
From Action to Reflection

Designing Video-Assisted Debriefings for Simulation-Based
Mountain Rescue Training

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To "learn from experience" is to make a backward and forward connection between what we do to things and what we enjoy or suffer from things in consequence.

—John Dewey (1916, p. 164)

The debriefing is where the “magic” happens.

—Richard “Dick” Duke (2011, p. 348)

Summary

Mountain rescue organisations are a vital part of the emergency rescue chain and operate in challenging rural or mountainous environments. Due to the complexity of their missions, their members need to develop a broad range of skills. Simulations are a central aspect of their training, as they offer a safe and effective way to prepare for rare, complex, and high-risk situations. However, learning from simulation does not emerge from participation alone. Debriefing after simulation-based training (SBT) is needed as it supports learners in reconstructing, reflecting, and recontextualising their experiences. With mountain rescue organisations being comprised mostly of volunteers, their training time is limited. Improving debriefing practices is therefore of particular interest.

Consequently, the goal of this dissertation is to improve learning from SBT by advancing debriefing practices in the specific field of mountain rescue. To address this goal, the overall aims focus on what aspects of and influences on simulation performance should receive attention during debriefing, and to identify and implement the most promising debriefing approach in the context of the Bavarian mountain rescue organisation. A total of three complementary empirical studies were conducted.

The first major finding of the dissertation is to provide evidence that the focus of debriefings should be multidimensional. Study 1 showed that resuscitation performance in mountain rescue training cannot be reduced to one general aspect of performance. Technical skills (TS) and non-technical skills (NTS) did not significantly correlate, suggesting that strong technical performance cannot be assumed to imply equally strong non-technical performance, and vice versa. Mountain rescuers with more real resuscitation experience showed better TS performance, whereas simulated resuscitation experience and experienced patient deaths were not significantly related to resuscitation performance. Furthermore, participants could not correctly assess their colleagues' performance during the simulation.

These findings suggest that performance, experience, and perception are only partially aligned.

A second important finding is that high-tech video-assisted debriefing (VAD) can be considered the most promising debriefing approach. Study 2 showed that videos can support debriefing by providing a shared visual reference point for reconstructing simulation events. Compared with verbal debriefing (VD), VAD made it easier to ground feedback in observable situations and is therefore useful to make team processes and NTS visible. However, the same visibility that supports a more objective debriefing process also may threaten the psychological safety of participants, as some reported feeling stressed or negative emotions knowing that they were recorded. Moreover, the facilitators also reported higher cognitive demands within VAD. These findings indicate that although VAD was found as the promising debriefing approach, it needs careful implementation to mitigate possible negative effects.

The third contribution of this dissertation lies in providing insights into a context-sensitive implementation of VAD. The utilised design-based research (DBR) process identified three recurring challenges for the facilitators: maintaining psychological safety, operating the VAD technology, and managing cognitive demands. In response, supporting scaffolds were developed and refined across implementation cycles. The implemented VAD approach was associated with positive facilitator and participant experiences. Participants' perceived stress increased before the VAD but decreased significantly after the debriefing, and consistently high debriefing quality ratings were achieved over all training days. The findings suggest that VAD can be successfully implemented using a structured, pedagogical approach.

Across the three studies, the dissertation shows that advancing debriefing practices requires attention to three interrelated dimensions: the focus of debriefing, the debriefing approach, and its implementation. Together, the findings contribute to empirically grounded and pedagogically informed debriefing practices for voluntary rescue organisations.

1 Simulation-Based Training Within Mountain Rescue Organisations

Mountain rescue organisations play an important role within the emergency rescue chain, particularly in regions where patients need to be reached and treated under difficult environmental conditions. This leads to specific challenges regarding the response and overall mission time, with rescue missions taking place in mountainous areas taking significantly longer than in urban or suburban regions (Rauch et al., 2018). Additionally, with the prospect of sustaining multiple trauma due to high-risk activities or unpredictable weather conditions in alpine regions, it is argued that patients may face worse outcomes than in an urban environment (Sumann et al., 2020). With patients having to move through the “chain of survival”, starting with care from bystanders or mountain rescuers at the site of injury and ending with professional care inside hospitals, the pre-hospital phase has been titled as the “weakest link in the chain” (Bakalos et al., 2011, p. 1130). This can, on the one hand, be attributed to the varying medical expertise of random bystanders and on the other hand, the various demands placed on mountain rescuers (e.g. coordination and communication with other entities within the rescue chain, repeated risk assessment, etc.) combined with limited time for training due to the voluntary nature of most mountain rescue organisations (Elsensohn, 2024; Gezelius et al., 2026).

To strengthen the knowledge and skills of mountain rescuers, their training has undergone a major transformation over recent decades, evolving from traditional lecture-based teaching to interactive, learner-centred approaches such as simulation-based training (SBT) (Brodman Maeder et al., 2024). This shift is important because expertise research has revealed that expertise does not continuously develop through exposure to routine tasks alone. Instead, complex skills require deliberate, structured practice, particularly when learners encounter certain situations only rarely, or not at all, during real-life practice (Lehtinen, 2023). SBT offers a way to address this gap by allowing mountain rescuers to repeatedly train challenging scenarios in a controlled learning environment. Its value is supported by research

across domains, where simulation-based education has been shown to improve technical performance, diagnostic reasoning, problem-solving, situation management, communication and teamwork (Chernikova et al., 2020, 2024). However, it remains unclear which simulation elements are most effective, for which learners, and under which conditions (Hofmann et al., 2021).

What is known, however, is that debriefing is essential to learn from simulations. It is even argued that “simulation without including adequate debriefing is ineffective and even unethical” (Kriz, 2010, p. 669). Studies that have compared learning outcomes after simulations with and without debriefings support this argument, showing significantly worse scores for team efficacy, non-technical skills and knowledge in the conditions without debriefing (Coppens et al., 2018; Savoldelli et al., 2006; Shinnick et al., 2011). For mountain rescue organisations, where training time is limited, the quality and design of debriefing are therefore of particular importance.

Despite its importance, debriefing is not a uniform practice. For example, debriefings can differ in their focus and form, which raises two central questions for mountain rescue training. First, debriefings need to address the aspects of performance that are most relevant to the intended learning objectives of the SBT. If training time is limited, facilitators must decide which skills, prior experiences, or participant assessments should be the focus of reflection. Second, debriefings need to be conducted in ways that support learners and facilitators in making sense of complex simulation experiences. While different debriefing approaches can have different strengths, they may also introduce new challenges.

Against this background, the goal of this dissertation is to improve learning from SBT by advancing debriefing practices in the specific field of mountain rescue training. To achieve this goal, the dissertation examines which aspects of and influences on simulation performance should receive attention during debriefing, how different debriefing approaches are experienced by participants and facilitators, and how the most promising approach found

can be implemented in a context-sensitive way within the Bavarian mountain rescue organisation.

2 Theoretical Background

2.1 Experience as the Foundation for Learning

Learning can arise through a variety of educational activities, including instruction, observation, social interaction, and experience. Among these different sources of learning, experience occupies a prominent role in contemporary learner-centred approaches to education (Prince & Felder, 2006). Slavich and Zimbardo (2012) argue that experiences enable learners to engage with concepts in personally meaningful ways, connect abstract knowledge to practical situations, and create opportunities for reflection and personal insight. Consequently, understanding how experiences contribute to learning has become a central concern of educational theory.

The educational significance of experience is most prominently reflected in experiential learning theories, which view learning as a process grounded in the interpretation and transformation of experience (Yardley et al., 2012). One of the most influential conceptualisations is Kolb's (1984) Experiential Learning Theory (ELT), which defines learning as "the process whereby knowledge is created through the transformation of experience" (p. 41). According to ELT, learning originates from concrete experiences that are subsequently reflected upon, conceptualised, and tested through further action (Poore et al., 2014).

From this perspective, educational approaches that deliberately create meaningful experiences provide learners with the starting point to engage in learning processes. SBT thereby represents a practical and widespread method, as it allows learners to encounter realistic experiences within an educationally safe environment (Breckwoldt et al., 2014). This is especially relevant in high-risk domains, as simulations provide repeatable situations that

might otherwise occur only infrequently, unpredictably, or under conditions unsuitable for learning (Lateef, 2010). Consequently, simulations are used successfully in a variety of fields in which real-life practice is not always feasible or requires preexisting skills, such as higher-education, medicine and aviation (Chernikova et al., 2020; Hays et al., 1992; Okuda et al., 2009). Although ELT is often cited to explain how simulation-based learning works, it is better understood as having a multiple explanatory base that also touches on adult learning theory, constructivism and deliberate practice (Jossberger et al., 2022). The lack of a unified theory is typically not seen as a weakness, but as a strength to inform the design of the many different components of which simulations are comprised. Furthermore, the different theories have in common, that with the practice-based approach of simulations, aimed at replacing or amplifying real experiences, the transferability of skills and knowledge can be achieved (Breckwoldt et al., 2014; Gaba, 2004).

This assumption is reflected in the concept of authenticity, whose importance is increasingly emphasised to ensure that SBT resembles professional practice (Stürmer et al., 2024). A close relation between learning activities and workplace requirements is considered beneficial for the development of practice-oriented knowledge and skills, as it prepares learners for the situations they are likely to encounter in professional settings (Codreanu et al., 2020). Therefore, learning contexts that feel authentic also have a positive affective, cognitive, and behavioural effect on learners, such as increasing motivation and interest (Betz et al., 2016). Importantly, authenticity in simulation-based learning is not solely determined by the physical resemblance of a situation to reality. Rather, it is conceptualised as the experience of how learners perceive and engage with the learning situation (Bland et al., 2014; Lavoie et al., 2020). Consequently, authentic learning experiences can be created even when certain aspects of reality are simplified or complexity is deliberately reduced (Codreanu et al., 2020).

Despite their educational potential, however, authentic experiences from SBT do not automatically result in learning. While simulations provide learners with opportunities to engage in meaningful and practice-oriented situations, participation alone does not guarantee that learners will develop accurate understandings or draw appropriate conclusions from their actions. Consistent with ELT, learning requires learners to actively engage with their experiences, as “knowledge results from the combination of grasping and transforming experience” (Kolb, 1984, p. 41). Thus, the educational value of SBT exceeds the creation of authentic experiences and requires pedagogical processes that support learners in making sense of those experiences. Debriefing is thereby widely regarded as one of the most important mechanisms for facilitating this process, as it enables learners to critically reflect upon their actions and connect experiences with future practice (Gardner, 2013). Results from empirical studies demonstrated that learning from simulations is substantially reduced when opportunities for debriefings are omitted (Coppens et al., 2018; Savoldelli et al., 2006; Shinnick et al., 2011).

2.2 Debriefing as a Pedagogical Transformation of Experience

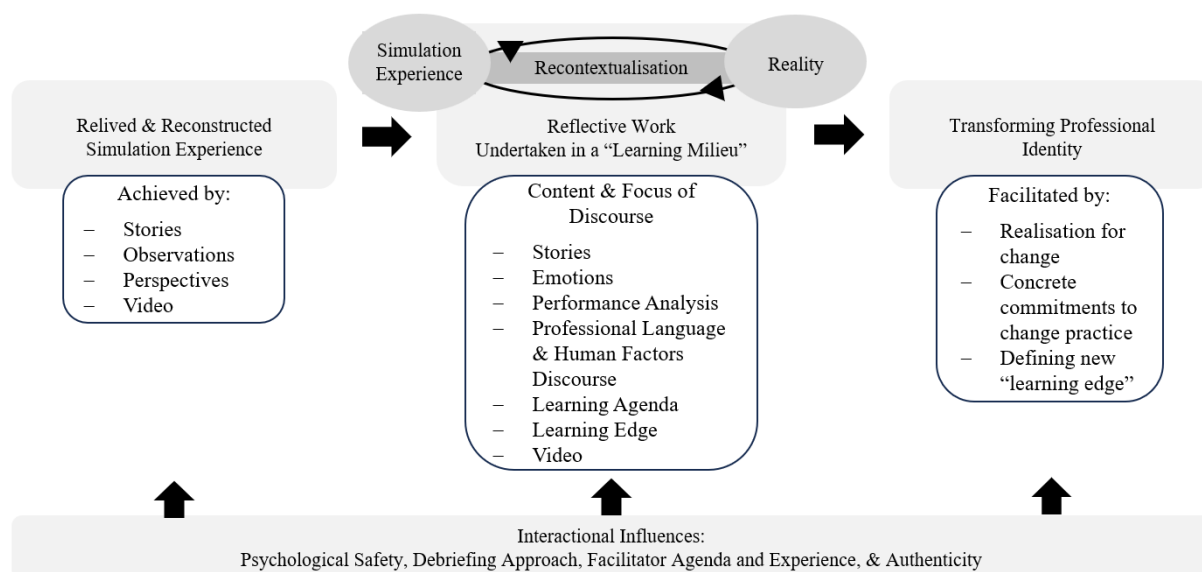
Debriefing can be described as a guided reflective discussion with the intent to “analyse, making sense and assimilating learning experiences” (Fanning & Gaba, 2007, p. 116). It is derived from research on reflective practice and builds upon the concept of “reflection on action” as debriefings are typically situated right after the experience, with the goal to reflect on what has happened (Fey & Morse, 2024). Although learners may reflect upon their experiences spontaneously following a simulation, such reflection is unlikely to be systematic and may not occur at all when the stress of the experience still lies on the learners. Debriefings are therefore usually guided by a facilitator who deliberately reconstructs the events before progressing towards interpretation, analysis, and the consideration of implications for future practice (Fanning & Gaba, 2007). Therefore, at its most fundamental

level, debriefing involves two elements: those who participate in the reflective discussion and those who facilitate it (Lederman, 1992).

As employing facilitators is resource-intensive, learners may also engage in self-led debriefings by reflecting upon their own experiences (Kumar et al., 2025). However, research consistently emphasises the importance of the facilitator in ensuring the quality of the debriefing process (Endacott et al., 2018; Paige et al., 2015). Rather than merely providing feedback, facilitators enable learning by progressing through the phases of *relived and reconstructed simulation experience*, *reflective work undertaken in a “learning milieu”*, and *transforming professional identity*, as depicted in Figure 1 (Kainth & Reedy, 2024).

Figure 1

Overall Theoretical Model of how Learning Occurs in Debriefings (Adapted from Kainth & Reedy, 2024)



Note. The terminology was slightly adjusted to fit the context of the present dissertation. The terms *faculty agenda and experience* and *clinical reality* were adapted to *facilitator agenda and experience* and *reality* to align the model with the terminology and training context.

Although visualised as a linear progress, Kainth and Reedy's (2024) meta-ethnographic synthesis implies that these phases should not be understood as a rigid sequence. Instead, they describe a general trajectory of sense-making during debriefing, while interactional influences such as psychological safety, the debriefing approach, facilitator agenda and experience, as well as perceived authenticity, affect how the process unfolds throughout.

In the first phase, the simulation experience is reconstructed through narratives, emotions, observations, and, if available, video material. Participants can describe their experiences and emotional reactions, while facilitators contribute additional observations. The authors of the model describe these contributions as fragmented elements that illuminate different aspects of the simulation, which can be combined into a shared reconstruction of what occurred. In this way, the simulation experience becomes available for further discussion not merely as an individual memory, but as a collectively reconstructed account of events.

The second phase concerns reflective work within a "learning milieu". In this phase, the reconstructed simulation experience is related to reality. Actions, events, emotions, behaviours, rationales, and perspectives are discussed in relation to the demands of clinical or professional practice. Kainth and Reedy (2024) frame this as a process of recontextualisation, in which simulation experience and professional reality are connected. This reflective work may include performance analysis, discussion of human factors, professional language, emotions, and learning needs. The extent to which the discussion moves beyond description towards deeper analysis depends strongly on interactional conditions, especially facilitator guidance, psychological safety, authenticity, and the chosen debriefing approach.

The third phase concerns the possible transformation of professional understanding and identity. Through debriefing, learners may recognise a need for change, identify developmental needs, and formulate commitments for future practice. Debriefing can therefore support learners in moving from the immediate experience of a scenario towards a

more generalisable understanding of their own performance, their role within a team, and the demands of future practice.

2.3 Supporting Learning in Debriefing

Although Kainth and Reedy (2024) frame the outcome of debriefing in terms of professional identity within healthcare simulation, their model is useful for the present dissertation as well. SBT in mountain rescue also requires learners to reflect on their role within a team, their performance, and their future actions in practice. In this context, the model is not used primarily to claim professional identity transformation, but to describe how debriefing can move learners from a reconstructed simulation experience towards practice-oriented understanding and commitments for future action. Additionally, the model defines important parts of debriefings that should be examined more closely with the goal of further supporting learning in debriefing. One of these parts is labelled as the content and focus of discourse within their model and is addressed in the subsequent paragraph.

2.3.1 Determining the Focus of Debriefing

Although debriefing can support learners in transforming simulation experiences into learning, especially complex and lengthy simulation experiences as a whole cannot be addressed exhaustively. Lee et al. (2020) pointed out that “debriefing too long contributes to fatigue and information overload” (p. 11), suggesting a debriefing length of 20-30 minutes. It is therefore recommended for the facilitators to have a learning agenda congruent with the learning objectives of the SBT, defining which aspects of the simulation experience should become the focus of the debriefing (Decker et al., 2013; INACSL Standards Committee, 2016; Kainth & Reedy, 2024). Consequently, facilitators have to know what skills the SBT and the subsequent debriefing should target.

In medical and rescue-related simulations, technical and non-technical skills represent typical areas of interest. While technical skills (TS) refer to the task-specific actions required to perform procedures correctly, non-technical skills (NTS) are often understood as human

factors like situation awareness, teamwork, decision-making, leadership, and management of stress and fatigue (Flin et al., 2010). NTS are considered important, as they can improve the chances of either avoiding or capturing errors and thus remedying them, before adverse events happen (Flin et al., 2013). Evidence from resuscitation research suggests that NTS can support performance in clinically relevant ways. For example, Dewolf et al. (2020) found positive effects of NTS training on the timing of critical first steps, team management, and teamwork knowledge, while Cormack et al. (2020) reported that proficient NTS was associated with good TS performance in out-of-hospital cardiac arrest management. Nevertheless, the relationship between TS and NTS remains only partially understood and has received comparatively limited empirical attention (Gamborg et al., 2024). This uncertainty is especially relevant for the Bavarian mountain rescue organisation, where NTS are not a mandatory component of basic medical training. Therefore, it remains unclear to what extent mountain rescuers display NTS during simulated resuscitation and whether these skills are associated with (technical) performance. Beyond the relationship between TS and NTS, previous experiences can also affect how mountain rescuers perform in simulations and what they bring into the subsequent debriefing. The recency and amount of real or simulated resuscitations may positively influence their resuscitation skills, while having experienced potentially traumatic events, such as witnessing a patient dying, might have the opposite effect. However, if rescuers who have had this experience receive adequate support, it can also transform into a positive learning experience (Batley et al., 2017). In addition, the ability to monitor and judge a colleague's performance is relevant for team-based medical action, as it can support the recognition and correction of errors during resuscitation. Taken together, these considerations suggest that TS, NTS, previous resuscitation experiences, experiences with patient deaths, and the ability for peer assessments may all represent relevant areas for understanding resuscitation performance.

Therefore, Study 1 addressed the first aim of this dissertation by examining how TS, NTS and previous experiences relate to mountain rescuers' performance during simulated resuscitation in order to identify relevant areas of focus for debriefing.

2.3.2 Selecting and Implementing a Debriefing Approach

Despite the presented educational importance of debriefing, there is no uniform approach to it. Reviews have shown that debriefing designs vary considerably and that findings regarding specific design features remain inconclusive (Cheng et al., 2014). Accordingly, it remains unclear which debriefing forms are most promising (Sawyer et al., 2016).

Among the available approaches, video-assisted debriefing (VAD) has received particular attention and has been titled the “gold standard” for debriefing (Levett-Jones & Lapkin, 2014). In contrast to verbal debriefing (VD), which relies on participants' and facilitators' recollection of events, VAD allows both parties to revisit the simulation experience through video recordings. As the displayed videos themselves are not subject to recall bias, VAD is often regarded as being more objective than VD (Keiser, 2024; Villado & Arthur, 2013). By having a shared reconstruction of what has happened during the simulation as the goal of the *relived and reconstructed simulation experience* phase of Kainth and Reedy's (2024) model, the use of video material may support the establishment of a common understanding of events. Similarly, disagreements regarding what happened during the simulation and how specific actions were performed can potentially be reduced through video evidence (Schertzer & Waseem, 2024). As most VADs provide a third-person perspective of the simulation, learners can observe both their own actions and those of their team members during debriefing. Therefore, it has been proposed that VAD also incorporates an observational learning component (Villado & Arthur, 2013). This idea has been supported by previous research, which has found that visualising the team processes within simulation supported the reflection of NTS (Ha, 2014; Jacobs, 2017). Combined with facilitator

guidance, the reconstruction of events also led to changes in participants' perceptions of their own performance as a result of VAD (Johansson et al., 2017).

Despite the theoretical advantages of VAD over VD, literature reviews show mixed results that do not support the supposed superiority of VAD (Cheng et al., 2014). A possible reason might be the influence of VAD on psychological safety, which was also included as a relevant factor for debriefing in the model of Kainth and Reedy (2024). With psychological safety being referred to as “the perception that it is safe to take interpersonal risks and that one will not be embarrassed, rejected or otherwise punished for speaking their mind, not knowing or asking questions” (Kolbe et al., 2020, p. 164), it is widely considered an important prerequisite for effective debriefing (Rudolph et al., 2014). Due to the possibility of having mistakes displayed prominently on video, previous studies reported that participants experienced stronger fear of negative feedback, higher stress and intimidation, and less natural behaviour during simulations when VAD was used (Cantrell, 2008; Ha, 2014; Rosvig et al., 2023; Zhang et al., 2019a).

Adding to the inconclusive findings comparing VAD and VD, Cheng et al. (2014) also noted that debriefing characteristics are often incompletely reported, making it difficult to determine which elements of a debriefing approach are responsible for its effects. While previous studies have provided valuable insights into VAD, they have examined either participants' experiences (e.g., Ha, 2014; Rosvig et al., 2023) or facilitators' perspectives (Krogh et al., 2015). However, as debriefing relies on the interaction between participants and facilitators, both views are needed to understand the strengths and challenges of VAD. In addition, VAD is not a fixed approach, as it can be implemented with different levels of technical support (Krogh et al., 2015).

Study 2 therefore addressed the second aim of this dissertation by examining participants' and facilitators' experiences with VD, lower-tech VAD, and high-tech VAD to

inform the selection and adaptation of the most promising debriefing approach for mountain rescue training.

Identifying the perceived strengths and challenges of a debriefing approach is, however, only one step towards its use in practice. It has been argued that the implementation of a debriefing approach is of importance regardless of whether or to what extent additional technology is used (Krogh et al., 2015). This is especially relevant for the use of VAD, where video material can easily be treated as a technical add-on rather than as an element that needs to be deliberately incorporated into the structure and flow of the debriefing (Yeun et al., 2019; Zhang et al., 2019b). Recent studies have moved towards more structured and pedagogically grounded uses of VAD, reporting positive effects on learning outcomes and debriefing experiences compared with VD (Gasteratos et al., 2024; Zhang et al., 2020a, 2020b). These findings suggest that the value of VAD may depend not only on the existence of video recordings but also on how it is implemented within SBT. However, this evidence stems from professional medical settings, which differ from voluntary rescue organisations as their members have limited and varying training resources, especially if they have primary occupations outside the medical field (Baker et al., 2026; Elsensohn et al., 2009).

With the specific context having potential implications for the effective implementation of VAD, Study 3 therefore addressed the third and fourth aims of this dissertation by developing, evaluating and refining a context-sensitive implementation of VAD within mountain rescue training through iterative DBR cycles.

3 Aim of the Thesis and Overview of the Studies

3.1 Aim of the Thesis

The goal of this dissertation is to improve learning from SBT by advancing debriefing practices in the special field of mountain rescue training. The overall aims are to examine what aspects of and influences on simulation performance should receive attention during

debriefing, and to identify and implement the most promising debriefing approach in the context of the Bavarian mountain rescue organisation.

The specific aims of the three studies conducted are as follows:

1. To examine how TS, NTS, and previous experiences relate to simulation performance in order to identify relevant areas of focus for debriefing.
2. To explore the experiences of both participants and facilitators within different debriefing forms (VD and VAD), identifying their respective strengths and challenges to inform the selection and adaptation of the most promising approach.
3. To develop and refine a context-sensitive implementation of VAD within mountain rescue training through iterative design-based research cycles.
4. To evaluate the effects of the context-sensitive VAD approach on facilitators' experiences, as well as participants' perceived stress and overall experiences.

3.2 Overview of the Studies

To achieve the overall aims, three complementary studies were conducted. Two studies have been published in peer-reviewed journals, while the third study has been submitted for publication. The studies are briefly outlined below.

Study 1 - Evaluation of Mountain Rescuers' (Non-)Technical Skills During Simulated Resuscitation

This study – reported in Chapter 4 of this thesis – examined how different factors are related to simulation performance by conducting a quantitative study involving $N = 103$ mountain rescuers. The simulation featured the task of cardiopulmonary resuscitation, as it requires both technical and non-technical skills, and is directly related to patient survival, thereby representing a task of high relevance. The guiding research question was: how are TS, NTS, previous resuscitation experience, experienced patient deaths, and peer assessments related to mountain rescuers' resuscitation performance? The findings provided insights into

the relationships between performance, skills, and experience, thereby helping to identify relevant areas of focus for debriefing (Aim 1).

Study 2 - Mountain Rescuers' Experiences With Video-Assisted and Verbal Debriefings: A Qualitative Study

This study – reported in Chapter 5 of this thesis – addressed how different debriefing approaches are experienced by participants and facilitators. Following SBT sessions featuring VD, lower-tech VAD, and high-tech VAD, a qualitative study was conducted with $N = 47$ mountain rescuers, including focus group interviews with $n = 42$ SBT participants and individual interviews with $n = 5$ facilitators. The guiding research question was: how are VD and VAD experienced by participants and facilitators? The results displayed the characteristics of different approaches to debriefing, including their influence on reflection, acceptance of feedback, and psychological safety. Through the comparison, the study found that VAD is the most promising but also challenging approach, thus providing a basis for the subsequent design and implementation of VAD in Study 3 (Aim 2).

Study 3 - Facilitating Video-Assisted Debriefing in Mountain Rescue: A Design-Based Approach

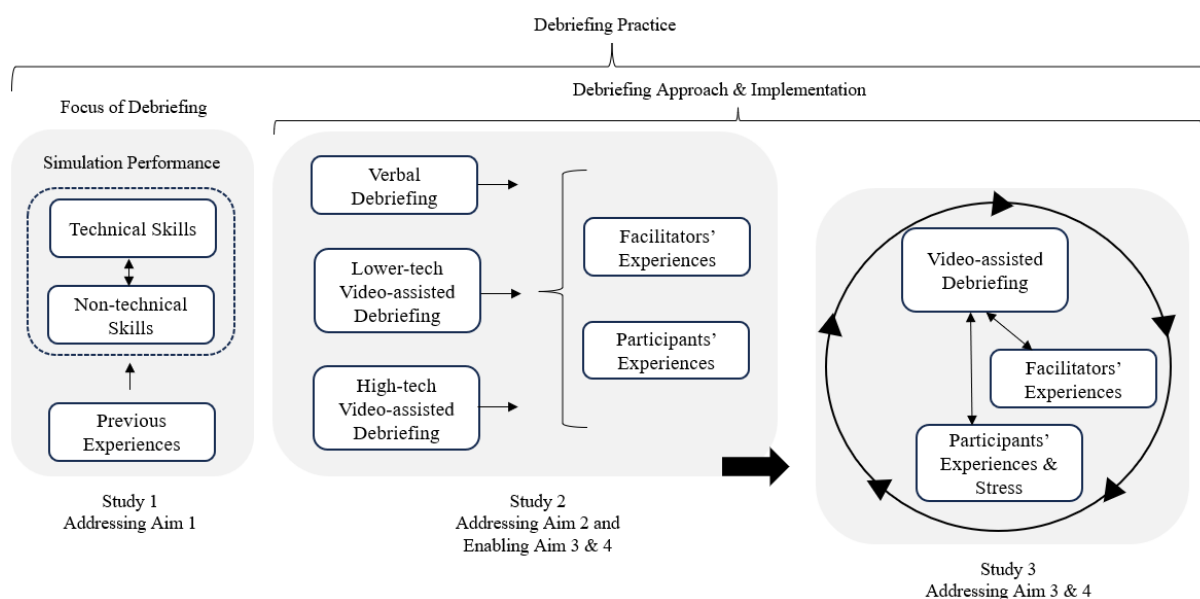
This study – reported in Chapter 6 of this thesis – focused on the context-sensitive implementation of VAD within mountain rescue training by using an iterative DBR approach. Qualitative and quantitative data were collected across five implementation cycles involving a total of $N = 78$ mountain rescuers, including $n = 72$ SBT participants and $n = 6$ facilitators. The two guiding research questions were: (1) What challenges do facilitators experience during the implementation of VAD, and how can these be addressed within the DBR process? (2) How does VAD influence participants' perceived stress and overall experience in simulation training? The findings demonstrated that DBR can be successfully used to develop and refine the implementation of VAD (Aim 3). Furthermore, the resulting VAD approach was

associated with positive participant and facilitator experiences as well as reduced stress following debriefing (Aim 4).

Figure 2 further visualises the complementary nature of the three studies. The following chapters present the studies described in full detail.

Figure 2

Visualisation of the Research Model



4 Study 1: Evaluation of Mountain Rescuers' (Non-)Technical Skills During Simulated Resuscitation¹

Abstract

Mountain rescuers work voluntarily but must provide high-quality cardiopulmonary resuscitations (CPR). As demands for their services rise, the factors influencing CPR skills are investigated. Research has shown that technical skills (TS), non-technical skills (NTS), experience, experienced patient deaths, and monitoring impact resuscitation performance. This study explores the influence of these factors for this kind of voluntary medical personnel. A total of 103 mountain rescuers participated. A specially created NTS observation form, questionnaires and simulation manikin were used to measure NTS, TS, experience, and monitoring skills. Results indicate that NTS and TS did not correlate significantly. Only the number of real resuscitations differed significantly between the TS of experienced and inexperienced mountain rescuers. Experienced patient deaths were not significantly related to CPR performance. Furthermore, mountain rescuers could not fully correctly assess their colleagues during simulation. The study shows that previous research results might not hold true in a different medical domain.

4.1 Introduction & Theoretical Background

Because of the increased popularity of mountain sports and the trend of an ageing population, mountain rescuers are facing a growing number of missions (Egger et al., 2020; Jung et al., 2018). A total of 3482 cases, for instance, marked the peak of the mission statistic for the Bavarian mountain rescue force last year (Demmelhuber, 2020). Hence, the training and assessment of the skills needed for rescuing patients in the alpine regions shifts into focus.

¹ This chapter was previously published as: Hanus, S. A., Jossberger, H., & Gruber, H. (2022). Evaluation of mountain rescuers' (non-)technical skills during simulated resuscitation. *Studies in Educational Evaluation*, 72, 101122. <https://doi.org/10.1016/j.stueduc.2021.101122>

Most mountain rescuers in Europe and America work voluntarily for their respective rescue organisations (Elsensohn et al., 2009). This is uncommon for pre-hospital care providers. Besides smaller voluntary groups, like the community first-responder groups in the UK, only mountain rescue services alongside fire departments are predominantly staffed with voluntary medical personnel (Brandweeracademie, 2019; Timmons & Vernon-Evans, 2013; U.S. Fire Administration, 2021). Other members of emergency medical services, such as emergency medical technicians (EMTs) or paramedics, work mostly as paid medical professionals (Cash et al., 2020). Aiding in the pre-hospital work of EMTs and paramedics, even higher-skilled emergency physicians are also paid for their services (Timmermann et al., 2008).

Due to the voluntary nature of their work, voluntary medical personnel only have a limited amount of time in which they can devote themselves to learning and training the needed skills for rescuing and treating their patients (Nichols et al., 2014). The basic training for mountain rescuers can take from 16 to over 500 h (Elsensohn et al., 2009). While these numbers can vary from region to country, it takes significantly less training to become a mountain rescuer than an EMT, paramedic, or emergency physician. Unlike mountain rescuers, the European mean for EMT training is 408 h, for paramedics is 2000 h, and for emergency physicians it is their medical education plus between 400 h and 1 year of additional training in prehospital emergency medicine (Chenaitia et al., 2011).

Mountain rescuers and other professional pre-hospital care providers differ both in the length of their training and medical education. While both groups rely mostly on traditional lectures to gain knowledge about the fundamental treatment of patients, a difference exists in practicing medical procedures. Emergency physicians, alongside most medical professionals, can train “hands-on” with real patients alongside simulators (Konstantinidis et al., 2020). Although practice on real patients has decreased due to rising concerns about patient safety (Reznek et al., 2002), “hands-on” practice with patients in clinics or in the field is

not feasible for mountain rescuers. This is due to the voluntary nature of most mountain rescue services in Europe and America (Elsensohn et al., 2009). As their voluntary work is not paid, mountain rescuers usually work full-time in other jobs that are not necessarily connected to healthcare, which induces a constraint in time for mountain rescue training.

The Role of Simulations for Mountain Rescuers

With not being able to train on real patients, simulations play a vital role in the medical training for mountain rescue organisations. Simulated environments are used to repeatedly conduct realistic scenarios that are safe for the participant and the (simulated) patient (Breckwoldt et al., 2014; So et al., 2019). Simulations also offer standardised scenarios to assess the actions of the participants to control for confounding variables. Additionally, simulations are often embedded in a larger educational framework, which allows the participants to reflect on their experience and deepen their learning via debriefings and other methods (Brown et al., 2018). Two recent meta-analyses showed that structured debriefings positively affect learning outcomes in simulations and that simulation-based learning significantly improves learning across different domains in higher education (Chernikova et al., 2020; Lee et al., 2020). It is argued that simulations can, therefore, prepare mountain rescuers for their real missions, although their training does not reach the length or scope of training compared to professional emergency physicians.

Resuscitation and the Importance of Technical and Non-Technical Skills

While simulations can mimic various scenarios with different relevant tasks, for example, the treatment of a patient suffering from hypothermia, cardiopulmonary resuscitation (CPR) still marks a core task for mountain rescuers. This is because minor injuries do not imminently threaten a patient's life, whereas serious medical emergencies (e.g. a patient suffering cardiac arrest) require quick and effective treatment; otherwise, the survival rate of the patient drops with each minute that passes (Hansen et al., 2015). As the time to respond plays a crucial role in the mortality rate of patients, mountain rescue services

are especially important since they are usually first responders in rural or mountainous regions.

To treat patients with cardiac arrest, mountain rescuers need to perform CPR, which requires sufficient technical skills (TS) and various non-technical skills (NTS) (Barelli & Naso, 2017; Gjeraa et al., 2014). Following Flin et al.'s (2013) definition, NTS are defined as “the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance” (p. 1). NTS can be divided in specific categories. While the NTS categories and their respective behavioural indicators can change between different occupations and work settings, they can be grouped into three broader categories: social (communication, teamwork, and leadership), cognitive (decision-making and situational awareness) and personal resource factors (ability to handle stress and fatigue) (Ounounou et al., 2019). NTS are meant to enable mountain rescuers to create a mental model of the situation shared between the leading rescuer and the team members. As medical emergencies may require the mountain rescue teams to assemble “ad-hoc”, NTS can help mountain rescuers to provide safe and effective treatment for their patients, even if team members differ in expertise or have no routine working together.

Besides the situation within the mountain rescue team itself, NTS are also deemed important for the work between mountain rescuers and other medical teams (Pietsch et al., 2016). Complex scenarios require cooperation with emergency physicians or helicopter emergency medical services. As scenarios become more complex, the physical and cognitive demands for mountain rescuers rise, inducing an increase in stress. This can lead to a shift in focus, where one's own actions are prioritised, and the perspective on the team and the scenario gets lost (Vincent et al., 2021). Reducing focus on the team and the overall situation can cause mountain rescuers to deprioritise and ultimately discard important safety procedures, such as checking each other for errors and monitoring the workload of team members (Flowerdew et al., 2012). As the NTS considers these possible shortcomings, it was

found that they are especially valuable under stressful situations (Krage et al., 2017). With sufficient NTS, building upon the shared representation of the situation and tasks at hand, mistakes can be limited beforehand, or corrected if they do occur (Casali et al., 2019).

Although the relationship between NTS and TS performance remains partially understood, there is a body of evidence showing the positive influence of NTS (Peltonen et al., 2020). Dewolf et al.'s (2020) meta-analysis showed that NTS significantly improves the timing for performing critical first steps alongside team management and teamwork knowledge. Also, Cormack et al. (2020) found that teams that demonstrated proficient NTS showed good TS performance and vice versa. Since focusing on NTS aids existing technical training and fosters patient safety, NTS training has become increasingly popular (Nicolaidis et al., 2018). With increased awareness of the importance of NTS, teaching programmes have been implemented all around Europe and found their way into the resuscitation guidelines of the European Resuscitation Council (Greif et al., 2021; Kodate et al., 2012). Although studies have found that adding NTS segments into existing training improved both NTS skills and overall CPR performance, training has not been implemented everywhere (Prattes et al., 2015). The Bavarian mountain rescue organisation has not included mandatory NTS sessions in their basic medical training. Whether or not these skills are taught depends on their perceived importance, according to the instructor in charge of the medical training. Since specific NTS lessons are not part of the mandatory training, it is unclear whether the displayed NTS skills correlate positively with the TS of mountain rescuers.

Additional Factors Influencing CPR Performance

Adding to TS and NTS, prior research has indicated that experience, experienced patient deaths, and peer assessment can influence CPR performance. Recent research findings are briefly reported here. Research has revealed that mountain rescuers' experience is relevant for resuscitation performance; results have shown that the number of simulated and real resuscitation experiences improves performance (Fischer et al., 2012; Sullivan et al., 2015).

While the time since the last training plays a role in skill retention, it has been shown that the number of training (or, if applicable, certifications) is a better predictor of subsequent CPR performance (Anderson et al., 2012). As voluntary medical personnel probably could not frequently train their CPR skills, better retention may be achieved with a solid base of knowledge and motor skills. However, the inconsistent approaches of the instructors regarding the NTS, and the *in situ* debriefings performed after real resuscitations, raise the question of whether experienced mountain rescuers show better CPR performance than their inexperienced colleagues.

Empirical evidence showing that other forms of experience, such as witnessing a patient's death, influence resuscitation performance is scarce (Krage et al., 2017). Although medical practitioners are expected to encounter dying or patient deaths regularly, studies exploring the effects of these events remain limited (Batley et al., 2017). Research has shown that the deaths of younger patients or futile resuscitations can elicit strong emotional reactions, thereby inducing stress while affecting the quality of medical care (Meier et al., 2001; Redinbaugh et al., 2003). Regarding mountain rescuers, the study of Basiaga-Pasternak et al. (2015) showed that the death of the patient was also considered one of the most stressful situations in their work. Although patient deaths can negatively impact medical care providers, avoiding them is often not possible. However, it is argued that if patient deaths are supported with the right framework (e.g. counselling, debriefings), witnessing patient deaths can also be a learning and potentially transformative experience for students (Batley et al., 2017).

In practice, medical practitioners often report needing more support in handling traumatic events, such as losing patients (McIlwaine et al., 2007; Van Rooyen et al., 2005). As for the situation within mountain rescue organisations, Dolan and Tedeschi (2018) alongside Küpper and Morrison (2020) showed that data on the rescuer's mental health is sparse and that most participants see a deficiency in formal psychological support.

Regarding simulation practice, it remains a controversial topic whether or not patient deaths should be included in simulated medical emergencies (Corvetto & Taekman, 2013; Weiss et al., 2017). It is widely accepted that, if the death of a patient is simulated, the possible psychological consequences for the learner have to be controlled and minimised. Therefore, the use of debriefings and other methods to handle the potential detrimental effects of dying manikin is generally recommended (Truog & Meyer, 2013). As the death of a patient can demonstrate various effects, and because we lack knowledge of the supporting conditions for practitioners, it is unclear whether having witnessed patient deaths affects the CPR performance of mountain rescuers.

Good resuscitation performance can only be achieved if mountain rescuers can detect their own mistakes and those of their team colleagues during CPR. Mountain rescuers, like most medical emergency teams, assemble ad hoc after the emergency call. Thus, the members of the resuscitation team might not know each other well, let alone have conducted a simulated or real resuscitation with their colleagues (Walker et al., 2011). To minimise possible mistakes, experienced medical practitioners tend to monitor the actions of their colleagues (White et al., 2018). This procedure reduces the possibility of mistakes, as team members can reveal mistakes that the person performing the task might not have noticed otherwise. To monitor colleagues, medical practitioners need the experience to know when it is a good time to divert their attention from their own tasks and monitor their colleagues. Moments of momentarily lower workloads are deemed appropriate for these interactions (Van Harten et al., 2020). The practice of monitoring and actively judging team members has found its way into various NTS scales, including the Anaesthetists' Non-Technical Skills (ANTS) or the Observational Skill-based Clinical Assessment tool for Resuscitation Observation Form (Flin et al., 2010; Walker et al., 2011). Specialised training can significantly improve the monitoring skills of professional medical care providers (Raurell-Torredà et al., 2021). With

the absence of a formal NTS or other monitoring-related training programme for mountain rescuers, it is unlikely that they can monitor and assess their team colleagues correctly.

In summary, various factors potentially influence the CPR performance of mountain rescuers. However, most research studies have focused on the professional medical field, in which more time is devoted to training and guided practice with patients. This study, however, turns to a special group within the voluntary medical field and examines the factors deemed to influence mountain rescuers' CPR performance.

Hypotheses

As the presented brief review of prior research indicates, there are several influencing factors that can impact resuscitation performance. Although some findings reveal a specific direction, other results are rather inconclusive. Therefore, the following directed and undirected hypotheses are addressed:

- I. NTS correlate positively with the displayed TS of the mountain rescuers.
- II. Experienced mountain rescuers show better CPR performance than inexperienced mountain rescuers
- III. Mountain rescuers who have experienced patient deaths differ in CPR performance from those who have not
- IV. Mountain rescuers cannot correctly assess their colleagues during resuscitation

4.2 Methods

Design and setting

A quantitative study was designed in which observational data were combined with the technical output of a simulation manikin and two questionnaires. A correlational research design was used to examine hypotheses I and IV. To explore hypotheses II and III, an ex-post-facto design was used to compare mountain rescuers with different levels of expertise

(including patient deaths). Participants were divided into two groups, relative to their level of experience, and their differences in CPR performance were investigated.

The study was conducted in the central facility for the safety and training of the Bavarian mountain rescue organisation. Data were collected while the mountain rescuers had their mandatory yearly simulation training, which comprised a circle of simulated emergency events, including a patient in need of CPR. The focus for this study was solely on the CPR simulation, which started after a team of two mountain rescuers rappelled themselves from a simulated helicopter mounted on the roof of the simulation centre. After their landing, the mountain rescuers' task was to perform CPR and treat the manikin like a real patient. No additional information about the patient was provided. During resuscitation, which lasted between five and seven minutes, a simulated asystole was introduced into the scenario to act as a distraction. The asystole did not allow the automated external defibrillator (AED) to release the shock on the simulated patient, which forced the participants to seamlessly continue with the CPR.

To capture the non-technical aspects of the resuscitation performance, researchers placed two cameras at a 45-degree angle and aimed towards the upper body of the simulation manikin. This was done to avoid information loss if the movement of the mountain rescuers created visual obstructions. The designated main camera was linked to a wireless microphone mounted on the climbing harness of the leading first responder. The other camera recorded the ambient noise as a backup.

Participants

The sample size comprised 103 mountain rescuers (10 females; 93 males). On average, the participants were about 40 years old ($SD = 13.10$) and had experienced more simulated ($M = 23.82$, $SD = 42.80$) than real resuscitation scenarios ($M = 4.71$, $SD = 11.28$). Their last simulated resuscitation was experienced more recently ($M = 9.28$ months ago, $SD = 9.69$) than their last real resuscitation ($M = 30.64$ months ago, $SD = 61.32$).

Instruments

Questionnaires. Basic biographical data (e.g. age, gender, profession) and information regarding the experience of mountain rescuers (operationalised through some simulated/real resuscitations and patient deaths) were collected via a biographical questionnaire.

To gain additional information about the perceptions of the participants, a post-simulation questionnaire was developed, which included a question about the performed task. The leading first responders were asked to assess the overall resuscitation performance of their partner. As the mountain rescuers were not acquainted with the NTS concept, NTS and TS were not distinguished for the rating of this peer assessment. The resuscitation performance rating is therefore viewed as a general rating for a combined NTS and TS score. Since situational awareness is an integral part of NTS, participants were not instructed explicitly to monitor their colleagues while performing CPR. A ten-point Likert scale was used for the peer assessment, ranging from zero (very bad) to nine (very good).

Observation Form. To gain access to the NTS, the video and audio data from the resuscitations were evaluated by four independent observers using a Mountain Rescuers' Non-Technical Skills (MORE-NTS) observation form. This observation form was developed based on the original ANTS behavioural marker system (Fletcher et al., 2003). The ANTS was developed for anaesthetists; therefore, it had to be adjusted to fit the context of the basic life support (BLS) provided by the mountain rescuers. While the ANTS behavioural marker system comprised four distinctive subcategories (task management, teamwork, situation awareness, and decision making), the MORE-NTS was originally designed with three subcategories (task management, teamwork, and situation awareness). As it is not advised to simply transfer an NTS behavioural marker system to another discipline without adequate adjustment, we decided to omit the “decision making” category (Hayes et al., 2020). This was done to eliminate a subcategory deemed “not observable” in this specific setting. A pre-test of the instrument and equipment revealed that the standardised BLS algorithm for resuscitation

provided by mountain rescuers does not allow for considerable decision making compared to the advanced life support provided by anaesthetists. To further examine the three subcategories, an initial principal component analysis (PCA) was conducted. The PCA proposed a seven-factor solution as seven factors reached an eigenvalue of over 1. With limited interpretability of the seven-factor solution, a three and two factor solution were tested because of (a) previous theoretical support and (b) a ‘levelling off’ of eigenvalues on the scree plot after two factors. During the examination of both solutions, items with a factor loading below .30, limited interpretability, or cross-loadings were eliminated. As the two-factor solution provided a better fit between items and factors, the NTS subscales for the MORE-NTS are (1) task management and (2) teamwork. As suggested by the PCA, the two remaining “situation awareness” items were assigned to the “task management” subscale.

The first factor of the two-factor structure reached an eigenvalue of 2.10 and accounted for 19.12 % of variance. The second factor had an eigenvalue of 1.92 and accounted for 17.43 % of variance. Together, this two-factor structure explained 36.55 % of total variance. The factor loading of every remaining item for the two-factor structure is presented in Table 1.

Table 1

Factor Loadings From the Principal Component Analysis of the MORE-NTS Observation Form

MORE-NTS item	Factor loading	
	1	2
Factor 1: Task management		
Continuous ventilation of the patient.	.74	-.23
Leading first responder recognises when to stop CPR.	.63	.09
Leading first responder is following the instructions of the AED.	.59	.01
Leading first responder reacts to feedback.	.53	.11

Leading first responder prepares (or delegates to prepare) ventilation instruments within reasonable time.	.50	-.10
Leading first responder prepares (or delegates to prepare) the AED within reasonable time.	.38	.07
Factor 2: Teamwork		
Leading first responder validates his/her actions/information by double checking with his/her team member.	.28	.67
Leading first responder passes on important information from the AED to his team member.	-.06	.67
Leading first responder assigns tasks to his/her team member at the beginning of the CPR.	-.05	.65
Leading first responder passes on the patient status to his/her team member before starting the CPR.	-.05	.63
Seamless resumption of CPR after repositionings or breaks.	-.06	.41

Note. $N = 103$. The extraction method was a principal component analysis with an orthogonal (Varimax) rotation. Factor loadings above .30 are bold.

Like the ANTS form, the observed behaviour was rated on a four-point scale; ratings ranged from “poor” (0) to “good” (3) with an additional “not observable” option. Items of the “task management” scale related to the general handling of the situation. The “teamwork” scale contained items measuring the quality of work and communication between team members. Table 2 shows the example items for each subscale.

Table 2*MORE-NTS Scale and Subscales Characteristics*

	NTS (total)	Task Management	Team Work
Number of items	11	6	5
Example item	n/a	The team leader notices when it's time to interrupt the CPR.	The team leader communicates the patient status.
Min	1.30	1.60	0.60
Max	3.00	3.00	3.00
Cronbach's Alpha	n/a	.554	.633

Note. Possible ratings ranged from “poor” (0) to “good” (3) with an additional “not observable” option.

After data collection, the videos of the resuscitations were rated by four independent raters. As using NTS taxonomies reliably requires practice, the rating was done in groups until the intraclass correlation coefficient for inter-rater reliability between all four independent raters over four videos consistently exceeded .80, which was considered substantial (Perinetti, 2018). Ensuing finishing the NTS ratings for all mountain rescuers, the Cronbach's alpha values for the NTS subscales were calculated. “Task management” reached a Cronbach's alpha value of .55 and “teamwork” a value of .63. Both Cronbach's alpha values are commonly considered “acceptable” or “moderate” (Taber, 2018).

Simulation manikin. The information about the TS was provided by the digital training manikin (Ambu® Man, Ambu, Ballerup, Denmark). The simulation manikin provided various items for ventilation and chest compression. From Table 3, the data were interpreted using the prescribed parameters established by the American Heart Association in 2020 (Merchant et al., 2020).

The data from the simulation manikin, comprising all the items displayed in Table 3, were pooled into a general TS variable. To create this variable, the existing data were z-transformed.

Table 3

Output of the Training Manikin and the Prescribed Parameters by the AHA (2020)

Item	Proposed values
Respiratory minute volume	1,5 – 3,6 l/min
Ventilation rate	3 – 6 /min
Chest compression frequency	100 – 120 /min
Tidal volume	0,5 – 0,6l
Gastric inflation	0%
Depth of compression	50,8 – 61mm
Hand position	0%
Releasing pressure	0%
Break between cycle	≤ 9s

Note. All percentage values are error values (number of wrong actions divided by total actions).

Procedure

To gain access to the sample of mountain rescuers, the researchers approached the people in charge of the central facility for the safety and training of the Bavarian mountain rescue organisation. All participants who completed their mandatory yearly simulation training and certification for AED utilisation were eligible to participate. Every requested

individual was willing to participate. The mountain rescuers were informed about the assessment taking place but were not aware of the focus of the study.

Upon their arrival, the mountain rescuers were given a brief introduction and the option to not participate in the study. After completing a written declaration of consent and before the start of the simulation, the participants received a biographical questionnaire.

Having completed the simulated CPR, the team continued with the other stations of the simulation circle (e.g. rescuing a person out of a stuck ski lift). Subsequently, they started the second round of rappelling and CPR, where the role of the leading first responder switched. While treating the simulation manikin, the mountain rescuers were video recorded. The focus was on the participant representing the leading first responder. After each simulated CPR, the leading first responder received the post-simulation questionnaire. In total, 103 videos of approximately six minutes each were recorded and analysed.

Analysis

Data were collected and calculated using a statistics programme (SPSS 24, IBM, Armonk, NY, USA). To test hypotheses I to IV, descriptive and inferential statistical analyses were performed.

To examine whether the NTS correlates positively with the displayed TS of the mountain rescuers (hypothesis I), two linear regression analyses were conducted. The first linear regression analysis focused on the correlation between the “task management” NTS subscale and TS; the second centred on the correlation between the “teamwork” NTS subscale and TS.

To illustrate whether experienced mountain rescuers demonstrate better CPR performance than inexperienced mountain rescuers (hypothesis II), and to overview the NTS and TS performance of both groups, descriptive analyses were conducted first. For the differences in CPR performance between groups, three *t*-tests and one Welch *t*-test were conducted. To define the individual groups, the sample was divided into three segments based

on the number of simulated resuscitations conducted by each participant. Only the two outer groups (most experienced/least experienced mountain rescuers) were included in the *t*-test. Thus, the 20 most experienced participants were compared with the 45 least experienced participants, leaving out 36 persons. Due to the high number of mountain rescuers who have never experienced a real resuscitation (43 out of 102), participants with zero real resuscitations were omitted from the calculations. The same procedure was used to divide the mountain rescuers by the number of real resuscitations. After omitting the participants who had never performed a real resuscitation, the 19 most experienced and the 34 least experienced mountain rescuers were compared, leaving out six persons (plus 43 persons that had never performed a real resuscitation).

To investigate whether there is a difference in CPR performance between mountain rescuers who have experienced patient deaths and those who have not (hypothesis III), a moderation analysis with the number of real and simulated resuscitations alongside the number of experienced patient deaths was conducted first. No moderation effect was found; therefore, the sample was divided into two groups. Since about half of the tested mountain rescuers (47 out of 96) had never witnessed a patient death during resuscitation, a median split was performed (0 vs > 0 patient deaths). After grouping, two *t*-tests were performed.

Finally, to see if the mountain rescuers can correctly assess their colleagues during resuscitation (hypothesis IV), a correlation analysis between the ratings of the team colleagues and their general resuscitation performance was performed. To create the general resuscitation performance variable, the NTS and TS values were *z*-transformed and pooled into one variable. This was done because the resuscitation performance rating of the team colleagues also comprised a combined NTS and TS score. This combined value was chosen because the mountain rescuers were not acquainted with the NTS concept; therefore, a distinction between NTS and TS could not be reliably made.

Table 4 shows the values for the participants who were included in the calculations.

Table 4*Descriptive Analysis of the Variables Used to Answer the Hypotheses*

	<i>n</i>	<i>M</i>	<i>SD</i>	<i>Max</i>	<i>Min</i>
NTS	103	2.42	0.35	3.00	1.30
task management	103	2.64	0.34	3.00	1.60
team work	103	2.17	0.56	3.00	0.60
TS	97	-0.01	0.35	1.05	-0.58
Simulated resuscitations	101	23.82	42.88	300	0
Real resuscitations	102	4.71	11.28	65	0
Experienced patient deaths	96	3.34	8.91	50	0
Colleague performance	103	7.01	2.00	9	0

Note. Possible ratings for the NTS (and subscales) ranged from “poor” (0) to “good” (3) with an additional “not observable” option. The values for the TS were z-transformed. Possible ratings for the resuscitation performance of their colleague range from zero to nine, while zero marking the worst possible performance.

4.3 Results

Hypothesis I states that NTS values correlate positively with the displayed TS of the mountain rescuers. A linear regression analysis between the “task management” subscale and TS explained 0 % of the variance and did not reach statistical significance ($F < 1$). The second linear regression, including the “teamwork” subscale and TS, explained 0.5 % of the variance and failed to reach statistical significance, too ($F < 1$). Therefore, Hypothesis I was not supported.

Hypothesis II states that experienced mountain rescuers show better CPR performance than inexperienced mountain rescuers. When the NTS scores for the experienced and inexperienced mountain rescuers were combined, they reached a mean value of 2.18 ($SD = 0.56$) for the subscale “teamwork” and a mean value of 2.65 ($SD = 0.34$) for the subscale “task management”. Table 5 shows the TS of experienced and inexperienced mountain

rescuers together. The three items “releasing pressure”, “tidal volume” and “respiratory minute volume” were incorrectly performed by over 50 % of the participants.

Table 5

Descriptive Analysis of the TS Displayed by Mountain Rescuers

	<i>n</i>	Correctly performed (%)	Incorrectly performed (%)	Over (%)	Under (%)
Respiratory minute volume	103	50 (48,5%)	53 (51,5%)	88,6%	11,4%
Ventilation rate	101	86 (85,1%)	15 (14,9%)	0%	100%
Chest compression frequency	103	75 (72,8%)	28 (27,2%)	7,1%	92,9%
Tidal volume	97	34 (35,0%)	63 (65,0%)	4,8%	95,2%
Gastric inflation	103	69 (66,9%)	34 (33,1%)	100%	0%
Depth of compression	103	57 (55,3%)	46 (44,7%)	36,9%	63,1%
Hand position	103	91 (88,3%)	12 (11,7%)	100%	0%
Releasing pressure	103	29 (28,1%)	74 (71,9%)	100%	0%
Break between cycle	103	95 (92,2%)	8 (7,8%)	100%	0%

Note. The prescribed ranges for the technical parameters are displayed in Table 3. The columns marked as “Over” and “Under” indicate if the value for the incorrectly performed task is above or below the prescribed range.

As for the comparison between experienced and inexperienced mountain rescuers (defined by the number of simulated resuscitations), the results showed that the more experienced participants had a higher average NTS score ($M = 2.44$, $SD = 0.42$) and a higher average TS score ($M = 0.01$, $SD = 0.36$) than their inexperienced colleagues ($M = 2.39$, $SD = 0.31$ [NTS]; $M = -0.02$, $SD = 0.39$ [TS]). The differences in the NTS scores ($t(63) = -0.44$, $p = .329$) and the TS scores ($t(59) = -0.21$, $p = .416$) were not significant. The comparison between experienced and inexperienced mountain rescuers, based on the number of real resuscitations, revealed that the experienced mountain rescuers had a lower average NTS score ($M = 2.37$, $SD = 0.47$) than their inexperienced colleagues ($M = 2.46$, $SD = 0.28$). Regarding the difference in average TS score, the experienced mountain rescuers had a higher

score ($M = 0.11$, $SD = 0.41$) than the inexperienced mountain rescuers ($M = -0.08$, $SD = 0.29$). Finally, the difference between the NTS scores of the two groups was not significant ($t(25,36) = 0.75$, $p = .231$), but the difference in the TS scores was ($t(47) = -1.95$, $p = .028$). Therefore, Hypothesis II was only partly supported.

Hypothesis III examines whether mountain rescuers who have experienced patient deaths differ in CPR performance from mountain rescuers who have not witnessed the death of a patient. A significant correlation was found between the number of experienced patient deaths and the number of simulated ($r(93) = .47$, $p < .001$) and real resuscitations ($r(94) = .98$, $p < .001$). However, the moderator analysis with NTS showed that the interaction effect between the number of real and simulated resuscitations and the number of experienced patient deaths was not significant ($F(3,91) = 1.09$, $t(91) = 0.39$, $p = .696$). The same was true for the moderator analysis, including the TS and the interaction effect between the number of real and simulated resuscitations and the number of experienced patient deaths ($F(3,85) = 1.55$, $t(85) = 1.13$, $p = .261$).

With no indication of the experience (simulated and real resuscitations) of the mountain rescuers moderating the effect of the number of experienced patient deaths on CPR performance, the possible differences in CPR performance between mountain rescuers who had and had not experienced patient deaths were examined. The descriptive analysis showed that mountain rescuers with experienced patient deaths had a higher average NTS score ($M = 2.48$, $SD = 0.34$) than their colleagues who had not experienced the death of a patient ($M = 2.42$, $SD = 0.34$). Conversely, mountain rescuers with experienced patient deaths had a lower average TS score ($M = -0.02$, $SD = 0.36$) than those without this experience ($M = -0.01$, $SD = 0.33$). However, the differences in the NTS scores did not reach statistical significance ($t(94) = -0.85$, $p = .199$), nor did the differences in the TS scores ($t(88) = 0.11$, $p = .456$). Therefore, Hypothesis III was not supported.

Hypothesis IV assumed that mountain rescuers cannot correctly assess their colleagues during resuscitation. The correlation between the teammate rating and CPR performance (total value) was positive on a descriptive level but not significant ($r(97) = .04, p = .706$). Therefore, Hypothesis IV was not supported.

4.4 Discussion

In this study, we evaluated mountain rescuers' CPR performance in simulations by investigating the role of TS, NTS, experience, experienced patient deaths and peer assessment. The assessment was made by combining technical output provided by modern medical simulation equipment with a newly created observation form and biographical data.

Regarding hypothesis I, our research demonstrated that neither NTS subscale correlated significantly with the displayed TS. Although two recent meta-analyses showed a positive connection between certain aspects of NTS and TS, our study did not demonstrate a similar result (Cormack et al., 2020; Dewolf et al., 2020). Unlike some studies, other studies in different medical domains have also found no correlation between TS and NTS (Gjæraa et al., 2016; LeBlanc et al., 2009). We therefore agree with other authors that the relationship between NTS and TS in resuscitation remains partially understood (Krage et al., 2017; Peltonen et al., 2020).

Research exploring the connection between these two variables mainly focuses on professional medical staff who either have NTS training already implemented in their curriculum or have received special NTS training. However, the mountain rescuers in this study represent a particular group of voluntary medical personnel who have to rely on simulation-based learning environments and have not yet adopted mandatory NTS sessions in their training.

A possible explanation for the missing correlation might be that NTS was measured for the leading first responder only, but the technical data were the result of the work of both mountain rescuers. Hence, even if the leading mountain rescuer did not achieve a high NTS

score, the colleague was still responsible for half of the technical skills displayed in the data output. Although the decision to score the TS as a product for both mountain rescuers might have blurred the relationship between NTS and TS, in reality, TS performance is always a combined product of all the mountain rescuers involved in CPR. The missing correlation between NTS and TS should therefore not be seen as positive evidence for the current practice of not having mandatory NTS training.

Regarding hypothesis II, the results indicated that the mountain rescuers who had completed more simulated resuscitations showed higher NTS and TS scores but did not differ significantly from mountain rescuers with fewer simulated resuscitations. When the experience of the mountain rescuers was differentiated by the number of real resuscitations, the inexperienced mountain rescuers showed a higher NTS score than their experienced peers, but no significant difference was found. Looking at the TS scores, mountain rescuers who had completed more real resuscitations had a significantly higher score than their inexperienced colleagues.

Although having more experience should theoretically induce better performance, how voluntary medical personnel gain experience also matters. Solely repeating the CPR process might not form a solid base of knowledge and motor skills, which, in turn, does not enable experienced voluntary medical personnel to have an advantage over their inexperienced peers. Research has shown that training in the medical field greatly benefits from deliberate practice (Duvivier et al., 2011; Ericsson, 2004). Deliberate practice is defined as an individualised solitary practice directed by a qualified teacher. It focuses on performance improvement and is effortful. Thus, it is not mere practice that matters; rather, specific conditions need to be met (Ericsson & Harwell, 2019). For CPR, deliberate practice could focus on particular aspects that are difficult and not yet performed correctly. Rigorous assessment would identify these aspects, and timely feedback could be provided by the trainer so that trainees know what to improve. The voluntary nature of the mountain rescue force and others might challenge this

kind of approach, but as volunteers are usually highly committed and motivated, they are probably willing to participate in deliberate practice (Vink et al., 2015).

The significant difference in TS for mountain rescuers who have experienced more real resuscitations might be related to a training and assessment approach that is similar to deliberate practice. As NTS are still not mandatory and therefore have a lower status than TS, the *in situ* debriefing after real CPR might be more focused on specific technical aspects of their work. Considering that mistakes in the treatment of a patient (e.g., exceeding the recommended chest compression depth) can cause perceptible damage, a personal focus on training certain aspects of CPR procedures might arise (Hellevuo et al., 2013). As Table 5 shows, the items “releasing pressure”, “tidal volume” and “respiratory minute volume” were performed incorrectly more often than they were performed correctly. These items create an area to focus on during training and *in situ* debriefings after real resuscitations.

Concerning the rather surprising (but not significant) difference in NTS between the mountain rescuers with more real resuscitations and their less experienced peers, it can be argued that existent non-mandatory NTS segments in their training can cause inconsistencies between both groups. As *in situ* debriefings after real resuscitations might not touch on NTS skills, it is unlikely that NTS are gained through self-reflection after performing real resuscitations.

As for the non-significant differences in NTS and TS between mountain rescuers with more and fewer simulated resuscitations, similar reasoning can be applied. If NTS training is not mandatory, it is rather unlikely that mountain rescuers will gain significantly more NTS with the number of training sessions they complete. However, since TS are indeed an integral part of their training, it was unanticipated that the experienced mountain rescuers do not show significantly better TS scores than the inexperienced. A closer consider the biographical data revealed that the last simulated resuscitation for the experienced mountain rescuers was, on average, more recent ($M = 8.45$, $SD = 10.38$ [months]) than for the inexperienced mountain

rescuers ($M = 10.22$, $SD = 9.68$ [months]). As CPR skills deteriorate significantly as early as after three months, we argue that both groups have comparatively similar and rather large time gaps after their last trained CPR, which possibly reduces their differences in TS to a non-significant level (Anderson et al., 2019).

Regarding hypothesis III, the experienced patient deaths did not seem to have a significant influence on overall CPR performance. Neither the mountain rescuers who have witnessed the death of the patient nor those who have not differed significantly in their displayed NTS or TS. This is probably because, in Europe, after initial treatment as first responders, mountain rescuers hand over the patient to an emergency physician who then continues the CPR. This procedure is known as the “stay and stabilise” approach, where the best possible treatment is administered right at the scene of the emergency (Al-Shaqsi, 2010). Thus, the emergency physician is, therefore, the person who decides on the death of the patient, or the patient is transferred to a clinic where further care is taken. This handover may induce a diffusion of responsibility, which results in the weakening of the possible effects for mountain rescuers. Besides the possible diffusion of responsibility, it is also imaginable that psychological support after these events reduced the possible impact of witnessing the death of a patient. As there is no information about the psychological support our participants received, it is unclear whether these measures were applied or if they were successful.

This study’s results parallel research findings, showing that simulated deaths either have no effect or even have positive effects on NTS or TS (DeMaria et al., 2016; Goldberg et al., 2017). Due to ethical reasons, most data are limited to the death of the simulation manikin. However, considering the realism of some simulations, these learning settings can be highly authentic and engaging. Therefore, the findings might be comparable to the real death of the patient.

Concerning the last hypothesis (IV), we found that mountain rescuers could not fully correctly assess their colleagues during resuscitation. Although we did not find a negative

correlation between the ratings of the team colleagues and the general resuscitation performance variable, the positive correlation that we found did not reach statistical significance. We therefore conclude that the mountain rescuers had some oversight of their colleagues' tasks, but there remains room for improvement. A possible explanation for this finding is that mountain rescuers lack the training that experienced medical practitioners have that would allow them to devote their attention partly to the work of their partner. Research has shown that experts "check in" on their colleagues more if they have lower trust in them to complete the given task (White et al., 2018). While decreased monitoring reduces cognitive load, having greater oversight over the tasks of others increases cognitive load. As mountain rescuers may need to assemble "ad-hoc" to respond at emergencies, leading first responders might not have the highest levels of trust in the abilities of their colleagues. Therefore, the goal of training should be for mountain rescuers to develop routines in their CPR so that cognitive load can be devoted to monitor their colleagues. With being able to monitor others, the possibility of detecting and correcting mistakes that would otherwise have gone unnoticed rises. Awareness of possible mistakes is therefore a crucial first step in correcting others' errors, which contributes to a safer team-based work environment during medical emergencies.

Limitations and Future Research

Our study reveals the complex facets of mountain rescuers' CPR performance and the ways in which different skills and experiences correlate with it. To evaluate this array of factors, a specialised observation tool was designed and tested. Using the results of the MORE-NTS observation tool alongside the technical output of the simulation manikin, insights into a unique field of voluntary medical personnel were given. However, some cautionary remarks should be considered.

In this study, over 600 min of footage from the simulated resuscitations were watched and analysed, which was considered an adequate sample size for a partially exploratory study.

For future studies, a larger sample size might be desirable to strengthen the generalisability of the results. However, the feasibility of analysing more than 103 videos of approximately six minutes of length requires consideration.

In our study, the TS score was based on team performance, while the NTS score was the individual score of the observed leading first responder. In hindsight, it is possible that the role of the NTS is slightly diminished, as the work of both mountain rescuers forms the TS score for the leading mountain rescuer. This setup would allow two well-trained (but with insufficient NTS skills) mountain rescuers to still achieve high TS scores. In future publications, to determine whether NTS correlates with TS and whether NTS skills can make a difference, standardised “less-than-ideal” situations need to be created. Moreover, the results shown in this study should still hold true in a “normal” real-life resuscitation scenario.

This study provides a first look into the relationship between experiencing patient deaths and CPR performance in a voluntary medical field but leaves room for speculation about why there was no connection between the variables. In future studies, qualitative interviews about cognitive processes and the possible diffusion of responsibility might shed more light on the effect of patient deaths on CPR performance. Additionally, information about the perceived support after witnessing a patient’s death should also be included. Together, this data could also influence decisions about the necessity of trauma interventions and stronger supporting frameworks for mountain rescuers.

Finally, ratings of team colleagues were measured to determine whether rescuers can assess the possible mistakes made by their partners. Since the mistakes of their colleagues were unobserved in our study, the leading first responder could have correctly guessed their partner’s performance without seeing or correcting their mistakes. This should be changed in future studies by asking the leading first responder to be more precise in the performance evaluation and matching the ratings with the observed mistakes made by their partner.

Conclusions and Practical Implications

Our evaluation of the NTS and TS of mountain rescuers found that the mountain rescuers perform the TS items “releasing pressure”, “tidal volume” and “respiratory minute volume” incorrectly especially often; therefore, these tasks need further attention in training sessions. As for NTS, mountain rescuers reached a lower “teamwork” score than in the “task management” category. Although a direct comparison of NTS skills in this medical area is missing, NTS training, if implemented, should focus on this subset of skills.

This study’s results do not support previous research that found a correlation between NTS and TS (Cormack et al., 2020; Dewolf et al., 2020). Similar to other studies that did not find a significant correlation between both factors (Gjeraa et al., 2016; Krage et al., 2017; LeBlanc et al., 2009), we conclude that the relationship between NTS and TS remains inconclusive and needs further research. Gjeraa et al. (2016) hypothesised that both skills are intertwined but not directly correlated with each other. For instance, the authors mention the “proverbial highly skilled professional with limited social abilities” (Gjeraa et al., 2016, p. 43). Another reason for the missing correlation between NTS and TS might be the level of stress perceived by the participants. Krage et al. (2017) showed that the correlation between both variables occurred only under higher levels of stress. We therefore believe that, in adverse situations, NTS can make a valuable difference in resuscitation. As an additional benefit, the implementation of NTS into the training of mountain rescuers would theoretically also help in identifying the mistakes of their partners (Gordon et al., 2012). Future studies should further elaborate on the interconnection between stress and NTS and TS.

The results indicate that the peer assessment skills of mountain rescuers still leave room for improvement, as the positive correlation between their colleagues’ ratings and the general resuscitation performance variable did not reach significance. A mandatory NTS segment in mountain rescuers’ medical training could also improve their assessment performance. Jäger et al. (2018) showed that NTS segments do not have to be very long or

elaborate to create positive results. Therefore, including a short standardised NTS segment in the curriculum of mountain rescuers seems feasible. For training purposes, the Bavarian mountain rescue organisation could consider designing a learning environment that focuses on deliberate practice. Specific and individual feedback can help reduce mistakes and improve overall CPR performance.

Concerning the aspect of simulation and assessment, the results show that, without the specialised NTS observation tool and the assessment, common beliefs about the factors impacting how well CPR skills are displayed in simulated resuscitations would not have been challenged. We therefore encourage scholars to further assess and test common conceptions in a safe and standardised simulation-based environment.

5 Study 2: Mountain Rescuers' Experiences With Video-Assisted and Verbal Debriefings: A Qualitative Study²

Abstract

The reflection on previous performance during debriefing plays an important role in learning from simulations. While debriefings are traditionally held as verbal debriefings (VD), advancements in video and software technology led to an increased use of video-assisted debriefings (VAD). Although VAD is nowadays considered to be the gold standard, prior research has found mixed results concerning the experiences connected to this form of debriefing. This study sheds light on the experiences of all the actors involved in the process, by including both participants and facilitators. A distinction between their experiences within VD, lower-tech and high-tech VAD was made. In total, 42 mountain rescuers and five facilitators participated in this study during three one-day-long simulation training sessions. While participants shared their experiences in focus group interviews, the facilitators were invited for individual interviews. The results indicate that both participants and facilitators preferred high-tech VAD for its ability to objectively review their performance in detail. It was seen as beneficial to gain a deeper understanding of how mistakes occurred during the simulation and the visualisation improved the acceptance of feedback. However, it has also been found that VAD in general can be intrusive and cause additional cognitive demand, stress, and unpleasant emotions. The study shows that VAD can have advantages over VD but requires careful implementation by the facilitators to prevent the possible drawbacks.

5.1 Introduction & Theoretical Background

In the event of a medical emergency, it is important that emergency rescue services quickly attend to patients to save their lives and protect their health (Nehme et al., 2016).

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While providing fast and adequate medical care outside of hospitals is already challenging, harsh and mountainous regions further complicate these tasks. Therefore, mountain rescuers take a special place in the rescue chain. With operations in remote locations and adverse conditions (e.g., weather, terrain, multiple casualties) their work is considered particularly demanding (Callender et al., 2011). While members in other rescue services (e.g., emergency medical service [EMS] professionals in the United States) are usually paid professionals, mountain rescuers in Germany provide their work voluntarily (Cash et al., 2020). Due to the voluntary nature of their work, mountain rescuers face constraints on the time available for training and providing service (Cowlshaw et al., 2010; Nichols et al., 2014). With only a limited amount of time available and comparatively high demands, their training has to be especially effective. Therefore, the majority of European and American mountain rescue services rely on simulations to learn and evaluate their skills (Elsensohn et al., 2009).

The Role of Simulations

To prepare mountain rescuers for their tasks, “hands-on” training on real patients is not only problematic due to time constraints, but training with real patients might also raise concerns in terms of patient safety. Additionally, the expenses associated with training on real patients can be prohibitive. These costs encompass not only equipment and training facilities but also potential liabilities arising from any adverse outcomes during training exercises (Pietsch et al., 2016).

In the absence of opportunities for practical training on real patients, simulations assume a pivotal role in the medical training of mountain rescue organisations (Elsensohn et al., 2009). Simulated environments mimic lifelike scenarios, thereby offering a safe yet authentic training experience for both participants and simulated patients (Ayaz & Ismail, 2022; So et al., 2019). While simulations provide a safe opportunity to practice rare and possibly dangerous procedures, the debriefing afterwards is considered one of its most

important components for learning as it allows reflecting on previous performance (Dreifuerst, 2009; Lee et al., 2020; Shinnick et al., 2011).

Importance of Debriefings

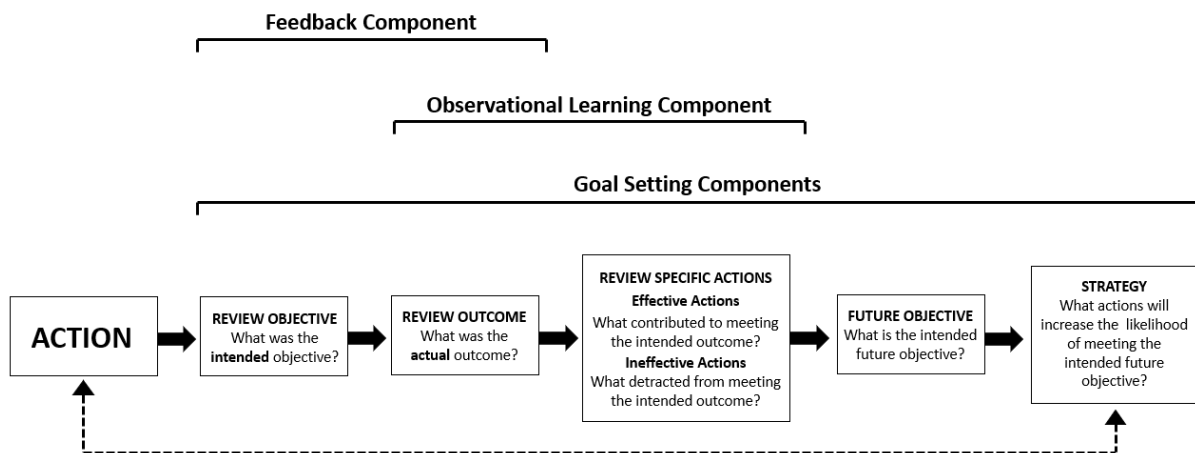
The practice of discussing, interpreting, and learning from previous experiences is known as after-action review, after-event review, huddles, hot-washes, postmortems or debriefing (Allen et al., 2018). While originating from military practices, the term “debriefing” is the most common in healthcare services and research (Keiser & Arthur, 2021). Therefore, “debriefing” will be used throughout this paper. While there can be differences in the structure or formality of the procedure, the purpose remains the same: “to systematically review individuals’ performance on a recent task or event in order to create a learning opportunity with the aim of improving subsequent performance” (Villado & Arthur, 2013, p. 515). Several meta-analyses have shown that debriefings improved learning and team performance (Cheng et al., 2014; Couper et al., 2013; Tannenbaum & Cerasoli, 2013).

Although there are different ways to conduct debriefings, Villado and Arthur (2013) divided the process into five primary phases. Each phase can be linked to a well-established psychological theory or concept thus explaining the effectiveness of the process. As depicted in Figure 3, the first two phases of the debriefing focus on the possible difference between target and actual performance, thus, providing feedback for the participants. This can be linked to feedback intervention theory (Lipnevich & Panadero, 2021). During the third phase, the specific actions of the team and their outcomes are reviewed in detail. The goal of this phase is to identify and discuss behaviours and their results. Participants receive individual feedback and team-related feedback. In addition, they also often experience the individual feedback that is provided to other members of the team. Combined with the video from the simulation, phases two (“review outcome”) and three (“review specific actions”) can be linked to observational learning theory (Luo et al., 2021). The last two phases focus on the goals of the participants by discussing future objectives and the strategies needed to meet the

intended objectives. Combining the last two with the previous phases, the whole process of debriefing applies the principles of goal-setting theory (Keiser & Arthur, 2022).

Figure 3

Depiction of Primary Phases of the Debriefing Process and the Associated Psychological Theories (Villado & Arthur, 2013)



Debriefing With Media Support

While the process of debriefing in its origins is over four decades old, new ways to conduct it are steadily developed (Morrison & Meliza, 1999; Sawyer et al., 2016). One of the most discussed methods to conduct debriefings is to integrate video playback into the process.

Traditionally, debriefings are performed verbally under the guidance of an experienced facilitator. These debriefings can be classified as verbal debriefings (VD). A more modern approach to debriefings combines verbal feedback with additional video footage of the simulation. This type of debriefing is called video-assisted debriefing (VAD). While some authors refer to VAD as the “gold standard” for debriefing (Levett-Jones & Lapkin, 2014), others found no significant effects on subsequent performance when comparing VAD to VD (Grant et al., 2014; Savoldelli et al., 2006; Sawyer et al., 2012). Newer research found that the advantages of VAD may be coupled with other debriefing characteristics such as the

facilitation approach, with self-led debriefing profiting the most from VAD (Keiser & Arthur, 2021; Tannenbaum & Cerasoli, 2013).

In theory, VAD is expected to have advantages over traditional VD. As conceptualised in the study by Zhang et al. (2020), VAD can be integrated into the experiential learning theory (ELT) by Kolb (2015). The ELT framework describes learning as a cyclical process that can be divided into four phases. During simulation, the participants first engage in a *concrete experience*. This is followed by the debriefing, in which the previously made experience is reflected upon (*reflective observation*). By analysing the perceptions during the debriefing, lessons and principles are extracted from the experience (*abstract conceptualisation*). Lastly, the gained knowledge gets prepared and applied to future scenarios (*active experimentation*). While the last three steps generally apply to VD as well as VAD, the phase of *reflective observation* should benefit the most from VAD, as it provides visual and auditive material on which to base the observation and reflection.

VAD is also considered to be a more objective way to debrief than VD (Villado & Arthur, 2013). While VD relies on the correctness and accuracy of recall by the facilitator, VAD can show scenes from the simulation reducing potential recall bias. The reduction of potential bias in recall also applies to the participants, who are less likely to accurately memorise certain events or behaviours, due to the high cognitive demand of the simulated tasks. Therefore, arguments about what and how actions have happened can potentially be limited with video evidence within VAD (Schertzer & Waseem, 2024).

Another advantage directly connects to the underlying theoretical understanding that explains how debriefings work. As depicted in Fig. 1, phase two and three of the debriefing are linked to observational learning theory (Luo et al., 2021). Observational learning can be fostered with video playback, as key behaviours and scenes during simulation are being made visible again. Therefore, learners can direct their attention to the displayed behaviour and its consequences to gather the required information that is needed to mimic or in general learn

from the observed actions (Johnson, 2020). During simulation, it is unlikely that the participants have the time and cognitive resources to direct enough attention towards others to learn from their behaviour. Therefore, reviewing the simulation with video can foster observational learning.

VAD typically provides an outside perspective of the simulation and its participants. By providing an overview of the team and its processes during simulation, communication and interpersonal dynamics within teams can be visualised and are therefore easier to reflect upon (Ha, 2014; Jacobs, 2017). With the combination of an outside perspective and joint reflection with a facilitator, VAD can lead to a different view on the simulation performance in contrast to the original assessment made by the participants themselves. It has also been shown that VAD increased the perceived importance of teamwork (Johansson et al., 2017).

Besides the positive factors associated with VAD, research has also found negative aspects commonly connected with this method. Due to the prominent display of negative behaviour or mistakes, participants within VAD can feel stressed, intimidated, and even humiliated (Cantrell, 2008; Ha, 2014). This is problematic, as one of the key requirements of debriefings is the psychological safety of participants (Salas et al., 2008). Psychological safety can be defined as “[.] individuals’ psychological state where they feel safe and can easily speak up and share their thoughts, perceptions, and opinions without risking retribution or embarrassment” (Kang & Min, 2019, p. E6). Without psychological safety, reflective learning conversations may be inhibited which in turn reduces the effectiveness of debriefings (Kolbe et al., 2020).

Combining verbal explanations with video sequences during debriefing might also influence the attention of the participants. In the study by Savoldelli et al. (2006), the authors argue that the additional visual information provided by VAD led to an information overload that distracted participants away from the constructive information given by the facilitator. Reed et al. (2013) found that participants rated the expertise of facilitators differently

depending on the type of debriefing they attended. Facilitators who conducted VAD received lower ratings than those who held VD. Similar to the conclusion of Savoldelli et al. (2006), the authors hypothesised that the video took away the attention from the facilitator towards the video on display.

Furthermore, the integration of VAD can potentially increase the time for the debriefing as well as the overall costs of the simulation (Garden et al., 2015). Both aspects can vary depending on the video equipment, software, and overall implementation of the VAD.

Current studies mainly focus on the effectiveness of VAD compared to VD (Keiser & Arthur, 2021; Niu et al., 2021; Zhang et al., 2019b). Although it is important to examine which debriefing form is the most effective in terms of learning and performance outcomes, the experiences of participants and facilitators have not been thoroughly examined yet. However, these experiences are important as well. For instance, negative emotions such as intimidation or humiliation during debriefing have consequences for the psychological safety of the participants and in turn their learning outcome (Lateef, 2020). The few existing qualitative studies that focussed on participants' experiences found that VAD enhances the perceived objectiveness and acceptance of feedback. Participants also said that they learned from viewing others and that VAD reduced their own recall bias. However, participants also reported a stronger fear of negative feedback, indicated unnatural behaviour during the simulation and overall higher stress and intimidation in the VAD condition (Cantrell, 2008; Ha, 2014; Rosvig et al., 2023; Zhang et al., 2019a). To our knowledge, there is currently only one study, conducted by Krogh et al. (2015) that explores the perspective of the facilitators in VAD. The facilitators in this study viewed VAD as a tool for various purposes, such as triggering reflection and discussion, or to neutralize criticism. They also see the potential drawbacks of VAD, with the possibility of distracting the participants from the verbal feedback they try to give, as well as having to stop the debriefing to find the video segment that they want to show.

Aim of the Study

The few existing qualitative studies that focussed on the experiences connected with VAD and VD either examined solely the facilitators or the participants of the debriefing. By interviewing both groups, this study combined the experiences connected to all the actors involved in the debriefing process. Additionally, the VAD was held in two ways, as there is no universal or standardised framework on how to implement the technology. Therefore, this study examined the experiences of facilitators and participants within VD, high-tech and lower-tech VAD. The following research questions were addressed:

RQ 1: How did the participants experience high-tech VAD, lower-tech VAD, and VD?

RQ 2: How did the facilitators experience high-tech VAD, lower-tech VAD, and VD?

5.2 Method

Research Design Overview

To answer the research questions, a qualitative interview study with mountain rescuers has been conducted. As the participants went through the different simulations and debriefings in groups of four, focus group interviews were held within the respective groups. Facilitators were interviewed individually.

Simulation Cycle. The study was conducted during a time period of three days in the central facility for the safety and training of the Bavarian mountain rescue organisation. Data was collected within a “medical simulation training”-cycle (SIMMed), consisting of three simulation stations. The simulation stations featured the following scenarios: Unconscious patient with Hypothermia in need of Resuscitation (UHR), Femur fracture caused by a Fall from approx. 3 m (Child patient) (FFC) and Unconscious climber with Head Trauma due to falling rocks on a climbing route (UHT). As shown in Table 6, the scenarios were tied to one of the three different debriefing forms (VD, lower-tech VAD & high-tech VAD) held subsequently at the end of each simulation.

Table 6*Overview of the Simulated Scenarios and their Respective Debriefing Forms*

Scenario	Scenario Description	Debriefing form
UHR	Unconscious patient with H ypothermia in need of R esuscitation	VD
FFC	Femur fracture caused by a F all from approx. 3 meters (C hild patient)	Lower-tech VAD
UHT	Unconscious climber with H ead T rauma due to falling rocks on a climbing route	High-tech VAD

Note. Each scenario had its own debriefing form that followed right after the end of the simulation.

During the UHR station, the participants had to rescue and resuscitate an unconscious hypothermic patient inside a large cooling chamber (temperatures ranged from -5 to -10 degrees Celsius) with low-light conditions. The participants had to climb to the simulation mannequin, which was placed on a narrow edge four meters above ground. Participants secured themselves with a guide rope while approaching the patient. Following the initial diagnosis, the participants had to start resuscitation and administer medication based on the hypothermic condition of the patient. After stabilising the patient, the mannequin was placed inside a rescue bag and was evacuated by rope.

Within the FFC scenario, the participants had to treat and rescue a child patient suffering from a femur fracture, after falling into a small enclosure from approx. 3 m. The participants had to rappel themselves from a simulated helicopter to the child mannequin. After the initial diagnosis, the emergency physician within the group had to administer the appropriate dosage of medication, while the rest of the team secured the patient. Once the child patient received adequate treatment, the mannequin was evacuated by a simulated helicopter using a rescue bag.

The UHT scenario featured an unconscious climber with head trauma due to falling rocks on a climbing route. The participants were transported to a position halfway up a large climbing wall (approx. 20 m) and had to climb to the simulation mannequin positioned at the top edge of the wall. Once the mannequin was initially diagnosed, the medical condition of the mannequin was changed by the facilitator, thus creating a more challenging situation. After stabilising the patient, the mannequin was secured inside a rescue bag and both participants and patient were evacuated by a simulated helicopter.

Although the three scenarios featured different tasks, they were designed to be similar in terms of complexity and the problems presented to the participants. All three scenarios shared technical challenges to reach the simulated patient (climbing, rappelling), difficult medical tasks (patient with hypothermia, child patient and patient with changing medical conditions) and logistic challenges to evacuate the patient (evacuation by rope and simulated helicopter).

Debriefing Forms. All debriefings were structured based on the facilitator's training and certification within the Bavarian mountain rescue organisation. The facilitators were given technical training to operate the new VAD equipment and the freedom to integrate the video recordings into their existing debriefing structure as they found most effective. Therefore, the facilitators used the video recordings during VAD based on their professional judgment.

During VD, the facilitator held the debriefing without any technical equipment solely by discussing the course of the simulation as well as the actions and decisions made by the participants. The VAD differed regarding the complexity of the technical equipment used.

Lower-tech VAD included a tablet (Apple iPad Pro, 11 inch) mounted on a tripod with an external microphone (Rode NTG-2) attached. The start of the video recording was manually matched with a stopwatch by the facilitator. Timestamps of important events were

written down by the facilitator to rediscover the scenes during debriefing. The chosen video segments were then played back via ‘AirPlay’ onto a large TV screen by the facilitator.

High-tech VAD captured the perspectives of two mounted cameras and the audio from lapel microphones for each participant. Within the simulation, two facilitators were necessary to simultaneously manage the simulated scenario and the equipment needed for the high-tech VAD. The facilitator in charge of the scenario was equipped with a stopwatch and a portable two-way radio. The second supporting facilitator managed the specialised video-debriefing software “LearningSpace” developed by ‘CAE Healthcare’ with a laptop and an external mixer for the audio recordings of the lapel microphones. During the occurrence of important events, the facilitator in charge of the scenario transmitted information about the time and additional information to the second supporting facilitator, who was also equipped with a portable two-way radio. The communication via radio was necessary, as the simulated scenario only offered a limited amount of space for the technical equipment needed for high-tech VAD. The facilitator who led the simulation also held the debriefing by choosing video segments that were marked with timestamps during simulation. Within the debriefing, the selected scenes were displayed on a large screen and contained both camera angles as well as the additional information that was transferred between the facilitators.

During the one-day-long SIMMed training, the participants experienced all debriefing forms as groups of four. The SIMMed training was designed as a simulation cycle, meaning that the groups simultaneously started at different simulation stations and went through the cycle successively. As the debriefing form was directly connected to the simulated scenario (see Table 6), the variation in the initially experienced debriefing form between the groups was intended to minimise the influence of possible sequencing effects. As each participant engaged with all three debriefing forms, the study used an exploratory approach comparing the experiences within cases.

During each simulation day, the facilitators were permanently assigned to one simulation station. Qualitative data from participants and facilitators was gathered after every simulation day during focus groups (participants) and individual interviews (facilitators). Only the facilitators who led both the simulation as well as the debriefing during high-tech VAD were included in the individual interviews.

Study Participants

In total, 42 mountain rescuers (9 females; 32 males) and five facilitators (1 female; 4 males) agreed to participate. One individual did not provide personal information. All participants were members of the Bavarian mountain rescue force with an advanced medical background (emergency physician, emergency medical technician, rescue paramedic, or equivalent qualification). On average, they had about 14 years of active membership in the Bavarian mountain rescue organisation. The facilitators, in comparison, held a longer active membership in the rescue organisation of about 20 years and carried out the SIMMed as facilitators on average nine times. Three of the five facilitators had previous experience with conducting VAD. Of these three individuals, one had conducted VAD four times and the other two only once.

Instruments

Questionnaires. Basic biographical data (e.g., age, gender) and information regarding the experience of participants and facilitators were collected via a biographical questionnaire.

Focus Group Interview. Interview questions were asked based on the Debriefing Experience Scale (Reed, 2012) and the Debriefing Assessment for Simulation in Healthcare (DASH) – Student Version (Simon et al., 2010) questionnaire. The questions were grouped into four main sections: (1) overall experience, (2) learning and reflection, (3) skills of the facilitator and (4) additions. While the first two parts were centred around the differences between the debriefings and the learning involved, the third section was focused on how the facilitator led the debriefing. Lastly, the trainees shared further thoughts.

Individual Interview. Facilitators who performed VAD were asked how they experienced the debriefing modality compared to the previously performed VD. The questions for the interview were based on the DASH – Instructor Version (Simon et al., 2012) questionnaire and were divided into four sections: (1) use of VAD, (2) experiences of the participants, (3) (technical) challenges and (4) additions.

Data Collection

As the facilitators had limited experience with VAD, all of them received a technical introduction to both VAD systems. The introduction took place on a separate day before the three days of SIMMed training started. Facilitators received instructions to use the VAD technology as they deemed most appropriate.

At the start of the pre-briefing, the participants were informed about the planned study one week ahead of time within their central online knowledge management tool. With this tool, the participants had the option to prepare themselves for the simulated scenarios and to gather information about the study in advance. At the beginning of the SIMMed simulation cycle, the participants were introduced to the context and objectives of the simulated scenarios including their relevance for mountain rescue. Furthermore, the study and the different debriefing methods were presented. During this presentation, the facilitators emphasized the importance of being able to make mistakes without the fear of judgment. Moreover, the confidentiality of the performance during simulation and the content of the debriefing was assured.

Following the pre-briefing, both facilitators and participants were given the option to not participate. Each person filled in a written declaration of consent and the APA Ethical Principles of Psychologists and Code of Conduct were followed. Starting the data collection, both facilitators and participants received the biographical questionnaire. Next, the participants were told to separate themselves into groups of four. Each group consisted of at least one emergency physician to perform certain tasks that are prohibited for other medical

personnel by German law (e.g., dispensing of medications). The groups were then randomly assigned to one of the stations of the simulation cycle. After each scenario, they received the debriefing form of the respective station in a separate room (UHR station – VD; FFC station – lower-tech VAD; UHT station – high-tech VAD). With the completion of the scenario and the corresponding debriefing, each group changed to the next simulation station until they completed the full cycle. Facilitators were permanently assigned to one simulation station and conducted the debriefing that was linked to the scenario of the station. At the end of the simulation cycle, the participants were interviewed in their respective groups while the facilitators were interviewed individually. The interviews were held in German by the first author and two research assistants. To ensure correct transcription, the interviews were audio recorded. The interviews of the participants ranged from 21 to 38 min ($M = 28.75$, $SD = 6.01$) and the facilitator interviews took between 8 and 16 min ($M = 12.83$, $SD = 3.14$). Overall, a total of 11 participant interviews and five facilitator interviews were transcribed verbatim.

Analysis

The data was analysed by using qualitative content analysis with a deductive and inductive approach (Mayring, 2014). To get familiarised with the statements of both participants and facilitators, the first and second author of the study as well as one of the research assistants repeatedly went through the transcriptions and audio recordings of the interviews. Notes of early impressions and ideas for the coding scheme were taken. The main categories for the group interviews with the participants and the individual interviews of the facilitators were deductively formed, focussing on previous research and the structure of the interview.

Smaller analytical categories and changes to the deductively formed categories were then created inductively during the coding process by the first and second author of the study as well as one of the research assistants. To ensure agreement between the coders, the coding was done collaboratively between the first and second author and one of the research

assistants. In case of discrepancies in the coding, a systematic resolution process was established. During the process, discrepancies were discussed among the coders by explaining each individual interpretation of the coded segment and the reasoning behind the coding decisions. The coders then referred to the coding manual to see whether the existing definitions and rules for the categories were able to resolve the discrepancies. If this was not the case, the coders re-evaluated the coded segment until an agreement was reached. Consequently, the coding manual was revised to minimise possible discrepancies.

The following main categories emerged: (1) Overall preference for the debriefing form, (2) outside view and its value, (3) acceptance of feedback, (4) dealing with emotions, and (5) future of debriefings. In succession to coding the interviews of the participants and the facilitators, the first author reorganised overlapping themes between both groups. Together with the second author, the overlapping themes were evaluated to ensure a sensible structure in analysing the reported experiences. Additional subcategories were created to further divide the five main categories. An overview of the final five main categories and their respective subcategories can be found in Table 7.

Table 7

The Main Categories of the Results and Their Respective Subcategories

Main categories	Subcategories
Overall preference for the debriefing form	
Outside view and its value	Learning from observing others Own perspective vs. outside view
Acceptance of feedback	Use of video evidence Discussions during debriefing
Dealing with emotions	Debriefing forms and different emotions Balancing positive and negative feedback

The future of debriefings	Current difficulties
	Possible future improvements

5.3 Results

To present the results of our study, we will first share the findings of the participants, followed by those of the facilitators. Wherever possible, a distinction between high-tech VAD and lower-tech VAD will be made. Direct quotations of the participants are labelled with an indication of the focus group and participant (FG 1–11, P 1–4). Facilitators are abbreviated with FA and a number that refers to the specific person (FA 1–5).

Overall Preference for the Debriefing Form

Of all 42 participants, the majority (20 participants) preferred high-tech VAD. In their opinion, high-tech VAD provided better audio and video quality compared to lower-tech VAD. The higher quality was perceived as useful because it did not pick up unwanted background noise and captured the scenario from two different angles. Together with the option to put timestamps in the recorded video, the participants felt that the debriefing was more focused and “to the point”. With the mentions of seven participants, the second most preferred debriefing form was VAD in general. Within VAD, participants enjoyed the outside perspective, which gave them a broader view and showed the different interactions during the scenario as illustrated by the following quote: “I think the great advantage of video debriefing is that you can see or revisit situations that you did not experience [...]. And that offers many more opportunities to assess the entire situation” (FG 10, P 4). Low-tech VAD and VD share the third place regarding the preferred debriefing form of the participants (each mentioned by six persons). Within lower-tech VAD, participants favoured the lack of lapel microphones which made them feel “under pressure” and hindered them from displaying “natural behaviour”. Moreover, the participants stated that without having to pay attention to the wires of the lapel microphones, they felt more comfortable. The advantage of VD was seen in the

clear structure of the debriefing. The participants felt that this debriefing form allowed them to discuss different ways to solve their tasks, without focusing on one specific mistake that they had made. Lastly, three participants had no preference regarding the debriefing form. They were either satisfied with the debriefings in general or said that “It always depends on the situation or the task at hand” (FG 9, P 3).

All five facilitators preferred VAD in comparison to VD. The facilitators liked the possibility of visualising important events that happened during the scenario to give precise feedback. FA 2 explained: “I think that you can communicate more clearly what you want to say to the participants [...]”. Another advantage was seen in the objectivity of the video on display. According to the facilitators, VAD provided the opportunity to review the simulated scenario without bias, which in turn reduced the need to justify or discuss negative feedback. In addition, all facilitators stressed that the video display acknowledged their professional opinions. Having video evidence supporting their position was perceived as helpful because participants seemed to accept negative feedback more easily regardless of possible differences in hierarchy. This is expressed by FA 1: “And yes, when I say something [*referring to VD*], trainees do not necessarily have to believe me. Especially when discussing with doctors as a non-doctor my position can be tricky. But as soon as they can see the situation and themselves again, it has a different effect.”

The Outside View and its Value

Learning From Observing Others. Participants reported that viewing the scenario from an outside perspective allowed them to see the actions of their colleagues. Seeing how the actions of themselves and their colleagues were related to the performance of the team was considered highly beneficial. One participant explained it as follows:

I think it is really important to see what the others are doing because you often see that one of your team members was stressed out or someone had lack of information. Then you realise for yourself that communication might be important in that case. In fact,

you often just do not notice that. Especially when you are working as a doctor at the head of the patient, you are so focused on your task. And then you can ask yourself:

Why wasn't the information present? (FG 1, P 3)

Besides understanding how the actions of the team relate to each other, it was also considered helpful to see others making mistakes. According to participants, revisiting the situation with the help of the video clarified the origin of negative outcomes on the team level. Moreover, participants indicated that they gained insights into how errors could have been prevented. Some participants, however, admitted that they mainly focused on themselves when watching the video. They emphasised that their own performance was their biggest concern and they wanted to detect whether they had made any mistakes.

The facilitators had a similar impression mentioning that most participants were mainly focused on themselves during VAD. FA 1 stated: "[...] when they watched the video, I had the impression that most of them were looking at themselves: How did I behave? How did that work out for me? And they want to take away a positive result that - to put it mildly - they did great."

Own Perspective vs. Outside View. Seeing themselves on video provided a contrast to the picture the participants had of themselves. Many participants reported a deviation from what they felt and thought during the simulation compared to what they saw on video. This deviation is expressed in the quote by FG 3, P 3: "Actually, I think I evaluate myself correctly most of the time. However, now I realise that the mistakes, which I actually considered not to be so serious present themselves differently on screen." Participants also stated that they easily lost track of time during the simulation. Showing them video segments in combination with a timeline of the scenario was experienced as very helpful in improving their feeling for the time elapsed during different tasks. Participants who described themselves as self-critical mentioned that VAD also provided the possibility to gain a more positive view of their performance.

Similar to the participants, the facilitators also stressed the importance of having a neutral outside perspective because it is very rare for the participants to see themselves during training or in real-life situations. They highlighted that the video by itself is unfiltered and it is up to the participants to reflect upon themselves. For example: “You see yourself impartially and without prejudice, mercilessly but also mirrored: This is how you act. Live with it and draw your conclusions. The decision is up to you” (FA 1). It was difficult for the facilitators to judge what kind of conclusions the participants drew from the video and the debriefing. According to the facilitators, the participants usually do not state publicly whether their perceptions have changed after the debriefing.

Acceptance of Feedback

Use of Video Evidence. Sympathy and the way the facilitators provided the feedback during the debriefing were considered important for the acceptance of feedback by the participants. This was especially true for VD as no objective review media was supporting or refuting the claims of the facilitators. For example:

If you only receive verbal feedback, it [*referring to the acceptance of feedback*] depends on the type of facilitator. How likeable is s/he? Sometimes you can accept the feedback more and sometimes less easily. The facilitator’s way of providing feedback has an impact on how much you take away from the debriefing. However, if there is video evidence, you simply cannot argue about the feedback, no matter how unpleasant or friendly the way of giving the feedback was. (FG 1, P 1)

The unbiased nature of the video itself can be used by the participants to strengthen their position and to dispute the feedback of the facilitator. For example: “After a normal debriefing [*referring to VD*], you sometimes leave with the impression: ‘That did not happen like that.’ You cannot clarify it. With VAD, however, we can say ‘Let us look at it again.’” (FG 1, P 4). Although the participants expressed an advantage by using VAD to have objective evidence supporting their perception, they also acknowledged that the video can confirm the critical

comments of the facilitator. When seeing their mistakes on video, participants indicated that they often came to the same conclusions as the facilitators which resulted in accepting the provided feedback.

Facilitators shared a similar impression stating that the participants appeared to accept the feedback more easily. They also felt that VAD increased the credibility of their feedback as indicated by FA 4: “I believe that the feedback is accepted better. It is a bit like being a video-referee. With the other debriefing [*referring to VD*], they probably whisper behind my back: ‘He has no idea’.” However, facilitators also stressed that accepting feedback still depends on the person receiving the feedback. They noticed that some participants tend to explain themselves regardless of whether they have received video feedback or not. Nevertheless, the facilitators were convinced that with VAD, those participants would reflect on their actions later.

Discussions During Debriefing. According to the participants, VAD was not only used to limit discussions about whether the critical observations of the facilitators were correct or not, but also to start a reflective discussion by showing segments of the simulation and asking open-ended questions. For example: “We had debriefings in which the facilitator gave us feedback and showed us video evidence afterwards. However, it was more interesting the other way around. Seeing the video first, then having to think along and ask yourself what has happened and why things unfolded as they did” (FG 10, P 1). Through this procedure, participants felt that they gained a deeper understanding of what the facilitator wanted them to take away from the debriefing. Moreover, participants mentioned that the process of debriefing was more purposeful within VAD because discussions caused by misunderstandings between facilitators and participants were resolved faster than in VD.

Facilitators expressed mixed opinions about discussions during the debriefing. Two facilitators thought that without video, the participants shared their views about what and how things have happened among themselves leading to an open discussion during debriefing. In

their opinion, showing the video to the participants resulted in simply agreeing with the feedback. However, three of the facilitators recognised that they could use the video segments in different ways, which fostered discussion among the participants. For example: “I think it depends on how you moderate the debriefing. You can also achieve deeper discussions without VAD. However, with VAD you can stay on a more factual level, without describing situations that might be ambiguous or biased” (FA 4). Similar to the impressions of the participants, the facilitators also felt that discussions caused by misunderstandings were reduced with VAD.

Dealing With Emotions

Debriefing Forms and Different Emotions. During high-tech VAD participants were aware of the technical equipment which strengthened their feeling of “being under observation”. For example: “During the first simulation scenario [*referring to high-tech VAD*] with the microphone and the two cameras, I thought: ‘Oh, now I am being recorded. Do not say anything stupid and perform well, because otherwise it will be noticed.’ Of course, it will be noticed anyways but everyone will see it again” (FG 2, P 1). The feeling of being closely monitored led some participants to feel “stressed”, “under pressure” and inhibited from showing “natural behaviour”. These emotions seemed to change after they had their first high-tech VAD: “At the beginning, I thought to myself: ‘Oh my god!’. However, during the debriefing, I saw that I was more active than I experienced myself. Therefore, it gave me a more positive image of myself than I had during the simulation” (FG 3, P 1). Participants did not report negative emotions related to the technical equipment of lower-tech VAD. However, the idea of watching footage in front of members of the team, which might contain mistakes was considered critical within both types of VAD: “Generally speaking, I do not like seeing myself in videos, because if the simulation does not go well, you can always be exposed” (FG 10, P 4).

Facilitators had mixed opinions about the emotions of the participants regarding the debriefing forms. On one hand, they saw that some participants did not like their mistakes being displayed to other members of the team indicated by FA 3: “In one group, I had the feeling that when I tried to give constructive feedback about a problem in the treatment of the patient, one person in the team felt attacked on a personal level.” On the other hand, the facilitators mentioned that other participants were genuinely excited and reacted positively to VAD. Even though they had positive experiences with the participants, some facilitators recognised the destructive capabilities of VAD and added disclaimers before the start of the debriefing. For example: “Before we started, I said: ‘Whatever happens during this debriefing, stays in this room. The video is just an aid and not a tool to keep you under surveillance.’ and so on. If you use the video in the wrong way, you can hurt people” (FA 4). Although all interviewed facilitators preferred VAD in comparison to VD, some also had negative emotions during VAD. Depending on whether they have used VAD before, facilitators stated that it felt unusual for them and that they had to get used to the equipment first.

Balancing Positive and Negative Feedback. Overall, the participants were content with the tone within the different debriefing forms and how the facilitators balanced their feedback. For example, “I think we have a pleasant atmosphere for years now and you do not need to be afraid of being embarrassed” (FG 1, P 3).

However, this has not always been the case, as one participant remembers: “In the past, it was more like ‘I will give you hell’, but nowadays you get the feeling that you are learning something new from the debriefing” (FG 1, P 1). This change was contributed to the facilitators and how they conducted their debriefing. The participants emphasised that the facilitators need to balance their feedback as expressed by the following quote: “[...] the moderation of the facilitator is important. Showing mistakes but also providing a positive learning opportunity without being ashamed is the goal at the end of the day. And that was implemented very well today” (FG 10, P 4). Participants stated that the balancing of feedback

depends on the facilitator and is not related to the debriefing form per se. While some facilitators were perceived as rather strict, others were experienced as mild, meaning that they revealed fewer mistakes or rarely provided negative feedback.

Facilitators also recognised that balancing their feedback is important and connected to keeping the participants within the voluntary rescue force. For example: “The participants should receive a take-home message. It should not be scathing criticism, but rather pointing out what they have learned and providing constructive feedback. It is important that they also enjoy the simulation training and say: ‘Today was a great day, I want to come back next year.’” (FA 3). Therefore, the facilitators stressed that they have used VAD not only for displaying mistakes and showing where they originated but also to visualise positive situations and interactions during simulation. With VAD, they realised that they could easily create an overly negative impression of the team’s performance, which they wanted to prevent. Instead, careful moderation was important to them.

The Future of Debriefings

Current Difficulties. While VD has been their standard method of debriefing, participants reported some difficulties with VAD technology. During lower-tech VAD participants complained about the sound quality of the external microphone. As the different simulation stations were all inside one large training facility, noise from other stations was picked up by the external microphone. This led to the following problem: “You could not assign voices to individual people and there were a lot of conversations that were simply not understandable. When everybody had individual microphones [*referring to high-tech VAD*] it was a lot better” (FG 3, P 3). Another difficulty mentioned was that the video gave the participants only one camera angle which was easily obstructed by the participants during the simulation. As for high-tech VAD, participants reported better audio and video quality, but also occasional technical failures with either the audio cutting out or one debriefing in which there was no video or audio at all. During the simulations, some participants mentioned that

their lapel microphones felt very uncomfortable and that they were distracted by the microphone and its cable slipping from its intended place. Participants mentioned that the facilitators generally needed more time for their debriefing in both forms of VAD. However, as the low-tech VAD did not feature an option to mark important sections of the video during the simulation, the participants found that the facilitators needed more time during lower-tech VAD, to find the video segments that they wanted to display. This was considered negative, as it took away time from the debriefing.

Facilitators shared the opinions of the participants regarding the differences in audio and video quality between low-tech and high-tech VAD, occasional technical failures of high-tech VAD and the time-consuming nature of VAD in general. Additionally, they also reported a high cognitive demand during VAD. Facilitators described that the high cognitive demand was caused by dealing with VAD technology in combination with having to lead through the simulation simultaneously. They indicated factoring in possible technical failures as well, which in turn increased their perceived cognitive demand. FA 1 described in the following way: “You have to have a backup plan because if you rely on the VAD technology and it stops working, you have to ensure that the participants still have something to take away from the debriefing.” However, they mentioned that after getting used to both the equipment and the VAD itself, the perceived cognitive demand was reduced. Facilitators also reported that the VAD drew away the attention from their verbal explanations thus limiting the flow during debriefing. For example: “As soon as you turn on the video, the participants only pay attention to the video. So, you have to stop, then talk again and then switch on the video again” (FA 4).

Possible Future Improvements. For future debriefings, the participants linked most of their feedback to the difficulties that they witnessed during the debriefing. Therefore, one of the possible future improvements focussed on the time that the facilitators needed to find the video segments, which they wanted to show to the participants. They either proposed a

system to mark important video segments in low-tech VAD or hoped that the facilitators would gain more experience with high-tech VAD to become more proficient in finding important video segments. They also touched on the audio quality within low-tech VAD, with the addition to also have a lapel microphone for the facilitator to relate their verbal information to what the facilitators have told them during the simulation. Similar to the possible audio improvements, they also wished for more camera angles within high-tech and especially low-tech VAD. Concerning the role of the facilitators and their use of VAD, the participants wished for a unified structure during all debriefing forms. For example: “What I would like to see is an overall more structured debriefing, because we had three debriefings that all had a different structure” (FG 1, P 4).

Facilitators had similar ideas to improve future debriefings. They expressed a wish for a more intuitive way to set markers in the high-tech VAD software, or the option to be able to set markers during low-tech VAD. They also stated that they would like to have soft- and hardware that is more suitable for their simulation conditions. For instance, they indicated, that the VAD equipment was not operable inside of the cooling chamber, which they used to simulate extreme weather conditions. Lastly, some facilitators expressed the wish to either get more experience with VAD or to visit some form of training to become more proficient with the technology.

5.4 Discussion

In this study, we explored the reported experiences within two forms of VAD compared to VD. By combining both the views of the participants and the facilitators, we wanted to gain a holistic view based on the input of all the actors involved in the debriefing process. With this approach, we were able to identify the perceived positive and negative aspects that come with each distinct form of debriefing. By doing so, we created an overview that can be used by practitioners and researchers to improve the experiences connected to debriefing and thus foster learning.

In relation to our first research question “How did the participants experience high-tech VAD, lower-tech VAD and VD?”, we found that the majority of participants preferred high-tech VAD over all the other debriefing forms. Participants appreciated the superior audio and video quality, with the possibility to review the simulation from two different angles and to jump to the important parts of the video by having timestamps within the debriefing software. However, despite these technological advantages, some participants favoured lower-tech VAD or VD as the absence of head-mounted lapel microphones and two cameras was considered less intrusive and led to a more natural behaviour during simulation. This can be seen as a conflict. On the one hand, we have the fidelity of the video recording but on the other hand, this visual material might not display the true behaviour of the participants. With VD, the participants preferred the clear structure and the fact that the debriefing allowed them to discuss different ways to solve their tasks without focussing too much on specific mistakes and how they originated. These different preferences indicate that each debriefing method may cater to the individual and situational (learning) needs of the participants.

Regarding our second research question “How did the facilitators experience high-tech VAD, lower-tech VAD and VD?”, the facilitators unanimously preferred VAD over VD as it allowed for a more clear and objective debriefing, which is in line with the depiction of VAD in previous studies (Schertzer & Waseem, 2024; Villado & Arthur, 2013). They reported that the video reduced possible biases and that it enhanced the credibility of their feedback. This was considered helpful, as the visual proof was less disputable especially if the facilitator was lower in terms of medical hierarchy than the participants.

However, the facilitators noted a higher cognitive demand when managing VAD, particularly during high-tech VAD. This was caused by having to deal with the technical equipment of VAD, while simultaneously leading through the simulation. Having to split their attention could lead to errors in the observation of participants or mistakes in controlling the simulation.

Learning and Reflection Through VAD

Participants as well as facilitators recognised the value of the external perspective provided by VAD, which allowed them to review both individual performance as well as team dynamics. By seeing oneself or others during VAD, the principles of observational learning can be applied (Johnson, 2020). Through observation, relevant actions can be identified and mimicked. With the external perspective, the participants were able to see and reflect on how the actions of themselves and their colleagues were related to the performance of the team. It also corrected possible misconceptions about their performance thus fostering further reflection by the participants. These findings are in line with the studies by Ha (2014), Jacobs (2017) and Johansson et al. (2017).

However, facilitators observed that participants often only focused on their own performance, which some participants have partially confirmed. The participants' prioritisation of personal performance during VAD can be seen as less critical than the focus on task-irrelevant aspects (e.g., personal characteristics, such as "looking good") as reported in similar studies (Fukkink et al., 2011; Johansson et al., 2017). However, by focusing on one's own performance, the chances of learning from others are reduced. This finding suggests a need for facilitators to guide participants during the debriefing to balance their self-assessment with team-oriented reflections to further benefit from VAD.

Emotions and the Acceptance of Feedback

Our study showed mixed emotional responses connected to the different debriefing forms. While the equipment used within high-tech VAD caused stress and self-consciousness among some participants, these feelings partially disappeared after the participants became accustomed to the technology. However, viewing videos that contained mistakes in front of other members of the team was seen as critical within both forms of VAD. In fact, it can be considered as a threat to psychological safety. To maintain psychologically safe conditions, the facilitators employed implicit and explicit strategies such as ensuring confidentiality and

conducting the debriefing in a private environment (Kolbe et al., 2020). Furthermore, both participants and facilitators expressed the importance of balancing feedback. To balance the VAD, facilitators did not only show errors but also highlighted the positive actions that happened during the simulation. This was done to maintain motivation and to ensure psychological safety by avoiding overly harsh and one-sided feedback. Similar to the findings by Krogh et al. (2015), facilitators also noticed that VAD can easily impair the psychological safety of the participants. Although the facilitators were aware of the destructive capabilities of VAD and used strategies to maintain psychologically safe conditions, they were not always successful. For instance, one facilitator reported that the constructive feedback given was perceived as a personal attack by the participant. We conclude that the efforts needed to ensure the psychological well-being of the participants seem to be especially important within VAD and breaches to psychological safety need to be recognised and responded to by the facilitators.

The role of the facilitator is similarly important during VD, as the acceptance of feedback is also dependent on the facilitators and their relationship with the participants. This is a critical finding, as subjective values such as the likeableness of the facilitator appear to have an impact on what and how much the participants take away from the debriefing. Moreover, without a video recording supporting the argument, participants might also easily dismiss significant feedback. With VAD, both facilitators and participants stated that the objectivity of the video improved the acceptance of feedback. These findings show that even though VAD might cause initial discomfort for the participants, it was perceived as a more objective learning experience of which they reported to have profited.

Future Improvements and Recommendations

Participants and facilitators highlighted various areas for improvement concerning VAD equipment and debriefing practices. Participants advocated for better audio quality and additional camera angles, especially within lower-tech VAD. Although high-tech VAD was

superior in both aspects, it still had technical flaws and came with the drawback of increased intrusiveness and less comfort for the participants. Participants also noticed differences in the structure of the various debriefings and therefore wished for a standardised debriefing procedure.

Facilitators shared these impressions and expressed the desire for more intuitive and stable VAD systems that are also better suited for their simulation training. However, as the facilitators did not have much time to get acquainted with these systems, repeated usage and training with VAD technology might improve their experiences even without technical changes.

In conclusion, even though high-tech VAD is generally preferred for its detailed and objective nature, lower-tech VAD and VD also have unique advantages. Future developments in high-tech VAD could try to incorporate the positive characteristics of low-tech VAD and VD. For instance, improving high-tech VAD might go along with balancing the sophistication and intrusiveness of the technical equipment to have both high-quality and natural footage of the participants. Moreover, as the facilitators play a key role in managing the VAD equipment as well as guiding the debriefing, special VAD training needs to be implemented to reduce cognitive demands and maximise the educational benefits of high-tech VAD.

Limitations of the Study

It has to be noted that even though the facilitators had a separate training day on which they received technical instructions on both VAD systems, they still had limited experience in the use of VAD at the start of our study. During data collection, they gained more experience which might have affected the findings to some extent. However, when it comes to the implementation of new technology at the workplace, the initial phase of adaptation is especially important for the acceptance and continuation of new technology. As the facilitators perceived VAD as an added value, it is probable that they continue this endeavour and try out different approaches that are feasible for the simulation settings relevant to mountain rescue.

These changes might also include a revision of the current debriefing practices or the adoption of a new debriefing model altogether. The facilitators had similar approaches to the structure, expectations, and goals of the debriefing due to their training and certification within the Bavarian mountain rescue organisation. However, the participants noticed differences in the practical implementation with the addition of the new VAD technology. This is a consequence of the flexibility the facilitators had in using the video recordings during VAD. Rather than having to cohere to a newly implemented, rigid, and possibly unfamiliar debriefing structure, the facilitators were given the option to use the video recordings in their debriefings as they considered the most beneficial. While these differences in the use of video recordings created distinct experiences for the participants, we believe that this approach aligns with the exploratory qualitative design of our study. However, future practice can be improved by standardising the implementation of video recordings within the debriefing, thus creating equal experiences for the participants.

By comparing the experiences of the participants within cases, the possibility of sequencing effects exists. To minimise sequencing effects, we varied the order of debriefing forms across participants. Additionally, we have checked our data and found no evidence of potential biases that might be related to the order of debriefings. This is also reflected in our results, which show a clear preference for high-tech VAD. The preference for high-tech VAD is not consistent with the logic of sequencing effects, as they would likely lead to a more even distribution of preferences, given that the participants started with different debriefing forms at the beginning of the simulation cycle.

Similarly, the simulation scenarios might have also affected our findings. To address this potential risk, we made sure that the scenarios were comparable and included similar technical, medical, and logistical challenges. Although these efforts were made, creating truly homogeneous experiences without using the same simulation scenario is not feasible and would possibly lead to other problems, such as practice effects.

6 Study 3: Facilitating Video-Assisted Debriefing in Mountain Rescue: A Design-Based Approach³

Abstract

Video-assisted debriefing (VAD) is increasingly used to support learning from simulation-based training (SBT), yet little is known about its implementation within the context of voluntary rescue organisations, where limited resources and varying experience levels create distinct challenges. Addressing this gap, this design-based research (DBR) study examines VAD implementation within SBT in mountain rescue. Specifically, the study investigates the challenges facilitators experience and how these can be addressed within the DBR process, and how VAD influences participants' perceived stress and overall experience. Across five iterative DBR cycles over nine months, researchers and facilitators analysed challenges and developed scaffolds to support context-sensitive VAD implementation. Data were collected through observation, facilitator interviews, debriefing ratings, and assessments of participants' perceived stress before the simulation and before and after VAD. A total of 78 mountain rescuers took part, including 72 SBT participants and six facilitators. Qualitative findings identified challenges related to psychological safety, operating VAD technology and cognitive demands. To address these challenges, iteratively refined scaffolds were created, providing procedural, technical, and communicative aid. Facilitators reported that these scaffolds supported focused reflection and enabled the integration of VAD into existing debriefing structures. Quantitative results showed significant changes in perceived stress, increasing prior to VAD and decreasing thereafter. Debriefing ratings were consistently high and showed no significant variation across days or conditions. Higher debriefing ratings were significantly correlated with lower post-VAD stress and greater stress reduction during debriefing. The

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study shows that DBR can successfully support VAD implementation in the specific context of voluntary rescue organisations.

6.1 Introduction & Theoretical Background

Simulation-based training (SBT) is widely acknowledged as a powerful means to improve decision-making, teamwork, and patient safety (Saragih et al., 2024; Sung & Hsu, 2025). Especially in high-risk domains such as healthcare, aviation, the military and mountain rescue, simulations are frequently used for training, as they provide opportunities to practice complex and dynamic situations in a safe and controlled environment (Jossberger et al., 2022; Sellberg & Lindwall, 2026). These practice opportunities are important, as they are needed to engage in training focused on improving specific tasks, thus allowing the acquisition of expert performance (Ericsson, 2008). Given their reliance on volunteers, voluntary rescue organisations (e.g. mountain rescue organisations) rarely have the time to practice in real-life conditions, making SBT a necessity to train effectively (Hanus et al., 2022). However, SBT is resource-intensive and requires specialised facilities, technical equipment and trained facilitators capable of conducting both simulations and debriefings (Elendu et al., 2024).

For effective learning to occur in SBT, facilitators play a crucial role (INACSL Standards Committee et al., 2021). During simulations, facilitators create structured experiential environments in which the participants can engage with authentic scenarios and apply their knowledge and skills (Levin et al., 2023). Afterwards, the debriefing is used to reflect on and analyse previous performance, thereby providing the basis for learning and initiating change (Dieckmann et al., 2009; INACSL Standards Committee et al., 2025; Tannenbaum & Cerasoli, 2013). The facilitators are also among the key elements in debriefing, as they guide the reflection of the learners, ensure psychological safety, and help translate experiences into learning (Gardner, 2013).

Although research and training providers have developed various debriefing models and guidelines to support their work, debriefing is still considered a difficult art to learn (Duff et al., 2024). This can be attributed to the complexity and breadth of tasks, as facilitators must simultaneously monitor learner performance, structure reflection processes, manage emotional reactions and maintain psychologically safe learning environments while addressing learning objectives (Fraser et al., 2018; Husebø et al., 2024). These demands become even more pronounced when new technologies intended to support learning and reflection are integrated into SBT.

Video-Assisted Debriefing as a Promising but Demanding Approach to Debriefing

An increasingly common approach to facilitate learning from SBT is to use the captured video from the simulation within the debriefing, transforming traditional verbal debriefing (VD) into video-assisted debriefing (VAD) (Krogh et al., 2015). In contrast to VD, VAD allows participants to directly observe and reflect their performance themselves through video (Rueda-Medina et al., 2024). Based on Experiential Learning Theory, this process of reflective observation is beneficial, as it enables participants to revisit and critically examine their concrete experiences from the simulation (Kolb, 2015). By revisiting the simulation, facilitators and participants can base discussions on observable events rather than relying solely on memory and subjective reconstruction. Consequently, VAD is considered to support more objective and evidence-based reflection processes (Keiser, 2024; Schertzer & Waseem, 2024). Similarly, the use of video may reduce recall bias among facilitators and participants and help structure the debriefing process around relevant moments from the simulation (Zhang et al., 2019b). By reviewing video recordings, participants are provided with a third-person perspective on their own actions and interactions within the team. This allows them to observe communication patterns, teamwork processes, and behavioural aspects that might have remained unnoticed during simulation (Johansson et al., 2017). In general, participants report that compared to VD, VAD supports deeper reflection, enhances satisfaction, and

improves the acceptance of feedback by providing a clearer understanding of their own performance (Rueda-Medina et al., 2024; Schreder et al., 2025).

Despite these proposed advantages, empirical findings regarding the superiority of VAD over VD remain mixed. Systematic reviews by Cheng et al. (2014) and Zhang et al. (2019b) conclude that VAD generally produces learning outcomes comparable to VD, particularly regarding knowledge acquisition. These findings suggest that the effectiveness of VAD may depend less on the mere presence of video technology and more on how it is applied and integrated into the debriefing process (Krogh et al., 2015). To ensure appropriate implementation, facilitators need to overcome distinct challenges associated with the use of VAD. These challenges are related to psychological safety, operating the VAD equipment, and managing the cognitive demands, as outlined in the following subsections.

Psychological Safety in VAD. One of the central challenges concerning the implementation of VAD is to establish and maintain psychological safety, as participants in VAD are confronted with recordings of their own performance and mistakes, potentially increasing feelings of expose and vulnerability. Accordingly, participants have reported defensiveness, negative emotional reactions, and fears of appearing less competent in front of their peers during VAD (Rosvig et al., 2023; Zhang et al., 2019a). Addressing these concerns is important, as psychological safety is considered a prerequisite for effective learning and needs to be actively co-constructed throughout the simulation and debriefing (Gormley & Nestel, 2025; Kolbe et al., 2020).

Consequently, facilitators need to create and maintain psychological safety at multiple points in time, such as before, during and after the debriefing (Kolbe et al., 2020). As VAD can be new to participants, it is important to establish a "safe container" as part of the prebriefing, outlining its use in the SBT environment (Rudolph et al., 2014). In addition, confidentiality also represents a relevant part of psychologically safe debriefings and therefore needs to be addressed before and after the debriefing process (INACSL Standards Committee

et al., 2025; Kolbe et al., 2020). Ensuring confidentiality can be even more significant in VAD, as video recordings can increase concerns regarding the potential distribution of participants' mistakes beyond the debriefing.

Operating VAD Technology. In addition to the issues concerning psychological safety, VAD also introduces technological and additional pedagogical challenges related to its operation. Implementing VAD requires facilitators to use potentially unfamiliar recording and playback systems. Depending on their prior experience, facilitators may need training to get used to both the operation of the VAD technology and its pedagogical function before they can utilise it effectively during debriefing (Mishra & Koehler, 2006). However, technical difficulties may still occur. Problems with the VAD technology can require facilitators to spontaneously adapt the debriefing process or revert to VD while maintaining the continuity of the debriefing (Krogh et al., 2015; Schreder et al., 2025). Therefore, facilitators need sufficient familiarity with both VAD and VD to flexibly respond to technological disruptions during SBT.

Furthermore, the integration of video technology can extend the duration of SBT, as reviewing recordings generally takes additional time (Garden et al., 2015). In fixed time settings, the use of VAD may also reduce opportunities for discussion, as participants first focus on watching recordings before engaging in reflection afterwards (Farooq et al., 2017). As a result, facilitators need to carefully select and prioritise relevant video sequences and direct participants' attention towards specific aspects of the recordings to ensure that the videos support rather than dominate the reflective discussion. Studies on video-supported reflection similarly emphasise that facilitators must actively direct participants' attention to relevant aspects of the recordings to support meaningful discussion and reflection (Borko et al., 2011; van Es et al., 2014).

Cognitive Demands Connected to VAD Facilitation. The pedagogical and technological challenges associated with VAD may ultimately increase the cognitive demands

placed on facilitators. Even without video support, facilitators need to monitor learner performance, manage simulations, structure reflection processes, and regulate emotional dynamics simultaneously (Fraser et al., 2018). The integration of VAD adds further tasks, as it requires the operation of recording systems, the selection and prioritisation of relevant video sequences, and the integration of these recordings into the debriefing process.

At the same time, facilitators need to create and maintain psychologically safe learning environments, guide participants' attention towards intended learning objectives, and initiate as well as respond to emerging discussion points during the debriefing (Krogh et al., 2015). The additional visual input provided by VAD can even further complicate these processes, as participants may become distracted by the recordings themselves rather than focusing on the intended reflection process or the facilitator's guidance (Savoldelli et al., 2006). Consequently, facilitators in previous research have reported high cognitive demands during VAD, particularly when operating the technology while leading the simulation and accounting for possible technical failures (Schreder et al., 2025).

Contextual Challenges of Implementing VAD in Voluntary Rescue Organisations

The implementation challenges associated with VAD become especially relevant in the context of voluntary rescue organisations. In contrast to standardised professional settings such as hospitals, voluntary rescue organisations rely on volunteers often working in nonmedical professions, thus having limited opportunities to acquire and maintain their skills (Baker et al., 2025). This results in a high variability of training programmes across different voluntary rescue organisations and heterogeneous experience levels among members (Elsensohn et al., 2009; Hanus et al., 2022). Furthermore, as their service is voluntary, the experiences and therefore the motivation of the members of the voluntary rescue organisations are essential for their retention (Haug & Gaskins, 2012). The rescuers are also frequently required to operate in dynamic and high-risk environments, demanding a broad range of technical skills (e.g. navigation, climbing and movement in difficult terrain), as well

as non-technical skills (e.g. teamwork and decision-making) (Conolly et al., 2015; Westman et al., 2024).

Facilitators implementing VAD within this context therefore need to support the development of both technical and non-technical skills while simultaneously adapting SBT and debriefing processes to participants with varying levels of experience in ways that foster positive learning experiences. As facilitators are often members of the voluntary rescue organisation themselves, opportunities for additional facilitator training may likewise be limited by the time and resources available outside their regular professional occupations. Consequently, possibilities to familiarise themselves with VAD systems and train their integration into SBT may remain restricted when VAD is not a part of their professional practice. These contextual characteristics suggest that implementing VAD in such settings requires a structured and context-sensitive approach that accounts for limited opportunities for facilitator training, heterogeneous experience levels, and the various pedagogical, technological and cognitive demands associated with VAD facilitation.

Design-Based Research as the Method of Choice for Implementing VAD

Educational techniques are increasingly understood as context-dependent, as learning processes and educational practices are shaped by the specific conditions in which they are implemented (Ellaway et al., 2014). Yet, previous research has often treated VAD primarily as an additional technological tool rather than systematically examining how it should be integrated into debriefing practice and adapted to specific learning contexts (Yeun et al., 2019; Zhang et al., 2019b). More recently, studies embedding VAD within structured pedagogical approaches have emerged, reporting superior learning outcomes and experiences compared to VD (Gasteratos et al., 2024; Zhang et al., 2020a, 2020b). However, these studies were conducted in professional hospital settings and therefore under conditions that differ substantially from voluntary rescue organisations.

As voluntary rescue organisations are characterised by heterogeneous experience levels and limited training opportunities, this potentially influences how VAD can be implemented and facilitated within SBT. To address the described context, Design-Based Research (DBR) can be utilised to support and refine educational technology in authentic settings through close collaboration between researchers and practitioners (Chen & Reeves, 2020; Dolmans & Tigelaar, 2012). DBR thereby connects perspectives from educational research with the practical expertise of the specific field (Schmiedebach & Wegner, 2021). By combining development with iterative analysis and adaptation, DBR accounts for the situated nature of learning and the need to align educational technology with the conditions of practice (McKenney & Reeves, 2021).

Aim of the Study

Despite the increasing use of VAD, no study has examined its structured and context-sensitive implementation within voluntary rescue organisations. Addressing this gap is important, as research suggests that its implementation might be responsible for the mixed results associated with VAD. As voluntary rescue organisations are a part of the broader medical domain, advancements in their training can translate into improved patient safety and quality of care. Within this broader context, mountain rescuers represent an especially demanding field of voluntary rescue work, as rescuers need a wide variety of technical and non-technical skills, while working within heterogeneous volunteer groups and operating under resource- and time-constrained conditions (Callender et al., 2012; Hanus et al., 2022).

Therefore, this study aims to develop and evaluate a structured implementation of VAD within the Bavarian mountain rescue organisation using a DBR approach. The role of the facilitators is focused, as they must utilise the VAD equipment and incorporate it into their debriefing process. Having to work with VAD requires them to establish and maintain psychological safety, operate the VAD technology and deal with the cognitive demands associated with facilitating VAD, making their experiences central to understanding the

challenges in the implementation. The use of VAD in turn also affects the participants, as it may influence emotional responses, such as stress, and the overall experiences during SBT.

Therefore, the following research questions are put forward:

RQ 1: What challenges do facilitators experience during the implementation of VAD, and how can these be addressed as part of the DBR approach?

RQ 2: How does VAD impact participants' perceived stress and the overall experience in simulation training?

6.2 Method

Research Design Overview

Simulation and Video-Debriefing Setup. The study was conducted within the Bavarian mountain rescue organisation providing SBT for rescuers involved in prehospital emergency care and rescue operations. VAD was implemented within two different SBT formats (Trauma Alpine and Medic Alpine). Each training consisted of four simulation stations through which participants rotated during the training day. Only one of the stations featured VAD, while the other stations concluded the simulation with traditional VD. Both training formats were held in the central facility for the safety and training of the Bavarian mountain rescue organisation.

Trauma Alpine Training. The Trauma Alpine training was designed for mountain rescuers without any further medical qualifications, except for the medical training provided by the mountain rescue organisation itself. The first half of the training day was used to practice task-specific skills together with the facilitators. During the second half of the day, the participants had to implement these skills within four simulated scenarios. The scenario with VAD featured a patient who had fallen a flight of stairs inside a cottage, resulting in a hip fracture. The patient was responsive, but in moderate to severe pain. Participants had to correctly diagnose, stabilise and transport the patient using a rescue bag, all within a confined

space. Learning objectives focused primarily on technical aspects, while facilitators also addressed non-technical skills (e.g., situational awareness), when applicable.

The simulation was recorded and debriefed using the mobile VAD system SIMStation Go (SIMStation GmbH, 2023), allowing multi-camera recording, different microphone setups and the placement of markers throughout the simulation to navigate between relevant scenes in the debriefing. The simulation station featured three mounted cameras, including one pan-tilt-zoom camera with four preset positions. Audio for the Trauma Alpine training was captured by a centrally mounted microphone. The facilitators used a tablet during the simulation to control the pan-tilt-zoom camera and to place markers. Some markers were pre-labelled to quickly tag important events (e.g., the repositioning of the patient). Facilitators were also able to create and label markers individually to find the specific video segments during debriefing more easily. The same tablet used during simulation was also utilised during debriefing to retrieve and display the marked scenes.

In the Trauma Alpine training, one facilitator conducted both the simulation and the VAD. Besides controlling the pan-tilt-zoom camera and setting markers, the facilitator also had to mimic the patient's voice, provide information on the patient's vital signs, and act as the dispatch centre during the simulation.

Medic Alpine Training. The Medic Alpine training was designed for mountain rescuers with an additional medical background (e.g., emergency medical technician). The training was split between two separate training days. During the evening of the first day, the participants attended three 60-minute workshops concerning airway management, crew-resource management and improvised rescue operations. As part of the crew resource management workshop, participants were first introduced to the VAD. Therein, the key elements of the decision-making process used in the simulation were presented and discussed. The following day featured four simulation stations through which participants rotated throughout the day. Similar to the Trauma Alpine training, only one of the simulation stations

featured VAD. The Medic Alpine scenario featured a child who went missing in the mountains and had developed an anaphylactic reaction. The child was placed on a small overhang further down a larger climbing wall. The patient showed widespread skin reactions and severe respiratory distress. Participants had to rappel down the climbing wall to reach the child and assess its medical condition. Appropriate treatment for anaphylaxis had to be initiated, followed by the evacuation of the child from the difficult terrain. Learning objectives focused primarily but not exclusively on crew-resource management aspects and other non-technical skills.

To record and conduct the debriefing, the same mobile VAD equipment was employed as in the Trauma Alpine training. However, changes were made regarding the equipment used to record the audio, as well as the pre-labelled markers. Instead of one centrally mounted microphone, each participant was equipped with a lapel microphone. This was done to ensure optimal audio quality to specifically target non-technical skills, such as communication during the debriefing. Furthermore, as the patient was positioned at a small overhang further down the climbing wall, the participants had to split up, which made the use of one centrally mounted microphone infeasible. As the simulated scenario was different to the Trauma Alpine training, the pre-labelled markers were adjusted accordingly.

In the Medic Alpine training, two facilitators were responsible for the simulation and the debriefing. Similar to the Trauma Alpine training, one of the facilitators remained near the participants, mimicking the patient's voice, providing information on the patient's vital signs, and acting as the dispatch centre. The second facilitator was in a separate control room, operating the pan-tilt-zoom camera and setting markers. This facilitator also conducted the VAD.

DBR Process. Building upon both training formats, the overall study followed Reeves four-phase Design-Based Research model (2006), consisting of (1) the analysis of practical problems, (2) the development of solutions, (3) the iterative cycles of testing and refinement,

and (4) the reflection to further improve the implementation of VAD. An overview of the DBR process and its application within the present study is provided in Figure 4.

The first phase began with reviewing the challenges surrounding the use of VAD within simulation-based training. Findings from prior research on the experiences with different debriefing formats (Schreder et al., 2025; Zhang et al., 2019b), as well as feedback from the head of training and simulation for the central training facility were examined. The preliminary consultation with the head of training and simulation revealed that the facilitators for this study vary in their medical and professional backgrounds. Their approach to debriefing was influenced by different training providers as well as their main jobs, reflecting the voluntary nature of the mountain rescue organisation. However, all facilitators were used to conduct their debriefing based on the *Debriefing With Good Judgement* model (Rudolph et al., 2006), with its advocacy-inquiry approach. A step-by-step instruction sheet on how to perform the debriefing according to this approach already existed within the central online knowledge management tool of the mountain rescue organisation. Regarding the technical implementation, the organisation had purchased a new VAD system, replacing an earlier system that had been used on a limited basis and was considered inferior. At the start of the DBR project, this system had not been in use yet. To complete the first phase of analysis, an initial simulation training featuring the new VAD system was conducted, and semi-structured observations were made.

In the second phase of the DBR process, an initial design for the implementation of the new VAD system was developed. As the facilitators within the mountain rescue organisation were all familiar with the same approach to debriefing, the *Debriefing With Good Judgement* model was adapted as the basis for VAD. Facilitators were instructed to present the selected video recording to participants and invite them to describe their observations. The aim was to enable the participants to identify potential errors or suboptimal performance on their own, before the facilitator adds any further elaboration. If the participants do not point out the

intended aspects, the facilitators are still able to replay the footage, use still frames and share their own observations. This adaptation maintained the original advocacy-inquiry structure while performing VAD. Additionally, as the video recordings can be perceived as exposing and potentially threaten the psychological safety of the participants, guidelines to establish a safe learning environment were also added. To introduce the facilitators of the first training day (Medic Alpine, May 2025) to the project and actively involve them in the process, an online introductory meeting was held. It outlined the project objectives, the partnership between the research team and the mountain rescue organisation, the key findings from prior research, and the adapted debriefing model. The session concluded with room for questions and discussion, allowing the facilitators to contribute their perspectives and to identify potential challenges or impractical elements. Furthermore, all facilitators received an online introductory meeting to the new VAD system by the manufacturer. During this meeting, the key functions and setup of the system were explained.

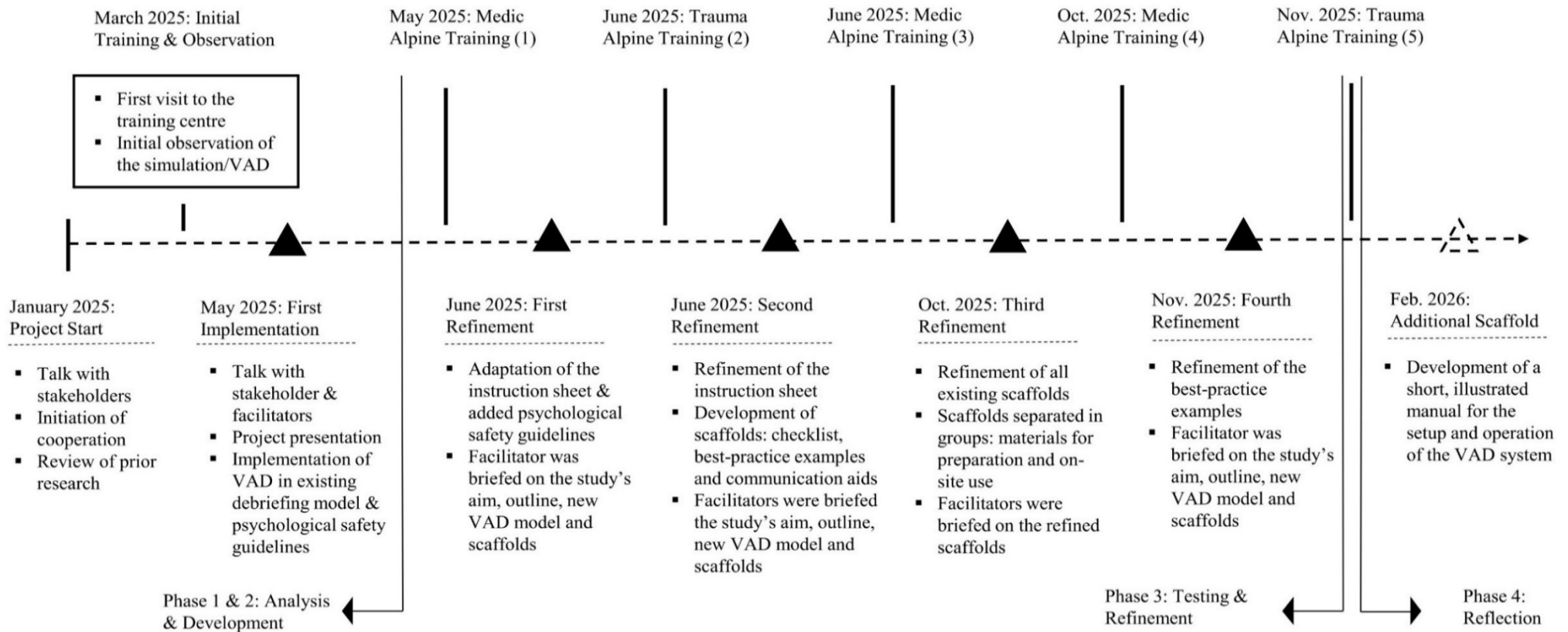
During the third phase, the new VAD system, the adapted debriefing model and the guidelines to establish psychological safety were implemented in five separate training days and iteratively refined over the course of nine months. After each training day, the qualitative and quantitative data were reviewed. Based on the data, adjustments to the model as well as additional scaffolds were made to support the facilitators. As depicted in Figure 4, the scaffolds created over time included an adapted step-by-step instruction sheet on how to perform the VAD, best-practice examples (differentiated in Medic Alpine, Trauma Alpine, and general application), a VAD checklist (covering preparation and in-session use), a communication aid (e.g., for initiating VAD sequences and directing attention to relevant aspects), and a short illustrated manual for the setup and operation of the VAD system, including key functions. The materials were structured according to their intended use: resources for preparation (best-practice examples and the instruction sheet) and materials for

on-site use immediately before or during training (VAD checklist, communication aid, and the short manual).

For the final phase, the iterative development and implementation of the VAD is reflected within the results and discussion part of this paper.

Figure 4

Depiction of the DBR Progress and the Developments Within the Course of the Study



Participants

The study included all facilitators and participants available for the Medic and Trauma Alpine training sessions conducted within the DBR project period. The resulting sample consisted of 78 mountain rescuers, including 72 SBT participants and six facilitators. Of all participants, 40 attended the Medic Alpine training and 32 the Trauma Alpine training. One participant did not provide any demographic details.

The Medic Alpine training was intended for skilled mountain rescuers with an additional medical background, which was reflected in the biographical data showing higher levels of experience. As displayed in Table 8, the participants of the Medic Alpine group reported a higher number of missions per year and had considerably more prior experience with VAD than those in the Trauma Alpine group. The mountain rescuers participating in the Trauma Alpine training were on average older and held a longer membership within the mountain rescue organisation.

Table 8

Participant Characteristics by Training Group

Variable	Medic Alpine	Trauma Alpine
Age	36.40 (12.38)	41.94 (13.06)
Years of active membership	14.10 (10.75)	15.61 (13.08)
Missions per year	26.30 (36.07)	15.18 (15.01)
Experienced VAD sessions	3.18 (6.93)	0.03 (0.18)

Note. Displayed values are mean (SD). *N* ranging from 70 to 71 due to missing values.

The six facilitators had a mean age of 40.67 years ($SD = 11.66$) and had been members of the mountain rescue organisation for an average of 21.67 years ($SD = 10.84$). Only half of them had already experienced VAD as facilitators themselves. The facilitators were assigned

to either one of the training formats, except for one facilitator who worked in both training formats.

Instruments

Biographical Questionnaires. Biographical details (such as age and gender) as well as information about the participants' and facilitators' experience were gathered using a biographical questionnaire.

Observation Form. A semi-structured observation form was used to document all relevant aspects that happened during each simulation day, serving as the basis for additional interview questions to revisit and further explore noteworthy events. The form included bullet points addressing possible differences between simulation days (e.g., procedural changes) and specific sections that focused on the prebriefing, simulation and debriefing. An open field was provided for additional notes.

Semi-Structured Interview. All facilitators were asked questions about their implementation and use of the VAD, how the participants experienced the debriefing, what (technical) challenges they had to overcome and how to further improve the implementation of VAD. The interview incorporated questions adapted from Schreder et al. (2025). These questions were, in turn, derived from the DASH – Instructor Version questionnaire (Simon et al., 2012), which was used as the conceptual foundation. Additional questions were generated based on the observations made during the training day (e.g., when there was a disruption in the debriefing process). Depending on whether the facilitator had prior experience with VAD, questions comparing their individual experiences were also added.

Stress and DASH Questionnaire. Perceived stress was measured using a 100 mm Visual Analogue Scale (VAS), where participants marked their current stress level on a continuous line with its end points defining the extreme limits of stress (0 = no stress to 100 mm = extreme stress). Scores were calculated by measuring the distance of the mark from the zero anchor in millimetres and converting to a 0-10 scale (e.g., 56 mm = 5.6). The VAS was

chosen as a valid and especially time-efficient measure of stress, showing comparable sensitivity to differences in stress levels as other instruments, such as the Perceived Stress Scale (Lesage et al., 2012). Measurements were taken prior to the simulation (T1), before VAD (T2), and immediately after VAD (T3).

To measure the perceived debriefing quality of the VAD, the German participant version of the Debriefing Assessment for Simulation in Healthcare (DASH) questionnaire was utilised (Simon et al., 2013). Featuring six items on a 7-point Likert-type scale (1 = extremely ineffective/detrimental to 7 = extremely effective/outstanding) a good internal consistency of Cronbach's $\alpha = .872$ was reached. Descriptive statistics for the individual items are presented in Table 9.

Table 9

Descriptive Item Statistics and Internal Consistency for the German DASH Short Form

Item	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Item 1	6.14	0.72	4	7
Item 2	6.18	0.72	4	7
Item 3	5.94	1.05	2	7
Item 4	6.08	0.97	3	7
Item 5	6.18	0.90	3	7
Item 6	6.06	0.93	3	7

Note. Internal consistency: $\alpha = .872$. *N* ranging from 70 to 71 due to missing values.

Data Collection

At the start of the training day, participants were welcomed and briefed about the course of the training day and the upcoming simulations. Special emphasis was placed on introducing the VAD, establishing psychological safety and explaining the data collection. To ensure the psychological safety of the participants, possible errors during the simulation were

framed as learning opportunities. Participants were also informed that the video recordings were only used during the debriefing of the respective team and immediately deleted afterwards, thereby maintaining confidentiality. Furthermore, it was explained that the VAD would be as respectful and constructive as VD.

After the prebriefing, the participants were given the option to decline participation in the study and the VAD. All participants then completed a written consent form, and the APA Ethical Principles of Psychologists and Code of Conduct were followed. Next, the participants received the biographical questionnaire. Once the biographical data collection was completed, teams of three to four rescuers were formed. Depending on the training, the rescuers were completely free to form their teams (Trauma Alpine) or needed to include at least one emergency physician on their team (Medic Alpine), to perform procedures otherwise prohibited under German law (e.g., administering medication). Subsequently, participants either started with the simulation cycle (Medic Alpine) or trained task-specific skills for the first half of the day and then transitioned into the simulation cycle (Trauma Alpine). Before the start of the scenario featuring VAD (T1), the participants were asked to make an initial stress rating. After the simulation, the participants were guided to the debriefing room, where they gave their second stress rating just before the start of the VAD (T2). After the VAD, the participants had to fill in the DASH questionnaire and make a last assessment of their perceived stress (T3).

Facilitators were informed in advance about the study and data collection and received a consent form as well as a biographical questionnaire. All eight individual facilitator interviews were conducted after the training day by the first author. Except for one interview, audio recordings were made to support the transcription. Due to technical difficulties in this case, detailed written notes were taken during the interview and expanded afterwards. Interviews had a duration ranging between 25 and 78 minutes ($M = 54.38$, $SD = 16.61$). All

interview data was described verbatim, and quotes have been translated from German to English for the purpose of illustration.

The semi-structured observation form was used during the prebriefing, simulation and debriefing phases of the training day. Handwritten notes of the observations were made by the first author of the study. As no member of the research team was able to attend one of the Medic Alpine training days, no observational data was collected. Nevertheless, the training proceeded as scheduled, and all remaining data collection instruments were administered by the facilitators as well as the head of training and simulation of the training facility.

Analysis

Qualitative Analysis. Qualitative Data was analysed using a deductive and inductive approach in line with Mayring's (2021) qualitative content analysis methodology. Grounded in previous research and the structure of the interviews initial deductive categories were created. During the coding process, these categories were refined, and additional inductive categories and subcategories were added based on facilitators' responses. As displayed in Table 10, a total of 12 categories with between three and eight subcategories emerged.

Table 10

Overview of All Qualitative Categories and Their Respective Subcategories

Category	Subcategory
1. Implementation and structure of VAD	Explicit debriefing structure
	Implicit debriefing structure
	Adaptation of predefined structures
	Integration of VAD in the existing structure
	Handling of interruptions
2. Use of videos in the debriefing	Didactic use of videos
	Number and duration of video sequences
	Marking strategies

	Camera position and perspective
3. Emotions and psychological safety	Positive experiences Challenging or unfamiliar experiences Negative experiences Management of psychological safety
4. Participants' responses and learning processes	Participants general reactions Reflective processes Acceptance of feedback Observational learning Facilitation of in-depth discussions Clarification of uncertainties and problems Individual feedback and learning needs Learning outcomes and behavioural change
5. Technology and technical issues	Operational difficulties System failures Audio and video quality issues Workflow disruptions Appropriateness of the technical setup
6. Technology-related improvement requests	Usability and time efficiency improvements Contextual adaptation of technology Optimisation of camera and audio equipment Communication systems for instructors
7. Facilitators' cognitive demands	Multitasking Concentration over time Role-related cognitive demands Attention management strategies
8. Cooperation between facilitators	Role allocation Coordination and communication Role and position experiments Information asymmetry

9. Suggestions for improvement	Project-level improvements Improvements to supporting scaffolds Future-oriented development ideas Development of facilitators competencies
10. Developments within the project and facilitators' experience	Influence of facilitators experience Developments within the current project References to prior experiences
11. Contextual conditions	Voluntary nature of participation Professional background of participants Comparison of training formats Technical training on the VAD system Planned but unrealised framework conditions
12. Added value of the project	Value of the introductory meeting and briefing of the facilitators Use and value of the supporting scaffolds Value of the participation in the interviews Value of the researchers' support

Coding was performed by the first and second author. After the first author coded 25% of the material and iteratively refined the categories, both authors discussed the coding frame in detail, reviewed the coded interviews together, and revised the codebook. Inter-coder agreement was calculated after separately coding another interview and resolving ambiguities, resulting in Cohen's $\kappa = 0.78$, indicating substantial agreement. The remaining interviews were coded independently by the first author, with an additional joint coding of the penultimate interview to ensure coding frame stability.

For the purpose of reporting, the categories and subcategories were subsequently condensed and synthesised into higher-order themes that align with the research questions. The results section therefore focuses on overarching themes that capture facilitators'

experienced challenges, how they were addressed within the DBR process (both RQ 1), and participants' experiences as perceived by facilitators (part of RQ 2).

Quantitative Analysis. To further answer the second research question, the quantitative analysis was separated into three sections. First, the development of stress across the three points of measurement (T1-T3) was examined using a repeated-measures ANOVA to evaluate whether the perceived stress of the participants changed significantly over the course of the simulation and VAD. This was done to examine whether VAD both elicits stress (T2) and successfully reduces it immediately afterwards (T3), all in comparison to a baseline measurement (T1).

The second section focused on possible changes in the perceived debriefing quality both between and within the different simulation days. Descriptive data, as well as a linear regression analysis was used to investigate whether the quality of debriefing has significantly improved over the duration of the study. To see if there was any within-day variation in DASH scores, indicating the possibility of improvement through practice or a deterioration caused by exhaustion, a linear regression was conducted. Group order was included as the predictor and simulation day entered as a categorical control variable. As the two training formats had a different facilitator setup (one facilitator [Trauma Alpine]; two facilitators [Medic Alpine]) a moderation analysis was used to see if the difference in workload moderated the relationship between group order and DASH ratings. This analysis explored whether the debriefing quality declined over the course of the simulation day due to the possibility of increased fatigue when facilitators had to conduct both the simulation and the debriefing alone.

For the last section, relations between the debriefing quality (DASH) and the different points of stress measurements were analysed. Descriptive statistics, as well as a correlation analysis over all three points of stress measurements (T1-T3) and the mean DASH score, were calculated. Correlations with stress at T1 and T2 were used as baseline checks to see whether

associations with DASH ratings reflected pre-existing stress differences. An additional Pearson's correlation between the difference in stress between T2 and T3 and the DASH score was performed to assess whether perceived debriefing quality relates to stress reduction rather than initial stress levels.

As there was no data for the group order on one measurement day, only four measurement days provided data for the within-day and moderation analyses within section two. For all other analyses, the full number of participants over five measurement days was used.

6.3 Results

The results of this study are presented in two parts and structured according to the research questions. To answer research question one, qualitative findings concerning the facilitators' challenges in implementing VAD are presented, focusing on psychological safety, operating the VAD equipment and managing cognitive demands. These challenges are then further examined in terms of how they were addressed within the DBR process.

To address research question two, participants' experiences are described from the facilitators' perspective, including their reactions to VAD, its influence on reflection, acceptance of feedback, and the provision of an outside perspective. In addition, quantitative results regarding participants' perceived stress and debriefing quality are reported. Direct quotes from facilitators are labelled using anonymised identifiers (FA 1-6).

Facilitator's Challenges and Strategies in Implementing VAD

Psychological Safety. Overall, facilitators described that creating and maintaining psychological safety was an integral challenge for them. One aspect mentioned in this context was that participants can enter the SBT with pre-existing negative feelings regarding the facilitators, which may be reinforced by VAD. As FA 4 further explained: "In the past, it was often the case - and unfortunately, this is still quite present in people's minds - that participants would say, 'Oh God, let's see which instructor is there. Depending on that, I'll

either be fine, or I'll be treated like a student.' [...] I think it is still an issue that, depending on how the instructors present themselves, participants can experience stress in these situations."

In addition, FA 3 reported that the knowledge about being recorded influences the behaviour of participants. In one instance, a participant retrieved a climbing harness despite being informed that it was not required for the specific scenario. The participant stated that it would look better on video and left to retrieve the harness, causing a brief delay. FA 3 interpreted this reaction as a sign of uncertainty and increased self-awareness when being recorded.

Lastly, facilitators also have to remember to establish and maintain psychological safety themselves. FA 1 reported having omitted to address psychological safety at the beginning of the debriefing, which was then prompted by the second facilitator. As FA 1 explained: "I had it in mind, but I forgot to mention it during the first scenario. The second facilitator then pointed it out, and I realised, 'Yes, that's right.' I included it in the second round, but I did not notice a clear difference myself."

Operating the VAD Equipment. Another challenge concerned the operation of the VAD equipment itself. This was in part due to the design of the SBT, as within the Medic Alpine training the two facilitators responsible for the training station were separated from each other. While dealing with technical difficulties, FA 4 and FA 5 noted the lack of a direct communication channel between each other. This limited their ability to respond to technical issues in real time, for example when problems with the audio setup occurred. As FA 4 stated, it would have been beneficial "to have some form of connection [...] so that if something failed or could not be heard, you could stay in contact."

In addition to these situational constraints, differences in facilitators' prior experience also influenced the operation of the VAD equipment. While some facilitators had prior experience with similar systems, others had little to no experience with VAD in general. Facilitators with experience reported only minor handling-related issues, such as being

unaware of certain functions (e.g., selecting specific camera angles during debriefing). These issues were largely resolved during the training day through the support provided by the head of training and simulation, as well as the first author.

In contrast, facilitators with limited or no experience expressed dissatisfaction with the initial technical introduction provided by the manufacturer, which was described as theoretical and lacking opportunities for hands-on practice. FA 3 reported that: “It was only an online session. The representative from SimStation was connected remotely, and six of us were sitting in a room while everything was explained to us [...] We did not have the chance to do scenarios and practise the basics, such as switching views or using play and pause. It was a classic manufacturer introduction.”

The complexity of the system was also described as a barrier for inexperienced facilitators. As the Medic Alpine training consisted of two facilitators, FA 4 chose to remain in the role of conducting the simulation rather than operating the VAD equipment and later lead through the VAD. FA 4 explained: “I had another look at the technology beforehand because I was not sure how it would actually work and whether it would function for me. I think you have to sit down and try it, and trust that you can handle the system [...] The debriefing itself did not put me off at all. It is the technical side - operating everything within the given time and then bringing it all together into a coherent debriefing.”

Managing Cognitive Demands. The challenges in managing the cognitive demands of operating the VAD equipment and conducting the debriefing was described differently between the two training formats. Facilitators in the Trauma Alpine training reported a higher cognitive load, which they mainly attributed to having to manage multiple tasks at once, including leading through the simulation, operating the VAD equipment and acting in different roles. While some facilitators reported that handling these demands became easier during the day, they also described a decline in concentration over time. This affected their ability to find relevant scenes as FA 3 stated: “[...] by the fourth group, I was already

cognitively quite exhausted, and it became very difficult to identify meaningful moments to focus on.” In addition, identifying and setting appropriate annotations was described as demanding within the Trauma Alpine training. Facilitators reported that the available time and cognitive resources were often too limited to precisely label the individual annotations during simulation. In some cases, the imprecise labelling then led to confusion during the debriefing phase. FA 3 reported: “I had a case where I set a marker and labelled it ‘comm’ for communication, and then another one also as ‘comm’ for communication. In the end, I had three markers labelled communication, and I found myself wondering what exactly I had meant with each of them.”

Lastly, generally having experience as a facilitator was also described as helpful in regulating cognitive demands, as FA 1 explained: “There were times when I did not write down anything for about ten minutes. I was, in a way, taking a short break because I knew that not much was going to happen. I kept my focus on what was going on, but in a way that allowed me to switch off half of my brain, and that does help.” However, this was only possible within the Medic Alpine setup as the facilitator was separated from the participants and was not directly involved in the simulation.

Strategies to Support the Implementation of VAD. Based on the identified challenges, several strategies to support the implementation of VAD were developed and refined as part of the DBR process. These strategies were operationalised using the scaffolds introduced in the method section. The following sections describe how these supporting scaffolds were used to address challenges related to psychological safety, operating the VAD equipment, and managing cognitive demands.

To address challenges related to psychological safety, the step-by-step instruction sheet explicitly included the establishment of psychological safety and provided example formulations. This aspect was also integrated into the VAD checklist to reduce the likelihood of omission. In addition, during the study the placement of cameras was adjusted to minimise

intrusiveness while retaining good coverage over the scenario. However, the different microphone setup between the Medic and Trauma Alpine training remained a trade-off between audio clarity and perceived intrusiveness. While the centrally mounted microphone used in the Trauma Alpine training was considered sufficient in terms of overall sound quality, facilitators reported difficulties in distinguishing individual voices, which limited their ability to focus the debriefing on non-technical skills such as communication. This problem did not exist in the Medic Alpine training, where individual lapel microphones allowed for more precise feedback but increased participants' awareness of being recorded.

Supporting the operation of the VAD equipment, technical additions were introduced, and their use was described within the supporting scaffolds. To connect the facilitators during the Medic Alpine training, both received a handheld radio. As specified in the best-practice examples, this communication channel was intended to be used for quick coordination in case of technical issues. However, in one instance, the handheld radio was utilised to influence the scenario in an unplanned manner. In this case, the facilitator operating the VAD equipment instructed the facilitator in charge of the scenario to deteriorate the patient's condition, which had not been predefined or coordinated beforehand. This led to a temporary stop of the simulation, as the participants were unable to respond adequately. The facilitator responsible for the scenario later described negative emotions related to this incident, particularly due to a lack of shared understanding of the intentions behind the intervention. Although problematic in this case, the handheld radio was described as a useful tool for adapting the difficulty of the simulation in real time, particularly when dealing with participants with different skill levels. However, this requires prior coordination between both facilitators. Following this instance, guidance on the use of the handheld radio was updated within the best-practice examples. Focusing on the differences in facilitators' prior experience the VAD checklist included a preparation section suggesting facilitators to familiarise themselves with the system and ensure its functionality at the beginning of the training day. Additional guidance was provided

within the best-practice examples. In later stages of the DBR process, a short step-by-step manual was developed to support facilitators in recalling key functions of the VAD system, as some facilitators reported that they had already forgotten parts of the initial technical introduction. Facilitators also raised the idea of additional hands-on training or supervision by more experienced facilitators which could not be implemented as part of this study, due to organisational constraints.

To help the facilitators reduce cognitive demands, annotations matched to the content of the scenarios were created, thus reducing the need for labelling during simulation. The VAD checklist as well as the best practice examples both encouraged the facilitators to review and individualise the annotations if needed before the start of the SBT. Further suggestions for effectively managing cognitive demands were included in the best-practice examples, such as the use of prioritisation strategies. As part of the supporting scaffolds, the VAD checklist and communication aid were both designed to be used during the debriefing itself, helping with a structured approach and serving as a fallback in situations of high cognitive demands.

All materials were iteratively refined based on facilitators' feedback and observations throughout the study. For example, the VAD checklist was revised, reduced in size and laminated to improve usability during training. Within the course of the study, facilitators also developed their own strategies. As an example, FA 3 adapted a small situational practice to reduce hierarchical differences and gain an initial impression of participants' emotions. This was done by simply walking into the debriefing room together with the participants, resulting in a more collaborative atmosphere and reducing anticipatory tension. Having contact with the participants right after the simulation also allowed the facilitator to gain insights into the immediate reflections and emotional responses of the participants, thus offering hints to direct the focus of the debriefing. Overall, the facilitators reported that they were able to successfully integrate VAD into their existing debriefing practices and stressed the positive effects of the supporting scaffolds. FA 3 stated: "[...] I was able to integrate it [VAD] quite

well into my existing debriefing structure, which made it easier, from my perspective, to conduct a brief and meaningful debriefing.” Concerning the supporting scaffolds, FA 6 noted: “I find the checklists really useful. They definitely influence my debriefing because they provide structure. Overall, they are worth reviewing and can be useful to have on hand during the video debriefing.”

Participants’ Perceived Stress and Experiences with VAD

Participants’ Experiences from the Facilitators’ Perspective. The facilitators described that the participants were interested and open towards the debriefing approach, as many had little or no prior experience with VAD. FA 4 noted: “They found it quite exciting to see what happened, how they did and what it looked like from an outside perspective.” In some cases, the participants even expressed the wish to take the video recordings home. The facilitators contrasted the present context with professional medical settings, in which attendance is mandatory and was perceived to negatively influence the participants’ engagement with the debriefing.

It was also reported that the VAD has stimulated reflection among the participants, as FA 1 explained: “I heard it afterwards during the break, because the participants talked about it. Then you heard things like, ‘Was it really like that?’, ‘Oh no, really?’, or ‘I think I need to change something’.” However, the facilitators also noted that the participants did not always take part in the reflective processes the same way. When non-technical skills were addressed and no clear errors were visible, facilitators perceived some participants as indifferent to the feedback, often justifying their actions on established routines.

At the same time, facilitators reported that VAD supported the acceptance of feedback when relevant actions were clearly visible. As FA 3 explained: “It makes the debriefing much easier, because if you try to explain something verbally, some participants will say that they did not notice it, while others say it was not that bad. But when you show the video, it becomes a much more striking argument.” Nevertheless, the same facilitator also

acknowledged that this effect depends on the subjective experience of the participants and how well the video displays what the facilitator wants to focus on.

Finally, the facilitators described that the outside perspective provided by VAD was beneficial for the participants' understanding of what had happened in the simulation. The participants were perceived as being highly focused during the simulation, which limited their situational awareness. The video offered an additional perspective that could support reflection on individual and team performance. However, depending on the focus of the debriefing, learning from peers was described as more limited, especially when non-technical skills were targeted. As FA 2 noted: "In this particular case today, I found it difficult because it was often not about actions, but mainly about communication."

Stress Development During the Simulation Training. The repeated-measures ANOVA showed a significant effect of time on participants perceived stress ($F(2,138) = 22.22, p < .001, \eta p^2 = .244$), with a large effect size of $f = .57$. Participants reported low stress prior to the simulation (T1: $M = 1.50, SD = 1.21$), increased stress immediately before VAD (T2: $M = 2.46, SD = 1.60$), and decreased stress after VAD (T3: $M = 1.00, SD = 1.18$). Bonferroni-corrected pairwise comparisons indicated that stress was significantly higher at T2 than at T1 ($p < .001$), and significantly lower at T3 compared to both T1 ($p < .001$) and T2 ($p = .046$).

Change of Perceived Debriefing Quality (DASH) Between and Within Training Days. Over the course of the study, the participants' mean DASH ratings indicate a high level of perceived debriefing quality, with a score of $M = 6.10 (SD = 0.69)$ on the 7-point scale. The DASH scores for each of the five measurement days were 5.92 ($SD = 1.01$), 6.49 ($SD = 0.37$), 5.95 ($SD = 0.58$), 6.26 ($SD = 0.49$) and 5.82 ($SD = 0.66$), respectively. A linear regression analysis showed no significant effect of time (measurement day) on DASH scores ($F(1,69) = .40, p = .53$).

To examine potential within-day variation, first, a linear regression was conducted with group order as the predictor and simulation day included as a categorical control variable. The overall model was not significant ($F(2, 58) = 1.72, p = .188$), and neither the group order ($t = -1.65, p = .105$) nor the simulation day contributed significantly to the model ($t = -1.01, p = .317$). The second regression including facilitator setup (one facilitator [Trauma Alpine]; two facilitators [Medic Alpine]), and its interaction with group order also yielded no significant effects ($F(3, 57) = 0.90, p = .445$). The interaction between group order and facilitator setup ($t = -0.30, p = .768$), the main effect of group order ($t = -0.99, p = .325$), and the main effect of facilitator setup at the mean level of group order ($t = -0.52, p = .603$) were not significant.

Relations Between Debriefing Quality (DASH) and Stress. Descriptive statistics and correlations between the overall DASH score and the stress measurements (T1 – T3) are presented in Table 11. Higher perceived debriefing quality, as measured by the DASH, was significantly associated with lower levels of residual stress immediately after VAD ($r = -.35, p < .01$).

To examine whether the perceived debriefing quality was also related to the change in stress across the debriefing period, an additional Pearson's correlation was conducted using the difference in stress between T2 and T3 and the DASH rating. The analysis showed a positive association between the difference score and the DASH ($r = .24, p = .047, N = 70$), indicating that higher DASH ratings were associated with greater reductions in stress after VAD.

Table 11*Correlations Between the Overall DASH Score and the Stress Measurements at T1 to T3*

Variable	<i>M</i>	<i>SD</i>	1	2	3	4
1. Overall DASH score	6.10	0.69	—			
2. Stress before simulation	1.51	1.20	-.17	—		
3. Stress before debriefing	2.45	1.58	.03	.15	—	
4. Stress after debriefing	1.05	1.25	-.35**	.01	-.04	—

Note. Values are Pearson correlations (two-tailed). Pairwise deletion was used with *N* ranging from 70 to 72 due to missing values.

** $p < .01$.

6.4 Discussion

This study explored the structured implementation of VAD within the specialised context of the Bavarian mountain rescue organisation. In our DBR approach, we focused on the facilitators' challenges and their iterative resolution. By comparing the stress and the experience of participants over time and between different training formats, we further evaluated the results of the implementation. Although the facilitators reported various difficulties, the overall findings point towards a successful integration of VAD. However, it is also evident that the refinements developed through the DBR process can create new challenges requiring further adaptation.

Regarding our first research question, “What challenges do facilitators experience during the implementation of VAD, and how can these be addressed as part of the DBR approach?”, we discovered that even when implementing new technologies, facilitators have to consider the past experiences of the participants, emphasising the importance of establishing and maintaining psychological safety. Previous studies repeatedly highlighted the challenge connected to participants' feeling of psychological safety, as they fear being exposed as less competent by the video recordings (Ha, 2014; Rosvig et al., 2023). Consequently, psychological safety was explicitly addressed during dedicated phases of the

SBT, such as the prebriefing and prior to the debriefing itself, following recommendations from the literature (Kolbe et al., 2020; Rudolph et al., 2014). However, as there are multiple tasks involved in conducting VAD and the experience of the facilitators varied, we found that steps in the debriefing process may be forgotten or confused. The DBR approach addressed this by embedding important practices in supporting scaffolds, such as the VAD checklist, helping facilitators to consistently handle central elements (e.g., establishing psychological safety) and reducing the likelihood of omission in practice (cf. Sellmann et al., 2022).

Our findings further suggest that both organisational and individual factors influenced the challenges connected to operating the VAD equipment. While facilitators with prior experience reported smaller handling-related difficulties, facilitators with limited or no experience were intimidated by the technology. The technical introduction held by the manufacturer did not allow for hands-on training in a low-pressure environment, therefore the facilitators were not able to build confidence in operating the system. While the DBR approach led to the development of supporting scaffolds and technical additions aimed at facilitating the operation of the system, larger structural improvements (e.g. additional practical training or supervision) were wished for but could not be implemented due to organisational constraints. The limited feasibility of additional interventions reflects the general contextual conditions of voluntary mountain rescue work, in which scarce time resources affect opportunities for learning and practice (Hanus et al., 2022; Nicols et al., 2014). The introduction of the handheld radio as a technical addition showed that the unintended use of supporting materials can create new problems and require careful preparation. This aligns with the iterative logic of DBR, in which solutions created to address existing problems may also create new tensions or challenges that require further refinement within the process (Amiel & Reeves, 2008).

Concerning the cognitive demands associated with conducting VAD, we found differences based on the training format. Facilitators within the Trauma Alpine training had to

do more multitasking, as they also needed to act in different roles and manage the simulation by themselves. This led to problems in recognising their annotations during debriefing and increased fatigue over time, affecting their ability to identify relevant scenes while facilitating the simulation. Experienced facilitators were able to regulate their attention and manage the cognitive demands of VAD, however this was only possible within the Medic Alpine condition. Fraser et al. (2018) defined debriefing as a complex and cognitively demanding activity that requires facilitators to simultaneously manage multiple pedagogical, social, and organisational tasks. The authors further suggest that frameworks and cognitive aids can support facilitators in managing these demands. Accordingly, these suggestions were implemented in the present study, as the VAD approach was embedded within the already established debriefing framework of *Debriefing With Good Judgement* (Rudolph et al., 2006), and the supporting scaffolds appeared to have assisted the facilitators in managing the cognitive demands by providing structure.

In relation to our second research question, “How does VAD impact participants’ perceived stress and the overall experience in simulation training?” we found that the perceived stress ratings changed significantly over the three measurements (T1-T3), showing that participants experienced low stress before the simulation, followed by an increase immediately before VAD and a decrease immediately afterwards. These findings are partly consistent with Zhang et al. (2020b), who also reported a decrease in stress following VAD. However, unlike the present study, their participants reported the highest stress levels prior to the simulation, followed by decreasing stress throughout the simulation and debriefing process. Looking more closely into the participants’ perceived stress, we saw that higher perceived debriefing quality was associated with lower residual stress after VAD, while higher DASH ratings were also related to greater reductions in stress across the debriefing period. Similar to the results and argumentation of Zhang et al. (2020b), we assume that anticipating debriefing is generally stressful, as participants might have concerns about negative

evaluation and their professional self-image. At the same time, the reduction in stress after the debriefing suggests that VAD itself did not function as an additional stressor. Rather, participants who perceived the debriefing as supportive and well-structured also appeared to leave the debriefing with lower residual stress.

Investigating the overall experiences of the participants, the scores of the DASH questionnaire measuring the perceived debriefing quality showed comparatively high values across all six items. These findings are in line with previous studies reporting similarly high DASH ratings when debriefings are conducted by experienced facilitators (Brown et al., 2018; Fey et al., 2014). Although no significant increase in DASH scores was observed over the course of the study, the consistently high ratings indicate a stable perception of debriefing quality. This is interesting given that the facilitators reported increasing fatigue over time, which did not translate into a deterioration of perceived debriefing quality. Similarly, despite higher reported cognitive demands in the Trauma Alpine setting, no significant differences in DASH scores were measured between the training formats. Taken together, these findings may indicate that structured VAD approaches, supported by scaffolds, help maintain a consistent level of debriefing quality even under varying facilitator demands.

To further contextualise the high DASH scores, facilitators' perspectives on the experiences of the participants suggest that VAD was widely perceived as positive. This aligns with previous research indicating that VAD can facilitate participants' engagement in reflective discussions and their acceptance of feedback (Rueda-Medina et al., 2024; Schreder et al., 2025). However, facilitators also noted that the acceptance of feedback depended on participants' individual reactions to the recordings and on whether the video provided a clear basis for discussion. Similar to the study of Johansson et al. (2017), the additional outside perspective provided by VAD appeared to support a broader understanding of the simulation. Facilitators reported that it helped to accept the feedback when relevant actions were clearly visible. Participants also seemed to learn from observing their peers, although it was less

pronounced when the debriefing focused on non-technical than technical skills. In this context, the findings indicate limitations regarding the discussion of non-technical skills, as some participants appeared to be reluctant to further analyse their behaviour and instead justified their actions through established routines. A possible explanation may lie in the reflective nature of the debriefing approach, which requires participants to actively engage in analysing their own behaviour (Rudolph et al., 2007). Participants who are less familiar with reflecting non-technical skills may therefore initially struggle and might benefit from more directive forms of feedback (Sá-Couto et al., 2023).

In conclusion, the study showed the relevance of a structured pedagogical approach for the successful implementation of VAD, especially in complex and less standardised contexts such as voluntary rescue organisations. While VAD has previously also been successfully implemented in professional medical settings (cf. Gasteratos et al., 2024; Zhang et al., 2020b), this study describes how varying experience levels, as well as training formats, can introduce additional challenges that require targeted support. DBR provided the framework to systematically identify and address these challenges, even when contextual conditions limited the implementation of larger structural improvements. We suggest that similar approaches may also be suitable to implement VAD in other voluntary rescue organisations.

Limitations and Future Research

When interpreting the findings of the present study, several methodological and contextual aspects should be taken into consideration. First, the qualitative insights into the participants' experiences were derived from the facilitator's perspective and stress was assessed using a single-item VAS measure, limiting the depth of interpretation. However, this was done to ensure participation, as the participants attended the extensive and physically demanding training outside their regular professional obligations. In addition, the positive perception of VAD may be partially influenced by a novelty effect, as especially the

participants of the Trauma Alpine training had limited or no previous exposure to VAD. It is therefore unclear if the observed motivation and engagement would persist over time. This is especially relevant in a voluntary setting, as it might influence the participants' willingness to attend the training in the future. Finally, as we agree that experiences are relevant to the implementation of new technologies, it is important to measure their effect on learning outcomes (Royle & Hargiss, 2015). While some studies found an advantage of VAD over traditional VD, mixed findings in terms of learning outcomes also exist (Grant et al., 2014; Levett-Jones & Lapkin, 2014; Niu et al., 2021; Zhang et al., 2019b). Consequently, further research is warranted to investigate how VAD can be implemented and adapted within specific training formats to best support learning processes and outcomes.

7 General Discussion and Reflections

This dissertation investigated how simulation-based debriefing practices can be advanced within mountain rescue training. Across three empirical studies, the dissertation examined which aspects of and influences on simulation performance should deserve attention during debriefing, how different debriefing approaches are experienced by participants and facilitators, and how VAD can be implemented in a context-sensitive way within the Bavarian mountain rescue organisation. Taken together, the findings show that advancing debriefing practice requires attention to both the focus of reflection and the way in which debriefings are facilitated and implemented.

The following discussion revisits the key findings in relation to the aims of the dissertation and situates them within the theoretical framework developed in Chapter 2. Chapter 7.1 discusses how the findings inform debriefings in simulation-based mountain rescue training, with particular attention to relevant objects of reflection and the need for guided reflection. Chapter 7.2 focuses on VAD as a means of supporting reflection and discusses why its implementation requires context-sensitive adaptation. Chapter 7.3 outlines limitations and implications for future research, before Chapter 7.4 derives practical implications for SBT within the field of mountain rescue organisations.

7.1 Determining the Focus of Debriefing in Mountain Rescue Training

An important argument within this dissertation is that debriefing requires decisions about what should become the focus of reflective discussion. While simulation experiences may generate many possible points for reflection, not all aspects can be addressed during debriefing due to cognitive limitations (Lee et al. 2020). Therefore, this part of the general discussion focuses on how the findings of Study 1 inform the identification of relevant aspects for reflection in simulation-based mountain rescue training.

Study 1 addressed the first aim of this dissertation by examining how TS, NTS, previous experiences, experienced patient deaths, and peer assessments relate to mountain

rescuers' performance during simulated resuscitation. Within the overall logic of the dissertation, the purpose of this study was not to establish a comprehensive model of resuscitation performance. It was conducted to clarify which aspects of performance and experience may deserve attention when debriefing simulation-based mountain rescue training. In this sense, Study 1 contributes to the *content and focus of discourse* dimension of debriefing practice (Kainth & Reedy, 2024). It provides an empirical basis for considering what may become an aspect of reflection when learners and facilitators reconstruct, reflect, and recontextualise simulation experiences.

A first contribution of Study 1 lies in showing that resuscitation performance in mountain rescue training cannot be reduced to a single performance dimension. Technical and non-technical skills did not significantly correlate with one another. This challenges the assumption that NTS are closely connected to TS as proposed by previous research (e.g., Riem et al., 2012). The results suggest that strong technical performance cannot simply be taken as evidence of strong non-technical performance. Conversely, technically weak performance does not necessarily imply deficits in NTS, such as teamwork or task management. In other words, TS and NTS may need to be treated as distinct areas of reflection. Based on the findings, debriefings after complex simulations that focus too narrowly on only one dimension of performance should be considered with caution.

The second contribution involves the role of previous experience. The findings suggest that experience does not translate into performance in a simple or uniform way. Mountain rescuers with more real resuscitation experience showed better TS performance, whereas more simulated resuscitation experience did not lead to significant differences in TS or NTS. Experienced patient deaths were also not significantly related to CPR performance. These results align with ELT and the theoretical argument developed in Chapter 2.1, indicating that experience provides a foundation for learning, but experience alone does not guarantee learning (Kolb, 1984). However, real-life events may support certain technical aspects of

performance, especially when these situations provide repeated routine procedures. Although it was generally not a differentiating factor concerning CPR performance, previous experience should not be disregarded during debriefing. Participants bring with them different experiences from prior simulations, real missions and emotionally salient events. Study 1 indicates that such experiences should not be interpreted as straightforward indicators of competence. Instead, they may function as reference points to recontextualise the simulation experience (Kainth & Reedy, 2024). For example, the absence of a relationship between patient-death experiences and performance does not mean that such experiences are irrelevant for debriefing. It means that their relevance may lie in how learners interpret, process, and integrate similar simulated experiences into future practice.

A third contribution of Study 1 concerns performance perception. Mountain rescuers could not fully correctly assess their colleagues' performance during the simulation. This finding is of importance because it suggests that relevant aspects of performance and teamwork may not be readily available to learners themselves by recalling the simulation. During resuscitation, participants are engaged in time-critical action, technical procedures, communication, and coordination (Bailey & Gesch, 2023). Under such conditions, it is possible that learners do not notice all relevant aspects of their own or others' performance. Evidence for this assumption was also found in Study 2 and Study 3, as well as in previous research (e.g., Johansson et al., 2017), showing that video recordings from the simulation could inform participants about aspects that they had not picked up before. Thus, video recordings can have the power to change their previous perceptions. This supports the theoretical argument that debriefing is needed because the quality of the simulation performance is often not self-evident for its participants. Therefore, the joint reconstruction of the simulation experience is important, as facilitators can share their own observations as well and provide video evidence within VAD if available (Schertzer & Waseem, 2024).

Taken together, Study 1 shows that determining the focus of debriefing in mountain rescue training is not a trivial task. The findings do not support a simple conclusion such as “focus primarily on NTS” or “experience predicts performance”. Instead, they reveal a more complex picture in which performance, experience, and perception are only partially aligned. Therefore, the value of Study 1 does not lie in identifying one dominant focus for debriefing, but in demonstrating that facilitators should approach debriefing content as multidimensional. Additionally, by showing a discrepancy between participants’ perception and CPR performance, the need for a debriefing that best supports the reconstruction, recontextualisation and shared understanding of events becomes visible. This leads to the other aims of the dissertation, focusing on identifying and implementing the most promising debriefing approach within the context of the Bavarian mountain rescue organisation.

7.2 Supporting Reflection Through Video-Assisted Debriefing

With Study 1 contributing to the question of what debriefings should focus on, Study 2 and Study 3 address how reflective discussions can be best supported by the debriefing approach itself. In chapter 2, VAD was presented as an approach that can assist the progress through the three general phases of debriefing, by providing video recordings as an objective resource for reconstructing and reflecting on the simulation (Kainth & Reedy, 2024). At the same time, previous research has not consistently demonstrated the superiority of VAD over VD and revealed challenges concerning establishing and maintaining psychological safety (e.g., Cheng et al., 2014; Rosvig et al., 2023). Therefore, Chapter 7.2.1 discusses VAD as both a support and a challenge for reflective discussions. Furthermore, it was argued that the implementation of the debriefing approach is of importance and might explain the mixed results in previous research. Consequently, Chapter 7.2.2 focuses on discussing the implementation of VAD in context-sensitive ways.

7.2.1 VAD as Support and Challenge for Reflective Discussions

Study 2 addressed the second aim of this dissertation by analysing how participants and facilitators experienced VD and two forms of VAD. By comparing both participants' and facilitators' experiences, the study examined the debriefing forms from both perspectives. Similarly, as VAD is not standardised, the study also featured a variation of VAD concerning the level of technical support (lower-tech and high-tech VAD).

The first contribution of Study 2 lies in showing how VAD can support the structured reconstruction of the simulation experience. Compared with VD, which depends more strongly on participants' and facilitators' recollection of events, VAD provided a shared visual reference point. This made it easier to ground feedback in observable situations and to discuss specific actions rather than having to rely solely on memory, interpretation, or professional authority. Similar results were found in previous research describing VAD as a more objective debriefing approach (e.g., Villado & Arthur, 2013). This contribution is especially relevant in the context of mountain rescue training, as Study 1 showed that the participants face difficulties in assessing their colleagues correctly, which might hint at problems in recognising or recalling relevant aspects of performance and teamwork.

A second contribution of Study 2 is that VAD made team processes and NTS more accessible for reflection. By allowing participants to observe the situation from a third-person perspective, the origin, spread, and possible capturing of errors became visible. While evidence for the observational component of VAD was found (e.g., Villado & Arthur, 2013), learning from observing their colleagues was limited, as most participants tended to focus on their own performance. Study 3 also revealed that learning from observing others is perceived as even more sparse when less tangible skills, such as NTS, are focused on during VAD. Although NTS were more accessible within VAD, the facilitators of Study 3 reported reluctance in accepting feedback aimed at improving the NTS when they were not clearly connected to technical errors made within the simulation.

A third contribution of Study 2 lies in identifying the tension between the strengths and challenges of VAD. The same visibility that supports the joint reconstruction of the simulation can also make debriefing more exposing. Participants and facilitators described VAD as helpful because it made performance more concrete and feedback easier to accept. However, this concreteness also means that mistakes can become more visible to the individual, the group, and the facilitator. Especially due to the noticeable technical equipment within the high-tech VAD condition, participants were aware of being recorded and reported negative, stressful emotions in some instances. These findings connect to the concept and importance of psychological safety, which was introduced in Chapter 2 as one of the interactional influences within the model of Kainth and Reedy (2024). With psychological safety not intact, learners can become defensive and disengage from the joint reflection (Kolbe et al., 2020). VAD may therefore support the reconstruction and recontextualisation of the simulation experience, but it can also increase the risk of breaching the psychological safety of learners.

The fourth and final contribution of Study 2 is that it showed that utilising VAD is more demanding for the facilitators. This was caused by having to operate the VAD equipment while simultaneously leading the simulation. Additionally, the facilitators also had to keep relevant scenes from the simulation in mind, to be able to spontaneously switch to VD if the VAD technology stopped working.

Considering the overall results of Study 2, high-tech VAD was selected as the most promising debriefing approach for the subsequent Study 3. Although posing higher demands on facilitators and a potential risk to the psychological safety of the participants, the strengths of the debriefing approach outweigh. The results of Study 2 also emphasise the importance of the facilitators, as they decide how video sequences are selected, used, and connected to the learning agenda. Furthermore, they need to establish and maintain psychological safety, especially when critical situations need to be addressed. The next step was therefore to

develop and refine a context-sensitive implementation that supports the facilitators in their use of VAD.

7.2.2 Implementing VAD in Context-Sensitive Ways

Study 2 established VAD as the most promising approach to debriefing but also showed challenges related to the cognitive demands of the facilitators and the psychological safety of the participants. Therefore, Study 3 addressed the third and fourth aims of this dissertation by developing, refining, and evaluating a context-sensitive implementation of VAD through iterative DBR cycles. It is important to note that the VAD within Study 3 can be considered a high-tech VAD. However, it was not named this way, as there is no other form of VAD present within this study.

A first contribution of Study 3 lies in showing that implementing videos within debriefing should be understood as an instructional design challenge, rather than a purely technical task. The introduction of video material into debriefing revealed that it changes what facilitators need to attend to, how the debriefing conversation is facilitated and what is necessary to ensure the psychological safety of the participants. This supports the argument developed in Chapter 2.3.2 that VAD should not be treated as a technical add-on to an otherwise unchanged debriefing practice.

A second contribution concerns the role and experiences of facilitators in the context-sensitive implementation of VAD. Study 3 identified three recurring areas of challenge: ensuring psychological safety, operating the VAD technology, and managing the cognitive demands associated with facilitating VAD. Facilitators who had to operate more tasks simultaneously reported higher cognitive demands than in the training condition with fewer tasks. Under such conditions, the potential of VAD to support reflection can be limited if facilitators are not adequately supported. The DBR process made it possible to respond to these challenges through the iterative development of supporting scaffolds. These scaffolds provided procedural, technical, and communicative aids for facilitators. Their function was

not to replace facilitator judgement with a rigid protocol, but to reduce uncertainty with a potentially unfamiliar debriefing approach and to help facilitators use VAD in a more focused and consistent way. This was considered necessary within the context of voluntary rescue organisations, as facilitators might not have worked with VAD before or have limited opportunities to practice VAD outside their regular professional occupations. The results showed that the scaffolds helped facilitators to reduce cognitive demands, provide structure and make the establishment of psychological safety less dependent on their memory or routine. At the same time, the findings also showed that the scaffolds cannot remove the complexity of VAD facilitation entirely and that some adaptations created new challenges.

The third contribution of Study 3 involves the effects of the context-sensitive VAD approach on participants' perceived stress and overall experiences. Study 2 had shown that VAD can create stress and feelings of exposure, particularly when mistakes are made visible to the group. Study 3 adds to this finding by showing that these risks can be adequately addressed through establishing a "safe container" during prebriefing and a structured approach to ensure psychological safety. The results revealed that participants' perceived stress increased before the VAD debriefing but also significantly decreased afterwards. This is partially in line with previous research (Zhang et al., 2020b) and can be attributed to the idea that anticipating debriefing is generally stressful, especially if the debriefing approach is unknown to the participants. More importantly, debriefing quality was rated consistently high over all five separate training days with results similar to professional medical settings (Brown et al., 2018; Fey et al., 2014). Similarly, the facilitators perceived the participants as excited to participate in VAD and that the debriefing fostered reflective discussions.

In summary, Study 3 demonstrated that a successful context-sensitive implementation of VAD does not necessarily require large structural changes. It can also involve targeted support to help facilitators integrate a new debriefing approach, building on established models such as *Debriefing With Good Judgement* (Rudolph et al., 2006).

7.3 Limitations and Implications for Future Research

Although this dissertation makes a meaningful contribution to the advancement of simulation-based debriefing practices in mountain rescue training, several limitations need to be considered. The following limitations concern the conceptual scope of the dissertation, the methodological approaches used across the three studies, and the specific training context in which the research was conducted. They also indicate directions for future research.

7.3.1 *Appraisal of Concepts and Methods*

The goal of this dissertation was to improve learning from SBT by focusing on the content and approaches to debriefing. It has been widely demonstrated within research that debriefing has a significant impact on the learning outcomes from simulations (e.g., Coppens et al., 2018). While informing the debriefing content, as well as finding and implementing the most promising debriefing approach, most certainly has a positive effect on learning, this was not measured directly within the dissertation. Recent studies by Gasteratos et al. (2024) and Zhang et al. (2020a) already found superior learning outcomes compared to VD when utilising a structured implementation of VAD. As the setting within the Bavarian mountain rescue organisation is not identical to the professional medical field, it could be of interest for further research to see whether the context-sensitive implementation of VAD also leads to better learning outcomes. However, the strength of this dissertation lies within its exploratory, partially qualitative nature, as Lymer and Sjöblom (2024) stated, that the field “largely lacks qualitatively grounded knowledge through which generalised findings regarding efficiency may be contextualised and interpreted” (p. 2).

Another limitation concerns the methodological structure of the dissertation. The three studies used different designs because they addressed different aspects of the overall aims: quantitative performance assessment in Study 1, qualitative exploration of debriefing experiences in Study 2, and a design-based multiple-methods approach in Study 3. This methodological diversity can be seen as a strength, as it allowed the dissertation to approach

debriefing practice from complementary perspectives rather than reducing it to a single outcome measure. At the same time, it limits direct comparability across studies. The findings do not form one continuous causal chain in which the same variables are measured and tested repeatedly. Future research could therefore extend the present work through more integrated designs, for example, by combining repeated simulation assessments, structured observation of debriefing interactions, participant interviews, and longitudinal follow-up measures.

7.3.2 Appraisal of the Training Context

All three studies were situated within mountain rescue training, or more precisely, the Bavarian mountain rescue organisation. Their voluntary structure, limited training time, heterogeneous backgrounds, and demanding operational requirements create the need for efficient debriefing practices and a feasible implementation of VAD. By embedding the studies within authentic training conditions, the results are directly usable for the Bavarian mountain rescue organisation and have a real-life impact. At the same time, it limits the extent to which the findings can be transferred to other settings without adaptation.

While mountain rescue organisations are a part of the broader field of voluntary rescue organisations and share common features, other voluntary rescue organisations (e.g., community first-responders) may differ in their tasks, structures, training traditions, medical responsibilities, and available resources in general. Therefore, the findings should not be interpreted as universally applicable. For example, in organisations where different debriefing approaches are established, or where facilitators have less experience with structured debriefing methods such as *Debriefing With Good Judgement*, the implementation of VAD may require different forms of preparation and support. Similarly, organisations with fewer technical or financial resources may not be able to adopt high-tech VAD. Future research should therefore examine how VAD can be adapted to other voluntary rescue contexts.

7.4 Practical Implications

Based on the three studies included within this dissertation, a range of practical implications can be drawn.

The results of Study 1 propose that facilitators should view the debriefing content as multidimensional. However, if every aspect of performance is attended to in detail, longer debriefings are needed, which is not ideal, due to learners' limited cognitive capacity (Lee et al., 2020). This problem can be solved through either simulation design or making the learning goals of the SBT explicit. Simulations can be designed in a more task-focused way, reducing unnecessary complexity and allowing the debriefing to concentrate on technical execution. Such reductions would not necessarily weaken authenticity, as authentic learning experiences can still be created when certain aspects of reality are simplified or not present within the simulation (Codreanu et al., 2020). In contrast, more complex scenarios may be appropriate when NTS need to be trained. In such cases, facilitators should make clear that the simulation goals and the learning goals are not always identical (Crookall, 2023). A scenario may include technical actions that must be performed correctly, but the debriefing can still focus heavily on NTS if these were the predetermined learning goals.

The dissertation also points to the need to strengthen the status of NTS within mountain rescue training. Study 1 showed that TS and NTS should not be treated as interchangeable dimensions of performance. Study 3 further indicated that feedback on NTS may be more difficult for participants to accept when it is not clearly linked to visible technical errors. Mountain rescue organisations should therefore make the importance of NTS more explicit within their training curricula. If participants understand beforehand why communication, task management, situational awareness, and teamwork matter, NTS-related feedback may be easier to accept during debriefing.

The findings also support the increased use of VAD in mountain rescue training, especially when it is adapted to the specific context. VAD appears especially valuable for

complex team-based scenarios in which reconstruction by memory alone may be insufficient. However, as stated within the limitations of the training context, the results may not be directly transferable to other voluntary rescue organisations. Organisations interested in VAD should therefore begin with small implementation cycles, collect feedback from facilitators and participants, and refine the approach before using it more broadly. The aim should not be to copy one fixed VAD model, but to develop a debriefing practice that fits available resources, facilitator expertise, participant needs, and established training routines.

8 Concluding Remarks

Going back to the overall aims of this dissertation, namely to examine what aspects of and influences on simulation performance should receive attention during debriefing, and to identify and implement the most promising debriefing approach in the context of the Bavarian mountain rescue organisation, the following results were found:

First, the findings show that the focus of debriefing in mountain rescue training should not be reduced to one general aspect of performance. TS, NTS, previous experiences, and performance perception may all become relevant objects of reflection, depending on the learning goals, the simulation and their use within debriefing (e.g., recontextualisation). Second, high-tech VAD was found to be the most promising debriefing approach, as it was perceived as useful to reconstruct events, make team processes visible, support feedback acceptance, and reflect on aspects of performance that participants may not have noticed during the simulation. At the same time, its use posed higher demands on facilitators and required careful attention to psychological safety. Third, the implementation of VAD should be understood as an instructional design task rather than as the introduction of a technical tool. The DBR process demonstrated that VAD can be implemented in a context-sensitive way when facilitators receive supporting scaffolds, a clear structure, and overall attention to the organisational context is paid.

In sum, this dissertation contributes to SBT by showing that debriefing practice can be advanced through an integrated consideration of content, approach, and implementation. For mountain rescue training, the findings provide empirically grounded guidance on what debriefings may need to address and how VAD can be introduced without neglecting facilitator demands and participants' psychological safety. More broadly, the dissertation stresses that technology-supported debriefing becomes educationally meaningful not through the presence of video alone, but through the pedagogical and contextual conditions under which video is used.

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