CHARACTERIZING AN INCREASINGLY DIVERSE AND GROWING BACKCOUNTRY COMMUNITY: A HOLISTIC AND INFORMATIVE APPROACH USING AUDIENCE SEGMENTATION

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KEYWORDS: Forecast users, user characterization, risk communication.

1. INTRODUCTION

Over the past two decades, there has been tremendous growth in winter backcountry recreation. National sport participation surveys (e.g., Bürgi et al., 2021) and upward trends in alpine club membership (e.g., Alpenverein Österreich, 2023), avalanche course enrollment, and social media engagement (Avalanche Canada, 2021 & 2022) highlight the increase. While this trend already existed before COVID-19, the pandemic exacerbated winter outdoor recreation popularity (Schlemmer & Schnitzer, 2023).

Risk communication research has shown that personal and contextual differences impact how individuals perceive and apply risk messages (Lundgren & McMakin, 2018; Demuth, 2018; Wachinger et al., 2013), and it is well established that a good understanding of the target audience is critical for effective risk communication (e.g., Lundgren & McMakin, 2018; Balog-Way et al., 2020). A common approach to better understand target populations is audience segmentation, which divides heterogeneous populations into smaller, more homogeneous segments based on relevant characteristics (Metag & Schäfer, 2018; Slater, 1996). Once meaningful segments have been identified, tailored messages can be created for the intended recipients.

In the avalanche safety community, backcountry recreationists have traditionally been understood and segmented through their level of formal avalanche safety training and activity type. This is reflected in the format of public avalanche forecasts where the information is presented in a pyramid (EAWS, 2023) with each tier of information increasing in complexity and catering to a higher level of training. Similarly, avalanche safety course curricula and materials have been customized based on different backcountry activities (e.g. Floyer & Robine, 2020; Floyer et al., 2020).

While activity type and training level are valuable starting points, the informative value of the current segmentation approach for the design of avalanche safety communication and education is limited. For example, it does not include any information about what type of experiences recreationists are seeking or what types of terrain they expose themselves to. This information is critical for determining an appropriate level of avalanche risk management and what constitutes relevant information. Similarly, it does not consi-

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der recreationists' current risk management practices, which could allow warning services to tailor their information products even further. Lastly, the current segmentation approach does not consider information about recreationists' preferences about when and where they recreate, which could be used to identify the best times for specific messages. Hence, having a richer understanding of the recreating public can provide avalanche warning services and educators with valuable insight to ensure that their products are as informative as possible, resonate with, and address the needs of the intended audience.

This study aims to introduce the avalanche safety community to a more informative, holistic, and evidence-based approach using audience segmentation to illustrate how it can provide a rich picture of the backcountry community for the improvement, design, and evaluation of targeted avalanche safety communication and education.

2. BACKGROUND

Our approach builds on a long tradition of segmentation, which divides an audience into distinct and homogeneous groups based on relevant characteristics, behaviours, and preferences. The goal is to provide communicators with information on the specific needs and traits of each group to increase the effectiveness of their communications (Slater, 1996; Metag & Schäfer, 2018). This ensures that communication efforts are informed by the community, which strategically maximizes risk communicators' ability to reach the intended audience and have the desired impact.

The fields where audience segmentation has been applied are diverse. In public health, for example, audience segmentation has become integral to targeting particular subgroups of the population (Boslaugh et al., 2005). In disaster and crisis risk communication, audience segmentation is found to be effective at targeting and supporting vulnerable groups, adapting messages to situational variability, and improving community participation among other benefits (Bartolucci et al., 2023). It is also a well-established tool in outdoor recreation and tourism due to its range of applications for enhancing visitor experiences (e.g. Komossa et al., 2019), parks and land use planning (e.g. Farías & Torbidoni, 2011), communications and marketing initiatives (Perera et al., 2012), and promoting sustainable recreation (e.g., Hall et al., 2010).

Segmentation studies in winter sport tourism have overwhelmingly focused on resort skiers. For example, Alexandris et al. (2009) segmented recreational skiers by motivations from a ski resort in Northern Greece to inform marketing techniques. They suggest that marketing to the "naturalists" segment should be different from marketing to the "multi-interested" segment. Other studies have also segmented skiers' motivations to understand destination choice attributes (e.g. Miragaia & Martins, 2015) satisfaction (Tsiotsiou & Vasioti, 2006), visitor frequency (Tsiotsou, 2006), and constraints to participation (Priporas et al., 2015).

3. METHOD

3.1 Dataset

The data for this research draws from the sign-up survey for the avalanche forecast user research panel of the Euregio[1] and Swiss Avalanche Warning Services, which was established in collaboration with Simon Fraser University (Haegeli et al., 2023). The analysis data was downloaded on August 15, 2023, and includes 7277 participants who completed the questions used in this study. The analysis is focused on backcountry recreationists and does not include individuals who manage avalanche risk in a professional capacity 10 or more days per winter.

3.2 Relevant sign-up survey questions

The sign-up survey for the forecast user panel includes a wide range of questions about recreational engagement and preferences, motivations, backcountry experience, level of safety training, avalanche risk management practices, and demographics (see Haegeli et al. (2023) for full listing). Here, we only discuss the response options to the questions relevant for the present analysis.

Winter Backcountry Activities

Activity type remains an important consideration as it has a strong effect on how recreationists interact with the landscape and avalanche hazard. Activity options included backcountry skiing[2], out-of-bounds skiing, on-piste skiing, snowshoeing, ice climbing, mountaineering, and other. Experience was measured by the total number of years involved as well as the average number of backcountry recreation days per year to learn about participants' annual engagement. Both questions provided five response options. For collective years of experience, options ranged from this is/was my first winter to more than 20 winters, while days per year ranged from 1-2 days per winter to more than 50 days per winter. To better understand when and how risk messages can be presented, participants were asked when they typically recreate with options including regular weekends, statutory holidays/long weekends, winter vacations, and regular weekdays. Additionally, participants were asked to report their home residence and their

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[1]Includes the avalanche warning services of Tyrol (Austria), South Tyrol and Trentino (both Italy).

[2]We use the term skiing to refer to both skiing and snowboarding.

preferred areas for winter backcountry recreation.

Preferred Terrain

While activity type already relates to the type of terrain that recreationists typically access, the range of possible avalanche hazard exposure levels depends heavily on personal terrain preferences. We measured participants' terrain use patterns employing the avalanche terrain exposure scale (ATES; Statham et al., 2006; Statham & Campbell, 2023). Participants were asked to rate how frequently they recreated in non-avalanche, simple, challenging, complex, and extreme terrain when avalanche conditions allow on a 5-point Likert scale from never to always. To simplify the survey for participants, backcountry and out-of-bounds skiers were not presented with the non-avalanche terrain item, and the snowshoe version of the survey did not include extreme terrain. Ice climbers and mountaineers were not presented with this question as their activities require them to travel in extreme terrain.

Desired Backcountry Experience

We used 15 items selected from the recreation experience preference (REP) scales, developed by Driver (1977,1983) and later validated by Manfredo et al. (1996), to learn about participants' motivations. Items were selected based on their applicability to winter backcountry recreation and some phrasing was adapted to fit the avalanche risk context. For each item, respondents were asked to rate the importance of each motive on a 7-point Likert scale from not at all important to extremely important.

Avalanche Safety Training

Continuing with the existing practice of linking risk messages to avalanche safety training levels, participants were asked to indicate their highest level of completed avalanche safety training. Options included none, seminar, introductory recreational (1-2 days), advanced recreational (3-5 days), and training aimed at avalanche professionals (e.g., guides). For the analysis, seminar was combined with none since they are not considered formal training.

Trip Planning

Consulting the daily avalanche forecast for trip planning is an important risk management tool. However, research by St. Clair et al. (2021) highlighted that there are distinct patterns in how recreationists interact with avalanche forecasts, which they describe through a bulletin user typology. The typology consists of five levels that categorize forecast users based on their ability to find, interpret, and incorporate bulletin information into their travel decisions. Participants were presented with bulletin user typology statements developed by St. Clair et al. (2021) and were asked to indicate which statement best describes their personal practices. To supplement this information, participants were also asked to indicate how frequently they checked the forecast using a 5-point scale from never to every day during the winter.

In the Field

While the sign-up survey did not cover in-field risk management practices in detail, it did include a question on the use of avalanche safety equipment. Participants were asked to indicate what items they typically bring into the backcountry to determine who brings essential safety gear (i.e., transceiver, shovel, and probe).

3.3 *Data analysis*

Our analysis plan consists of several steps. After an initial exploration of the dataset using standard descriptive statistics, we preprocessed several sets of questions to make them more suitable for the segmentation analyses. We then employed two different approaches of audience segmentation to illustrate its utility: a) a conventional audience segmentation analysis that identifies distinct latent (i.e., not directly observable) segments and b) an exploratory and more targeted segmentation that starts with a specific question of interest. To further explore the nature of the identified segments, we performed various post-hoc comparisons using Pearson chi-squared tests, Wilcoxon rank-sum tests, or Kruskal–Wallis tests depending on the nature of the variable of interest. We used a p-value threshold of 0.05 to determine whether differences are statistically significant. All our data preparation and analysis was conducted in the R statistical environment (R Core Team, 2023).

The main analytical tool for our study is latent class analysis (LCA; McCutcheon, 1987), a probabilistic clustering technique for categorical variables. In a LCA the observed variables are considered indicators of a latent higher level grouping variable with a limited number of mutually exclusive classes (Collins & Lanza, 2010). The goal of a LCA is to identify the number of classes that best describes the variations in the observed response patterns, and respondents are subsequently assigned to the class with the highest probability. We used the R package poLCA (Linzer & Lewis, 2011) to perform all LCAs. We estimated a range of models with different numbers of classes and identified the best fitting model using the Bayesian Information Criterion (BIC; Schwarz, 1978) with lower values indicating better model fit. However, we also considered classification diagnostics (e.g., average assignment probabilities), as well as the interpretability and utility of the estimated models.

Pre-processing of sign-up survey responses

Several variables required pre-processing before they could be included in the segmentation analysis. The responses to the 15 motivation items were converted into a single categorical variable using k-means clustering as described by Neweduk and Haegeli (in prep). Each participant was assigned to one of seven motivation profiles (Table 1) that desc-

Table 1: Motivation types (size of sample: 2339)

Id	Label	Above avg. ratings	Below avg. ratings	N
1	Overall keeners	All		332
2	Least enthusiastic		Most	328
3	Peak & prestige	Completing classic tours, reaching summits		374
4	Relax & social	Spending time with family and friends; relaxing	Navigating challenging terrain; experiencing risk and adventure	324
5	Challenge & risk	Navigating challenging terrain; experiencing risk and adventure	Spending time with family and friends; relaxing	353
6	Skills & social	Developing skills (technical & avalanche); mentoring, spending time with family and friends	Completing classic tours, reaching summits	364
7	No interest in developing skills		Developing skills (technical & avalanche); mentoring, navigating challenging terrain, experiencing risk and adventure.	264

Table 2: Exposure variable (size of sample: 2390)

Label	N	Likelihood of spending at least "sometimes" in ATES terrain class					Proportion of participants within activity		
		Cl. 0[a]	Cl. 1	Cl. 2	Cl. 3	Cl. 4[b]	BC	OB	SS
Most conservative	187	28	94	42	1	1	6	6	50
More conservative	278	8	100	95	4	1	16	16	30
Moderate	503	3	89	98	27	< 1	23	15	20
More aggressive	739	0	87	100	96	22	34	34	0
Most aggressive	470	0	70	99	98	70	21	30	0
Mountaineers	83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ice climbers	30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[a] ATES terrain class 0 not presented to backcountry and out-of-bounds skiers; analysis assumes "never".
[b] ATES terrain class 4 not presented to snowshoers, analysis assumes "never".

ribes their general motivations for engaging in their particular winter backcountry activity.

We used a LCA to reduce the terrain preference items into a single variable. The analysis revealed five distinct terrain use patterns for the backcountry skiers, out-of-bounds skiers, and snowshoers ordered from most conservative to most aggressive terrain choices. We added the mountaineers and ice climbers as separate classes due to the unique terrain use patterns of these activities. This resulted in a new 7-level categorical variable that describes participants' exposure to avalanche terrain (Table 2).

Lastly, participants were categorized into locals, close-by residents, and more distant tourists based on the location of their primary residence. Participants whose postal code were within the forecast regions of the local avalanche warning services were considered locals; participants residing within a three-hour drive from the forecast regions were classified as close-by residence, and everybody else was considered a tourist.

Segmentation approaches

The conventional audience segmentation analysis was conducted using the following variables for the creation of what we call competency profiles: participants total years of experience, average number of days per winter, level of avalanche safety training, bulletin user type, frequency of bulletin use, and use of essential safety gear. The aim of the competency profiles are to describe what common combinations of experience, training, and risk management practices exist within the research panel participants.

To illustrate the benefits of more targeted segmentations, we identified two participant segments that we compared against the rest of the sample:

- Panel members included in the motivation cluster that is characterized by a distinct disinterest in developing avalanche safety skills (no interest in developing skills cluster).

- Panel members that recreate in terrain with considerable exposure to avalanche hazard (more

and most aggressive terrain use pattern classes, mountaineers, and ice climbers) but do not check the avalanche forecast before every trip.

Both groups might be of interest to warning services as they represent potential at-risk cohorts where avalanche risk management skills or practices might be misaligned with their exposure to hazard.

4. RESULTS

Our dataset included 7277 recreationists. It consisted of 79% identifying as male, 21% as female, and 34% of participants were between the ages of 25-34. Most participants were from Switzerland (34%), followed by 27% from Austria, and 25% from Germany, with the remaining 14% of participants from other countries.

Backcountry skiers presented an overwhelming majority of the sample representing 79% of all respondents. The least represented activities were mountaineers at 1%, and ice climbers at 0.5%. Avalanche training level was distributed slightly more evenly, as 15% reported no training, 43% reported intro level training, 28% reported advanced level, and 14% reported professional level. Overall, 28% of participants reported participating in their winter activity for 20 or years followed by 24% recreating between 2-5 years. Only 2% reported that it was their first year of participation. Most people recreated on average between 21-50 days in a season (42%) while only 1% reported 1-2 days per season. Similarly, bulletin users who reported a Type E use pattern represented 40% of the sample and 2% did not check the bulletin at all. Almost the entire sample carried the essential safety equipment while recreating (97%).

4.1 Conventional segmentation

The audience segmentation LCA (N=6590) produced four distinct competency profiles (Table 3): limited (25%), rudimentary (10%), foundational (43%), and developed (45%). As we move from the limited to the developed profile, there is an observable and gradual increase in complexity of bulletin user typology, bulletin use frequency, and level of avalanche safety training. However, no distinct progression was seen for participants combined years of experience and annual engagement levels. Majority of participants in all profiles carried essential safety equipment.

The post-hoc comparisons provide additional insight into the characteristics of the panel members across the competency profiles. There are significant differences in the distributions of activity type across the three competency profiles ($\chi^2 = 339.24$, df = 15, p < 0.01). More specifically, there were significantly more out of bounds skiers (13%) in the developed profile and more on-piste skiers (10%) and snowshoers (13%) in the rudimentary profile.

Cross comparisons between the competency profiles and exposure patterns also elicited significant differences ($\chi^2 = 299.26$, df = 18, p < 0.01). From rudimentary to developed, each profile contains significantly more individuals who recreating in increasingly aggressive terrain. In addition, there are significantly more mountain climbers in the rudimentary (7%) and limited profiles (19%). Because mountaineering is known to occur in high exposure terrain, these results are noteworthy.

While each distribution was relatively even for each profile across the motivation clusters, results revealed statistically significant differences between all except for the limited profile ($\chi^2 = 48.18$, df = 18, p < 0.01). There are significantly more from the skills and social cluster (19%) in the developed profile, whereas the foundational profile contains significantly more from the relax and social cluster (18%). The rudimentary profile contains significantly more from the peak and prestige cluster (22%).

The developed profile has a significantly larger proportion of local participants (48%) and the rudimentary (26%) and limited (41%) profiles have significantly more tourists ($\chi^2 = 126.86$, df = 6, p < 0.01). In addition, the foundational profile recreates during the weekend and on holidays (51%) significantly more as opposed to the limited profile that contains significantly more who recreate on long weekends and holidays only (21%, $\chi^2 = 87.64$, df = 6, p < 0.01).

4.2 Question-driven segmentation

While the conventional segmentation provides a meaningful overview of the sample, the question-driven approach provides the opportunity to explore segments in more detail. We began by exploring the characteristics of motivation cluster 7 (N = 264), who were categorized based on their distinct disinterest in technical and avalanche safety skills development. Interestingly, a significant difference was observed in the distribution of age and years of experience. There are significantly more people who reported recreating for 20 or more years (53% vs 32%, W = 296835, p < 0.01) and more people aged 45 and above (68% vs 41%) in the motivation cluster compared to the rest of the sample. Conversely, the motivation profile also contained a significantly higher proportion of individuals who recreate between 3-10 days per year (19% vs 12%, W = 205567, p < 0.01) and whose highest formal avalanche safety training is introductory level (52% vs 41%, $\chi^2 = 15.457$, df = 3, p < 0.01). This motivation cluster also contained individuals who recreate significantly more in the most conservative exposure class (13% vs 7%) and less in the most aggressive terrain class (12% vs 21%) compared to the rest of the sample ($\chi^2 = 23.15$, df = 6, p < 0.01). No significant differences were fou-

Table 2: Competency profiles showing most frequent and the second most frequent response pattern for each variable.

Competency Profile	Developed N = 2999 (45%)		Foundational N = 2808 (43%)		Rudimentary N = 658 (10%)		Limited N = 125 (2%)	
Distribution Frequency	Most Frequent	2nd Frequent	Most Frequent	2nd Frequent	Most Frequent	2nd Frequent	Most Frequent	2nd Frequent
Bulletin User Type[a]	Type E 62%	Type C 18%	Type D 41%	Type C 28%	Type B 42%	Type C 41%	Not Checked 100%	n/a
Bulletin Use Frequency	Daily 46%	Every Trip+[b] 41%	Every Trip+ 70%	Every Trip[c] 16%	Every Trip 33%	Some-times[d] 24%	Not Checked 100%	n/a
Essential Safety Equipment	Yes 99%	No 1%	Yes 100%	No 0%	Yes 78%	No 22%	Yes 85%	No 15%
Avg Number of Days per Year	21-50 60%	50+ 21%	11-20 51%	21-50 27%	3-10 32%	11-20 32%	21-50 42%	11-20 26%
Total Number of Years	20+ 44%	11-20 30%	2-5 36%	6-10 31%	2-5 51%	20+ 13%	2-5 30%	20+ 28%
Avalanche Safety Training	Advanced 39%	Prof[e] 29%	Intro 67%	Advanced 23%	None 64%	Intro 35%	Intro 42%	None 34%

[a] Levels of bulletin user typology (St. Clair, 2019; abbreviated): Type A: Does not use bulletin; Type B: Typically uses danger rating to decide whether or not it is safe to travel in the backcountry; Type C: Combines danger rating with knowledge of terrain; Type D: Base decision on avalanche problem information; Type E: Use bulletin as starting point for personal assessment in the field.
[b] Before every trip in the region and occasionally in between   [c] Before every trip in the region
[d] Before most backcountry trips in the region   [e] Professional level training

nd when comparing gender, the competency profiles, and activity type.

The second question-driven exploration led us to separate participants who recreate in the two highest terrain classes (aggressive and most aggressive) or are a mountaineer or ice climber, but do not check the avalanche bulletin before every trip (N = 72). Out of the comparisons between this group and the rest of the sample, no statistically significant distributions were found when comparing gender, activity type, motivations, and level of formal avalanche safety training. However, this group had significantly more people who have been recreating for 20 or more years (48% vs 27%, χ^2 = 24.65, df = 4, p < 0.001). The proportion of individuals segmented into the limited competency profile was significantly higher (14% vs 2%, χ^2 = 62.78, df = 3, p < 0.01), and they were statistically less likely to carry the essential safety equipment (9% vs 3%, χ^2 = 4.90, df = 1, p = 0.026). There was also a significantly larger proportion of the interest group who reported that they never check the bulletin (15% vs 2%), as well as significantly less who reported a type C (36% vs 24%) or type D (13% vs 26%) bulletin use type (χ^2 = 77.09, df = 4, p < 0.01).

5. DISCUSSION

Both the conventional and question-driven segmentation analyses draw on insights gathered from un-derstanding recreationists characteristics, preferences, and practices to inform meaningful improvements to avalanche risk communication. In the conventional segmentation, we observed a trend where levels of safety training and pre-trip risk mitigation increased from the limited to developed profiles in alignment with existing assumptions. Surprisingly, this pattern was not observed in years of experience and annual engagement as measured through days of backcountry recreation per year. This finding provides evidence that some highly engaged recreationists have limited risk competency levels, which challenges prevailing assumptions about recreationists risk management and recreation behaviours. The opportunity this research provides to uncover additional hidden patterns like this could enable the avalanche safety community to characterize and communicate with recreationists more effectively.

This opportunity is nicely illustrated by the question-driven exploration, which independently explored two potentially at-risk groups that might benefit from targeted risk communication initiatives: (1) the motivation cluster disinterested in developing avalanche and technical safety skills and (2) those who recreate in high exposure terrain but do not check the bulletin before every trip. Cross comparisons confirmed patterns suggesting that risk mitigation practices and knowledge may be poorly matched to the types of experiences they seek and terrain they are exposing themselves to. Interestingly, both interest groups

also contained significantly more participants who have been recreating for 20 or more years compared to the rest of the sample. This information is informative when combined with other research. A study by Finn (2020) highlighted that older demographics performed less well on bulletin literacy tests and Peitzsch et al. (2020) have shown that the age of avalanche victims has increased over time. The findings of the exploratory approach highlight its ability to identify segments of the population who may benefit from risk messaging and products that cater more directly to their needs. In this case, this cohort may benefit from outreach emphasizing the importance of early season skills practice or even inform curriculum development for refresher avalanche safety courses.

5.1 *Limitations*

While the present analyses provided useful insights into the characteristics of the members of the Euregio and Swiss avalanche forecast user panel, our sample overrepresents male backcountry skiers with high experience levels. It is important to remember that the sample is not representative of the respective forecast user communities nor the backcountry community. Hence, caution should be used when extrapolating our results to these or other populations. This is particularly true for the conventional segmentation, which is more sensitive to the characteristics of the sample than the question-driven segmentations.

A more specific limitation of the research panel is that the current sign-up survey does not include a question meaningful at capturing the in-field risk mitigation practices of recreationists. This is an important consideration that should be incorporated into future segmentation analyses.

6. CONCLUSIONS

This research aimed to demonstrate how research panels can be explored to help us understand the characteristics of avalanche forecast users. Through segmenting the audience into more homogeneous groups of similar interest, skills, and practices, we can better inform the design of avalanche risk communications, products, and education to be more targeted and effective.

We envision expanding upon the methods presented in this paper in multiple ways. First, we envision developing a dashboard interface for the collaborating avalanche warning services to explore the nature of their research panel. This would enable the warning services to perform the type of analyses presented in this paper with their own research questions to gain broader insights into who is accessing their services, why, and how they could be better supported.

Second, to overcome the potential limitations of the research panel, warning services may be interested in developing an (optional) membership program for their forecast products, where an initial sign-up asks questions paralleling the ones used in this study. The warning services that implement this would acquire a more representative sample, which could identify a more meaningful range of users and their needs. Knowing how users navigate forecasting websites would provide even broader insights into the user community as well as product challenges and opportunities.

While customized avalanche forecast products for different audience segments have so far been unthinkable due to limited resources, the current trends towards an increased use of models and automation (e.g., Pérez-Guillén et al., 2022) creates the foundation for the efficient production of a more diverse set of avalanche safety communication products that may be able to better meet the needs of different individuals. Overall, this research contributes towards the development of a more user-centric and evidence-based approach to avalanche risk communication.

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