

Causes of Injuries in the Mountains: A Review of Worldwide Reports into Accidents in Mountaineering

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Abstract

This review presents a selection of sources from the UK and around the world that have reported on both incidents and accidents in the mountains. Common themes are extracted to illustrate the circumstances under which accidents, injuries and fatalities occur and the underlying factors that have contributed to incidents in the first place. There is an attempt to dispel some 'myths' surrounding accidents in mountain based activities. The purpose of highlighting these issues is to allow those undertaking them to understand where the greatest risks lie. This enables the individual, team leaders, rescue services and those involved in the overall management of wilderness areas to plan accordingly, with the aim of reducing injuries and deaths.

"There have been joys too great to be described in words, and there have been griefs upon which I have not dared to dwell; and with these in mind I say: climb if you will, but remember that courage and strength are nought without prudence, and that a momentary negligence may destroy the happiness of a lifetime. Do nothing in haste; look well to each step; and from the beginning think what may be the end."

Edward Whymper, Scrambles Amongst the Alps, 1871

Introduction

Mountains cover huge geographical areas and these are used for many and varied activities such as farming and industry as well as recreation. Discussion is here limited to data gathered about those injuries and deaths caused by incidents and accidents involving recreational activities, with particular reference to mountaineering and climbing. The most comprehensive reporting, recording and analysis of injuries has been carried out when incidents involve the emergency services. Clearly there are incidents that are not reported to these services and where they have no role. However, the majority of serious incidents (certainly where significant accidents and injuries have occurred) are likely to be attended.

Clarification of terms

For the purpose of this review, an incident is defined as an event that has either been reported by the participants themselves or logged by the emergency services. An accident occurs when elements of that incident have, or could have, led to injury or death of those involved. Injury describes a situation when medical attention, whether significant or not, has been required by one or more of the individuals involved. The term adverse event is used to encompass incidents, accidents, injuries and deaths.

The outcome of any incident will depend upon a multitude of variables, causes and contributing factors. This review considers data from records of incidents where injuries are sustained, as well as information from UK Mountain Rescue services that

record all incidents (whether injuries occurred or not). Despite these differences, many factors involved in a broad spectrum of incidents demonstrate common themes across the range of adverse events in the mountains. It is also worth noting that many incidents (without injury) could represent episodes of potential 'near misses' and so yield useful information relating to prevention and risk management. One man's incident could well be another man's injury.

The distinction between causes and contributory factors is also relevant in that adverse events, whilst possibly having only one direct or immediate cause (e.g. a broken leg sustained in a fall) may have had multiple contributing factors, such as high winds, poor visibility, and navigational errors. This information is important in the formation of recommendations regarding comprehensive planning and risk management in mountain areas. Demographic data may also be relevant in terms of contributing factors, by identifying those individuals who may be at greater risk (e.g. categories of age, experience level, employment).

The relative risk of participating in mountain sports

As mountain sports have become more popular, and wilderness areas more accessible through improvements in the transport infrastructure, there have been a corresponding increase in adverse events in these environments. In the UK, incidents involving mountain rescue teams in England and Wales continue to increase year on year, involving more people and with a corresponding increase in the number of injuries and deaths [1]. 2008 saw 1,179 people assisted in 870 incidents, with 46 fatalities and 547 injuries (Table 1).

With more specific reference to mountaineering, data from the USA shows that whilst adverse events are not on the increase, numbers appear to have stabilised following a peak in the mid 1980's [2]. However, large numbers of incidents in mountaineering still occur. Between 1951 and 2009 there were 6,571 accidents reported to the American Alpine Club from within the USA alone, involving 11,979 people. This involved 5,550 people being injured and 1,451 deaths. Table 2 provides a more detailed look at these figures, alongside annual data at points over the past twenty years.

By their very nature, mountains are dangerous places and thus activities undertaken in them will inevitably have associated risks.

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Year	Incidents	People assisted	Injured	Fatalities
2008	870	1179	547	46
2007	782	1121	499	33
2006	748	1013	453	32
2005	693	800	424	39
2004	609	804	376	25
2003	597	742	391	33
2002	655	824	438	23
2001*	421	518	274	18
2000	679	916	435	19
1999	635	835	390	37
Total	6689	8752	4227	305

Table 1. Mountain incidents responded to by Mountain Rescue England and Wales (MREW) 1999 – 2008. *Foot and mouth closures had an impact on activity. Adapted from [1].

Year	Number of accidents reported	Total persons involved	Injured	Fatalities
1951 – 2009	6,571	11,979	5,550	1,451
2009	126	240	112	23
2008	112	203	96	19
2007	113	211	95	15
2006	109	227	89	21
2005	111	176	85	34
1989	141	272	124	17
1988	156	288	155	24
1987	192	377	140	32
1986	203	406	182	37
1985	195	403	190	17

Table 2. Accidents reported to the American Alpine Club 1951 – 2009. Adapted from [2]

However, mountaineering and climbing are far from being the most dangerous of sports in terms of accidents. Schussman et al compared climbing with different sports, finding a rate of 2 accidents per 1000 climbers (0.2%) [3]. Sporting activities such as rodeo riding (20%); American football (12.5%); wrestling (5%); and riding (0.35%) indicate that other sports can be far more hazardous. When considering mountain based activities in general, Sharp makes the point that “people go to the mountains for enjoyment and the vast majority come to no harm at all – even after a lifetime of mountaineering. It is worth noting that

when the number of annual incidents is set against the number of mountaineering participation days, the risks are minimal. In fact, the chances of requiring the services of a mountain rescue team are so slim that someone living in Scotland would need to walk/climb in the mountains non-stop every day for around 125 years before they had an accident!”

Although the overall incidence of accidents is higher in other sports, the occurrence of fatalities tends to be much lower than in mountaineering. Weinbruch et al demonstrated the high incidence of fatal accidents in elite mountaineers [5], and Malcolm [6] presented data from Mount Cook National Park in New Zealand showing that the risk of death is far greater than other recreational activities. Monasterio [7] conducted a prospective cohort study on the subject. Over a four year period in New Zealand, the activity of 49 climbers was monitored where 44 (90%) had been climbing for over 5 years. During the study period, 23 (47%) climbers were involved in 33 accidents. Then, over a further four year period, nine more accidents and four deaths were reported. This demonstrates that mountain climbing is associated with a high risk of serious injury and death.

Risk, its appreciation and management, is therefore an important consideration when enjoying activities in the mountains. To take part in these activities safely, it is crucial to understand what these risks are and how they might be mitigated or reduced. Looking at the various causes of injuries in the mountains, and their contributing factors, can offer a way of understanding how accidents and injuries occur, and therefore how they may be better avoided in the future.

Review of incidents, accidents, injuries and deaths

Detailed information about cause and contributory factors allow an examination of the chain of events that can lead to incidents. This provides the opportunity to identify patterns as well as areas of potential skill development and the improvement of overall mountain safety. Both MREW and the Mountain Rescue Committee of Scotland (MRCS) also collect data on their entire activity, which includes responses to incidents relating to recreational activities based on the mountain, for example air sports.

In an effort to identify those groups most at risk, Sharp [8] surveyed professionals involved with mountain activities regarding safety in the Scottish mountains in an analysis of 1000 incident reports. Sharp then further examined records of MRCS from 1996 to 2005 [4], encompassing over 2500 incidents responded to by mountain rescue teams across Scotland. Summaries of outcomes and causes are presented in Tables 3 and 4.

	%
Overdue	29
Slips	27
Lost	21
Falls	16
Cragfast	14
Avalanched	2
River crossing	1

Table 3 Outcomes (Direct/immediate causes) of mountain incidents from MRCS reports 1996-2005 (N=3315). Adapted from [4]

	%
Poor navigation	23
Bad planning	18
Inadequate equipment	11
Medical	11
Poor timing	8
Group separation	7
Inadequate footwear	5
Inadequate clothing	4
Rockfall/hand hold give way	3
Poor level of fitness	3
Inadequate skill	2
Avalanche	2
River crossing problem	2

Table 4 Causes (contributory factors) of mountain incidents (N=2466) in MRCS reports 1996-2005. Adapted from [4]

This comprehensive study can be looked at alongside data gathered from MREW records from 2000 to 2008 [1] (Table 5).

However, it is worth noting that for mountain rescue services, the “outcome” of incidents may be more consistently recorded as useful data for their own service and resource planning [4]. Often, therefore, it is more difficult to study in detail the background factors of adverse events. These details would potentially be of considerable use for those participating in mountain sports, as they are likely to yield valuable information in terms of avoiding and managing the risks associated with these activities.

For an international comparison with a specific focus on mountaineering, the American Alpine Club (AAC) have published annual reports of climbing incidents since 1951 [2]. The reports are narrative accounts of accidents and sent in voluntarily by climbers and rescue teams. While they may not be wholly representative of all incidents, the accounts offer a broad collection of experiences over a lengthy period. These descriptive accounts also capture the multiplicity of factors and circumstances that contribute to incidents and injuries in the mountains. Tables 6 and 7 present data relating to the overall number of immediate causes and contributory factors.

Representing incidents in greater range mountaineering, extensive records from Nepal exist within the Himalayan Database, compiled by Elizabeth Hawley and Richard Salisbury and published in 2007 as ‘The Himalaya by the numbers’ [9] (Table 8). The database holds information on all expeditions between 1905 and 2003, for over 300 Nepalese peaks higher than 6000m.

	2008 N=876	2006 N=732	2005 N=695	2004* N=609	2002 N=656	2001 N=419	2000 N=678	1999 N=634	1998 N=626	1997 N=695
Avalanche	0	0	0	0	1	0	0	1	0	1
Belay/runner failure	5	4	3	3	6	3	7	14	16	12
Benighted	29	20	13	15	18	15	23	14	13	22
Cragfast	34	38	35	26	37	28	33	32	11	22
Fall or tumble	223	157	165	135	169	103	126	151	135	162
Lightning	0	1	0	0	0	0	0	0	1	0
Lost	123	118	87	98	86	43	96	73	62	74
Medical collapse or illness	52	63	59	46	44	25	52	53	68	62
Overdue or missing	68	72	58	44	62	41	77	86	87	82
Rockfall	1	0	0	1	0	0	4	0	1	7
Shouts, lights or flares reported	30	18	16	16	12	12	17	24	23	35
Slip, trip or stumble	213	208	196	193	193	135	193	178	189	199
Unable to continue	27	16	22	17	23	18	36	44	31	49

Table 5 Mountain Rescue - England and Wales Main Causes of Mountain Incidents 1997 – 2008 (Data unavailable at time of writing for 2003 and 2007. *Foot and mouth closures). The MREW Statistician footnotes on the original table read : “This table summarises the main causes of Mountain Accidents. It is based on a search of key words used in incident reports. All causes have not been listed, so the column totals may not agree with the total number of incidents. A typical report will illustrate another problem with totals:- ‘...tripped on footpath whilst walking and fell two metres onto rocky ground.’. This will result in contributions to the ‘Slip, Trip or Stumble’ and the ‘Fall or Tumble’ categories.” Adapted from [1].

	1951-2009	%	2009	%
Fall or slip on rock	3648	39	59	28
Slip on snow or ice	1050	11	27	13
Falling rock, ice or object	636	6.8	10	4.8
Exceeding abilities	555	5.9	5	2.4
Illness ¹	409	4.4	9	4.3
Stranded	351	3.7	6	2.9
Abseil failure/error ²	303	3.3	6	2.8
Avalanche	295	3.2	5	2.4
Exposure	278	3	3	1.4
Nut/chock pulled out	243	2.6	7	3.4
Loss of control/glissade	215	2.4	4	1.8
Failure to follow route	213	2.4	25	12
Fall into crevasse/moat	167	1.8	2	1
Faulty use of crampons	115	1.2	6	2.8
Piton/ice screw pulled out	95	1	0	0
Ascending too fast	67	0.7	1	0.5
Skiing ³	58	0.6	2	1
Lighting	46	0.5	0	0
Equipment failure	16	0.2	1	0.5
Other ⁴	522	5.6	31	15
Unknown	61	0.7	0	0
Total	9343	100	209	100

Table 6 - Immediate cause - USA 1951 - 2009 (N = 9343) from AAC reports. Adapted from [2]

	1951-2009	%	2009	%
Climbing unroped	1021	16.4	8	9
Exceeding abilities	917	14.8	2	2.2
Placed no/inadequate protection	794	12.8	32	36
Inadequate equipment/clothing	701	11.3	11	12.4
Weather	481	7.7	2	2.2
Climbing alone	408	6.6	4	4.5
No hard hat	354	5.7	6	6.7
Inadequate belay	228	3.7	10	11.2
Nut/chock pulled out	201	3.2	0	0
Poor position	188	3	3	3.4
Darkness	150	2.4	4	4.5
Party separated	117	1.9	0	0
Failure to test holds	105	1.7	4	4.5
Piton/ice screw pulled out	86	1.4	0	0
Failed to follow directions	73	1.2	0	0
Exposure	64	1	0	0
Illness ¹	40	0.63	0	0
Equipment failure	11	0.17	0	0
Other ⁴	271	4.4	3	3.4
Total	6210	100	89	100

Table 7 - Contributory causes - USA 1951-2009 (N = 6210) from AAC reports.

AAC statistician notes (from original) on Tables 6 & 7: ¹These illnesses/injuries, which led directly or indirectly to the accident, include: minor foot injury from tight boots; chest pain (1 infection and 1 blocked artery); extreme fatigue and low O₂ sat. level, lower leg injuries; hypothermia; heart attack; hand burn (from belay rope); dehydration; dislocation/sprain/strain-so had to be lowered.²These included: rope diameter too small for Grigri; rope too short; no knot in end of rope; gear sling caught on rock strangling climber.³This category was set up for ski mountaineering. Backcountry touring or snow shoeing incidents-even if one gets avalanched-are not in the data.⁴These included: unable to self arrest (8); failure to turn back (4); handhold/foothold came loose (4); ran out of food/water and no working stoves; misread snowpack; two bolt hangars "failed"; running rope through webbing - burned through; miscommunication (3); rappelling/lowering - rope too short (3), no knots in ends (3), rope diameter too small for Grigri; ice block came off (2); rappel rope stuck in crack; late start; fell on partner; dove on partner to stop fall; strangled in gear sling." (AAC Editor's note: Under the category "other", many of the particular items will have been recorded under a general category. For example, the climber who dislodges a rock that falls on another climber would be coded as Falling Rock/Object. A climber who has a hand or foot-hold come loose and falls would be coded as Fall On Rock and Other - and most often includes Failure To Test Holds.) Adapted from [2]

Less extensive data sets are also available for other areas where climbing/high altitude mountaineering incidents take place. Shussman et al reported accidents in Grand Teton National Park, USA (Table 9), with rock climbing representing the predominant form of mountaineering in the Tetons [3].

In Alaska, McIntosh et al reported that of the 96 deaths occurring between 1903 and 2006 on Denali, 45% were from injuries sustained in falls [10]. Finlay analysed 317 incidents involving 406 casualties during a four year period in three Canadian National Parks. Slips and falls were responsible for

50.2 % of these casualties. Of 40 fatalities, 27.5% were due to slips and falls; 45% due to avalanche [11].

Despite the differing scopes of the above studies, they yield valuable information regarding both cause and contributing factors relating to incidents, accidents and in general, adverse events. Some caution is warranted given differing definitions and categories used across these studies, but when considered together they provide an interesting view of common themes across a range of activities from an array of different mountainous areas both in the UK and around the world.

Cause of death	Total no.	%
Avalanche	272	34.8
Fall	255	32.6
AMS	57	7.3
Exposure/frostbite	36	4.6
Illness (non AMS)	32	4.1
Disappearance	29	3.7
Other	23	2.9
Exhaustion	20	2.6
Falling rock/ice	19	2.4
Icefall collapse	17	2.2
Crevasse	16	2.0
Unknown	6	0.8
AMS related	67	8.6
Weather/storm related	50	6.4

Table 8 Causes of death on Nepalese peaks > 6000m 1950 – 2006. Adapted from [9]

Precipitating event	N = 108
Slip on snow or ice	37
Rock climbing fall	34
Rockfall	11
Slip (approach)	7
Rappel failure	3
Lost/off route	6
Misc (HAPE, panicked, ate poisonous mushrooms etc)	7

Table 9. Causes of accidents from Grand Teton National Park data, 1981 - 1986. Adapted from [3]

Discussion

Drawing out patterns and pertinent lessons

Many individuals engage in a range of activities in mountainous areas; others are employed in various roles to assist with the development of skills and both the promotion of safety and management of risk in these areas. Despite the limitations inherent in comparing the above data sets, extracting general themes and highlighting common issues is likely to be worthwhile. It may also be useful to reflect on some established ‘myths’ surrounding incidents and accidents in the mountains. These are chosen as they may represent widely held beliefs amongst both mountaineers and those with an interest in the outdoors. Whether from a crag or an armchair, it may be worthwhile to challenge their often accepted wisdom.

Causes

A clear finding across studies is that falls, tumbles, slips, trips and stumbles are overwhelmingly the major cause of injuries in the mountains. This is unlikely to come as any great surprise. However, the variety of circumstances under which these events occur can provide some valuable lessons.

In Grand Teton National Park, the majority of climbing is done in summer, but despite this a high number of slips on snow and ice were reported (37 out of 108 accidents) [3]. Ranger and climber reports reveal most occurred retreating from climbs and having completed the apparently more ‘dangerous’ aspects of the chosen climb. Incidents took place often over small, non technical patches of snow where climbers were often wearing their smooth soled climbing shoes and were without an ice axe and/or crampons.

‘The Himalaya by the numbers’ makes an interesting comparison between cause of death for expedition members and staff (e.g. guides and porters) during more commercial expedition years (1990 to the present). The greatest number of expedition members die in falls (39.1%), compared with avalanches (48.3%) for expedition staff. It is suggested this is likely to reflect staff spending considerably more time establishing and supplying camps in avalanche prone zones [9]. This provides an interesting insight both into how the nature of commercial expeditions can place individual mountaineers at risk, and how risk varies with location on mountains.

A worrying trend noted annually by the AAC [2] and highlighted in the Grand Teton reports [3] is the number of abseiling errors or inadequate anchors: “The usual cases – rope too short and no knot in the end(s) of the rope(s) – were indicated ... It is hard to understand why we are still seeing these errors when so much basic information is to be found in ‘how to’ books, catalogues, on the Web, and at frequently visited climbing sites.” [2]. The following excellent and representative narrative is given by an experienced climber and demonstrates the most basic of these errors, made whilst re-equipping a bolted climbing area in New Mexico: “It must have been a nightmare. Seriously, I don’t do that. I know better. Way better. I’ve been climbing for over 12 years without an accident and just plain know better. Only rookies do that. Apparently not so ... I started rappelling down and got down at least two thirds of the route, maybe more, when I noticed a curious and quick sensation – the rope whipped through my Grigri ... I have taught new climbers how to climb/rappel and stress the importance of tying a simple knot in the end of the rope so something like this doesn’t happen, yet I failed to practise what I preach.” (Jason Halladay, originally published on MountainProject.com [2]).

This climber cites rushing and distractions as contributing factors to the mistake, despite his obvious experience. The relevance of basic safety precautions and action are also highlighted when it comes to lowering errors and injuries sustained due to glissading with crampons [12]. These represent areas where careful training and adherence to basic technique could reduce risk considerably.

Contributory factors

In terms of overall reported contributory factors, these generally relate to:

- poor navigation [1,4,13], also reflected in Jones [14], Anderson [15] and Greene [16];
- bad planning [4,10,13];
- and inadequate equipment [2,4].

With more specific reference to mountaineering, contributing factors are most commonly:

- climbing unroped [2];
- exceeding abilities [2,3];
- placing no or inadequate protection [2,3];
- inadequate clothing and equipment or the use of [2,3];
- and Acute Mountain Sickness (AMS) [9].

Schussman et al specifically identified incidents where climbers had committed errors, defined as such if it was obvious to the authors or stated by the reporting Rangers. Eighty six per cent of accidents on snow/ice and 56 % of rock climbing accidents were demonstrated to have either precipitated or increased the severity of accidents. The commonest of these were failure to ice axe self arrest, frequently as no ice axe was carried; lack of protection; climbing unroped. The vast majority (92%) of 34 rock climbing falls in Grand Teton National Park were by the lead climber and deemed by Rangers, or the climbers themselves, to have been related to attempting moves above their ability [3].

Mountaineers and climbers will often climb unroped to save time, as limiting the time spent on a climbing route, to avoid incoming bad weather and the onset of darkness for instance, is considered a justifiable safety measure. However, it must always be tempered by difficulty of the climbing and the ability of the group and, importantly, their least skilled member.

The harsh mountain environment, especially at high altitude, can also change mountaineers abilities during the course of a climb. For instance, what may have been simple ground to cover when ascending a peak, may be far more difficult, and thus beyond a mountaineer's abilities when in descent, many hours later, when exhausted in poorer weather and reduced visibility as light fades. Of course, this should always be considered when route planning.

AMS is highlighted by Hawley et al as an important contributing factor, certainly to falls at the higher altitudes [9]. Although not applicable to all mountain areas, it presents a risk over 3000m. It is also possible that, due to its insidious nature, AMS is relevant to more incidents but not always recorded or reported.

Enjoying the mountains safely can also require a great deal of, often expensive, equipment. This may have some bearing upon the issue of inadequate equipment or perhaps it relates more simply to a lack of experience so that individuals fail to realise the conditions they may encounter. There are numerous accounts of under equipped individuals and parties, such as the case of 39 schoolchildren rescued from Meall a' Bhuachaille (810m) in the Cairngorms wearing bin liners [17]. A quote from John Allen, leader of the rescue team from Cairngorm Mountain Rescue, illustrates this well "*We were appalled to discover they were all wearing skirts and trainers. Some had bin liners and plastic sheets wrapped round them to act as waterproofs. They had no idea what they were doing or what they were expected to be doing.*"

There is also a generally held view that many of our most popular mountain spots are frequented daily by those simply wearing their normal day to day clothes, and carrying no safety equipment, having failed to realise either the severity of the ground underfoot, or the changeable nature of the elements. Mountaineer Graham Davies comments on what will be familiar to many as a 'typical day' on Snowdon "*A lot of people who go out on the hills are on the edge of it: they buy the gear, map and compass, they might buy a GPS, then they basically start learning and improvising whilst they're out there. Other elements we know go up Snowdon in the [sic] trainers and trackie bottoms. I saw quite a few of them when I went*

up the Snowdon path up to Clogwyn. Of the 100 people I saw in the space of two hours about 40% were wearing trainers and not the [sic] adequate trousers or coats. Most of the others had basic waterproofs on, but no ice axes or crampons, and these people were heading up to the snow line. So, I was quite alarmed by the majority of people up there who had no experience nor had any intention of gaining the experience." [18]

This quote also demonstrates wider issues of experience. It appears rare, and obviously so, that those with the correct type and amount of experience will equip themselves inadequately, possibly only becoming unstuck when, for instance, a particular climb requires more equipment than previously thought; when conditions change quickly and unexpectedly; or due to another factor, such as benighting that then leaves a party light on equipment. These mountaineers will generally learn from their experience. However, this may be harder for those with relatively less experience and for whom a small number of factors may quickly conspire to become overwhelming.

Aside from the impact of human planning and decision making, there are contributory factors outside one's control. For example, the weather plays an important role and in particular the wind is often cited in incidents and accidents. From the MRCS report, weather at the time of the incident was recorded, with wind being reported in nearly half (46%) of all incidents leading this to be the most prevalent weather condition at the time of incidents.

The effects of wind, as well as other adverse weather conditions, contribute to other issues such as navigation errors. Jones [14] reported poor navigation as a leading contributing cause of mountain incidents. The wind affects navigation by making map management more difficult, unwittingly pushing those following bearings off course and, especially when combined with winter conditions, this can result in a reluctance to stop and check bearings and map features as often as may be necessary. Wind can also affect communication, particularly between mountaineers who may be a rope length apart and trying to make important decisions whilst shouting against the howl of a gale. The simplest of its effects is in the slowing of progress, or even causing walkers or climbers to loose footing. Schussman et al reported that in 9% of accidents, deteriorating or stormy weather played a significant factor in precipitating the accident. In weather-related accidents, the climbing rangers reported a common sequence: the weather deteriorated, the climbers hurried, and thus mistakes were made which led to accidents [3]. Hawley et al highlight deteriorating weather as a crucial factor in many accidents also [9].

Weather is obviously a factor affecting all mountain activities and one that can only be allowed or accounted for rather than altered. It is another excellent example of when experience; adequate clothing and equipment; training (in basic meteorology and navigation in poor conditions); good decision making (for example, when to turn back); and route planning (as in the use of a planned escape or low level route) can mean the difference between a challenging day in the mountains and an adverse event.

Preparation for undertaking activities in mountain areas

Of core importance is the understanding of each particular undertaking and the requirements of this in terms of preparation, planning and equipment. Building experience is key to the knowledge required for engaging in mountain activities, which may come in different forms, e.g. reading relevant publications; spending time in wilderness areas or;

attending courses. Authorities and those responsible for safety need to understand how individuals make their first approach to mountain activities and how best to communicate valuable lessons in terms of educating those less familiar with mountain activities and environments.

One example how this may be achieved is the common practice of popular car parks at the base of well known mountains being equipped with clear noticeboard warnings of the dangers of entering mountain areas ill prepared. Certain demographic groups also have a significantly higher chance of injuries and death. Registration systems and screening methods provide ways to target at-risk groups with information and training and improve safety [3]. McIntosh demonstrated that fatalities were decreased by 53% after a National Park Service registration system was established in 1995 on Denali [10].

Common Myths

There are some widely held beliefs amongst mountaineers about why accidents occur. Challenging these can lead to walkers and mountaineers re evaluating their own levels of risk in light of an evidence base.

Most incidents involve those less experienced.

This statement may find some initial supported from sources such as Schussman et al, who demonstrates that less experienced climbers in the Tetons were more frequently involved in accidents. It was possible to determine the experience level in 50% of accidents and of these, 50% had no previous experience or less than one year [3]. However, both the MRCS and AAC data suggest it is more experienced mountaineers that are involved in a higher number of accidents. The MRCS [4] report 62% of incidents occur to those 'experienced', compared to 38% who were 'inexperienced'. AAC records [2] also confirm this when looking at the most recent data (Table 10).

	1951-2009 %	2009 %
None/little	23.4	7.3
Moderate (1-3yrs)	21.7	13.6
Experienced	26.8	55
Unknown	28.1	25

Table 10. Experience level 1951 - 2009 (N = 7612) from AAC reports. Adapted from [2]

Sharp [4] suggests this may be related to those who are 'experienced' engaging in increasingly more hazardous activities such as winter and solo climbing, as well as being more inclined to participate in activities despite poor conditions when objective dangers are greater and skills required more exacting.

Despite the above examples of ill-equipped, poorly experienced and inadequately prepared parties, it would certainly be oversimplistic to assume all incidents and accidents occur to those without experience. Overwhelmingly, the Scottish and US data show that incidents do involve experienced individuals and groups, who for various reasons do not always use their knowledge fully. The narrative record of the abseiling incident by Jason Halladay demonstrates how even the most experienced climbers make errors.

It is possible that issues such as complacency, over-confidence or a failure to make use of skills and knowledge held represents a contributory factor as relevant as lack of experience in other situations. There is often a fine line between the growth and development of skill and wisdom through experience, with (over) confidence and (over)familiarity through repeated exposure.

Most accidents occur on the way down when climbers are tired and off guard.

Again, this common belief at first appears to be supported by both data from Denali and in the Tetons. McIntosh et al report 61% of fatal accidents occur on descent [10] and Schussman et al document 81 % of snow related accidents also occurring in descent [3]. Hawley et al further describe how 48.2% of fatal falls occur when descending from a summit bid, compared to 16.1% in ascent. It should be noted though that 30% occur during route preparation, and there is no differentiation between ascent and descent with this figure [9].

However, when considering the large longitudinal data set from the AAC records covering all forms of mountaineering, this is challenged as it reports more accidents occur in ascent, (Table 11). This would appear to relate to the largest contributing factor in the US data being "climbing unroped" [2].

		%
Ascent	3668	74
Descent	1068	21
Unknown*	251	5
Total	4987	100

Table 11. Ascent or descent - 1951-2009 (N = 4987). *Mostly solo climbers Adapted from [2]

It is vital that mountaineers realise then that they are under substantial risk during both phases of a climb, particularly when unroped, and attempting routes at the limits of their skills.

Most accidents happen on steep or 'dangerous' ground.

In terms of overall mountaineering incidents, the majority in Scotland involve hill walkers (77%) with 23% on hill paths whilst snow/ice climbing, rock climbing and scrambling involve 21% combined [4], proportions mirrored by Anderson [15] and a figure similar to that reported in Snowdonia, Wales, by Jones [14]. Finlay reports that 43.5% of all incidents involved hikers [11]. Schussman et al report most climbers as injured on climbs of lesser technical difficulty [3], suggesting that those who one would assume were more experienced and competent climbers were safer, despite being on more difficult climbs. It is important to note that with regard to the severity of injuries, scrambling results in the highest proportion of fatal and multiple injuries [4]. Schussman et al also demonstrated that accidents due to climber error, such as poor ropework or use of ice tools, resulted in more severe injuries (Injury severity score (ISS) mean = 3.3) when compared to accidents in which no error occurred, i.e. walkers slips and climbers simple falls. (ISS mean = 1.4) [3]. These figures demonstrate that walkers should not consider themselves to be at little risk in the mountains and that it is climbers and mountaineers who are at most risk.

Conclusions

A range of causes and contributory factors to injuries across the spectrum of mountaineering activities and environments have been presented. Falls have been shown to be the most common cause of injury and death in the majority of cases, with avalanches playing a part in the Himalayas, Canada and the USA. With regard to technical climbing, climbing unroped, exceeding abilities and poor protection have all precipitated and increased the severity of accidents, whilst poor navigation, bad planning, inadequate equipment and poor weather all significantly contribute to adverse incidents across the spectrum of mountain-based activities. Data has been presented demonstrating that accidents occur to those with all levels of experience, in both phases of ascent and descent, and in addition across all types of ground (both relatively easy and steep) in equally significant numbers.

Many of these factors can be mitigated against with the correct education and experience gained in a controlled manner. Discussion with professionals involved in the outdoors suggests that training in outdoor skills is more widely available than ever. However, the challenge remains one of engaging both those new to mountain-based activities but also those with more experience to be able to honestly and realistically appraise their own abilities and limitations so they can be aware of what additional skills and practical learning they require. An improved skill base, coupled with mountaineers being willing to choose and appropriately plan for goals within their abilities should make avoiding that potentially fatal fall far easier.

“The true satisfaction is to be found not in courting unknown dangers for which you are ill prepared, but in matching your own skill and experience and the danger and difficulties of which you are aware.”

Edward Whympers, Scrambles Amongst the Alps, 1871.

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Further resources

The following websites hold archives of accident reports and statistics.

- www.supertopo.com
- www.mountainproject.com
- www.tuckerman.org
- www.mountrainierclimbing.blogspot.com
- www.friendsofyosar.org
- www.home.nps.gov/applications/morningreport
- www.himalayandatabase.com/index.html