A RESEARCH SYSTEM FOR A MORE INTEGRATED AND RESPONSIVE CONTRIBUTION OF SOCIAL SCIENCE RESEARCH TO AVALANCHE SAFETY INFORMATION PRODUCT DESIGN AND EVALUATION

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ABSTRACT: Having an in-depth understanding of how avalanche forecast users access, understand, and apply avalanche hazard information is critical for making informed decisions about how to improve existing services or develop new ones. While there is a growing body of survey research examining the practices and capabilities of forecast users, the impact of this research on product development decisions as well as its contribution to the understanding of the user community in general has been limited so far. Some of the reasons contributing to this challenge are the recruitment of diverse samples being challenging, academic research being too slow and not aligning well with development timelines, and studies typically being one-offs only focusing on a particular research question and not contributing to the development of a more comprehensive understanding of the user community.

We present a system for avalanche forecast user research that aims to help avalanche warning services and collaborating researchers overcome some of the practical challenges of this type of research and use online surveys more efficiently to create meaningful insights. Our system consists of i) a research panel, ii) a signup survey with standardized signup questions, and iii) a template for targeted research surveys to streamline survey design and deployment. Each of these components is explained in detail. Together, the research system aims to allow avalanche warning services to deploy shorter and more targeted research surveys more frequently, but still have the scientific rigor necessary to provide informative insight. Thereby, the system intends to foster a more continuous and structured two-way communication between avalanche warning services and their users, as well as more efficient collaborations between avalanche warning services and social scientists.

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KEYWORDS: Avalanche forecast, user research, survey research, social science

1. INTRODUCTION

It is well established in the risk communication literature that having an in-depth understand of the characteristics, needs and existing practices of the audience is critical for the development of effective risk communication messages and their subsequent evaluation (e.g., Balog-Way et al., 2020; Eastern Research Group and NOAA Social Science Committee, 2019; Lundgren and McMakin, 2018). Similarly, best practice guidelines for evidence-based development of public health initiatives highlight the importance of detail needs assessments that take a close look at existing individual, organizational, and community conditions in both the development and evaluation of intervention initiatives (e.g., Jacob et al., 2018; World Health Organization, 2021; Brownson et al., 2017). Hence, having a detailed understanding of how backcountry recreationists access, comprehend, and use avalanche safety products is essential for avalanche warning services (AWS) and avalanche safety educators to understand the effectiveness of their products and services, make informed decisions about how to improve them and develop new ones.

Social science research methods offer a wide range of approaches for studying how avalanche forecast users interact with existing products and services in a systematic way. From these methods, online surveys have established themselves as a popular tool for efficiently collecting substantial amounts of information from large numbers of users. Many AWS and research group have conducted user surveys in recent years (e.g., Engeset et al., 2018; Winkler and Techel, 2014; Fisher et al., 2021; Margalef et al., 2018), which has been at least partially facilitated by the development of easy-to-use survey platforms like Google Forms, Survey Monkey, or Qualtrix.

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Despite these developments, the use of survey studies for actual product development decisions and the overall contribution of this research to an improved understanding of the forecast user community seems limited so far. While Haegeli et al. (2023b) provide detailed reflections on how to improve the quality and practical relevance of social science research for improving avalanche safety in general, we believe that there are also some very real practical challenges that prevent this type of research from playing a more important role in development and evaluation of avalanche risk communication products and services. Some of these challenges include:

- Recruitment of meaningful samples being challenging and taking time,
- Surveys being too long,
- Academic research being too slow and not aligning well with development timelines, and
- Studies typically being one-offs only focusing on a particular question and not contributing to the development of a more comprehensive understanding of the user community.

All these issues together make it cumbersome for AWS to meaningfully include user research into their development cycles and prevent social scientists from contributing to the process.

The objective of this paper is to present a system for avalanche forecast user research that aims to help AWS and collaborating researchers overcome these challenges and use online surveys more efficiently to create meaningful insights for the development and evaluation of products and services that better align with the challenges, needs and practices of users.

2. CHALLENGES

To understand our design choices of the present research system, it is useful to discuss some of the most prominent challenges in more detail.

2.1 Limitations of convenience samples

The people who participate in our research projects fundamentally limit the conclusions we can draw from these studies and how informative our results are about the overall population of forecast users. Most survey studies in the avalanche safety community rely on convenience sampling, a non-probability sampling approach that takes advantage of easily accessible participants. They are typically recruited through banners on AWS websites, announcements on other community websites, club magazines, newsletter and social media channels popular among backcountry recreationists. While this way of recruiting participants is relatively quick and easy, the resulting survey samples are biased towards a very specific segment of the forecast user community: they are typically dominated by more frequent backcountry travelers who are more avalanche aware, more engaged with avalanche forecast products, and more confident in the value of their perspective. While there is value in hearing from these types of users, they do not meaningfully represent the full range of avalanche forecast users.

To understand the strengths and weaknesses of products and services more comprehensively, it is equally valuable to hear from more novice and infrequent forecast users, foreign tourists unfamiliar with the local services, or winter hikers and other backcountry users who do not think they expose themselves to avalanche hazard. Feedback from these audiences can highlight challenges in accessibility, presentation, and comprehension that otherwise remain unnoticed. Identifying these types of challenges seems particularly important in the context of the recent dramatic popularity boost of winter backcountry recreation (see Bürgi et al. (2021) for numbers on the development in Switzerland), which likely means that the backcountry community is become more diverse and includes more novice users. However, recruiting sufficiently large samples of these types of users is time consuming and expensive, and therefore often out of reach for individual studies.

2.2 Surveys being too long

Surveys examining forecast users' avalanche risk management practices and use of existing products use are often very long. It is not uncommon for participants to spend up to 30 minutes completing a survey, which is exceptionally long in the survey research world. While this might be acceptable for eager power-users of avalanche safety products, it is beyond what we can expect from regular users.

There are two main reasons for the excessive length of these surveys. First, the concepts we are trying to measure, such as risk perception, avalanche forecast comprehension, and the meaningful application of avalanche hazard information are complex and cannot be captured meaningfully with simple multiple-choice questions. Hence, our surveys often include elaborate exercises that participants need to complete several times (see, e.g., Fisher et al., 2021). The second reason for the long surveys is the fact that they generally include large numbers of personal background questions. This information is critical for putting the main results into context and providing user group specific insights beyond general overviews.

These two aspects together make it difficult to design short surveys that can still provide informative insight. However, the most sophisticatedly designed surveys are useless if participants do not complete them, and the excessive length of the current research surveys can be a hurdle to asking forecast users questions more frequently.

2.3 *Academic research being too slow*

The development of well-designed surveys that can produce insightful and actionable results is challenging and takes time. Accommodating this time in development projects can be challenging, especially if the user research component was not already considered during the inception and development stage of a project. While it is challenging to cut corners in study design without negatively affecting research quality, some of the more technical aspects of survey research (e.g., participant recruitment, deployment) can potentially be streamlined.

2.4 *Current studies primarily being one-offs*

Over time, user research should help AWS to develop a comprehensive picture of their forecast users' practices, capabilities and needs. However, at this point, most studies seem to be conducted in relative isolation and tackle a particular research question without contributing much to a bigger picture understanding of forecast users.

One of the factors that make it difficult to meaningfully synthesize information from multiple studies into an overarching picture is the inconsistency of question formats and response options in background questions across surveys. For example, differences in how experience or avalanche safety training is measured makes it difficult to compare samples and put results into perspective. The issue is even more challenging for harder-to-measure concepts like risk perception or information comprehension.

3. RESEARCH SYSTEM

The objective of the system for avalanche forecast user research presented in this paper is to address the above challenges and create a research environment that can facilitate a more continuous engagement with forecast users and produce research insights more quickly without compromising quality.

While existing survey platforms (e.g., Google Forms, Survey Monkey, Qualtrix), are very efficient for simple questionnaires, they have serious design limitations. First, the limited number of available question formats and the lack of control over survey logic and layout details prevent the design of the more sophisticated question formats necessary for studying concepts like forecast information comprehension and application. For example, it is very cumbersome if not impossible to design scenario-based exercises with forecast information that is dynamically created based on a statistical design and formatted to properly represent the layout of the forecast product being examined. Furthermore, these platforms are unable to support interconnected research systems where the responses to multiple surveys need to be linked together.

For all these reasons, the research system described in this paper is custom-built. The system was designed and built by Pascal Haegeli from the Simon Fraser University Avalanche Research Program (SARP) in the context of a multi-year research contract from the Tyrolean and Swiss AWS that aimed to better understand how their respective avalanche forecast products and services are uses, understood, and applied. Christoph Mitterer (Tyrolean AWS), Matthias Walcher (Tyrolean AWS) and Thomas Stucki (Swiss AWS) all contributed ideas to the design of the system, and Reto Rupf from the Zurich University of Applied Sciences provided additional survey expertise.

3.1 *Research panel*

The research system presented in this paper is built around the concept of research panels, which are one of the key research tools of market research and opinion pollster companies. Research panels are collections of pre-recruited individuals willing to regularly partake in online surveys, in-depth interviews or focus groups. When joining a panel, participants complete a detailed signup survey, which allows the company to have a detailed understanding of the type of people included in the panel and how they relate to the characteristics of the general population. When conducting individual studies, companies select relevant individuals from their research panels to compile survey samples that meaningfully represent their target population. This system allows researchers to get the desired insight about the targeted audiences quickly and reliably.

Many social science researchers purchase representative or targeted samples from market research companies for their survey studies. However, this is not an option for AWS and avalanche safety researchers since the available research panels do not include any information about participants' engagement in winter backcountry recreation and conducting our surveys with a general population sample is not meaningful.

To create meaningful samples for avalanche safety research studies for the Euregio[1] and Swiss AWS, we started the development of targeted research panels. This included the design of a web survey where interested backcountry users can sign up for the panel (explained in detail in Section 3.1) and an underlying database for storing the contact and background information of panel participants.

[1]The Euregio AWS is a joint venture of the avalanche warning services of Tyrol (Austria), South Tyrol and Trentino (both Italy) who jointly publish their avalanche forecasts at https://lawinen.report/ (Lanzanasto et al., 2018).

The goal is to build a diverse community of individuals interested in regularly participating in avalanche safety research and actively contributing to the development of new avalanche risk communication products and services. In other words, instead of just building a research instrument, the aim is to create a community forum that allows the collaborating AWS to continuously engage with their users about the effectiveness of their products and services in a systematic way. The intent is to let participants know that avalanche safety is approached as a community and that their perspectives on what works and what does not is important and valued.

Participants are recruited into the research panel by directing them to the signup survey, which is described in detail in the next section. While the traditional recruitment channels (e.g., website, press release, social media) are effective at capturing core users, the recruitment efforts should be complemented with other existing or new outreach initiatives (e.g., avalanche awareness events, trailhead outreach) and collaborations with community partners to reach some of the harder-to-reach audiences. For example, avalanche safety course providers can provide access to more novice backcountry users, and hotels and gear rental shops can assist in the recruitment of tourists. The ability to continuously work on the recruitment of harder-to-reach audiences allows the creation of sufficiently large samples for targeted survey projects for these communities that are completely out of reach for independently run studies.

While the recruitment and maintenance of the research panel requires an upfront investment, the possibility to repeatedly access large numbers of interested forecast users and the ability to produce meaningful samples for targeted studies make research panels a more constructive and ultimately more effective recruitment approach than recruiting separately for each individual research study. In addition, being able to repeatedly interact with the same individuals creates new possibilities for combining results from multiple studies and conducting longitudinal studies that follow the progression of participants over time. Together, this will lead to a much richer and more informative understanding of the forecast user community, the strengths and weaknesses of existing products and services, and opportunities for new developments.

While avalanche safety research generally benefits from an interested and committed user community, it is important to keep panel participants engaged. To create an active two-way conversation, it is ideal to regularly communicate with them. Regular communications about (preliminary) research results and updates on other product developments can bridge the time between invitations to research surveys and create a sense of connection and involvement. These communications can also include brief questionnaires from the AWS on topics that do not require detailed research surveys.

3.2 Signup survey with standardized background questions

To join the research panel, participants complete a signup survey with in-depth questions about their interactions with avalanche hazard. Before entering any responses, participants are presented with a detailed consent form explaining the nature of the collected information, how and where it is stored, and how it is used for research.

For recreationists, the signup survey includes detailed questions about recreational habits, backcountry experience, motivations, avalanche safety training, avalanche risk management practices and relevant demographics (Table 1). The intent is to create rich user profiles that contain important context variables for the analysis of research surveys (e.g., avalanche safety training) and help create meaningful samples for targeted studies (e.g., out-of-country tourists interested in freeriding with no avalanche safety training). See Neweduk and Haegeli (2023) for examples on how to use the collected information for segmenting avalanche forecast users.

Participants involved in professional avalanche risk management (e.g., guides, ski patrollers, members of avalanche commissions) complete an abbreviated version of the signup survey that primarily focuses on their certifications, professional activities, and demographics.

The wording and response options of the signup questions were designed to facilitate the consistent collection of background information across countries and studies. The questions were designed in English and have been translated into German, Italian and French. While having consistent questions is important for comparisons, the text of some questions were localized to improve clarity and make it easier for participants to answer them accurately.

> To make it easier to compare results from different social science studies and facilitate their synthesis, we encourage social scientists in the avalanche safety community to standardize their background questions.
>
> We are in the process of building a website to provide easy access to our signup questions and their translations. Please contact Pascal Haegeli at pascal_haegeli@sfu.ca for details.

While the main purpose of the signup survey is to collect information from new participants, it can also be used in an update mode that allows participants to

check their information and change it if necessary. This can be useful after new signup questions have been added, or the format of individuals questions has been updated.

3.3 Template for targeted research surveys

Research surveys general consist of the following three components:

- Pages with background questions, and
- Pages with research questions, and
- Supporting pages (e.g., landing page)

To simplify the design and deployment of research surveys, we created a template that defines the sequence of the survey pages and the content of the static pages that do not change between research surveys (Figure 1). This includes the majority of the supporting pages (shown in white) and the pages with background questions (shown in green), which

Table 1: Signup survey questions

Theme	Questions
Winter backcountry activities	• What recreational winter backcountry activities do you most often engage in? • Overall, how much experience do you have in all your recreational winter backcountry activities combined? • Which of the following regions do you commonly visit for winter backcountry recreation? [country specific wording and response options] • During what part of the winter season do typically recreate in these regions? • On what days do you typically recreate in these regions? • In which other countries have you pursued your recreational winter backcountry activities?
Preferred terrain	• When conditions allow, how often do you spend time in the following types of terrain when recreating in the backcountry? [activity specific wording] • How often do your backcountry trips involve short scrambles to either reach a summit or a ski line? [activity specific wording]
Desired backcountry experience	• In general, how important are the following motivations/experiences for your desired backcountry experience? [activity specific wording] • How important are the following motivations to your identity and self-esteem?
Avalanche safety training	• How important have the following knowledge sources been for the development of your avalanche risk management skills to date? • What is the highest level of formal avalanche safety training you have completed? • Have you or somebody you know ever been caught in an avalanche?
Decision-making role	• Which of the following statements best describes how you typically contribute to the decision on when and where to go into the backcountry and any avalanche risk management decision in the field? [activity specific wording]
Trip planning	• When planning a backcountry trip, which of the following information sources do you typically consult for getting an understanding of the current avalanche conditions? [country specific wording and response options] • How often do you use the avalanche forecast to check avalanche conditions? • Which of the following statements best describes your use of the avalanche forecast when planning a backcountry trip?
In the field	• Which of the following safety equipment items do you typically bring into the backcountry in the winter? • Do you regularly track your winter backcountry activities with a GPS device and upload your tracks to a website like Strava, Garmin Connect or similar?
Personal background	• Which gender do you identify with? • In which year were you born? • Are you part of any identifiable outdoor communities, organizations or clubs (e.g., trip report blogs, FB groups, hiking or mountain clubs)? • Where is your primary residence?

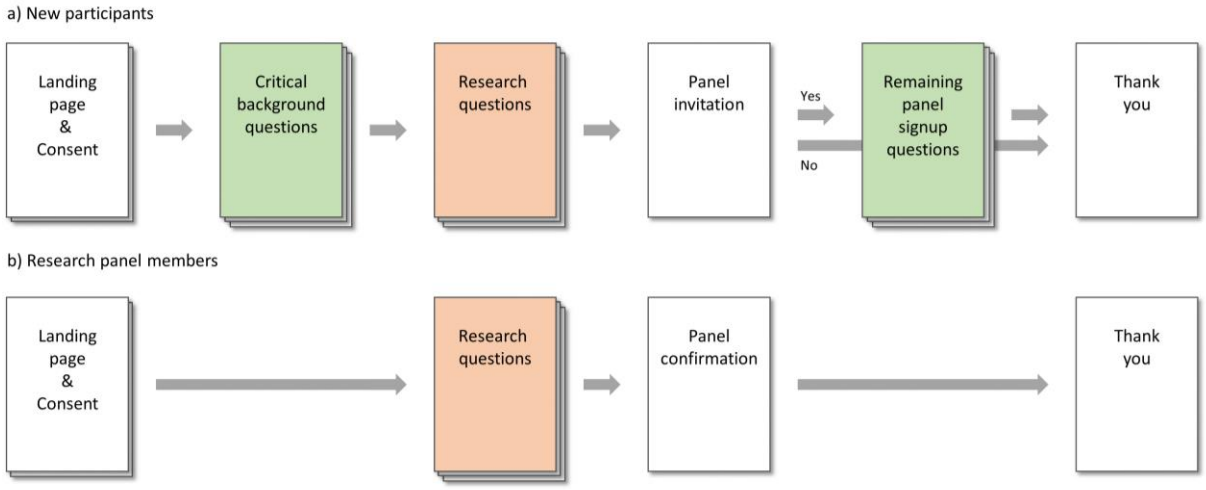

Figure 1: Flow of research survey for new participants (top panel) and research panel members (bottom panel). Green pages include background and research panel signup survey questions; orange pages include core research questions.

are imported from the signup survey. Hence, the design efforts for new research surveys can be focused on the content and presentation of the core research questions (shown in red) and the survey-specific landing page. The logic included in the survey template creates user-specific pathways through the survey to ensure that new participants and members of the research panel can complete the research survey as efficiently as possible.

Starting from the landing page, new participants (Figure 1, top panel) complete the consent form before they are presented with background questions that are critical for the analysis of the research questions at hand. They then complete the survey pages with the main research questions. After that, they are asked whether they are interested in joining the research panel. If they answer no, they are done and directed to the thank you page at the end of the survey. If they want to join the research panel, they have the choice to either complete the remaining signup questions right then or get an email with a personalized link to the signup survey for completing it later. The personalized link ensures that the information entered in the research and signup surveys can be linked properly.

Study-relevant members of the research panel receive an invitation email with a personalized link to the landing page of the research survey (Figure 1, bottom panel). The link includes the unique identifier of the participant, which allows the linking of the information entered in the various surveys. After completing the consent form, these participants are sent directly to the main research questions of the survey. Before sending them to the thank you page at the end of the survey, they are asked whether they want to continue being part of the research panel.

Having both of these pathways through the research survey gives more options for recruitment. The first pathway allow the survey to be promoted directly, and new participants can complete the survey and sign up for the research panel if they choose so. At the same time, the second pathway allows members of the research panel to complete research surveys much quicker.

Once the data collection for the survey has been completed, the background information of all new participants is transferred to the signup survey, and existing panel members who opted out are removed.

3.4 Technical details

The system is custom-built using the following barebones open-source technologies:

- MySQL database for data storage (www.mysql.com),
- PHP for web development (www.php.net),
- HTML, CSS, and java script for web design (www.w3schools.com),
- R for data access and analysis (r-project.org).

Building the surveys from the ground up allows for full control of the survey logic and question design, which is critical for high-quality and interactive research surveys.

The code was built in a modular fashion to make it easier to move/reuse questions and other survey components. This ensures consistency and minimizes the chance of errors.

New signup surveys and the general infrastructure for research surveys can be deployed with approximately one day of work. Additional time is required for localizations, translations, and the design and implementation of the specific research questions.

Surveys are developed in English and translation is done manually using the free version of the Transifex translation platform (transifex.com). The translated text is then integrated into the survey system using a series of json files. You can check out our translation projects at https://explore.transifex.com/sarp/.

While we are open to sharing the code of the entire system, it is not sufficiently self-explanatory to be shared and implemented independently.

Interested parties should contact Pascal Haegeli at pascal_haegeli@sfu.ca.

3.5 Future developments

The survey system is maintained and continuously developed by Pascal Haegeli. The following enhancements and updates are currently in planning:

- Building web page at avalancheresearch.ca for sharing standardized background questions and translations.
- Creating formal user accounts for signup survey to facilitate the updating of personal information and prevent multiple signups with the same email address.
- Improving the styling and functionality of the survey for use on mobile devices. However, a fully responsive design is likely not possible due to the complexity of the research surveys.
- Developing a shiny app dashboard to provide collaborating AWS and their community with an overview of their research panel.
- Simplifying and automating data transfer between databases and the sharing of contact information with collaborating AWS.
- Developing an approach to better facilitate the delivery of short and simple surveys that do not require custom-built survey design.

4. EUREGIO AND SWISS IMPLEMENTATION

The research panels for the Euregio and Swiss AWS were launched in the spring and fall 2021 respectively. As of August 25, 2023, a total of 4876 individuals have signed up for the Euregio research panel and 3084 for the Swiss panel.

The primary recruitment channels have been banners and messages on the avalanche forecast websites or apps (53%) followed by social media (18%), word of mouth (9%), and promotions in avalanche safety courses (8%).

Among the 7960 participants, 640 (8%) are avalanche safety practitioners working in a professional role more than 10 days each winter. Among them are 284 ski instructors, 260 mountain guides, 208 members of avalanche commissions, and 52 ski patrollers.

Of the 7942 panel participants who recreate in avalanche terrain, 6234 (79%) indicated their primary activity to be backcountry skiing/snowboarding, 902 (11%) out-of-bounds skiing/snowboarding, 301 (4%) on-piste skitouring, 287 (4%) snowshoeing or winter hiking, and 99 (1%) winter mountaineering.

Participants are generally well experienced with only about a quarter of the sample having less than 6 years of backcountry experience. Approximately 40% of the sample spends 21-50 days in avalanche terrain each winter, while another third recreates 11-20 days. However, the panel also includes a substantial sample of 1,058 individuals who spend 10 or fewer days in the backcountry each winter.

The research panel includes the full range of avalanche safety training levels. 43% of the panel have introductory avalanche safety training (1-2 days), 28% took an advanced recreational course (3-5 days), and 14% completed a course aimed at people pursuing a professional career in avalanche risk management (e.g., mountain guide training). Approximately one sixth of panel members do not have formal avalanche safety training.

This brief overview highlights the breadth of activities and experiences represented by the panel participants. However, additional, more targeted recruitment efforts are required to complement the existing participants with meaningful samples of harder-to-reach audiences (e.g., novice and more infrequent backcountry users). This will create new opportunities for examining the accessibility of existing products and services and the development of new ones.

Join the research panels by visiting the following websites:

Euregio panel:
https://eurosignup.avalancheresearch.ca/euregio

Swiss panel:
https://eurosignup.avalancheresearch.ca/slf

To-date, two large research surveys have been conducted with these research panels. The 2022 survey examined forecast users' ability to apply avalanche

forecast information in hypothetical assessment situations (Haegeli et al., 2023a) and how they navigate through the forecast website under different avalanche danger ratings. This survey was completed by 2154 panel members. The second research survey was conducted in the spring of 2023 and focused on assessing the accessibility and usefulness of the hazard descriptions in the avalanche forecast. This survey was completed by 4023 individuals, which highlights the power of research panels.

5. CONCLUSIONS

We present a system for avalanche forecast users research that aims to strengthen AWS' ability to study the effectiveness of their products and services and engage with their audience in a systematic and efficient way. The research system consists of survey infrastructure (signup survey and research survey template) and a research panel of avalanche forecast users interested in actively contributing to the development of avalanche risk communication products and services.

While there are other avalanche focused research panels (see https://uit.no/research/carepanel for more information on the CARE Panel), the close collaboration with AWS and the presented survey infrastructure makes this research system unique.

The design of this system emerged from a collaboration between the participating AWS and an academic research team. This is a good example of how combining the practical questions and information needs of public avalanche forecasters with academic social science research expertise can develop approaches for delivering practical insights based on rigorous scientific approaches. As suggested by Haegeli et al. (2023b) establishing such a partnerships allows the collaborative development of research objectives that align with development timelines and can be implemented in steps that work towards common long-term goals. In addition, collaborating with an academic research team more continuously can help develop social science expertise within forecaster teams.

While the description of our research system focused on surveys, it is important to realize that surveys are only one of the social science research methods for exploring how people interact, understand, and apply avalanche risk communication products and manage their risk. The research panels are equally useful for the targeted recruitment of participants for other research studies and engagement projects using methods like interview studies or focus groups.

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