued in 2003-2012 by PGHM in the Mont-Blanc mountains, they are not only over-represented (74% of victims), but also over-exposed to the fatal risk (81% of deaths) [10]. Similarly, more than 80% of deaths in the Austrian mountains are men, who represent “only” 65% of injuries. Aside from the fact that this over-representation of men is also a strong characteristic of the parent population (in mountaineering, ice waterfalls, etc.), it also implies that masculine practice is considerably more intense [24].
2/Profiles of hiking accident victims

The high age of hiking accident victims, combined with the fact that the over 50s is the only age bracket for which the number of rescue interventions increases every year [4], reflects the specific demographics of this activity and the ageing of its participant population. A more general basic tendency concerning mountain sport participation is revealed by the data collected in Austria since 1990 on accidental deaths (for all activities): 85% concern people aged over 40 [24].

Trauma-related deaths in hiking: preponderance of age and male gender

Focussing on fatal accidents, several sources agreed on the clear over-representation of over 40s and over 50s. In Switzerland, for example, half of the accidental deaths during hiking concern people aged over 50 [21]. Men are also largely more affected. The resulting combination: in Isère, male hikers aged between 40 and 60 years old are particularly exposed to the fatal risk [11].

On the geographic scale of the Mont-Blanc mountains, the oldest male hikers are also those who have the most fatal accidents; inversely, under the age of 47, they are significantly less concerned [10].

The situation is different for women. While there are roughly the same number of female as male hikers, women are significantly less likely to die during hiking than their male counterparts (3.5 male deaths for 1 female death). Furthermore, their “vulnerability peak” is at a younger age, between 48 and 57 years old and, to a lesser extent, between 38 and 47 [10].

Extension to include injuries related to “mass hiking”

The above focus (geographic and limited to fatal accidents) calls for the integration of subsidiary studies. If we extend our investigation to non-fatal accidents, 45% of hikers rescued by the emergency services in Haute-Savoie during the 2012-13 season were over 50 years old [5]. The over-representation of “seniors” is not therefore limited to fatal accidents.
Haran Larre (2011) provides more information, based on a study conducted in the Basque Country, in a medium altitude area. Again, two thirds of hiking accident victims were over 50 (average age significantly higher than that of the French population: 49 as opposed to 41). In terms of their sporting profile, more than one third of accident victims suffering trauma had no or little experience in mountain sports (they were mostly tourists). One quarter of the victims had good experience of mountain activities, but suffered the most serious accidents (14% of serious accidents, i.e. 50% less than among the inexperienced (19).

The case of hikers with a sporting federation license

The profile of FFME license-holders is unique: they are aware of the risks of the mountain environment, often fond of technical routes (Burlot & Lefèvre, 2004), and have a certain experience of these territories. Within the FFME, 78% of those reporting a hiking accident were aged over 40 (37% over 60) (15). The “experienced” population was largely over-represented (76%), compared with “experts” and “beginners” (equally concerned). Once again, slightly more accident victims were men. Injuries mainly occurred outside club excursions (56%), but such excursions were far from guaranteeing against accident occurrence. The two deaths reported during the period 2010-2012 concerned experienced hikers (15).

It should be remembered that this source comprises a limited number of accident declarations, which cannot be related to the total number of hikers within this federation.

3/Profiles of mountaineering accident victims

Overall, fatal accidents in mountaineering affect a younger population than in hiking. In Switzerland, the 20-29 age bracket is actually the most often concerned by mountaineering deaths (21).

Mountaineering deaths: mostly male and concentrated
in a number of “black spots”

The Mont-Blanc mountains represent an observatory for mountaineering accidents. The mortality rate here is concentrated in certain “black spots” (notably the Goûter corridor on the normal route to Mont Blanc) and positively international: more than 50% of rescued mountaineers in these mountains are foreign (10), compared with 38% in the rest of France (4) including the Mont-Blanc mountains.
Male victims are much more frequent than females. All age ranges are concerned between 18 and 67, but the most exposed to accidental death seems to be the 28-37 range, and even more so, 48-57 years old. Among women, the 28-37 age bracket is the most affected (10).

In terms of technical ability and experience, moderately experienced mountaineers (“experienced”) seem to be most concerned, compared with beginners and experts in the field (11).

**The case of mountaineers with an FFME license**

Within the FFME, 71% of mountaineering accident declarations concern the 18-40 age bracket, with 22% for 41-60s. Again, experienced mountaineers are most affected (60%), ahead of beginners (18%) and experts (22%) (15).

Although the sporting profile of these license-holders is likely to bias interpretation, the four deaths reported over the period 2010-2012 were mainly in the expert and experienced categories, with no beginners.

Finally, the proportion of mountaineering accidents occurring within club-organised excursions is 28% (15).

This information should be considered with caution since we have no information on the parent populations (number of mountaineers within the federation).

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3. A parallel can be drawn with rock climbing in natural environments, for which Bowie & al. (1988) propose a standard portrait of accident victims in Yosemite National Park: mostly experienced, regular climbers with a good level of technical ability; 88% men with an average age of 28 years.

4. Comparison with the practice of canyoning by FFME license-holders: 46% of accident victims are beginners, compared with 38% experienced and 16% experts. Men and women are roughly equally affected. A final noteworthy point: the proportion of accidents occurring during club excursions is high, reaching 60% (15).
4 / Profiles of ski touring accident victims

In Switzerland, the victims of fatal ski touring accidents are mostly aged between 40 and 49 [21], which places this sport between mountaineering and hiking in terms of age-related exposure. Regarding the cases of non-fatal accidents registered by FFME, the 41-60 age bracket is most affected (accounting for more than half of all accident victims), followed by 18-40s (38%) [15].

Within this same population, women suffer almost as many accidents as men (43%) in ski touring, with 53% of injuries occurring during a supervised excursion [15].

In France, on the scale of the Isère department, deaths related to ski touring almost exclusively affect residents of the department. The very few cases of exception concern residents of the surrounding Rhône-Alpes region [11]. Furthermore, it appears that experienced participants are particularly exposed to fatal accidents, especially due to avalanches [15].

Regarding non-fatal injuries, just 15% of accident declarations by FFME license-holders are made by beginners, and barely more by experts (17%); the experienced category represents by far the majority of accident victims in this database (68%) [15].

In terms of knowledge of snow conditions, in many cases the accident victims had sufficient experience to enable them to make the necessary observations and to perform the relevant decision-making tests [3]. Aside from the perception of danger, this observation raises the question of the participants’ attitude to an identified risk (change of itinerary, cancelling the excursion, etc.).

Finally, the geographic origin of the ski touring avalanche victims is also of importance. Over the past 30 years, the people perishing in France in this manner lived in the following locations:

<table>
<thead>
<tr>
<th>REGION</th>
<th>%</th>
<th>DEPARTMENT</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHÔNE ALPES</td>
<td>56.5%</td>
<td>SAVOIE</td>
<td>21.9%</td>
</tr>
<tr>
<td>PACA</td>
<td>17.7%</td>
<td>ISÈRE</td>
<td>18.3%</td>
</tr>
<tr>
<td>MIDI PYRÉNÉES</td>
<td>5.5%</td>
<td>HAUTES ALPES</td>
<td>12.2%</td>
</tr>
<tr>
<td>LANGUEDOC ROUSSILLON</td>
<td>4.3%</td>
<td>HAUTE SAVOIE</td>
<td>12.2%</td>
</tr>
<tr>
<td>RÉGION PARISIENNE</td>
<td>4.3%</td>
<td>RHÔNE</td>
<td>4.3%</td>
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<tr>
<td>AQUITAINE</td>
<td>3.7%</td>
<td>ALPES MARITIMES</td>
<td>3.7%</td>
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<td></td>
<td></td>
<td>HAUTE GARONNE</td>
<td>3.1%</td>
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<td></td>
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<td>HÉRAULT</td>
<td>3.1%</td>
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<td></td>
<td>PYRÉNÉES ATLANTIC</td>
<td>3.1%</td>
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<td></td>
<td></td>
<td>PARIS</td>
<td>3.1%</td>
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<tr>
<td></td>
<td></td>
<td>ALPES DE HAUTE PROVENCE</td>
<td>1.2%</td>
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<td></td>
<td></td>
<td>DOUBS</td>
<td>1.2%</td>
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<td></td>
<td></td>
<td>TARN ET GARONNE</td>
<td>1.2%</td>
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<tr>
<td></td>
<td></td>
<td>HAUTS DE SEINE</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Table 10 / Main place of residence of ski touring participants perishing as a result of an avalanche (restricted to people resident in France)

5. In order to limit the geographic origin of deaths to the French territory, the 18.8% of deaths by avalanche concerning foreign residents has been eliminated from this analysis.

6. Caution: in one third of deaths resulting from an avalanche, the department of origin of the victim is not recorded; these observations must therefore be considered with caution.

The introduction to this third part suggested an over-representation of “locals” among avalanche victims; this is also confirmed for deaths occurring during ski touring, an activity that is rapidly gaining popularity.
5/Profiles of avalanche victims

Following on from the previous point, it is important to develop the profile of avalanche victims beyond merely ski touring participants. ANENA has a database on this subject that we mainly used for the period 2000-2010 (419 victims for 289 deaths) [2]. The death rate among avalanche accidents recorded by this organisation over this period (to be considered with caution since it excludes most cases of self-assistance and rescue by companions) is around 70%.

Men are largely over-represented (86% of avalanche victims). The same is true in Canada, where 88% of avalanche deaths are men [27]. It is also important to note the continuing increase in the average age of these victims: an average age of 40 years in the 2000s compared with 37 in the 1990s and 35 in the 1980s [2].

In terms of sporting profile, the proportion of ski tourers among avalanche victims has decreased over the past two decades [2]: 50% of avalanche victims were ski touring during the period 1972-1994 but only 42% for the period 1972-2012, in spite of the development of this sport. Off-piste skiing and snowboarding have taken over (33% of deaths in 1972-1994, compared with 41% in 1972-2012). Mountaineers only represent 10% of reported deaths due to avalanche (which is an average of 4 per year in France). For the decade of 2000 alone, the following breakdown shows a situation that is quite similar to that today, independently of occasional random events related to weather and/or snow conditions.

![Fig. 3 / Avalanche deaths by sport (2000-2010)](source: ANENA database of avalanche victims in France)

Switzerland has the same breakdown between ski tourers and off-piste skiers/snowboarders [28]. One notable particularity concerns Canada: 30% of avalanche deaths involved snowmobiles, a figure that is far higher than the figures for mountaineers, snowshoes and ice waterfall participants put together (10%) [27].
In terms of equipment, the situation is changing quickly: 50% of ski touring avalanche victims had avalanche rescue equipment (beacon + probe + shovel) in 2000, compared with 60% in 2005 and 80% in 2010. The same change is slower for off-piste skiers and snowboarders, among whom the proportion of those with equipment has increased from 30 to 44% \(^2\). Obviously, just having this equipment is no life insurance policy: many of those who perished in an avalanche were relatively well equipped, as shown in the graph below:

![Equipment of avalanche victims (2000s)](image)

**Fig. 4** / Equipment of avalanche victims (2000s)

**Source:** ANENA database of avalanche victims in France

The increase in the equipment rate has probably had the effect of increasing the proportion of rescue interventions carried out by the other members of the avalanche victim’s party (25% in the 1980s, 44% in the 2000s) \(^2\). However, owning this essential, even vital, equipment is also liable to alter the overall attitude to risk situations.

**Accident victim profiles: the dominant effects of age, gender and experience**

The parent population profiles (in terms of age, gender, place of residence, etc.), weighted by the level of exposure (frequency of participation, level of engagement, etc.) appear to have an impact on the accident victim profiles. Thus the ageing of the hiking population or the local residence of ski tourers are identifiable when drawing up the profiles of accident victims.

At this stage, once again, we regret the analytic deficiencies induced by a lack of knowledge concerning the parent populations in many cases. This situation makes interpretation difficult: for example, is the ageing of ski touring avalanche victims simply due to the increasing average age of the French population (identified by INSEE), or to a specific age increase among the skiers enjoying this activity? Are young ski tourers more aware of the risks and/or better equipped than the older generation? While various explanations are possible, it is essential to interpret these observations with prudence.

Ultimately, what can be learned from this investigation of the profiles of victims of sporting accidents in the mountains? There is certainly a very marked gender bias and a serious age impact to be taken into account, as well as the influence of the level of experience, which counter certain preconceived ideas and which, at the very least, go against instinct. However, aside from a probable over-exposure of experienced or expert participants, much remains to be explained concerning the accident mechanisms and circumstances involved; these will be discussed in the next section of this report.
This section of the report aims to provide answers to the following questions: what events cause sporting accidents in the mountains? What are the contributing factors causing these unwanted events (UE)? The eminently complex question of the origin of accident situations cannot be summarised in just a few pages, but we have attempted to propose a modest summary of the knowledge considered most reliable to improve the pertinence of prevention actions. As in the previous part, the experience of rescue teams and snow experts can help to “set the scene”, dispelling certain preconceived ideas.

“Excessive self-confidence and certain reflexes often cause a lapse in concentration that may be fatal”.

Alpine CRS rescue team member

“You know that it might be critical… but you still want to go that little bit further, push back the limits. And that’s what triggers the avalanche, with people who are not necessarily lacking in experience”.

Frédéric Jarry, ANENA

Does this means there are “stupid accidents” in the mountains, most of which could be avoided? Such a suggestion is perhaps a little categorical. However, a trend is emerging from the multiple sources of information used: the fatalistic attitude, long-adopted to explain the regular occurrence of accidents, is losing ground to analyses that often indirectly suggest areas for improvement, enabling better identification of the various types of shortcomings (the term preferred over error) causing incidents that are still too commonplace.
1 / General information on accident circumstances

Before going into the specifics of each activity, a relatively surprising (even disturbing) general observation can be made: in many cases, mountain accidents seem to occur in areas described as easy, both officially and in the field, in terms of technical difficulty [24]. However, these passages may require the implementation of elaborate belaying techniques (such as dynamic belays), requiring vigilance and experience. Quite often, ignoring a basic rule of caution contributes an accident [23].

The occurrence of accidents in technically simple passages spares neither amateurs nor professionals [16].

In France [4], as in Switzerland [23] and in the USA [35], falling into a chasm (whether part of a roped party or not) is the cause of 65-70% of rescue interventions for trauma, far ahead of the feared events that dominate representations of sporting dangers in the mountains, such as avalanches, falling into crevasses, collapse of a cornice, falling rocks³, ice avalanche and so on. Each of these events only represents 3-4% of rescue interventions [23]. Fatal accidents recorded in Switzerland also confirm the low impact of falling rocks, even in mountaineering (5% of reported deaths) and a clear predominance of falls [21]. These initial revelations relativise the importance of so-called “objective” dangers.

2 / Local particularities

The very general above observation does not enable detailed description of geographic particularities at different scales. Some sites go hand in hand with typical unwanted events.

In Japan, for example, the analysis of several decades of accident and rescue intervention reports reveals that in this country, where 70% of the territory is mountainous of an overall moderate altitude and principally covered with thick vegetation, the main threat is exhaustion (Aoyama, 2007). Between a third and half of the accidents and/or interventions recorded concern people lost walking in thick forests, making it difficult to identify visual or cartographic landmarks. This is more than double the average observed in other countries, such as Canada, USA or England [29].

On a totally different scale, Descamps (2012) investigated a well-known “black spot” of the Mont Blanc normal route: the Goûter corridor (which accounts for 47% of accidents occurring between the Tête Rousse and Goûter refuges). Between these two refuges, roped party falls (49%), quickly followed by falling rocks (30%) are the main identified causes of accidents³. Two thirds of the victims of falling rocks while attempting to climb the highest European summit lost their lives during this 100m crossing. This is a logical consequence of the large number of people using this popular route which, like in other high mountain sectors, is the site of frequent rock falls.

Aside from these two particularly evocative examples, other particularities related to sites or areas will be discussed in this chapter.

1. It should be noted that a passage considered to be simple may become more complex due to conditions. Furthermore, it may be difficult to belay in simple passages and easy to belay in difficult routes (e.g. when climbing multi-pitch routes).

2. Abegg (2011) reports a similar level of 4% of falling rocks in the Mont Rainier natural park.

3. Bearing in mind that falling rocks have caused roped party falls without being cited as the initial cause in the Chamonix PGHM reports (period 1990 - 2011).
3/Typical events and contributing factors of hiking accidents

In hiking, most accidents occur during the descent.

In Austria, for example, this is true for 63.4% of incidents reported in this sport, compared with just 26.7% occurring during the ascent [24]. Experienced hikers (such as FFME license-holders) are no exception to this “rule”, also suffering mostly during the descent [15]. A study carried out in the Pyrenees supports this observation: 4 out of 5 accidents involving trauma occurred during the descent, compared with just 7% during ascent [19]. Inversely, health-related accidents (e.g. cardio-vascular incidents) mainly occur during the ascent (which is a medical risk factor) (Haran Larre, 2011).

Taking just fatal accidents into account, falling, often as a result of a slip, remains by far the most common unwanted event [10], far outstripping other situations. In terms of contributing factors, two appear to be over-represented: hiking off-trail and, to a lesser extent, hiking alone [11]. Combining the two, i.e. hiking alone off-trail (which can include simply taking a shortcut from a trail route) is therefore particularly hazardous.

Without limiting his study to fatal accidents, Haran Larre (2011) found that falls are responsible for more than four out of five hiking accidents. His study also identifies another key contributing factor: unsuitable footwear (involved in 42% of cases). He makes the credible suggestion that the lack of good quality non-slip soles, a common trait among bottom range footwear models, causes such falls. FFME license-holders reporting an incident also mainly suffer slips and falls. Detailed analysis of these incident declarations reveals that many occur on wet ground and, to a lesser extent, in icy or snowy areas (snow patches). Tripping up is also mentioned frequently, along with traumatic movements resulting in sprains [15].

It is possible, to a certain extent4, to compare all hiking accidents resulting in rescue intervention with fatal accidents, using the BSM mountain rescue database [4]. Off-trail, the main cause of general accident circumstances (40%) is taking the wrong direction, followed by slips and falls (29%). It is likely that a relatively large number of hikers rescued off-trail were blocked or lost. However, for the fatal accidents recorded, two thirds involve slips and falls, relegating itinerary mistakes to just 5%.

Finally, it is possible to extend the scope to include other contributing factors, notably based on a detailed case study report in Corsica, a mecca for hikers. Several elements combine to explain the particular vulnerability of hikers: a common idea that hiking is a non-dangerous activity; difficulties related to the Corsican mountains (rapidly changing climate conditions, steep, stony paths, summer heat); vast differences between local expert and tourist definitions of what represents a long hike or a difficult itinerary; desertification of the Corsican mountain region, and particularly the disappearance of shepherds, weakening the passage of information between hikers and hiking sites; very superficial and/or poor quality (even missing) route markers along certain trails; etc. Regarding this last point, the desire to maintain the “Corsican culture”, which avoids normalisation and tourist-oriented design, is probably significant.

4. Caution; these data only cover the four summer months (June-September).

5. The “other circumstances” category is often too large to allow meaningful conclusions to be drawn from the data collected.
4 / Typical events and contributing factors of mountaineering and trad climbing

In this sub-section, we invite readers to apply particular caution in terms of the scope of the analyses proposed, since the activities described are extremely heterogeneous in nature.

Several sources agree that fatal accidents are mainly caused by falls to the ground (45-55% of cases), resulting from a roped fall and, à fortiori, non-roped falls (in approximately 50% of reported cases) [10, 4]. They mainly occur during descent (61%) [11] (McIntosh & al., 2008). Risks generally classified as objective (avalanches, falling rocks, etc.) only represent a small proportion of fatal accidents (although a 13% peak in each category is reported on Mont-Blanc) [10]. Falls into crevasses and falling séracs only represent 3% each of mountaineering deaths [4, 10].

In line with the observation presented in the introduction to this section, most fatal accidents involving mountaineers occur on easy or relatively easy terrain, often with no form of belaying [11]. Combined with the actual unwanted event itself (fall), the absence of a belay is the main secondary cause of the fatal accidents reported [24]. Itinerary mistakes, making anchor points difficult to find, and bringing mountaineers into areas where the rocks are less reliable, are also implicated [11].

The rare cases of fatal accidents affecting FFME license-holder mountaineers (between 2009 and 2012), confirm this tendency: thus, dramatic situations are often caused by a loss of balance by a mountaineer not secured on a relay at the bottom of an abseil or in a passage with no apparent risk, a misstep by a member of a non-roped party, etc.

Here, we might make a brief aside concerning unroped climbers. “Clamberers” lost on steep terrain and expert solo climbers are two opposing sporting profiles: they are most often assisted without suffering any impact; however, climbing without belay also represents the main cause of death identified by Lack & al. (2012) [39%].

Concerning accidents in a wider sense (fatal and non-fatal accidents combined), falls represent between 30 and 40% of circumstances reported [26], on a par with belaying mistakes and failures. In 15% of cases, broken holds are the cause of the accident [15]. Once again, falling rocks and falls into crevasses are relatively rare (3-4% of cases). The American Alpine Club study over more than 60 years confirms the extreme rareness of accidents caused by defective equipment (only 0.1% of accidents reported), while the lack of suitable equipment or clothing is involved in 12% of cases [26].

In a large number of cases, mountaineering and trad climbing accidents occur in passages considered as being particularly easy [24]. Schussman & al. (1990) report that 81% of accidents occurring during courses on snowy or icy terrain, occur during the descent (particularly ill-controlled passage over snow or ice, sometimes with unsuitable footwear). Their analysis is as follows: these accidents very often occur on relatively simple routes, or once the victim has finished the technically difficult section of the ascent, in sectors presenting no major apparent danger. It is interesting to note that experienced mountaineers/climbers are involved as often as others with less experience. Regarding this last point, Bowie & al. (1988) confirm that the victims of accidents in Yosemite National Park with a (very) good level of sporting ability are injured in only 14% of cases when attempting a course of a higher level of technical difficulty than their previous achievements. Over-estimating one’s technical ability is therefore only involved a limited number of cases (6-16% of accidents reported to the American Alpine Club), as for excessive exposure (3%) [26].
As mentioned previously regarding hiking, the consideration of local particularities offers a little objectivity for descriptions that have been mainly “down to earth”. In the very particular case of Mount Everest, the type of accident evolves with the changes in population and practices. Thus, the multiplication of expeditions causes jams and slows parties down, contributing to the causes of accident sequences that can be dramatic (such as the 1996 storm which resulted in 8 deaths, on May 10-11th, or the 2014 avalanche which resulted in the death of 16 sherpas on April 18).

The hypothesis of the emergence of new mass accidents related to the relative massification of Everest ascents can also be put forward. On other mountain ranges, it is probable that the large number of people using certain popular itineraries affects the behaviour of certain mountaineers.

Before concluding this section, it is important to relativise the comments made based on the various sources used. While the scope of certain observations appears to be reinforced by the crossing of relatively coherent view points, it is also true that there are certain contradictions (and sometimes major contradictions). Thus, the Canadian and American Alpine Clubs recorded 3.3 times more accidents during ascents than during descents [26], for all sports combined. These data contradict several of the descriptions referred to previously.

5/Typical events and contributing factors of ski touring accidents

Throughout the French mountains, 12% of PGM and PGHM interventions involving ski tourers are related to an avalanche. This percentage increases to 55% for fatal accidents. Slipping and falling represent one third of interventions (31%) but 15% of fatal accidents [4].

A study carried out in Isère [11] further qualifies these figures: among the 11 fatal ski touring accidents between 2001 and 2006, as many were caused by falls/slips as by avalanches.

Based on the accident declarations by FFME license-holders [15], being buried by an avalanche is relatively rare (9% of cases), and yet its most common outcome by far is death.

In all, 4 out of 5 accidents occur during descent, in spite of the much shorter exposure time compared with the time spent in ascent. Falls cause most of these accidents (58%), particularly when snow conditions make it difficult to advance. Problems with bindings (non release in a fall or accidental release) are mentioned relatively frequently (16% of cases) [15]. The rare accidents during ascent (13%) are mainly caused by slips and falls in particularly steep sections [15].
6/Focus on ski touring avalanche accidents

The circumstances of avalanche accidents occurring during ski touring deserve specific attention. In France, ski tourers are the most vulnerable to this risk (just ahead of off-piste skiers) [2].

Since the 2000s, avalanche accidents involving ski tourers occur mainly in winter, (December to February), relegating spring (March to May) to second place [2].

In Switzerland, 98% of avalanches involving victims occur on slopes with a gradient of more than 30° [28]. The Canadian Avalanche Center, taking into account only fatal accidents, gives the figure of 96% [27], compared with 98.8% in France according to ANENA. The vast majority of accidents (63%) occur on gradients between 36° and 45° [28]. ANENA even reports that gradients between 35° and 40° are dominant (39% of cases), although 26% of accidents reported in France occur on slighter gradients (30° - 35°) [2].

In terms of risk level, most fatal off-piste skiing and ski touring accidents in the Swiss mountains occur in level 3 (53 %) or 2 (32 %) conditions [28]. In France, risk level 3 also corresponds, roughly speaking, to one in two accidents (fatal and non-fatal), but 30% of accidents occur in risk 4 and only 17% in risk 2 [2]. However, level 4 represents 8% of bulletins in France but just 2% in Switzerland, which suggests that comparisons may require some qualifying details. In Switzerland, off-piste skiing accidents mainly occur in risk 3 conditions (61%), while ski touring accidents are mainly in risk 2 (36%) or 3 (48%) [28]. Only 10% of fatal accidents occur under risk 4 or 5 conditions in Switzerland.

Spontaneous avalanches (i.e. not triggered by the victims themselves or their group) are rare, only concerning 8-10% of cases [27, 28].

In France, 70% of avalanche accidents affect groups of 3 or more (17% of lone skiers) [2]. It seems that in Canada, the groups affected by fatal accidents are larger (4 people or fewer in 50% of cases) [27].
According to ANENA, ski touring avalanche accidents occur more often during descent (51%) than ascent (34%) (not specified for 15% of cases).

There is a significant difference between activities regarding the fatal or non-fatal result of the avalanche: the survival rate of avalanche victims is 42% for ski tourers, compared with 46% of downhill skiers and just 35% of snowboarders [2].

The cause of death in an avalanche reported in Canada is asphyxiation in 74% of cases, ahead of severe trauma for the remaining 26% [27]. The chances of survival are obviously greatly improved if the victim is not totally buried (on average, 2 deaths are reported for every 5 people totally buried).

In terms of means of locating buried victims (including the dead), in Canada, 66% were found using avalanche beacons (compared with 70% in France), 14% by organised probing (7% in France) and 12% by dogs (9% in France) [27, 2]. The last two methods cited rarely enable lives to be saved. Having a beacon however, has a positive impact on the chances of surviving an avalanche accident [2].

An encouraging observation: the proportion of deaths among avalanche burial victims is declining (from 77% in the 1980s to 60% in the 2000s), while the number of people buried sustaining only injuries has risen over the same period from 9% to 29% [2].

### The need to associate quantitative and qualitative approaches

Within the databases used in this part, undetermined events and circumstances often account for a large number of cases, alongside the factors indicated, making it difficult to use these sources to improve our detailed understanding of accident situations and mechanisms.

Furthermore, it is important to point out a certain porosity between some of the categories used in these databases: there is sometimes little distinction made between the unwanted event and the circumstances contributing to its occurrence. On this subject, the American Alpine Club can be lauded for having differentiated between the main cause of the accident and its contributing factors, but the results still remain difficult to exploit (the same items appear in both categories) [26].

It is also evident that a combination of circumstances is often at the origin of an accident situation: technical error or fatigue causing a fall, for example. This underlines the importance of not taking the data and interpretations presented above as fact, but rather to include subsidiary methodologies, and particularly qualitative techniques. These involve breaking down the various “ingredients” of an accident sequence to highlight their conjunction in association with a time-based reasoning.

In fact, there is practically no doubt that the contributing factors work together (wrong direction, equipment aspects, fatigue, weather change, low light, etc.), resulting in a critical situation in which a final inadequacy may have dramatic consequences 9.

9. Reason (1993) proposes a particularly stimulating theory of accidents. it distinguishes between active failures (i.e. operator “errors”, generally later considered as being the main cause of the unwanted event) and passive failures which combine with the first (consequences of earlier decisions, sometimes taken by others, and having a delaying effect on the prevention barriers). It thus appears that the accident sequence sometimes starts months before the actual accident, due to “dormant” factors that may be present for long periods of time with no noteworthy consequences or obvious visibility until the occurrence of an accident liable to activate them.
7/Accidentology perspectives offered by feedback on mountain accident and incident feedback

There is a long history of this type of approach in North America, where the American and Canadian Alpine Clubs jointly publish a relatively detailed annual report on an average of 70 accidents (of variable seriousness), to enable the public to learn lessons from them. The official purpose is to transform these accidents into learning situations, not only for other sportsmen, but also for guides, instructors and rescue teams.

The cases are selected on the basis of their pedagogical contribution, in view of what it is better to do, or recommended not to do in terms of safety (26). In short, it means “showcasing” accident situations so that anyone who so desires can examine and learn from them, in the hope that this will have a positive impact on the person’s own decisions and behaviour. Similar initiatives have been implemented for avalanche accidents (32), occurring in North American national parks (33, 34), and in Austria (24).

Some of the stories are very detailed, providing a blow by blow account of the whole accident sequence. This reveals precursor elements of note in the origin of accidents: unplanned separation of the group, delay in starting the course, marginal route errors, unsuitable or insufficient equipment, etc.

A first limit lies in the small number of viewpoints taken into consideration (most are reports compiled by the rescue team members, who, by definition, were not present at the time of accident itself). Another limit is the frequent focus on management of the alert and rescue operation, rather than on the accident itself (also related to the role of the main reporter, as mentioned previously). For fear (understandably) of legal proceedings, ANAM (Accidents in North America Mountaineering) publishes no comments on the inappropriateness of certain decisions, providing mainly descriptive texts and thus limiting its analytic scope. Finally, a regular criticism concerns the profusion of information published, which may overwhelm readers.

Since the middle of the 2000s, similar initiatives have been undertaken in France. The implementation by FFCAM, CNISAG, ANENA or SNGM of qualitative and collective methodologies to manage feedback on the occurrence of accidents or secondary accidents is a major step forward for mountain sport accidentology.

For example, it has enabled SNGM to understand why, in accidents involving a mountain guide, the guide is generally less impacted than his/her clients: the guide is more experienced, in better physical condition, particularly able to adopt the right position in the right place in a critical situation, and thanks to his knowledge of the terrain, generally protects himself better. Above all, the collective accident feedback from SNGM has revealed certain particularly problematic situations in terms of safety: a course involving several guides (particularly if unplanned); the importance given to reassuring indexes to the detriment of low danger signals; the question of routine habits that sometimes make a person forget the fundamental rules of safety; excessive confidence placed in local guides, who tend to be reassuring, rather than trusting one’s own analysis of the risks; etc.

In each edition of Neige & Avalanche, ANENA publishes testimonials of avalanche incidents or accidents. After more than 12 years, this feedback reveals that in most cases, the people buried (or almost) had enough information to give them a correct view of the situation (proper reading of the early signs of avalanche or snow slide risk), and enabling a relatively accurate analysis (3). This insight enables progress to be made in terms of prevention: the main question is no longer that of the perception of danger, but equally if not more so, that of the decision to set out in spite of the danger.
The initiative of FFCAM’s prevention group is similar: the conclusions of this workgroup, which dissects non-fatal accident cases involving club members, agree on the need to work on cancelling an excursion or adapting a course to the actual conditions (preparation of itineraries with different options), rather than the simple technical ability to face up to extreme situations (equipment expertise and physical aptitude). Both FFCAM and FFME now aim to understand how decisions are made or not made, resulting in a situation whose resolution goes beyond a technical issue.

These discussions are all the more relevant since for many victims, accidents are preceded by “borderline” situations, which could have served as an alert. Bowie & al. (1988) point out that more than 30% of people injured in Yosemite National Park had already suffered an injury (other than slight). In ski touring, 26% of those interviewed in an exploratory survey said they had already been injured (even slightly). Among them, one third were injured the previous year, which corresponds to approximately 8% of injuries per year within this population (36). Accidents (serious or slight) are therefore an integral part of the career of mainly mountain sportsmen, which gives us something to think about.

Another trend is developing: the multiplication of testimonials not of accidents, but of incidents (avalanche triggered without burying anyone, for example). Here, we have all the ingredients of an accident, without having the bear the weight of its consequences. This makes the testimonial easier, and such feedback on incidents or near-accidents is extremely rich and precise (concerning the snow conditions in the sector, choice of route, individual and group decisions or degree of exposure).

Ideally, we must stop limiting ourselves to the sequences resulting in fatalities or serious injuries, but also use this multitude of situations, often banal in the mountain environment, generating mere incidents or “borderline” situations. Similarly, incidentology is also involved in the Near-Miss Survey [30] or in CAS’s Alpine Sicherheit [31]. Aside from the fact that there are, by definition, more safety improvement opportunities than accidents, the stakes (legal, emotional, institutional, etc.) are not the same.

The sharing of accident and incident experiences is also tending to develop via the social networks [17], although we can hardly speak of a standardised or systematic experience sharing practice according to a specific methodology.

In order to enhance the usefulness of these descriptions, which are sometimes extremely detailed [10], while eliminating the singularity of each situation, it appears wise to propose a graphic model. The “translation” of textual information into a tree structure improves its legibility. There is no question of “erasing” what makes these detailed stories interesting and rich, but it is important to identify recurrent danger factors and circumstance sequences. The concatenation (assembly) of multiple testimonials will thus enable us to overcome the consideration of these tales as individual cases.

This processing has been applied to two sets of testimonials [11]: 1) 70 tales of avalanche accidents and incidents involving ski tourers (published in Neige & Avalanche and posted on the camptocamp website); 2) several hundred cases of mountaineering accidents collected in the annual summaries of the American Alpine Club (Accidents in North America Mountaineering) between 2010 and 2012.

As an example, the main contributions of the first work can be underlined. A “bow tie” tree structure was used, which consists in placing in the centre a particularly feared event in ski touring (triggering of a snow slide or avalanche liable to harm ski tourers).

On the left are the decision factors contributing to the occurrence of this event according to the testimonials consulted (focus on the causes). On the right are the attenuating processes that enabled, in some cases, burial to be avoided or, most often, its impact to be minimised (focus on the consequences).
Obviously, certain geomorphological and snow/weather conditions are necessary to trigger an avalanche. What caught our interest however, are the other organisational and decisional ingredients that meant skiers came to be on or even overload a fragile snow mantle. To make things clearer, we have limited the diagram below to the left side of the tree structure, including only factors occurring in at least 10% of the testimonials analysed. The elements indicated by an orange flag are frequent (present in 15-20% of testimonials); a red background indicates those mentioned very often (in approximately one third of cases). The other components of the accident scenarios analysed, and their combinations, can be consulted on the Petzl Foundation website.

This extract of the left side of the tree structure enables certain cognitive mechanisms (other than inaptitude) to be identified as encouraging the under-estimation of danger: weight of habit, paradoxical effect of experience, too rare re-evaluation of the situation, etc. There are also other processes that result in the confrontation of a known danger. This type of modelling remains highly dependent on the sources used, which means that over-generalisations must be avoided. However, the sheer number of “inputs” (testimonials, feedback) is liable to eradicate their subjectivity and particularities, tending towards better knowledge of the processes that lead to an accident. These processes comprise various interacting factors which generate a certain complexity: the capacity to assess risk correctly, regardless of the method used, is therefore far from being the only factor in play.

In terms of training and prevention, this type of graphic representation offers a detailed vision of what happens prior to the event. We believe that it can help to define priorities for the barriers to be implemented to counter the impending accident sequences.

12. www.fondation-petzl.org
This last part of our report is devoted to the bodily impacts of accidents. To go beyond the most common categories (injured, unharmed, deceased, illness, etc.), it summarises medical information from several sources. These sources were selected for their reliability and complementarity; they provide information on the characteristic non-fatal injuries of several mountain sports.

There are a considerable number of medical diagnoses. However, the diversity of health care sequences makes it difficult to obtain reliable statistics (which are available for winter sports, mainly thanks to Association des Médecins de Montagne, an association of mountain doctors). The limited traceability of mountain sport accident victims within a system with little centralisation and a low level of uniformity, causes disparities in the epidemiological treatment and the presence of multiple databases, mostly local and partial (Sagues & Manteaux, 2007).

Several initiatives, mainly based on hospital data, overcome this fragmentation, producing useful knowledge for the prevention field.
1 /TRENAU database: an ideal observatory for serious trauma

The various computer records accompanying accident victims through hospital structures provide precious material for anyone wanting to find out about the specific injuries related to any one activity.

However, particular care must be taken as to the context of information production. For example, InVS EPAC (permanent inquiry into everyday life accidents), the scope of which is very wide, is based on admissions to emergency services of a small number of test hospitals; serious trauma victims are often directed to resuscitation or life support units, without entering the emergency ward, thereby escaping detection to a large extent. The results of interpretation shortcuts in this type of inquiry would suggest that paragliding is not a dangerous activity since there are few traces of paragliders passing through the emergency ward.

As mentioned in chapter 1, TRENAU focusses on serious accidents that are not fatal at the time of emergency medical treatment. Aside from the interesting estimation of secondary mortality related to mountain sports, its gradual development will ultimately make this a fundamental source of knowledge on serious trauma resulting from the practice of mountain sports (20). Publication of these results will be gradual, according to a scientific evaluation method applied to the data collected and analysed (120 patients per year since 2011, setting aside winter sports cases).

2 /IFREMMONT/RESAMONT 2: focus on non-critical trauma

The Nay study (2013), carried out within the framework of a cross-border project, Résamont, is complementary to TRENAU, since it deals with patients in a non-critical condition, who can be treated by emergency departments with no high-tech technical platform (18). Over a one-year period (July 1 2012 to June 30 2013), 4,627 patients were admitted to the emergency department of Sallanches and Chamonix (HPDMB, Mont-Blanc hospitals) for medical reasons and/or trauma resulting from the practice of a mountain sport. 60% of these admissions were related to downhill skiing, but a number of diagnoses were made on hikers, mountaineers and mountain bikers.

The low level of injury seriousness is attested by the fact that 56% of patients arrive at the HPDMB emergency department by their own means. The CCMU (clinical classification of emergency patients) is more objective, enabling assessment of the patient’s condition (level of clinical seriousness and medical prognosis).

<table>
<thead>
<tr>
<th>CCMU</th>
<th>Proportion of cases treated</th>
<th>Number of cases treated</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.0%</td>
<td>339</td>
<td>No additional examination</td>
</tr>
<tr>
<td>2</td>
<td>79.7%</td>
<td>3,398</td>
<td>Stable injured condition, additional examination(s)</td>
</tr>
<tr>
<td>3</td>
<td>12.0%</td>
<td>518</td>
<td>Condition that may deteriorate, without engaging being life-threatening</td>
</tr>
<tr>
<td>4</td>
<td>0.3%</td>
<td>12</td>
<td>Life-threatening condition</td>
</tr>
</tbody>
</table>

Table 11 / Medical profile of admissions to emergency departments of HPDMB following a sport trauma in the mountains (Nay, 2013).
No intra-hospital deaths occurred during this one year period and only 15% of patients had to be hospitalised. Exceptions aside, serious cases are directly oriented to care facilities better equipped to provide the medical treatment required. Therefore the Nay study (2013) provides information on the “ordinary” traumatology of mountain sports.

<table>
<thead>
<tr>
<th>ACTIVITY (Number of cases)</th>
<th>DIAGNOSIS DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIKING (492)</td>
<td>MOUNTAINEERING (333)</td>
</tr>
<tr>
<td>53% injuries of lower limbs</td>
<td>20% contusions and minor wounds</td>
</tr>
<tr>
<td>.24% sprains (of which 20% ankle)</td>
<td>19% frostbite</td>
</tr>
<tr>
<td>.13% fractures</td>
<td>18% fractures</td>
</tr>
<tr>
<td>17% injuries to upper limbs</td>
<td>.9% involving lower limbs (ankles 5%)</td>
</tr>
<tr>
<td>.8% fractures</td>
<td>.4% involving upper limbs</td>
</tr>
<tr>
<td>.3% dislocations</td>
<td>11% open wounds</td>
</tr>
<tr>
<td>11% illnesses</td>
<td>10% illness</td>
</tr>
<tr>
<td>6% thoracic injuries</td>
<td>including 3% acute mountain sickness</td>
</tr>
<tr>
<td>4% cranial trauma</td>
<td>9% sprains (mainly ankle)</td>
</tr>
<tr>
<td>7% other head injuries</td>
<td>3% cranial trauma</td>
</tr>
<tr>
<td></td>
<td>3% dislocations (mainly shoulder)</td>
</tr>
</tbody>
</table>

Table 12 / Diagnosis per activity (Nay, 2013)

This overview of the Nay study (2013) (available in full on-line for consultation) reveals certain trauma particularities: ankle sprains represents one quarter of diagnoses in hiking-related cases; frostbite represents one in five mountaineering patient cases; a majority of upper limb fractures, wounds and contusions observed in MTB, etc.

3/ Detailed traumatology of a single activity: the ski touring example

From 1990 to 1997, Saragaglia & al. (1999) analysed 118 injuries resulting from ski touring incidents. As for Nay (2013), their study is limited to “ordinary” traumatology (peripheral injuries to limbs), excluding particularly serious cases (trauma involving the head, spine and thorax/abdomen, and cases of multiple trauma). The proportions of accident circumstances and injuries observed were similar to those reported for downhill skiing, also covered by this study: lower limbs affected in 70% of cases, dominance of sprains over fractures and dislocations, etc. A few particularities deserve a mention however, bearing in the mind the narrowness of this panel:

- The rate of collision with trees and rocks (25% of cases) was higher than on slopes, but high speed and high energy trauma were less frequent.
- Fewer femur fractures were observed in ski touring (1.7% of injuries) than in downhill skiing (5%).
- Knee sprains were even more specific to ski touring (42.4% of cases) than to downhill skiing (32.5%); and were also more serious, including for cases of rupture of the anterior cruciate ligament (ACL).
- Instep injuries were the second most common injury for ski tourers (use of more flexible, slack-tied shoes, providing less support to the ankle): 14% compared with 4.6% in downhill skiers.
- The shoulder was the main site among upper limb injuries, with no reports of injuries to the elbow or forearm.

1. dumas.ccsd.cnrs.fr/docs/00/92/09/73/PDF/2013GRE15111_nay_camille_1_D_.pdf
2. The small sample size (118 ski touring injuries) invites prudence with regards to interpretation.
In the same health facility, Vejux and Picard (2012) compared the files of winter sport accident victims for seasons 1998-1999 (25 ski touring cases) and 2008-2009 (26 ski touring cases). Incidentally, the average age was high in 2008-2009 (39 years) within the sub-population in question. The 10-year interval study confirms the trends mentioned previously: increase in serious sprains (from 24% to over 42%), which has become the main type of injury in ski touring, largely ahead of fractures (36% in 1998-1999 compared with 31% in 2008-2009) and minor sprains (32% in 1998-1999 compared with 15% in 2008-2009). The small number of cases on which these observations were made invites prudence regarding generalisations; it is better to consider these as indicative trends, confirmed elsewhere by other sources.

Accident declarations from FFME license-holders also highlight the clear dominance of lower limb injuries, with a large majority of sprains (15). Finally, a victimisation survey carried out among almost 600 ski tourers (36) suggests a comparable trauma breakdown: the injuries suffered concern mainly the lower limbs, with the most common pathologies being sprains (22% of all injuries), followed by fractures (20%), then upper limb injuries, mainly contusions (11.5 %), sprains (8%) and fractures (7%).

It should be noted that the only injury that most results in rescue intervention is the lower limb fracture (60% of cases). For all other injuries (particularly upper limb fractures and lower limb sprains), most victims arrive at the healthcare structure (hospital emergency department or doctor’s surgery) under their own means. Most lower limb sprains are treated by the accident victims themselves (36).

4/ Detailed traumatology of a single activity:
the climbing example (natural site)

Among the non-fatal injuries in climbing, lower limb injuries are most common, followed by head, spine and upper limb injuries in that order (Lack & al., 2012).

This recent source confirms the older analysis proposed by Bowie et al. (1988), which provided similar results: representing 44% of pathologies related to climbing injuries, lower limbs come first. Ankles were particularly affected (30% of cases), and local fractures of this joint were the most common diagnosis. Cranial trauma only accounts for 6% of cases, but was fatal in over 50% of the cases reported.
Overall, the situation is relatively clear: a large majority of climbing injuries are minor. 59% have an ISS (Injury Severity Score) of less than 5; 36% have an ISS between 5 and 12; just 5% attain or exceed 12. Unsurprisingly, the bodily impact suffered by lead climbers is greater on average than that suffered by other climbers. Finally, it should be noted that while the average ISS was 4-5 for victims of climbing accidents, it was 9 in cases involving rescue team intervention (compared with an average of 4 for injured patients arriving in local healthcare structures under their own means).

Traumatology data: complementary sources in development

Aside from the type and location of the pathology, it would be useful, for prevention purposes, to have more systematic information on the average ISS for each mountain sport. With a view to refining accidentology and epidemiology for mountain sports, we can only encourage the continuation of additional work carried out within the framework of the TREN and Ifremond. These organisations produce cumulated databases, some of which are still in development, providing insight of different kinds into the traumatology of mountain sports. Furthermore, the continuing victimisation surveys also represent an additional means of developing knowledge. By going beyond hospital data, the information collected in this manner will provide an overview of all injuries suffered, including those with the least impact in medical terms. Such injuries, in view of their frequency, are not necessarily negligible to public health matters.
References of the data and surveys used in this study

The list below indicates the sources used to compile this report. This list does not include all the information requested and consulted, only that considered most relevant in terms of the objective set for this study. Certain elements intended to clarify the method and scope of each cited study are also provided, along with links to documents or reference websites accessible to the public.

(1) InVS survey of trauma-related mortality related to sport (Rigou & al., 2013)
Survey of accidental deaths occurring in France during 2010 within the framework of a sporting activity (n=246), based on several sources: collected from public institutions (ministries) for 35% of deaths identified, Internet sites (federations, ANENA, ONCFS, blogs) for 20% of deaths identified, regional daily press and on-line media for the remaining 45%. Focus on primary mortality.

(2) ANENA: Database of avalanche accidents resulting in rescue intervention
Database integrating all fatal accidents occurring in France for the past 40 years (an average of 20 per year, causing 30 victims), and 40-80 incidents and/or non-fatal accidents per year.
http://www.anena.org/5041-bilan-des-accidents.htm

(3) ANENA: Testimonials of avalanche accidents published in Neige & Avalanche (2000-2012)
Since 2000, each issue of the Neige & Avalanche magazine proposes feedback on a non-fatal avalanche incident or accident; the victim describes the facts and context and expert comments are provided (specialist in snow conditions and mountain guide).
http://www.anena.org/5042-la-revue-n-a.htm

(4) DGGN (French national mountain rescue service) database (2008-2012)
This database contains information on all the rescue interventions carried out in mountain areas by PGHM and PGHM rescue teams in France (30,630 victims rescued over the 5 years studied, representing an average of 6,156 victims per year).

(5) SDIS 74 data (fire and rescue service for department 74, Haute-Savoie)
Database of 800-900 rescue interventions per year in the mountains (fire rescue alone and/or in association with PGHM) for the Haute-Savoie department. Use of the form provided by SNOSM since 2007 (accident circumstances not specified) then transmission to the Haute-Savoie prefecture.

(6) DCCRS data (division of national safety companies)

(7) SNOSM (national mountain safety observation system)
National aggregation of mountain interventions carried out by the various specialized rescue services (e.g., n=5389 in 2012). These services submit their reports to the prefectures of mountain departments, which then pass them on to SNOSM.

(8) Prefecture 74 data (Haute-Savoie)
Annual aggregation of mountain rescue service operations for the Haute-Savoie department.

(9) Accidentology in the Gouter corridor (Descamps, 2012)
Secondary analysis of Chamonix PGHM data for a sectorial focus. Summary report available on the Petzl Foundation website:

(10) Previlirisk Mont-Blanc (La Chamoniarde)
Secondary analysis of PGHM interventions in the Mont Blanc mountains (French side) from 2003 to 2012 (excluding 2007, due to a lack of available figures), representing more than 11,000 victims. Study limited to mountain sports outside resort ski areas.

(11) Circumstances of deaths in the mountains in Isère (2001-2006)
Work carried out by Pierre Pelletier (CNEAS) on the circumstances of 159 deaths (average 26.5/year) occurring during the practice of mountain sports in the Isère department between 2001 and 2006 (sources: CRS intervention telegrams; analysis of Isère PGHM reports; registers; procedure reports).

(12) ODAPA: FFRP (French hiking federation) accidentology prevention assistance tool
Cartography of hiking accidents resulting in rescue intervention by PG or PGHM (place, date, type of accident, damage, circumstances, etc.). System supplied with data from PG(H)Ms to provide geo-locations for the accidents reported (GPS coordinates of interventions as mentioned in their intervention reports since 2008).

(13) FFAM data (French federation of alpine and mountain clubs)
Data collected and produced by the safety prevention group (15 investigators) directed by Damien Haxaire. It comprises a summary of the incidents reported to the federation’s insurance company (800 declarations/year), which can be crossed with the clubs’ statistics (for instructor-led activities), as well as a more detailed study of non-fatal accidents (10 cases/year) with on-site investigation and group analysis to identify the tree of causes and factors to be taken into account for training and prevention campaigns.

(14) FFS (French potholing federation) data
Statistics compiled by the insurance commission on the basis of incident declarations to the federation’s insurance company (60 declarations/year). Summary of SSF (French potholing rescue) activity (25 events/year): type of accident and consequences, cause analysis.
http://www.ffspeleo.fr/descendeur-123.html

(15) Accident declarations by FFME (French mountain and climbing federation) license-holders
437 incidents reported to the federation’s insurance company for the period 2011-2013. Brief explanation of the accident circumstances with a very variable level of detail for each case. For certain accidents (specific consequences or contributing factors), the declarations are sometimes associated with an expert comment.
(16) SGNM (mountain guide syndicate) feedback procedures
Annual meetings to enable group discussion of incidents/accidents occurring within a professional context. In parallel, a detailed study by a smaller committee of between 8 and 10 accidents per year (fatal and/or with serious legal impact pending) in order to identify the source of these events (clinical approach to identify the recurrent risk factors to be dealt with during training or refresher-training courses).

(17) Camplocamp.org: on-line descriptions of incidents and accidents
This website publishes reports of incidents or accidents occurring in relation to a mountain sporting activity (an average of 10-15 descriptions published every year on line, with a highly variable level of detail).
http://www.camplocamp.org/portals/388181/fr/recits-d-accidents-et-accidents

(18) Mountain medicine research and training institute (fremmont/resamont 2)
Descriptive study of 5,634 diagnoses concerning 4,627 patients admitted to the emergency wards in Sallanches and Chamonix (Mont-Blanc hospitals) over a one-year period (July 1 2012 to June 30 2013) for a medical disorder/trauma occurring in the mountains.

(19) Hiking epidemiology (Haran Larre, 2011)
Study based on a population of 140 victims of hiking accidents occurring in the Pyrénées Atlantiques department (64) between 2006 and 2009.
Sources: SAMU, GMSP, subsidiary telephone inquiry.

(20) TRENAY (north Alps emergency service trauma system) (Bouzat & al., 2013)
Listing of approximately 300 serious trauma cases every year since 2011 (Injury Severity Score > 15), resulting from a mountain sporting accident (including resort ski areas, representing 70% of such cases), treated by one of the 15 centres in the northern Alpes (Isère, Savoie, Haute-Savoie) belonging to this hospital network. Includes data on intra-hospital mortality but not on accident circumstances.

Excluding non-trauma related (sanitary) mortality but including secondary mortality (intra-hospital within one month). An estimated 90% of the actual number of sporting accident deaths are covered by this survey.
Sources: Club Alpin Suisse, Institut für die erste Hilfe und die alpine Rettung (snow and avalanche institute), Société suisse de sauvetage (rescue company), diving accident prevention office, Swiss free flight federation, accident insurance statistics centralisation service, etc.

(22) Himalayan Database
Data compiled from post-expedition reports concerning the summits subject to permit (Tourism ministry) in Nepal feeding a database that was computerised in 2004: precise description of the parent population, deaths, cause of death, certain serious injuries... Population considered: 1,8479 people (10,668 mountaineers and 7,811 sherpas) participating in Everest expeditions between 1951 and 2010.
http://www.himalayandatabase.com

(23) Swiss Alpine Club: emergency situations in the Swiss mountains 2007-2012
List of rescue organisation interventions involving mountain sport participants (excluding activities involving transportation means: MTB, base-jump, paragliding, etc.), representing 2,250-2,700 people per year.
Sources: Secours Alpin Suisse, REGA, BPA, federal office of sport, Organisation Cantonale Valaisanne des Secours, Centre de compétence pour le service alpin de l’armée, Fédération Suisse des amis de la nature, Club Alpin Suisse, Association Suisse des Guides de Montagne, Suisse Rando, Fédération suisse de ski, Association Suisse des Écoles d’Alpinisme, Institut für die erste Hilfe und die alpine Rettung.

(24) Alpine Sicherheit Austrian committee – Berg analysis
Independent national platform covering several Austrian institutions, aimed at the prevention of mountain sport accidents. Data are collected by way of anonymous surveys carried out by the police, then presented to the alpine safety board for expertise and evaluation.
http://www.alpinesicherheit.at/de/analyse-berg/

(25) Mountain Rescue – England & Wales Annual Incident Reports
British data available on-line since 1991. Annual 3-10 page reports containing statistics and comments concerning the past year: type of sport, accident cause and injury location.
http://www.mountain.rescue.org.uk/information-centre/incident-statistics

(26) American Alpine Club: Accidents in North American Mountaineering
Details of accidents reported (victim status: assisted, injured or deceased) collected over more than 60 years (since 1980, an average of 181 accidents reported, involving 370 people per year for the USA and Canada).
http://americanaclibclub.org/pr/ateam

(27) Canadian Avalanche Center
Trends observed between 1997 and 2007 based on the analysis of 105 fatal avalanches involving 155 victims.
http://wwwavalanche.ca/cac/library/patterns-in-avalanche-accidents/overview

(28) Accident prevention office (Switzerland): avalanche risk factors and risk prevention for ski touring and off-piste skiing (Walter & al., 2012)
http://www.bfu.ch/sites/assets/Shop/bfu_b_085.01_bfu-Grundlagen%20-%20Lawsenrundfalle%20beim%20Touren-%20und%20VARIANTENFahrten.pdf

(29) Accidentology of mountain sports in Japan (Aoyama, 2007)
Data from 1) Japanese clubs (70,000 members) based on accident declarations sent to insurance companies since 2001; 2) intervention statistics provided by the police since 1951.

(30) Alpine Near-Miss Survey: near accidents in the USA
Internet site accessible to all (rescue teams, guides, sportmen, etc.) devoted to collecting anonymous testimonial on close calls and incidents occurring during the practice of mountain sports. The stories submitted (in English) can be consulted on this North American website.
http://www.alpinenearmiss.org

(31) Sécouritéalpine.ch: near misses in Switzerland
Website set up by the Club Alpin Suisse and Swiss accident prevention office to collect stories of near-accidents and incidents occurring during the practice of mountain sports. (Some stories are turned into neutral, anonymous safety announcements).
http://www.alpinesicherheit.ch/index/index

(32) Northwest Avalanche Accident Summaries (USA)
Detailed avalanche accident reports including not only texts but also photos, maps, analysis of snow conditions, etc. (around ten reports per year). http://www.nwac.us/accidents/accident-reports/

(33) Mountain Safety in Canada’s National Parks
Detailed reports concerning accidents occurring in the Canadian national parks, including text descriptions, photos, maps, technical analysis, etc. (source: mountain rescue teams).

(34) Yosemite Search and Rescue (USA)
Since 2000, detailed descriptions have been added to purely statistical data. Reports drafted by the Yosemite National Park rescue teams based on their rescue interventions. Some information on accident circumstances is included, and the victim’s own testimonial. Case studies and detailed analyses also available (e.g.: fatal accidents on The Nose d’El Capitan).
http://yietensofas.org/rescues/rescues.html

(35) National Parks Service (USA)
http://home.nps.gov/morningreport/

(36) Victimisation survey among ski tourists
Exploratory survey conducted by our research team among a non-representative sample of 607 ski tourists (315 spectators at the 2013 Pierra Menta and questionnaires filled in by 292 people on the Ski Tour website).
Bibliography


Technical glossary

Accident: the materialisation of danger, a sudden, involuntary event that causes bodily harm and possibly material damage.

Accidentality: a term borrowed from road safety experts, this notion relates the accident rate to a variable that may be a population (number of people practising a sport, for example) or a volume (number of hours during which the sport is practised, for example, in which case, the term used is exposure).

Accident-generating: describes behaviour, an event or context conducive to the occurrence of an accident.

Accidentology: the study of accidents, in terms of their causes, and effects.

Accident cause: the idea of cause generally relies upon a single explanation, a mechanical model (cause a produces effect b). Tends to be replaced by the notion of risk factors (see below).

Criticality: product of the probability of event occurrence and the seriousness of its potential consequences. The criticality index enables risks to be sorted by priority.

Danger: threat, harmful event liable to happen (fall, collision, fatigue, dehydration). Danger is characterised by the type of event, the scenario leading up to its possible occurrence and the seriousness of the potential damage.

Risk factors: unlike the idea of accident cause, this notion postulates the existence of a number of interacting factors to explain the occurrence of an accident. The presence of a single factor is neither necessary nor sufficient to explain the materialisation of the danger.

Risk management: decision process consisting in 1) identifying the dangers; 2) modelling the sequences of events liable to result in each feared event (scenarios); 3) assessment of the criticality of each scenario; 4) determination of risk acceptability based on negotiation with the parties concerned in order to decide among various possible alternatives; 5) implementing action to neutralise/attenuate the identified events (crossing the exposed passage one by one, using the right length of rope between members of a roped party, etc.). This involves the implementation of prevention and/or protective barriers.

Impact: consequence of the materialisation of the danger (bodily harm in the case of accidents, or merely material damage in the case of incidents). The type and seriousness of the impact are variable: from contusion to death, including sprains, fractures, etc. This report focuses mainly on the body traumas that occur when the body is subjected to a sudden or short intolerable level of energy. Impact depends on both the intensity of the danger (height of fall, size of rock, volume of snow in a slide, morphology of the terrain, etc.) and the vulnerability of the target (altered by the wearing of protective gear, the presence of fall breaking mechanisms, etc.).

Incidentology: the equivalent of accidentology, but centred only on incidents or near-accidents. The number of situations liable to be analysed is thus much greater than when considering accidents only.

Injury Severity Score: a method to assess the seriousness of the trauma suffered by a victim and to measure his/her chances of survival. Used by rescue teams, it is based on a simple calculation combining the seriousness of the injury and the body part affected (for examples, see http://www.sfar.org/scores/triss.php). An accident is considered serious if the ISS is more than 15.

Seriousness index (or case fatality rate): number of deaths in relation to number of injuries for a given activity (expressed as an index, percentage, etc.).

Mortality: number of deaths occurring during a given period and within a given population. Primary mortality corresponds to deaths occurring immediately (or pronounced by the rescue teams at the scene). Secondary mortality (or intra-hospital) occurring after the start of medical treatment.

Near-accident or incident: sudden, unexpected event that does not cause bodily harm.

Accident feedback: in this context, accident feedback consists in analysing accidents or incidents to turn them into learning opportunities in the field of safety. The current trend is to adopt collective, systemic procedures, broadened to include organisational aspects to improve the identification of accident mechanisms.

Risk: means of approaching or considering a danger. What are the chances of an event occurring? Why? What are its possible consequences? These more or less objective evaluations are often based on knowledge, but also on beliefs. The ways in which we perceive danger vary, generating different points of view of the same threat.

Safety: in the strictest sense, a situation in which there is no danger. In practice, safety is mostly a goal, based on a set of measures. Primary safety consists in reducing the risk of accident by preventing its occurrence (prevention). Secondary safety consists in protecting the victim if the accident cannot be avoided. Finally, tertiary safety does not try to avoid the event, but to contain its consequences by optimising treatment of the accident situation (rapid intervention/assistance, suitable equipment, early medicalisation, etc.).

Accident sequence: also called the scenario, an accident sequence is a set of various factors (initiating events, specific contexts, decisions taken at different levels, etc.) which combine to transform a dangerous situation into an accident.

Victimisation (survey): this approach collects testimonials from accident victims via surveys, to assess the extent to which official statistics represent actual phenomena.
A pluri-disciplinary research group

The members of the research team favour complementary methods to develop their work on the risks related to sporting activities in the mountains. By identifying certain recurrent accident sequences, risk representations, the meanings of certain physical commitments, or the means implemented to manage risks, these researchers aim to help refine knowledge of mountain risks with a view to improving prevention.

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Petzl Foundation

Our support for this project reflects our ambition to develop knowledge in the field of mountain sport accidentology. We firmly believe that prevention actions and training content can be improved thanks to a better understanding of accident circumstances and frequency, and the risk factors involved.

Since 2006, Petzl Foundation has been providing support to non-profit organisations for the benefit of the mountain and climbing communities. Our efforts are concentrated in three fields:

• support for scientific research,
• accident prevention and risk management training,
• environmental preservation.

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