THE INCIDENT SUPPORT TOOL: A NOVEL FRAMEWORK FOR ENHANCING AVALANCHE RESPONSE OPERATIONS

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ABSTRACT: Avalanche response and forecasting operations often involve complex decision making before, during and after an incident. Responders navigate challenging experiences and manage engagement around wellness and mental health with minimal guidance. The Incident Support Tool (IST) was developed by Responder Alliance to systematically assess responder risks and to support psychological well-being. The tool is designed to be used by teams that operate regularly in stressful and hazardous conditions. The objective of the IST is to improve precision and efficiency in decision making in determining psychological support for responders after a potentially traumatizing experience. IST use is initiated by stress resiliency team members and can be used collaboratively on multi-agency responses. Leadership and incident commanders assign an Incident Appraisal Score (IAS) using an integrated scoring guide. Individual responders add a Responder Appraisal Score (RAS) by completing a similar exercise. A cumulative score of Incident Appraisal plus Responder Appraisal is calculated for each responder. The IST scores correlate with a color (red, yellow, green) and the tool provides recommended actionable steps. In the 2023-2024 North American winter season, a mobile application was tested by the Loveland Ski Patrol, Snowmass Ski Patrol, Parks Canada, and the Colorado Avalanche Information Center. The application allowed for direct entry and tracking of IST scores following incidents. A scheduling component provides leadership with a method of tracking workplace traumatic stress exposure, the responders attached to those incidents, and planning appropriate courses of action over time. For these four organizations, the IST application was used by 54 individuals for nine incidents. 35 IST scores were recorded within the app. This study presents findings from a feasibility and use of acceptance survey designed to assess the utility of the IST and the mobile application. Questions focused on demographics, perceived utility as a decision support tool, ease of use, and likelihood of use. Initial results suggest this is an effective method for addressing, tracking, and planning responses to minimize adverse effects of potentially traumatic events.

KEYWORDS: incident support tool, stress, injury, avalanche work.

1. INTRODUCTION

Avalanche responders must navigate challenging physical and emotional experiences while managing individual and team wellness, often with minimal guidance. Working in and around avalanche terrain requires frequent, complex decision-making in high-pressure situations with traumatic experiences. In accordance with the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5-TR, 2022), trauma is defined as an actual or threatened death, serious injury, or act of sexual violence. The role of potentially traumatizing events (PTEs) and serious life stressors (SLS) in the development of psychological and health conditions, if untreated, has long been recognized Frerichs et al. (1982). For avalanche professionals, stress is a foreseeable risk, yet stress injury is not an inevitable consequence.

Despite numerous studies—such as those by Haraldsdóttir et al. (2014), Peterson et al. (2023), and Mundo et al. (2023)—demonstrating the effects of PTEs on responders in various fields, including backcountry, emergency medical services, fire, and law enforcement, there remains a paucity of published data regarding the specific effects and mitigation strategies for stress injuries among avalanche responders, who are repeatedly exposed to PTEs.

Rescue professionals operating in avalanche conditions may exhibit post-traumatic stress disorder (PTSD) symptoms at significantly higher rates compared to other rescue professionals Haraldsdóttir et al. (2014). A study of avalanche responders highlighted the prevalence of substance use disorders, depression, anxiety, panic, acute stress disorder, PTSD, and adverse effects on personal relationships Dolan and Tedeschi (2018) .

While the long-lasting negative physical and psychological effects of work-related stress on avalanche responders have been recognized by researchers and the community, this population continues to lack effective and accessible field-based tools for psychological support. Creamer et al. (2012) noted that the reluctance among first responders to seek help, often due to stigma, fear of professional repercussions, and the difficulty of transitioning from a provider of help to a recipient. Nonetheless, Dolan and Tedeschi (2018) found that formal psychological

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assistance was perceived as both effective and well-received when accessible to avalanche responder professionals. Findings from their research conclude that focus on formalizing pre-incident psychological preparation and post-incident support would be beneficial to forecasters.

Limited interventions to prevent, prepare for, and rehabilitate stress injuries among first responders underscores the need to assess the efficacy of existing measures and to develop new tools tailored for this high-performing population. According to Meisnere et al. (2023), addressing stress awareness and promoting whole health are essential to reducing high turnover rates, ensuring that these teams and individuals can sustain overall wellness.

2. CURRENTLY AVAILABLE TOOLS

Sinsabaugh et al. (2018) describe "stress injury," a term utilized by the U.S. Marine Corps (USMC) since World War I to encompass the physical and emotional impact of operational stress, which spans a continuum. Stress is not a binary, either-or scenario, whereby a rescuer is either fine or stress impacted or injured. Opportunities for early intervention and early mitigation are vital for prevention of injury. The stress continuum visually represents states ranging from operational readiness and capacity to respond (green) to overwhelming stress associated with incapacitating reactions to trauma (red). The "red" zone is often linked to conditions such as depression, anxiety, PTSD, and substance use disorders. Building on the USMC's stress injury framework, Responder Alliance has developed and implemented a novel model to comprehensively support the well-being of wilderness first responders. Responder Alliance is an organization dedicated to training resilience among individual responders and teams facing cumulative and incident stress in the austere settings. Responder Alliance has designed a curriculum informed by responders to mitigate the implementation gap. This curriculum includes proactive tools and best practices aimed at managing the risk of stress injury and burnout (see Figures 1 and 2).

Figure 1: The Stress Continuum, Laura McGladrey, Responder Alliance, 2022.

2.1 *Critical Incident Stress Management*

Critical Incident Stress Management (CISM) has been a standard practice among emergency responders across various specialties, including pre-hospital, hospital, search and rescue, and law enforcement since its introduction by Everly and Mitchell (1997). However, CISM has not consistently proven effective in preventing psychiatric sequelae following traumatic events, particularly PTSD. More concerning, there is mounting evidence from Bledsoe (2003), Rose et al. (2002), and van Emmerik et al. (2002) indicating CISM may exacerbate stress-related symptoms in both patients and personnel. Therefore, there is a critical need for evidence-based tools to support the health and well-being of first responders, which is essential for maintaining the longevity and effectiveness of individuals and teams working in emergency services.

2.2 *Incident Support*

Numerous incident response frameworks have been developed to assist organizations in optimizing incident response, communication, collaboration, and the effective management and resolution of critical incidents. These frameworks guide decision-making and offer direction in stressful situations that are likely to overwhelm cognitive and decision-making capacities.

The North American Public Avalanche Danger Scale (NAPADS), developed by Statham et al. (2010), has become second nature for many snow professional and civilian recreators to consult before avalanche terrain travel. Designed to communicate avalanche risk to the general public, the NAPADS systematically utilizes objective observations to rate avalanche likelihood, size, and expected distribution should an avalanche occur on a five-point scale with one being *low* danger and five being *extreme* danger. The NAPADS rankings also correlate with *Travel Advice,* uniting field-based decision making with expert consensus to enhance precision in decision making.

Recognizing key factors leading to broad adoption and applications of USMC's stress injury framework, the NAPADS, and similar tools by both industry professionals and civilians, it became clear that an incident support tool for wilderness responders, to be widely effective and utilized, needed to be concise, quick to train on and deploy in a variety of situations, and provide actionable feedback all while not overwhelming decision making demand. The NAPADS has been adapted to reflect stress accumulation in snow workers as presented by Lazar et al. (2023).

To our knowledge, no widely used incident response framework specifically designed to evaluate stress exposure in snow professionals exists to date.

Responder Alliance has developed the Incident Support Tool (IST) to systematically stratify the risk of responder exposure to PTEs and screen those at high risk for intervention when appropriate (see Figure 2). The total IST score is a composite score of the Responder Appraisal (RA) and Incident Appraisal (IA). The IA domain consists of five factors specific to the nature of the incident itself (i.e. was there a child involved in the incident). The IA is designed to be completed collaboratively between leadership and with input from the responders that were in the field. The RA domain also consists of five factors, but these factors are designed to be specific to the responder (i.e. did the responder know the subject personally before the incident occurred). Due to the personal nature of the RA domain, RA factors are completed by each individual responder on their own. All ten factors are scored 0 (little or no exposure), 5 (moderate exposure), or 10 (significant exposure). A completed IST is a composite score ranging from 0 to 100, consisting of both the values determined with the team in the IA domain and values determined by oneself in the RA domain. Thus, each individual responder calculates an IST score specific to their own experience and needs.

The IST introduces a novel approach to field appraisal of risk, introducing precision by considering both leadership and individual responder perspectives when assessing risk. This approach aims to improve evaluation of stress factors in a population likely to minimize impacts of PTE's during field incidents. The combined scores from the IA and RA produce a risk score specific to each responder.

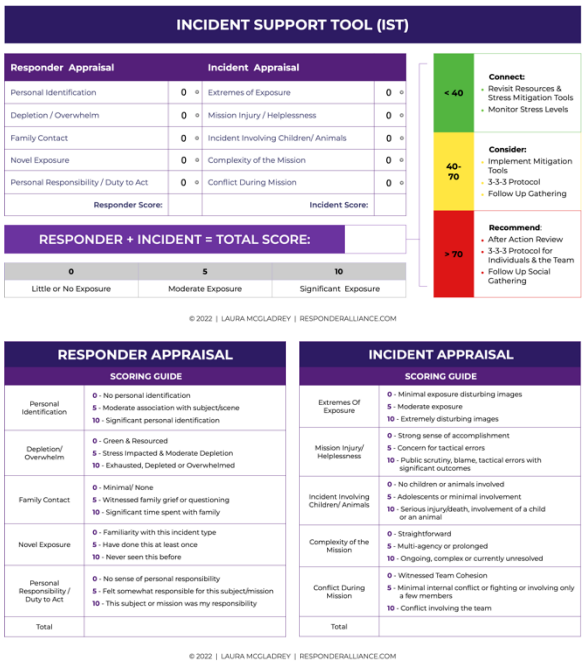

Figure 2: The Incident Support Tool, Laura McGladrey, Responder Alliance, 2022.

2.3 Novel Mobile Application

In previous investigations, such as that from Lazar et al. (2023), the IST has been administered using pen and paper. For austere professionals, however, this method limits robust utility both in the field and tracking purposes. In response to these limitations, a mobile application has been developed (see Figure 3). This application leverages a tool that most responders already carry—a smartphone—to enhance the IST utility and ease of use for austere professionals. The app includes features such as setting reminders to implement IST-recommended, evidence-based best practices following incidents. These reminders prompt responders to check in with one another and stay connected, thereby supporting both individual well-being and team health.

Reliable exposure identification and risk stratification in the field context increase the efficiency and precision in support of those snow workers affected by occupational stress. To facilitate this, the names associated with IST responses are recorded in a secure database accessible only by the organization's administrators. This system allows leadership to identify high-risk responses to allocate additional support and resources to those most likely to benefit. Furthermore, in a field characterized by high burnout and turnover rates, as evidenced by Mundo et al. (2023), maintaining a healthy team is essential for ensuring effectiveness both in and out of the field, as well as for retaining team members.

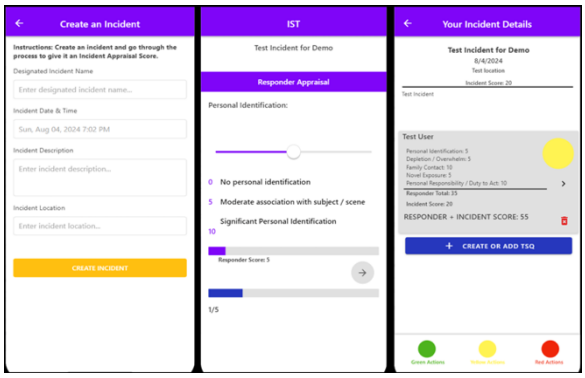

Figure 3: Stress Continuum Check In Mobile Application.

3. PARTICIPATING TEAMS

For the duration of this study, the following four teams utilizing the mobile application were instructed to encourage completion of an IST form within the mobile application following any major incident (e.g., avalanche or search and/or rescue operations).

3.1 Colorado Avalanche Information Center

The Colorado Avalanche Information Center (CAIC), a program within the Colorado Department of Natural Resources, Executive Director's Office, is a partnership between the Department of Natural Resources, Colorado Department of Transportation (CDOT), and the 501(c)(3) Friends of the CAIC. The CAIC team consists of approximately 25 forecasters and support staff aiming to provide avalanche information, education, and promote research for the protection of life, property, and the enhancement of the state's economy.

Throughout the winter, CAIC provides daily avalanche forecasts for recreational users, and in partnership with CDOT guidance, mitigation along Colorado roadways and infrastructure. Extensive use of Remote Avalanche Control Systems is employed, in addition to artillery and other means. Additionally, CAIC conducts avalanche incident investigations.

3.2 Loveland Ski Patrol

Loveland Ski Patrol consists of both paid and volunteer patrollers covering 1,800 lift-served skiable acres, with another 415 acres accessible via hiking. With the lowest elevation at 10,365 feet above mean sea level (AMSL) and the highest elevation at 13,010 feet AMSL, high alpine terrain is abundant in this area, which sits adjacent to heavily used backcountry areas.

The snow safety team guides avalanche risk reduction and manages avalanche hazards via forecasting, compaction efforts, explosives, and other active mitigation, as well as closures. Route leaders are assigned from the rest of the patrol. With one of the longest ski seasons in Colorado and in close proximity to Denver, Loveland attracts a high volume of visitors each season.

3.3 Parks Canada

Responsible for avalanche safety operations in the transportation corridor of Roger's Pass, in the Selkirk Mountain Range of Glacier National Park, Parks Canada works to mitigate avalanche risk along the transportation corridor. An average of 2,000 avalanches are reported in the area annually.

Parks Canada team members manage forecast operations, perform active avalanche mitigation, monitor avalanche protection structures, and execute backcountry rescue responses. Parks Canada employees participating in this study are tasked with managing the interaction between recreational user groups, maintaining transportation corridor safety, and working alongside multiple outside agencies, including the Canadian Armed Forces.

3.4 Snowmass Ski Patrol

Snowmass Ski Patrol, consisting of approximately 80 members, conducts medical and rescue operations, lift evacuations, and avalanche risk reduction and response in the Elk Mountains of Colorado's western slope. The largest of the four Aspen/Snowmass mountains, with 3,362 lift-served acres, 4,406 vertical feet, and 21 chairlifts, the ski area ranges from 8,100 to over 12,500 feet in elevation, with the tree line at approximately 11,500 feet.

Avalanche operations are guided by the Snow Safety Team, made up of 5 to 6 members. Avalanche risk reduction is accomplished using boot packing, ski packing, explosives, and other active mitigation methods, as well as closures.

4. RESEARCH METHODS

This retrospective study aims to describe the utilization of a mobile application to administer the IST and to evaluate the impact of the IST on decision-making regarding the level of support required for responders with high exposure to stress. Additionally, the study seeks to: (1) gain a deeper understanding of the potential role of the IST protocol in mitigating the individual and team impacts of experienced PTEs during critical incidents and near-miss trauma, and (2) assess the feasibility of implementing an IST mobile application among avalanche professionals.

4.1 Inclusion and Exclusion criteria

The study included participants who were employed as avalanche snow professionals, snow forecasters, or ski patrollers at one of the four pilot organizations.

The post-season survey was limited to individuals who had used the mobile application to complete an IST during the season. Furthermore, post-season survey participants must have been employed during the 2023-2024 North American avalanche season and have created an account within the mobile application during that period.

4.2 Mobile Application

The mobile application was piloted by the Colorado Avalanche Information Center, Loveland Ski Patrol, Parks Canada, and Snowmass Ski Patrol. Participants were invited by their team leadership to join the team account within the mobile application.

The application was made available for download on participants' mobile devices via TestFlight for iOS users or the Google Play Store for Android users. Upon installation, users were prompted to sign up with a unique login, which included reviewing the application's goals and agreeing to a release statement to proceed. Users were then required to select their affiliated organization and their role within that organization. Subsequently, an alert was sent to the organization's administrator, who had to approve the user's account before the application could be used to complete an IST.

Data collected through the application are stored in a database using Amazon Web Services (AWS), a cloud-based storage system that employs industry-leading encryption for data in transit and at rest. All data are encrypted at rest with AES-256, a block-level storage encryption standard.

4.3 Quantitative Survey

In July 2024, de-identified individuals who had completed an IST within the mobile application during the 2023-2024 North American winter season were invited to participate in a survey assessing their experiences with the mobile application and IST.

The survey was administered and hosted within the REDCap electronic data capture tools (Nashville, TN: Vanderbilt University) at the Colorado Clinical and Translational Sciences Institute, University of Colorado Anschutz Medical Campus. The Colorado Multiple Institutional Review Board (COMIRB) at the University of Colorado Denver determined that the project was EXEMPT from IRB review under a Category 2 exemption, as it involved the administration of a survey (COMIRB: 24-1126). No identifiers were collected.

The survey consisted of 19 self-reported items designed to assess: (1) the perceived effectiveness of the IST in screening and risk-stratifying responder exposures to potentially traumatic events, and (2) the feasibility and acceptance of IST use among first responders. Survey items were presented in various formats, including Likert-type scales, select-all-that-apply options, forced-choice questions, and short-answer responses.

5. RESULTS

Over the course of the 2023-2024 North American winter season, the four organizations collectively recorded a total of 35 individual IST reports across nine incidents within the mobile application. These incidents included scenarios involving individuals who were caught, buried, or killed in avalanches, overdue individuals, and survivable injuries requiring hospital care (see Table 1).

Table 1. Summary of Incidents

Incident		Description
1	Avalanche Incident	One skier caught, buried, and killed
2	Avalanche Incident	One skier caught, partially buried, and injured
3	Avalanche Incident	One skier caught, buried, and killed
4	Ski Crash	One skier crash, traumatic brain injury, graphic scene
5	Ski Crash	One snowboarder vs. tree injury
6	Ski Crash	One skier vs. tree fatality
7	Overdue Backcountry Recreator	Multiday, multiagency, search
8	Ski Crash	One skier injured, lengthy evacuation, poor conditions
9	Ski Crash	One skier vs. tree injury

5.1 Incident Appraisal

Regarding Incident Appraisal Scores, significant exposures (score = 10) were reported eight times across the nine incidents. These included four incidents involving children or animals (serious injury or death, involvement of a child or animal), three instances of extreme exposure (extremely disturbing images), and one case of mission complexity (ongoing, complex, or unresolved situations). Moderate exposures (score = 5) were reported ten times across the nine incidents, comprising four cases of mission complexity (multi-agency or prolonged), three instances of mission injury/helplessness (concerns about tactical errors), and two cases of moderate exposure to disturbing elements. The remaining 29 Incident Appraisal factor scores were reported as little or no exposure (score = 0).

5.2 Responder Appraisal

For Responder Appraisal Scores, significant exposures (score = 10) were reported 20 times, while moderate exposures were reported 48 times. Significant exposures included a personal connection to the involved parties (7 instances) and novel exposure (6 instances). Moderate exposures were reported in the following categories: personal responsibility/duty to act (14 instances), depletion/overwhelm (12 instances), novel exposure (9 instances), and personal identification with the subject or scene (9 instances).

5.3 IST Total Score

Among the 35 completed ISTs, one red score (≥ 70, indicating significant risk of stress exposure), six yellow scores (40-69, indicating moderate risk of stress exposure), and 28 green scores (< 40, indicating limited risk of stress exposure) were reported (see Table 2).

5.4 Survey Response

When respondents were asked about their preferred method of completing an IST, all indicated a preference for the mobile application, with 75% exclusively selecting the mobile app and 25% stating they would use either the mobile app or paper. In response to the statement, "I would recommend this tool to a colleague with similar work experiences," eight respondents (67%) strongly agreed, three (25%) agreed, and one (8%) was neutral. Concerning the tool's relevance to their current work, six participants (50%) found it extremely relevant, five (42%) found it very relevant, and one (8%) found it slightly relevant.

Table 2. Incident Support Tool Values per Incident

	Incident Appraisal Scores							Responder Appraisal Mean Scores (SD)						
Incident	Extremes Of Exposure	Mission Injury/ Helplessness	Incident Involving Children/ Animals	Complexity of the Mission	Conflict During Mission	Incident Appraisal Score	Personal Identification	Depletion/ Overwhelm	Family Contact	Novel Exposure	Personal Responsibility / Duty to Act	Responder Appraisal Score	IST Total Score Average
1	10	5	10	0	0	25	6.7 (2.9)	5 (0)	3.3 (5.8)	8.3 (2.9)	3.3 (2.9)	26 (11.5)	51
2	5	0	0	5	0	10	10 (0)	2 (2.7)	0 (0)	3 (2.7)	7 (2.7)	22 (5.7)	32
3	0	0	0	0	0	0	1 (2.2)	0 (0)	1 (2.2)	0 (0)	1 (2.2)	3 (2.7)	3
4	5	0	10	0	0	15	3 (2.7)	3 (4.5)	2 (2.7)	4 (4.1)	2 (2.7)	14 (4.2)	30
5	0	5	0	0	0	5	0 (0)	3.3 (5.7)	0 (0)	0 (0)	1.7 (2.9)	5 (8.7)	10
6	10	5	10	5	0	30	2.5 (3.5)	5 (0)	0 (0)	7.5 (3.5)	0 (0)	15 (5.7)	45
7	0	0	10	10	0	20	0 (0)	1 (2.2)	1 (2.2)	5 (5)	3 (2.7)	10 (6.1)	30
8	0	0	0	5	0	5	2 (2.7)	2 (2.7)	0 (0)	0 (0)	2 (2.7)	6 (6.5)	11
9	10	0	0	0	0	10	5 (7.1)	2.5 (3.5)	5 (7.1)	2.5 (3.5)	5 (7.1)	20 (28.3)	30
Mean (SD)	**4.4 (4.6)**	**1.7 (2.5)**	**4.4 (5.2)**	**2.8 (3.6)**	**0 (0)**	**13.3 (10)**	**3.4 (3.2)**	**2.6 (1.7)**	**1.4 (1.8)**	**3.4 (3.2)**	**2.8 (2.1)**	**13.4 (8.1)**	**26.9 (16.1)**

Regarding the ease of use of the IST, seven respondents (58%) agreed, and five (42%) strongly agreed with the statement, "I find the Incident Support Tool easy to use." When asked if the IST is clear and understandable, nine respondents (75%) agreed, and three (25%) strongly agreed. Responses on how individuals learned to use the IST were split: half reported learning from a teammate or supervisor, while the other half reported learning through in-person or online training provided by Responder Alliance, self-study, or a combination of methods.

When asked whether they felt capable of supporting a responder following exposure to traumatic stress,

two respondents (17%) reported feeling neutral, seven (58%) agreed, and three (25%) strongly agreed. In response to the statement, "The Incident Support Tool improves my decision-making by guiding if and when to seek the appropriate resources and support following a critical incident," three respondents (25%) were neutral, four (33%) agreed, and five (42%) strongly agreed.

6. DISCUSSION

The IST minimizes the adverse effects of PTE exposure by enabling early identification of stressors and providing recommended recovery strategies. All participants (100%) reported being able to recognize potentially traumatizing events during rescue operations. The deployment of the IST, alongside training for both individual responders and management, facilitates self-identification of stress impacts as well as the identification of such impacts in others. Survey data indicated that all participants were able to distinguish between different types of stressors. Self-appraisal is crucial in supporting decision-making at the individual level, allowing responders to seek help as soon as they recognize signs of stress that may not be immediately apparent to others.

The identification of stress impacts by peers and management is equally important. This practice can enable timely intervention even when the affected individual is unable to recognize symptoms or directly ask for help. However, the survey data revealed that organizational culture and personal beliefs surrounding mental health continue to hinder snow responder from utilizing psychological support tools such as the IST. Respondents noted that cultural change is slow, with workload and operational demands often taking precedence. Additionally, there was a reported fear of alarming colleagues when a responder remained in a red or orange state for an extended period. Stigma and fear of potential reactions present significant barriers to reducing stress injuries.

As demonstrated by the data, of the 35 completed ISTs, one individual's total score fell into the red category, six were in the yellow category, and the remaining 28 were in the green category. This distribution aligns with expectations, as exposure to a single PTE does not necessarily result in a stress injury. The IST's approach considers multiple factors from various perspectives, offering a unique opportunity to assess stress exposure and risk at both the individual and team levels. This individualized appraisal allows for the targeted deployment of resources to those at the highest risk based on their exposure. Moreover, in incidents that may present as relatively low exposure at the team level, the IST is sensitive enough to detect instances of increased risk at the individual level.

6.1 Field Application

The precision of stress injury risk evaluation on an individual basis, as facilitated by the IST, is exemplified in a typical avalanche incident familiar to most snow workers. When a call is received of a snowboarder caught and partially buried in a side-country slide, 12 responders are promptly deployed to the scene. The response team comprises four ski patrollers from a nearby resort, four search and rescue professionals, two avalanche technicians, one forecaster, and one representative from a local avalanche center. The subject is successfully extricated and transported to a nearby hospital with non-life-threatening injuries, while the ski partner who witnessed the slide is interviewed and released into the care of friends.

Although all responders participated in the same incident, each individual experienced a different exposure risk profile. For example, one responder was a friend of the subject, another was responding to an avalanche incident for the first time, two responders spent extended time with the distraught ski partner, and three identified feeling physically exhausted, task-saturated, or depleted upon their scene arrival.

In such an event, assigning a uniform score to the entire group overlooks the unique circumstances that contribute to the stress injury risk of each responder. While the Incident Appraisal is consistent for all responders, as it evaluates the variables present in the overall incident, while the responder appraisal incorporates individual-specific factors that also impact stress injury risk. This approach allows for more precise intervention and monitoring for those at moderate to high risk of injury. Universal screening and targeted resource management ensure that those most likely to benefit can more readily access the necessary support.

6.2 Limitations

The small sample size limits the strength of conclusions can be drawn from the data and generalizability to wider segments of snow responders. Future research must focus on gathering data across a greater range of geographical areas and longitudinally across multiple winters. This study was retrospective in design, so further research must investigate IST implementation prospectively.

6.3 Further Research

In this small-scale retrospective study, the IST demonstrated promising capabilities as a decision-making tool to support stress injury mitigation at both the individual and team levels among this small sample. Further investigation is needed to determine

the mechanism(s) of action, sensitivity and specificity, long-term impacts of IST use, and best practices surrounding its implementation and use. Longitudinal prospective studies are necessary to investigate the utility of the field-based mobile phone application as a means of administering and gathering IST scores. While avalanche response is inherently seasonal, longitudinal studies must examine the impact of IST use both pre- and post-season. Since the IST is designed to be applicable to a wide range of austere professionals, the utility and efficacy within and between additional austere professions must also be investigated.

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