SKIERS PERCEPTION AND KNOWLEDGE ABOUT AVALANCHE TERRAIN PRACTICAL IMPLICATIONS FOR AVALANCHE EDUCATION

Marit Svarstad Andresen[1]* and Linda Hallandvik[1]

[1]Sogn og Fjordane University College, Sogndal, Norway

ABSTRACT: In Norway, the number of people off-piste skiing in the backcountry is continuously increasing. This is also the case in Sogndal, a small village in Western Norway. On Saturday 31/01/2015, several avalanches occurred in a well-known and popular area. The regional avalanche danger on this day was level 3 and the avalanche problem was a persistent weak layer of buried surface hoar above 1000 m elevation. The aim of this study is to identify how these avalanches affected skiers' perception of touring in avalanche terrain. This study is based on quantitative data, carried out using the software program Murvey. 206 novice to expert skiers participated (42% women and 58 % men, from 15 years old and above). The data was collected four days after the avalanches occurred. The results showed that 67% of the skiers rated the terrain where the avalanches occurred as simple or challenging, according to the Avalanche Terrain Exposure Scale (ATES). When analyzing this terrain using the ATES, it is clear that this terrain is classified as complex. Further, 53% knew about the avalanche problem this day, whereas 37% did not know. Despite this, 75% currently use the avalanche forecast when generally planning a trip and 63% were more or less surprised about the occurring avalanches. Findings in this study indicate that we should pay greater attention to the terrain and the avalanche problem(s) when planning a trip.

KEYWORDS: Knowledge about avalanche terrain, snowpack, familiar terrain and avalanche education.

1. INTRODUCTION

Saturday 31st January 2015 in Sogndal, several avalanches occurred, both naturally triggered and human triggered. The snowpack contained a deep buried persistent weak layer (0.8—1.2 m) of surface hoar in all exposures above 1000 m elevation. The regional avalanche danger was level 3, and the snowpack construction made it possible for skiers to propagate avalanches. By triggering avalanches in these conditions, big avalanches were expected (size 3) (Varsom, 2015).

The number of skiers in potential avalanche terrain is increasing in Sogndal. Local residents, students and tourists are ski touring in the winter, and the number of skiers has increased during the past decade.

Because of the mild climate in Sogndal, snow conditions often create a stable snowpack. As of 31st January 2015 there have not been any fatal avalanche incidents in the region.

There are three aims of this study. Firstly, to determine skiers' awareness of the terrain, secondly, to gather information about skiers' perceptions of the snowpack, and thirdly to study how skiers could be influenced by the fact that they are skiing in familiar terrain. Based on this specific day of several large avalanches, we aimed for skiers' reflections concerning these three parts.

2. DESCRIPTION

According to Fredston and Fesler (2011), in addition of the presence of people, there are three environmental factors that contribute to avalanche risk; 1) terrain, 2) weather and 3) snowpack. Of these three environmental avalanche risk factors, the terrain component is the easiest to evaluate (Tremper, 2008; Fredston & Fesler, 2011). In this study, we will focus on terrain, snowpack and human factor familiarity.

* *Corresponding author address:*
Marit Svarstad Andresen, Faculty of Teacher Education and Sport, Sogn og Fjordane University College, Box 133 – N 6851 Sogndal; tel: +47 57676338; fax: +47 57676333; email: marit.svarstad.andersen@hisf.no

2.1 Terrain classification

Statham, McMahon & Tomm (2006) describes terrain awareness in Avalanche Terrain Exposure Scale (ATES). They divide the terrain in three classes; 1) Simple, 2) Challenging and 3) Complex. Which terrain class you are skiing in is dependent on different terrain factors. Highlighted descriptors in italics automatically default into that or a higher terrain class. Non-italicized descriptors must be considered in combination with the other factors, and will not trigger a default alone (fig.1).

	1 – Simple	2 - Challenging	3 - Complex
Slope angle	Angles generally < 30º	***Mostly low angle, isolated slopes >35º***	***Variable with large % >35º***
Slope shape	Uniform	Some convexities	Convoluted
Forest density	Primarily treed with some forest openings	Mixed trees and open terrain	Large expanses of open terrain. Isolated tree bands
Terrain traps	Minimal, some creek slopes or cutbanks	Some depressions, gullies and/or overhead avalanche terrain	***Many depressions, gullies, cliffs, hidden slopes above gullies, cornices***
Avalanche frequency (events:years)	1:30 ≥ size 2	1:1 for < size 2 ***1:3 for ≥ size 2***	1:1 < size 3 ***1:1 ≥ size 3***
Start zone density	Limited open terrain	Some open terrain. Isolated avalanche paths leading to valley bottom	Large expanses of open terrain. Multiple avalanche paths leading to valley bottom
Runout zone characteristics	Solitary, well defined areas, smooth transitions, spread deposits	Abrupt transitions or depressions with deep deposits	Multiple converging runout zones, confined deposition area, steep tracks overhead
Interaction with avalanche paths	Runout zones only	Single path or paths with separation	***Numerous and overlapping paths***
Route options	Numerous, terrain allows multiple choices	A selection of choices of varying exposure, options to avoid avalanche paths	***Limited chances to reduce exposure, avoidance not possible***
Exposure time	None, or limited exposure crossing runouts only	***Isolated exposure to start zones and tracks***	***Frequent exposure to start zones and tracks***
Glaciation	None	***Generally smooth with isolated bands of crevasses***	***Broken or steep sections of crevasses, icefalls or serac exposure***

Fig. 1: Avalanche Terrain Exposure Scale (ATES) (Statham et.al, 2006).

2.2 Snowpack

According to McCommon & Schweizer (2002) and Krunthaler, Mitterer, Zenke & Lehning (2013) several factors in the snowpack have to be considered to predict an avalanche.

1) Depth of the failure plan; Studies by Föhn (1987), Jamieson (1995) and Schweizer & Camponovo (2001) showed that skier forces dissipate rapidly below about 50 – 80 cm.

2) Week layer thickness; unfortunately there does not exist a standard of what “thin” means, but according McCammon & Schweizer (2002) 65% of the Swiss avalanche accidents, the weak layer was less than 2 cm.

3) Hardness transition; reported from Swiss accidents hardness transitions across fracture planes had a median value of 1.5 hand hardness steps (Schweitzer & Lütschg, 2001).

4) Grain type; depth hoar and surface hoar are the most common grain type in the weak layer (McCammon & Schweizer, 2002).

5) Grain size; a studie by Schweizer & Jamieson (2001) indicate grain size above 1.25 mm propagate more easily than smaller grains.

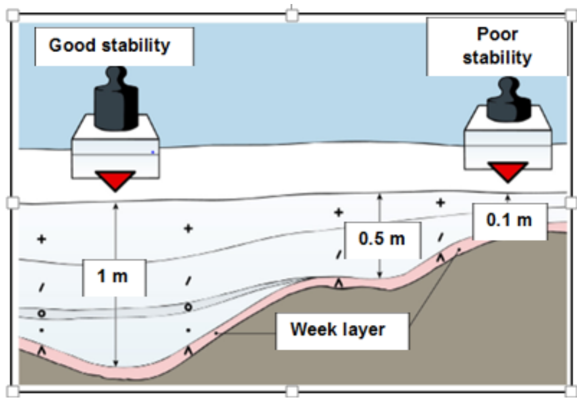

Fig. 2: Snowpack stability. Translated modell (Müller, Landrø, Haslestad, Dahlstrup & Engeset, 2014).

2.3 The human factor familiarity

Familiarity, which is one out of six heuristics described by McCammon (2002) that may bias our decisions in avalanche terrain, relies on our past actions to guide our behavior in familiar settings. Most of the time the familiarity heuristic is reliable. However, when hazards change, but the setting remains familiar, the rule of thumb can become a trap. According to McCammon (2004) advanced training groups often fall into this heuristic.

3. METHOD

This case study is based on skiers’ experiences and thoughts shortly after a day with several avalanches. Data is collected from an online survey.

Four days after the avalanches occurred, The Sogn og Fjordane University College, The Norwegian Water Resources and Energy Directorate and the ski festival Bratt Moro organized an ad hoc avalanche seminar. The aim for this seminar was to present and discuss the resent avalanches, what conditions that had created the weak snowpack and the experience from some skiers that triggered avalanches on 31st January 2015.

3.1 Online survey dataset

The results are based on quantitative data, obtained from a smartphone survey carried out using the Murvey software (Murvey, 2015). The first part of the survey included questions about age, ski touring- and avalanche skills and specific avalanche education. The rest of the survey contained questions about terrain, snowpack, trip planning, and human factors. The questions were asked using 5-point Likert scales with proposed factors (Likert, 1932).

The participants at the seminar were informed about the aim of the survey and confirmed participating by undertaking the survey. The online survey was open for participation for a total of three hours.

3.2 Selection

315 skiers joined the seminar. 206 (65%) skiers participated in the survey, of who 42% were women and 58% where men. All participants were from the age of 15 years old and above. The level of experiences were from novices to experts. 20% of the participants were skiing up to 15 days a winter, 29% 16-30 days a winter, 26% 31-45 days a winter and 25% more than 60 days a winter. Concerning to formal avalanche training, about 17% had no avalanche training, 45 % had basic avalanche training (3 days), 23% had more than basic avalanche training, 10% considered themselves as experienced and 5% were professionals like mountain guides, avalanche trainers and forecasters.

3.3 Analyses

The results are reported frequency distributions.

4. RESULTS

4.1 How do skiers understand awareness of the terrain?

9% considered the terrain as simple, 57% considered the terrain as challenging, and 33% considered the terrain as complex (1% did not answer the question). However, according to the ATES, the terrain is clearly complex.

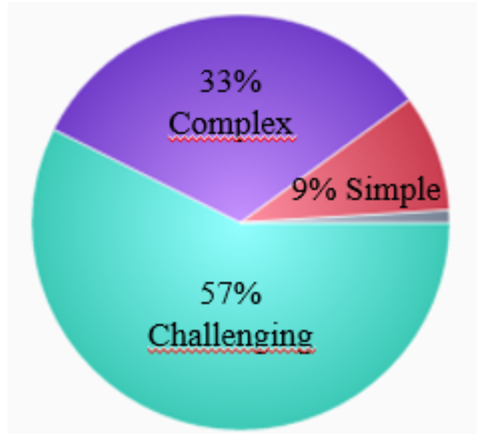

Fig. 3: Perceived terrain classification.

4.2 How do skiers understand the snowpack and the avalanche problem in the forecast?

Obvious clues as hollow sounds were observed by 5%. Collapsing or cracking in the snowpack were observed by 8%. 31% observed no signs of instability. Avalanche activity in the area was observed by 14%. Wind loading and signs of wind activity were observed by 42%.

75% are using the avalanche forecast when planning a trip. 53% were aware of the avalanche condition mentioned in the avalanche forecast. 47% were not aware of the avalanche condition mentioned in the avalanche forecast.

4.3 How the heuristic familiarity affect skiers in avalanche terrain?

Despite results in the avalanche forecast considering snowpack and avalanche problem, 63% of the participants in the survey were surprised in varied degrees of the avalanches occurring that day. 37.3% were not surprised.

When we asked for skiers' attitude to trip planning and ski touring after this day, as many as 65% were more concerned to make decisions in avalanche terrain.

5. DISCUSSION

Decision-making in potentially hazardous outdoor settings, such as avalanche terrain, is difficult, because situational attributes do not always distinguish which factors act in combinations to release an avalanche. When environmental information is complex and incomplete, relevant information may not be apparent. This makes sound judgement difficult (Hogarth, 2001; Kahneman, 2011; Kahneman & Klein, 2009; Shanteau, 1992).

5.1 *Terrain classification*

In this study, we found that skiers assume that terrain is more simple than it actually is. A clear understanding of the terrain we travel in is important. According to Fredston and Fesler (2011), terrain evaluation skills provide the most secure basis for decision making in avalanche terrain, and provide the best opportunity to base hazard evaluations on a solid foundation of facts, rather than on assumptions, feelings, guesses or fate. To make sound decisions in the field, classification of the terrain will be helpful.

By highlighting factors in the technical ATES (Avalanche Terrain Exposure Scale) (Statham et al., 2006) in the trip planning process, awareness of the terrain will be clarified. ATES (Statham et al, 2006) classifies all of the variables that constitute terrain exposure; slope angel, slope shape, forest density, terrain traps, avalanche frequency (events: years), start zone density, runout zone characteristics, interaction with avalanche pats, route options, exposure time and glaciations (slope angle and exposure time carry more weight than others; figure 1). The sum of these factors classifies the terrain to the public communicate model (simple, challenging, complex). Results in this study indicate that skiers perceive well-known terrain as more simple than it actually is. By using ATES as a tool, awareness of the terrain and potential risk will be more clear.

5.2 Snowpack

According to Fredston and Fesler (2011), conditional factor snowpack is hardest to predict. Skiers can use avalanche forecast and their own expertise to get knowledge about snowpack conditions. But in addition to expertise and knowledge about snowpack complexity, the skier needs extensive deliberate practice, variation in the practice and reflection on these experiences (Tozer, Fazey & Fazey, 2007). In this study, skiers' obtained few observations prior to the avalanche. This shows the complexity of considering snowpack, (depth of the failure plan, week layer thickness, hardness transition, grain type, grain size) especially when the week layer is deeply buried (Müller et al., 2014; Krunthaler et al., 2013; McCammon & Schweizer, 2002). It is hard to predict the deepness of the week layer because of terrain variations (fig. 2) (Müller et al., 2014). Therefore it is hard to know where to influence the week layer that could trigger an avalanche. Results in this study showed that when there is a persistent week layer in the snowpack, the skier needs to consider this when trip planning by choosing simple terrain to minimize the risk of triggering an avalanche.

5.3 The human factor familiarity

According to Tremper (2008), 83% of fatal avalanche accidents occurring are caused by heuristics. The heuristic familiarity is reliable most of the time (McCammon, 2004). Results in this study show that most skiers were surprised by the avalanches in the familiar terrain, at Blåfjell Mountain in Sogndal. When settings remains familiar, but hazards change, the rule of thumb can become a trap. According to McCammon (2004), skiers with the highest level of training expose themselves to significantly more hazard indicators in familiar terrain. This may explain why most skiers in this study, were surprised by the avalanches. Further results in this study also indicate that skiers are more concerned about trip planning after experiencing an avalanche. This is supported by Tremper (2008) who claims that those skiers who had experienced an avalanche turned out to have less faith in themselves and a lack of confidence in their own knowledge. This may explain why most participants in this study were more concerned about trip planning after the avalanches.

To avoid heuristics mentioned in 2.3 (McCammon, 2002), it could be useful to have clear guidelines in the group concerning; 1) trip planning, 2) travel technique, 3) physical state, 4) communication, 5) motivation, 6) decision making, 7) rescue readiness and 8) rescue ability (Uttl, Kisinger, McDouall, Mitchell & Uttl, 2010). Richardson (2011) also claim the importance of trip planning to avoid psychological discomfort, which can trigger a psychological stress response that leads to poor decision making. Solid trip planning minimizes uncertainty, and reduces stress and trouble.

6. CONCLUSION

The terrain component is the easiest to evaluate, as it is static and can be quite straight forward interpreted (Tremper, 2008; Fredston & Fesler, 2011). Our results indicate importance of terrain awareness during trip planning. This supports the argument for learning of terrain characteristics mentioned in ATES as the first step in avalanche education. With sufficient experience about the conditional factors, snowpack and weather in simple terrain, skiers can learn how to make sound decisions without fatal outcomes. Thus, we have to focus on how to avoid human heuristics, and integrate this in avalanche education.

REFERENCES

Fredston, J. and D. Fesler, 2011: *Snow Sense – A Guide to Evaluating Snow Avalanche Hazard.* Anchorage, Alaska: Alaska Mountain Safety Center, Inc.

Föhn,P., 1987: The stability index and various triggering mechanisms. *Avalanche Formations, Movement and Effects*, IAHS Pub. No. 162, 195-214. [Available online at http://www.aineva.it/previsori/Exner/Foehn%201987.pdf]

Greene, E., T. Wiesinger, K. W. Birkeland, C. Coleou, A. Jones and G. Statham, 2006: Fatal avalanche accidents and forecasted danger levels: Patterns in the United States, Canada, Switzerland and France. Proceedings of the *International Snow Science Workshop*, Telluride, CO, 640-649. [Available online at https://static1.squarespace.com/static/53fbfe1ce4b04ce86372f366/t/54457fe6e4b0878cfaf1c165/1413840870025/06_ISSW_Greene_etal.pdf]

Hogarth, R. M., 2001: Educating intuition. Chicago: The University of Chicago Press.

Jamieson, J. B., 1995: Avalanche prediction for persistent snow slabs, PhD Thesis, Dept. of Civil Engineering, University of Calgary, AB, 275 pp.

Kahneman, D. 2011: Thinking, fast and slow. New York: Farrar, Straus and Giroux.

Kahneman, D. and G. Klein, 2009: Conditions for Intuitive Expertise A Failure to Disagree. American Psychologist, 64(6), 515-526, doi: 10.1037/a0016755.

Kronthaler, G, C. Mitterer, B. Zenke and M. Lehning, 2013: The systematic snow coverdiagnosis: A process-based approach for avalanche danger assessment. Proceedings of the *International Snow Science Workshop*, Grenoble, Chamonix Mont-Blanc, 199-202. [Available online at http://arc.lib.montana.edu/snow-science/objects/ISSW13_paper_O4-11.pdf]

Likert, R., 1932: A Technique for the Measurement of Attitudes. Archives of Psychology, 140, 1–55.

McCammon, I., 2002: Evidence of heuristic traps in recreational avalanche accidents. Proceedings of the *International Snow Science Workshop,* Penticton, BC, 244-251. [Available online at http://avalancheacademy.com/uploads/resources/Traps%20Reprint.pdf]

McCammon, I., 2004: Heuristic Traps in Recreational Avalanche Accidents: Evidence and Implications. *Avalanche News,*68, 1-10. [Available online at http://www.sunrockice.com/docs/Heuristic%20traps%20IM%202004.pdf]

McCammon, I. and J. Schweizer, 2002: A field method for identifying structural weaknesses in the snowpack. Proceedings of the *International Snow Science Workshop,* Penticton, BC, 1-5. [Available online at http://www.snowpit.com/articles/lemons%20reprint%20copy.pdf]

McClung, D. M. and P. A. Schaerer, 2006: *The Avalanche Handbook*. 3rd ed The Mountaineers, 347 pp.

Müller, K., M. Landrø, A. Haslestad, J. Dahlstrup and R. Engeset, 2015: *Systematisk snødekkeundersøkelse.* Norges vassdrags- og energidirektorat. [Available online at http://www.varsom.no/Global/Faktaark/Faktaark%201-2015%20Systematisk%20sn%C3%B8dekkeunders%C3%B8kelse.pdf.]

Murvey online survey, 2015: [Available online at https://www.murvey.com/]

Odden, A., 2008: *Hva skjer med norsk friluftsliv? En studie av utviklingstrekk i norsk friluftsliv 1970-2004.* Doktoravhandling/PhD Thesis, NTNU. Norges teknisk-naturvitenskapelige universitet, fakultet for samfunnsvitenskap og teknologiledelse. Trondheim, NO.

Richardson, M., 2011: The Human Factor. The Psychology of Backcountry Safety. *The Avalanche Review, 29*(4), 14-15. [Available online at http://www.americanavalancheassociation.org/pdf/TheAvalancheReview/TAR_29_4_April_2011.pdf]

Schweizer, J. and C. Camponovo, 2001: The skier`s zone of influence intriggering slab avalanches. *Annals of Glaciology*, 32, 314-320. doi: 10.3189/172756401781819300

Schweizer, J. and B. Jamieson, 2001: Field observations of human-trigged avalanches. Proceedings of the *International Snow Science Workshop*, Big Sky, MT, 192–199. [Available online at http://www.wsl.ch/info/mitarbeitende/schweizj/publications/Schweizer_Jamieson_SnowCoverProperties_ISSW2000.pdf]

Schweizer, J. and J. B. Jamieson, 2003: Snowpack properties for snow profile analysis. *Cold Regions Science and Technology*, 37, 233-241. [Available online at http://www.ucalgary.ca/files/asarc/ProfileAnalysis.pdf]

Schweitzer, J. and M. Lütschg, 2001: Measurements of human-triggered avalanches from the Swiss Alps. Proceedings of the *International Snow Science Workshop*, Big Sky, MT, 200–207. [Available online at http://www.slf.ch/ueber/mitarbeiter/homepages/schweizj/publications/Schweizer_Lutschg_SkierAvalanches_ISSW2000.pdf]

Shanteau, J., 1992: Competence in experts - The role of task characteristics. *Organizational Behavior and Human Decision Processes, 53*(2), 252-266, doi: 10.1016/0749-5978(92)90064-e.

Statham, G., B. McMahon and I. Tomm, 2006: The Avalanche Terrain Exposure Scale. Proceedings of the *International Snow Science Workshop*, Telluride, CO, 491-497. [Available online at http://www.issw.net/2006.php]

Tozer, M., I. Fazey and J. Fazey, 2007: Recognizing and developing adaptive expertise within outdoor and expedition leaders. *Journal of Adventure Education and Outdoor Learning, 7*(1), 55-75, doi: 10.1080/14729670701349780.

Tremper, B., 2008: *Staying Alive in Avalanche Terrain, second edition.* Seattle, WA: The Mountaineers Books.

Uttl, B., K. L. Kisinger, J. McDouall, C. Mitchell and J. Uttl, 2010: Human Factors in Avalanche Avoidance and Survival: Consequences of Violating the Rules of Safe Travel. Proceedings of the *International Snow Science Workshop*, Squaw Valley, CA, 530-535. [Available online at http://www.docbob.ca/pubs/Uttl_2010_HumanFactorsInAvalancheAvoidance.pdf]

Varsom, 2016: Norwegian Avalanche Forecast. [Available online at http://www.varsom.no/en/Snow-avalanche/Sogn/?date=31/01/2015.]