RETENTION AND USE OF AVALANCHE FORECAST INFORMATION: FINDINGS FROM FIELD AND ONLINE SURVEYS

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ABSTRACT: When riding out of bounds or touring in the backcountry, many recreationists and professionals plan their trip with the aim of finding a tour at a personally acceptable level of risk. Particularly during the planning phase, information from the public avalanche forecast is considered. In Switzerland, the avalanche forecast summarizes avalanche conditions with a danger level (DL) and the aspects and elevations (AE) where the DL applies. Further, it informs about the relevant avalanche problems, including a text description. Previous studies have shown that most of this information is related to avalanche risk. However, it is poorly understood which information users consider helpful for trip planning and whether these (often) self-stated claims relate to what is remembered at the beginning of a trip. We therefore conducted two independent surveys. The online survey, with 3400 participants, showed that all information provided in the forecast is perceived as valuable for planning. The DL was considered the most important, followed by the avalanche problem(s). In comparison, the AE were considered less important. This ranking of the users is not in line with recent findings regarding avalanche risk. For the second survey, we went outdoors, either in a popular area for out of bounds skiing or at trail heads of ski tours and asked the users directly. Compared to the responses from the online survey, a different picture emerged: While the DL was well-remembered (90 % correct), only around half of the participants (44 %) could correctly name the avalanche problems. In an application exercise, a clear minority (24 %) could say whether slopes of a particular aspect and elevation were assessed as critical in the forecast. This apparent discrepancy between the self-stated use of forecast information during trip planning and the retention of the information at the start of a trip comes partly as a surprise. Especially the avalanche problems, intended to emphasize and focus on the cause of instability resulting in impact-oriented travel advice, are remembered poorly. The findings are supported by other recent surveys in Europe and show that the information from the forecast is not effectively retained, even at the start of a trip. It highlights the need to rethink and improve the communication of avalanche danger, including the level of detail. While providing detailed information may be helpful for experts, it may be overwhelming for less experienced users. Our study aims to contribute to the ongoing discussion on how to best communicate avalanche danger to reduce risks for recreational skiers.

KEYWORDS: Avalanche Forecast, Field Survey, Risk Communication, Information Retention, User guidance, Impact-oriented Warning

1. INTRODUCTION

Avalanche forecasts inform and warn about regional avalanche danger. These warnings convey complex information about current and future avalanche conditions to recreational and professional backcountry users but also preparedness authorities, with a wide range of skills and backgrounds, and, thus, different needs regarding information content and presentation. Nowadays, most forecast products present information using an inverted pyramid (Fig. 1a) by first summarizing the most relevant information on a map and providing more detail using a combination of graphical elements, lists, and narrative text (e.g., overview in Hutter et al., 2021). Commonly, the severity of avalanche conditions is summarized by using one of five danger levels (DL) (EAWS, 2023a). However, further content, depth, and form characterizing avalanche danger vary widely between forecast products. For instance, pre-defined avalanche problems are commonly used to explain the problem (EAWS, 2023b). However, providing additional details on where these are present, and on how they are characterized, range from brief text descriptions (e.g., in Switzerland, Fig. 1b) to providing comparably highly detailed and complex information on (problem-specific) snowpack stability, frequency of expected triggering locations and expected avalanche size (e.g., Tyrol, Austria or Livigno, Italy). Moreover, in Switzerland, sublevels show whether the expected avalanche danger is low or high within a DL (Lucas et al., 2023; Techel et al., 2022).

The users of avalanche forecasts now have access to much more comprehensive information than they did a few years ago. However, effective risk management depends on providing accurate and timely information and specifically tailoring these to the target

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audience's knowledge and perspectives, requiring an in-depth understanding of different user groups (Lundgren and McMakin, 2018). St. Clair (2019) identified different types of avalanche forecast users and created a typology characterizing recreationists' use of avalanche forecasts and showed that inexperienced users required simple, clear guidance, relying primarily on the forecast DL, while experts were looking for nuanced, technical details for informed decision-making. Other studies have explored the effectiveness of the information presentation on self-stated users' retention and understanding of forecast information (e.g., in Switzerland and Norway, Winkler and Techel, 2014; Engeset et al., 2018) or the relationship between risk and the information contained in the forecasts (e.g., Winkler et al., 2021, Techel et al., 2022). Techel et al. (2015b) showed that the avalanche DL is the best-known element of the forecast, having a high correlation with avalanche risk (Winkler et al., 2021, Techel et al., 2022). Engeset et al. (2018) suggested that the user's competency and the scenarios' complexity impact the warning's effectiveness. In the study conducted by Techel et al., (2015b) many users claimed to know the information provided in the forecast, but is this information still present when entering the field? With this study, we have two aims: Firstly, what information from the current Swiss avalanche forecast can backcountry users recall when entering the backcountry? And secondly, how does this relate to the self-stated usefulness of the different pieces of information in the forecast? We addressed these questions by conducting two surveys in Winter 2022/23, one in the field and one online, to gain insights allowing more effective avalanche hazard communication.

2. SWISS AVALANCHE FORECAST

During winter, the Swiss avalanche forecast is published twice a day. It informs about the expected regional avalanche conditions, summarized by indicating the highest anticipated DL in a region. Besides the DL, the forecast provides the sublevels, informs about the avalanche problem, indicates the critical aspects and elevations (AE), and a danger description (label 1 to 4 in Fig. 1b). Even though the Swiss forecast domain is divided into nearly 150 micro regions, for communication, these are grouped according into larger warning regions (e.g. region highlighted "orange" in Fig. 1b), where avalanche conditions are considered similar are described the same (Fig. 1b). Unlike many other forecasts, in Switzerland, information about critical AE (label 2 in Fig. 1b) specifies where DL applies, not where specific avalanche problems are present. This last point is crucial for understanding the Swiss approach to danger assessment.

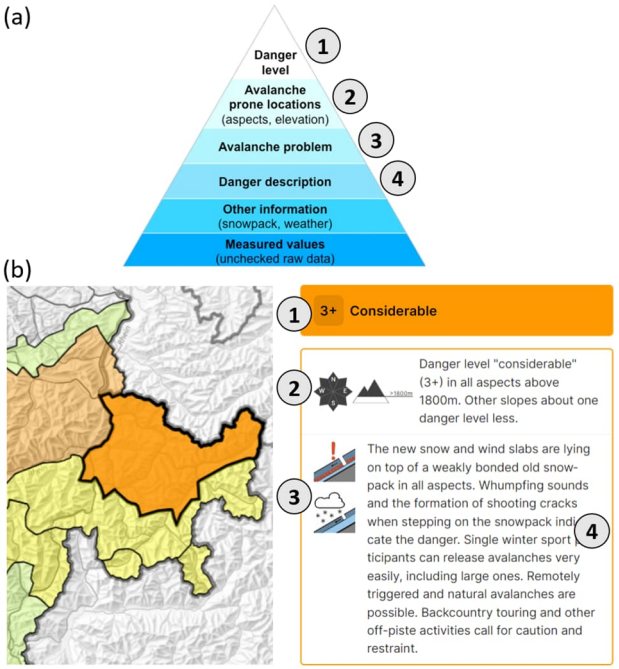

Figure 1: (a) Information pyramid (EAWS, 2023c), (b) Elements of the Swiss avalanche forecast: left) Danger map with colored warning regions, right) information characterizing avalanche danger. The labels 1 to 4 link the corresponding elements.

3. METHODS

We conducted two independent surveys: A direct survey in the field with a strongly reduced questionnaire to increase the participation rate and an extensive online survey.

3.1 Field Survey

In a survey on-site, we checked the users' current knowledge regarding the information provided in the avalanche forecast. At trailheads or ski area valley stations, groups were approached directly and asked to answer a few questions individually on their cell phones. We limited the questionnaire deliberately to the most essential; the completion took an average of 2 minutes.

The questions (Q) included the following three:

Q1: What is the current danger level issued in the forecast region?

- *1 (low)*
- *2 (moderate)*
- *3 (considerable)*
- *4 (high)*
- *5 (very high)*
- *I don't know*

Q2: For which of the following slopes does the danger level indicated in the current forecast apply?

- o *North facing slopes at 2500 m.*
- o *East facing slopes at 1700 m.*
- o *South facing slopes at 2300 m.*
- o *None of the above.*
- o *I don't know.*

Q3: Which avalanche problems are indicated in the current avalanche forecast?

- o *New snow*
- o *Wind slab*
- o *Old snow (persistent weak layer)*
- o *Wet snow avalanches*
- o *Wet snow avalanches in course of the day*
- o *Gliding snow*
- o *No distinct avalanche problem*
- o *I don't know*

Furthermore, we asked three characterization questions (role in the group, age, gender) and one question on equipment (avalanche transceiver, shovel, probe, airbag). The questionnaires took place between 2023/01/04 and 2023/02/22 in the Swiss alps.

3.2 Online Survey

To gain an understanding of the comprehension and use of the information provided in the daily avalanche forecasts, we conducted an online survey among winter sports enthusiasts in Switzerland. A further aim of the survey was to evaluate the effectiveness of the sublevels introduced last winter (SLF, 2023a; Techel et al., 2022). In the present paper, however, we addressed only those questions that were relevant to the analysis at hand. Readers interested in further results of the survey can refer to Lucas et al. (2023), in these proceedings and SLF (2023b).

The following three questions (Q) were asked in connection with the present study:

Q4: How often do you consult the SLF avalanche forecast before a day of ski touring / freeriding in Switzerland or Liechtenstein?

- o *Always*
- o *Usually*
- o *Sometimes*
- o *Rarely*
- o *Never*

Q5: What information do you check in the avalanche forecast? (For each information, one of the following options had to be provided: Always, usually, sometimes, rarely, never, unfamiliar)

- o *Danger level (e.g. 2 (moderate))*
- o *Sublevels (e.g. 3-, 3=, 3+)*
- o *Elevation zone (e.g. > 2000 m)*
- o *Aspects (e.g. "west to north to east facing slopes")*
- o *Avalanche problems (e.g. "wind slab, gliding snow")*

Q6: Which categories of information in the avalanche forecast are most important for you when planning a day of freeriding or touring? (For each information, one of the following options had to be provided: most important, fairly important, less important, least important, don't know)

- o *Danger level (e.g. 2, (moderate))*
- o *Sublevels (e.g. 3-, 3=, 3+)*
- o *Elevation zone (e.g. > 2000 m)*
- o *Aspects (e.g. "west to north to east facing slopes")*
- o *Avalanche problems (e.g. "wind slab, gliding snow")*

The survey was online between 2023/03/03 and 2023/03/13. Users were invited to participate via www.slf.ch, the SLF app Whiterisk, and the Whiterisk social media channels.

4. RESULTS

4.1 Participants

In the field survey, 219 responses were collected. Most participants were between 25 and 64 years old (92 %). 63 % of participants identified as male and 37 % as female. 67 % were on a ski or snowboard tour, 32 % were freeriding, and 1 % were snowshoeing.

In the online survey, 3403 valid responses were collected. Most participants were between 25 and 64 years old (87 %) and male (83 %). For more details, see Lucas et al. (2023).

Figure 2 shows the participants' distributions by role within the group (field survey, Fig. 2a) or level of avalanche training (online survey, Fig. 2b). While not directly comparable, the share of guides/group leaders was similar.

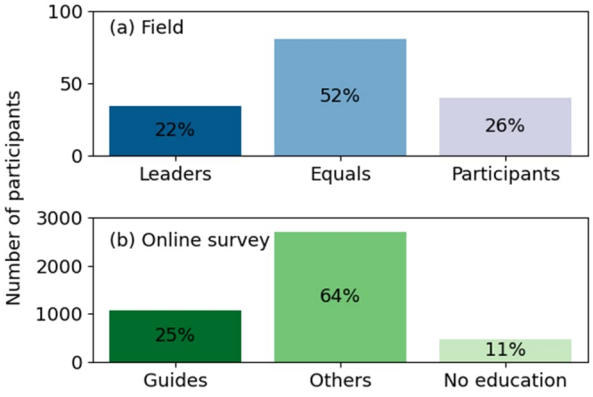

Figure 2: Distribution of survey participants according to (a) their role within the group (field survey) and (b) their level of avalanche training (online survey). (a) Leaders: Group leaders, Equal: Shared leadership

(they are on equal footing). Participants: Participants in a guided group. (b) Guides: mountain guides, aspiring mountain guides, and professional ski/snowboard instructors; Others: ski patrollers, people working in avalanche services, mountain rescuers, alpine club winter tour guides, people with at least a 1-day avalanche course; no education: people with no avalanche training.

4.2 Analysis

For the examination of the field survey, the responses were verified against the forecast valid on the day of the survey. For the questions with several correct answers (Q2 and Q3) and to be able to compare the results from the two surveys (Q4 to Q6), allocations according to Table 1 were made. Further, responses in Q6 to "elevation" and "exposure" were combined for AE.

Table 1: Allocations of the different answers of the two surveys.

	yes	*partly*	*no*
Q2/Q3 (field)	all answers correct	at least one correct answer	no correct answer
Q4/Q5 (online)	always	mostly, sometimes	seldom, never
Q6 (online)	most important	fairly important	less important, least important

4.3 Retention of information given in the forecast

In the field survey, 79 % of the participants stated that they had read the valid forecast. Only the latter were asked further questions. Of the other 21 %, the majority gave as reasons for not having read the forecast that they were participants of a guided group (33 %), had obtained information about the avalanche danger elsewhere (26 %), had already been out the day before (19 %), or other reason (22 %).

There are large differences in recalling different forecast contents (Fig 3). While the DL was well-remembered (90 % correct), around half of the participants (44 %) could correctly name the avalanche problems (Fig. 3). The question relating to aspect and elevation was more challenging as the information had to be applied to exemplary slopes rather than just checking whether respondents remembered correctly. A clear minority (24 %) could correctly indicate whether slopes of a particular aspect and elevation were assessed as critical AE in the forecast.

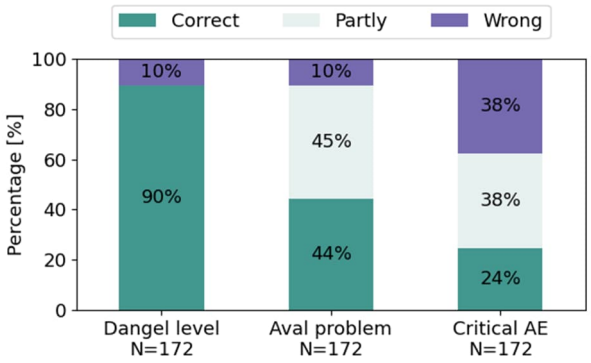

Figure 3: Main results of field survey. Percentage of people who knew the avalanche danger level, the avalanche problem(s) and who could link the critical aspect and elevation from the valid avalanche forecast with specific slopes.

4.4 Influence of role on retention in the field

The comparison of the retention of the AE within the different roles is shown in Figure 4. Although the group leaders performed comparatively better, only one-third knew the correct AE. The retention of the three groups was similar in terms of DL (90 % correct, variation between roles +/-3 %) and avalanche problems (44 % correct, variation between roles +/-4 %).

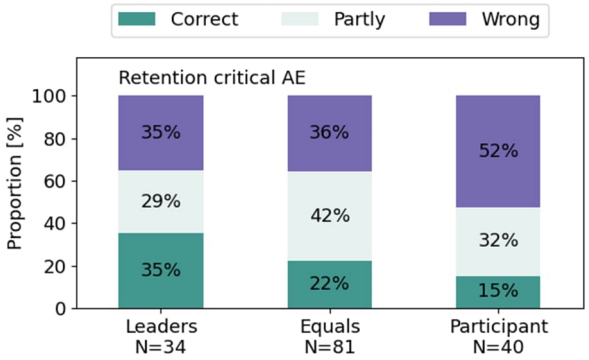

Figure 4: Comparison of the retention of the critical aspect and elevation, categorized according to their role in the group. Leaders: People stated they lead the group. Equals: Shared leadership (they are on equal footing). Participants: People stated that they are participating in a guided group.

4.5 Self-stated usefulness of forecast

The results of question 4 (Q4) of the online survey showed that almost 90 % stated that they always look at the forecast before each tour (8 % “Usually”, the rest stated “sometimes”, “rarely”, or “never”). A clear majority also looks at the complete content of the forecast: 95 % always look at the DL, 83 % at the avalanche problems, and 80% at the AE. (Fig. 5 a to c, left bar).

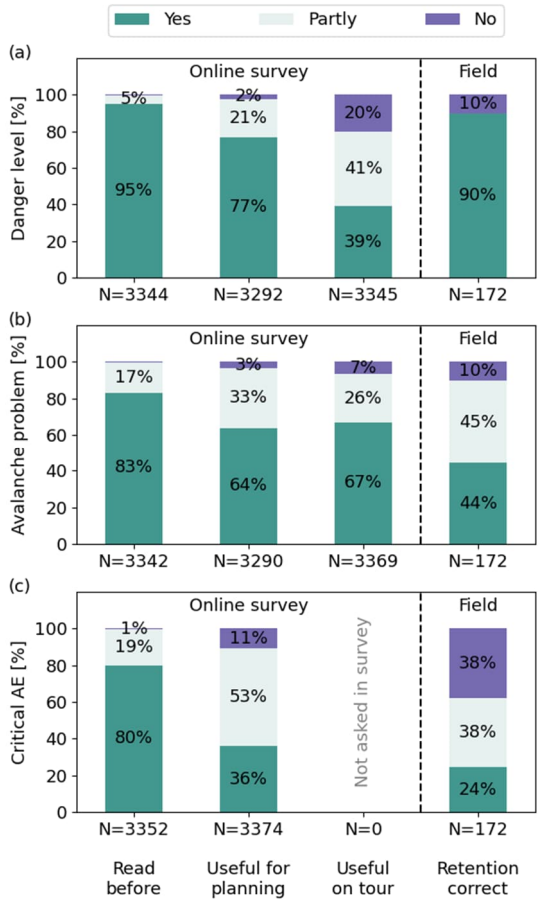

Figure 5: Self-stated usefulness (online survey, left) vs retention in the field (field survey, right) of information in the Swiss avalanche forecast. a) Danger level, b) Avalanche problem, c) Critical aspects and elevations.

For planning a ski tour, the vast majority considered the information contained to be valuable (Fig. 5 a to c, second bar, “yes” and “partly”). The DL was considered the most important, followed by the avalanche problem(s). In comparison, the critical AE were considered somewhat less important.

During a ski tour, the avalanche problem was rated more useful than the DL (Fig 5 a to c, third bar). For the critical AE, we did not ask this question.

5. DISCUSSION

5.1 *Retention of information given in the forecast*

The 90 % correct recall of the DL suggests that this information is easily remembered, presumably because it is well communicated and relevant to the users (Fig 3, left). This is positive since statistical analysis showed that the DL is the most crucial parameter related to avalanche risk, with a quadrupling of risk from one DL to the next (Winkler et al., 2021). It is, therefore, reasonable to adapt the selection of the tour and one's behavior to the DL (Techel et al., 2015a).

For the avalanche problems, less than half of the respondents remembered them correctly (44 %), and 45 % provided answers that were in part correct (Fig. 3, middle). Interestingly, there were only minor differences between the different forecast user groups (see Sect. 4.4). Since the avalanche problems are communicated using both text and pictograms (icons) (Fig. 1b, label 3), we expected that they would be easily remembered. This finding raises the question whether the avalanche problems highlighted in the forecast are read by the users but are not internalized enough. The avalanche problems are intended to help backcountry enthusiast to adapt their behavior in the field. However, the concept is unlikely to be implemented if the problems are not remembered. Perhaps using icons more directly with the recommendations could help. Regarding the avalanche problems relation to avalanche risk, Winkler et al. (2022) showed that in situations with persistent weak layers, the risk of triggering an avalanche is 1.5 times higher compared to situations without persistent weak layer, given the same DL.

The question regarding the critical AE (Q2) was more complex as we didn’t just test whether AE was recalled correctly but whether it could be applied to particular slopes. Only 24 % could give the correct answer. A study from Norway also confirms this difficulty (Engeset et al., 2018). Winkler et al. (2021), highlighted the importance of AE since inside critical AE the risk is six times higher than outside. Hence, retrieving and applying this information to the terrain would reduce the risk for backcountry skiers or enhance the freedom of movement. From a risk perspective, it would be reasonable to incorporate AE information more strongly in the decision-making process. However, the low retention of critical AE was also supported by Söllinger (2022), who even claimed a smaller retention rate for the forecast in Tyrol (Austria), where several AE are indicated (Tab. 2, last line). We suspect that presenting several AE segments makes the retention of this information too complex, even for people with higher avalanche education.

Overall, the high retention rate for DL suggests that it is the most accessible and possibly the most valued information. In contrast, the lower rates of correctly recalling the information provided in the forecast regarding the avalanche problems and the AE may be related to how they are presented in the forecast, to the value these have for the user, or may simply be too complex for most users. The large share of respondents failing the AE application question (partly: 38 %, wrong: 38 %) shows that quickly applying this information to slopes of specific aspects and elevations is difficult (Fig. 3). However, our study design did not permit us to distinguish whether this was due to respondents not retaining the information correctly

or whether it was due to applicants not applying it correctly.

Our findings in the field are consistent with similar surveys recently conducted in Europe (DAV, 2023; Söllinger, 2022). These studies confirm that some information from the avalanche forecast can only be recalled in fragments, even at the beginning of a tour (Tab. 2).

Table 2: Retention of forecast information in comparison of three independent studies. Percentages are the proportion of the correct recall.

	this study	*Söllinger, 2023 (Austria)*	*DAV, 2023 (Germany)*
Danger Level	90 %	71 %	93 %
Aval. Problem	44 %	32%	-
Aspect&Elev.	24 %	12 %	-

5.2 Discrepancy between the two surveys

Before discussing discrepancies in the findings obtained from the two surveys, we want to highlight that the answers result from two different study groups (field and online), which can't be linked directly. However, the different training levels are represented in similar proportions; therefore, we assume the groups are comparable (Fig. 2). Moreover, the findings in the field survey characterize the participants, which claimed having looked at the forecast.

Keeping these limitations in mind, the comparison of the two surveys shows an apparent discrepancy between self-assessment (online survey) and reality in terms of remembering and applying the information from the avalanche forecast immediately prior to a ski tour. Although the participants of the online survey stated that they considered all the information provided in the forecast as important and studied it before a tour, in practice, the field survey showed that this information was only partially remembered (Fig. 4a to c).

We suspect that some users overestimate their skills in remembering forecast information in the self-assessment. This assumption is supported by an older survey conducted following a redesign of the Swiss avalanche forecast in 2013: 100 % of respondents claimed they knew the DL accurately ("very accurately" or "fairly accurately") when traveling independently off secured slopes. For critical elevation, the rate was 96 %, and for critical aspects 98 %. For avalanche problems, which were still relatively new at the time, the rate was 91 % (Techel et al., 2015b). These numbers are far from the observed retention rates encountered in the field. For forecast producers, this discrepancy shows that the usefulness of different parameters cannot be tested reliably using exclusively online surveys.

Further, Figure 4 shows that only one-third of the guides knew the correct AE. One interpretation could be that the forecast is too complex even for the best-trained group, though we suspect that being capable of making own assessments in the field reduces the importance of the forecast. However, for users struggling to apply forecast information to the terrain during the planning phase, automated risk assessments of routes combining avalanche forecast information with terrain characteristics as presented on the skitourenguru-platform (Skitourenguru, 2023) might remedy the situation. On this platform, forecast information is prepared in a way that it is directly available for a go/no-go decision for specific routes at the planning stage. Therefore, it allows users to make use of all information related to avalanche risk instead of relying only on the DL. According to the field survey, the latter is, at present, the only piece of information well retained by a majority of the forecast users.

5.3 "One-Fits-All" approach correct?

There is a clear difference between experienced users, who demand more detailed and comprehensive information, and less experienced users, for whom simpler and more concise communication is more beneficial (St. Clair, 2019). For the latter, the amount of information can lead to misinterpretation. All in all, there are very different requirements for the forecast product, which contradict each other and thus pose a dilemma: Safety services vs. recreational users, tour planning vs. decision support in the terrain, as well as very different levels of knowledge: expert vs. beginner.

Thus, the "one-fits-all" approach to the forecast may not be ideal. The divergent needs and levels of skill and knowledge of the various user groups present a challenge that makes it necessary to provide information more flexibly. Consequently, an approach could be to provide basic information to all users but to provide specialized information exclusively to advanced users. But this raises the question whether some information should be withheld so as not to overwhelm novices? The answer is no. The application would be problematic (e.g., in the follow-up to avalanche accidents), and its justification rather delicate.

The structure of the Swiss avalanche bulletin puts an emphasis on communicating a small number of factors most related to describing the severity of avalanche conditions. This approach ensures that even users with limited recall or who have limited time to engage with the information provided will still capture the most essential points. At the same time, the forecasts' core content - starting with the DL - is prominently displayed to all users, from novices to experts. There needs to be more justification for dividing the forecast into separate versions for different skill levels. Instead, supplemental details can be gradually introduced for those who seek a

more comprehensive understanding. The forecast should retain a one-fits-all approach but with tiered levels of information to cater to varying user needs.

6. CONCLUSION

To convey warnings effectively and efficiently to the public, communication must address the competence and requirements of the forecast users (e.g., Engeset et al., 2018). This requires:

- User guidance: Information in the forecast must be clearly prioritized and structured according to its relevance concerning characterizing the severity of avalanche danger, which strongly impacts risk. The concept of the information pyramid (Fig. 1a) is still suitable for this purpose. Consequently, additional (new) information should be conveyed in a way, which doesn't reduce the users' focus on the most relevant parts of the forecast.
- Improved communication of critical aspects and elevation: With only 24 % of respondents applying this information correctly and given that this information is highly correlated with avalanche risk, there is an urgent need to review how this information is presented or explained. Therefore, we need to determine if this information is too complex, not emphasized enough, visualized poorly, or perhaps not perceived as critical.
- Field insights required: Given the stark contrast between online survey results and field observations, our findings highlight the need for forecast producers to complement online surveys with field studies to assess user retention and understanding of forecast information more accurately.
- Introduction of impact-oriented applications: In addition, technological advances can be used to provide automated tour planning tools with integrated risk assessment, for instance, by highlighting the most difficult/complex parts of a route (e.g., SLF App White-Risk) or by providing risk assessments of route applying avalanche forecast information in an automated way to terrain (Skitourenguru, 2023). Such tools can help ski tourers plan their tours more efficiently, thus increasing the consideration of the most critical parameters.

To this end, we believe it is essential to educate users about new and existing information in the forecast (such as avalanche problems or risk calculations) with the aim of empowering backcountry users to make safer decisions.

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