Thesis

Handover from the mountain rescue team to an emergency physician

Attempt at introducing a handover scheme

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Graz, 03.07.2025

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Graz, 03.07.2025 Lena Rettensteiner m.p.

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Zusammenfassung

Einleitung

Die strukturierte Übergabe von Patient:inneninformationen stellt einen entscheidenden Faktor für die Patientensicherheit in der Notfallversorgung dar. Besonders im alpinen Umfeld, wo Bergretter:innen unter extremen Bedingungen agieren, kommt einer klaren, verständlichen und vollständigen Kommunikation besondere Bedeutung zu. Diese Arbeit widmet sich der Entwicklung und Erprobung eines neuen, speziell für die Bergrettung konzipierten Übergabeschemas – PEAKS – und untersucht dessen Effektivität in Bezug auf Vollständigkeit und Qualität der Informationsweitergabe.

Material und Methoden

Im Rahmen dieser Diplomarbeit wurde ein simulationsbasiertes Crossover-Design verwendet, bei dem 30 angehende Bergretter:innen in zwei aufeinanderfolgenden Szenarien je eine strukturierte (mit PEAKS) und eine unstrukturierte Patientenübergabe durchführten. Die Qualität der Handover wurde mithilfe eines standardisierten Bewertungsbogens quantitativ erfasst. Ergänzt wurde die quantitative Analyse durch qualitative Rückmeldungen der Teilnehmenden zu Benutzerfreundlichkeit und praktischer Anwendbarkeit des PEAKS-Schemas.

Ergebnisse

Die Ergebnisse zeigen eine signifikante Verbesserung der übermittelten Information durch die Verwendung von PEAKS. Der Mittelwert der korrekt übergebenen Informationen stieg von 2,51 auf 3,59 Punkte, die Varianz sank, was auf eine homogenere Leistung hinweist. Auch das subjektive Feedback war überwiegend positiv – insbesondere weniger erfahrene Teilnehmende berichteten, dass PEAKS Orientierung und Sicherheit bei der Übergabe bot. Die Effektstärke war mit d = 1,43 sehr hoch, was die praktische Relevanz unterstreicht.

Diskussion/Schlussfolgerung

Die strukturierte Kommunikation stellt im alpinen Einsatz nicht nur eine theoretische Notwendigkeit, sondern eine praktisch wirksame Maßnahme zur Verbesserung der Patientensicherheit dar. Das PEAKS-Schema bietet ein anwendungsfreundliches, situationsgerechtes Tool, das die spezifischen Herausforderungen der Bergrettung berücksichtigt. Die Studie liefert damit einen praxisrelevanten Beitrag zur Standardisierung alpiner Notfallkommunikation und legt die Basis für eine mögliche organisationsübergreifende Implementierung im österreichischen Bergrettungswettungswesen.

Abstract

Introduction

Effective communication is crucial in emergency medicine, especially in mountain rescue, where unpredictable conditions, high stress and limited resources challenge information exchange. This study introduces PEAKS, a structured patient handover tool specifically designed for mountain rescue scenarios, and evaluates its effectiveness through a simulation-based crossover study.

Methods

Thirty volunteer trainees of the Austrian Mountain Rescue Service participated in two simulated handovers - one unstructured and one using the PEAKS scheme. The quality of communication was assessed using a standardised checklist. Quantitative results were complemented by qualitative participant feedback on the usability and perceived value of the new handover format.

Results

Participants provided significantly more critical patient information using PEAKS (mean score increased from 2.51 to 3.59). The structured format resulted in more consistent communication outcomes across participants. Feedback indicated that PEAKS was particularly helpful for less experienced rescuers, improving confidence and clarity during handovers. The observed effect size (Cohen's d = 1.43) confirmed a significant practical impact.

Discussion/Conclusion

This study demonstrates that a tailored, structured handover scheme significantly improves communication in simulated mountain rescue situations. PEAKS addresses the limitations of existing clinical handover tools by providing a simplified and context-sensitive format suitable for field use. The results support the integration of PEAKS into mountain rescue training and highlight the need for further field-based research and multi-agency standardisation.

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Abbreviations and their meaning

Abbreviation	Meaning
AMBO	Allergies, Medications, Background, Other
AED	Automated external defibrillator
ARAW	Alpine Rescue Committee Vienna
ATMIST	Age, Time, Mechanism, Injuries, Signs, Treatment
CRM	Crew Resource Management
CPR	Cardiopulmonary Resuscitation
EM	Emergency Medicine
EMS	Emergency Medical Services
HF	Human Factors
IBM	International Business Machines Corporation
ICAR	International Commission for Alpine Rescue
IMIST	Identification, Mechanism, Injuries, Signs, Treatment
I-PASS	Illness Severity, Patient Summary, Action list, Situation awareness and contingency planning, Synthesis and Summary
IS(O)BAR	Identification, Situation, (Observation), Background, Assessment, Recommendation
MD	Doctor of Medicine
MEDCOM	Medical Commission (ICAR)
ÖBRD	Austrian Mountain Rescue Service = Österreichischer Bergrettungsdienst
PAVISAR	Patient Data, accident, Injuries, Intubation, Symptoms, Contact person, Readback
PEAKS	Patient information, Event/Evaluation, Action taken, Key findings, Summary
ROSC	Return of spontaneous circulation
SAFE-PT	Situation, Assessment, follow up, Events, Pending, Teams
SBT	simulation-based training
SINNHAFT	Start, Identification, Emergency Event/priorities, Actions, Anamnesis, Conclusion, Team questions
SPSS	Statistical Package for the Social Sciences

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1. Introduction

High-quality communication is a key factor in the success of emergency operations. Especially in the alpine environment, where rescue missions often take place under extreme conditions, the transfer of information must be clear, structured, and efficient. Communication failures have long been recognized as a leading cause of adverse events in prehospital care, particularly during patient handovers between different emergency teams.

Unlike clinical systems, many alpine rescue services currently lack standardized handover protocols. As a result, communication practices vary and are often improvised, increasing the risk of lost or misunderstood information. In high-stress, time-sensitive scenarios such as mountain rescue operations, this can significantly impact patient safety and operational efficiency.

This thesis therefore focuses on the Austrian Mountain Rescue Service (ÖBRD*), a key organization in alpine emergency response, where the quality of handover communication plays a central role in overall care delivery.

ÖBRD= Österreichischer Bergrettungsdienst

1.1. The Austrian Mountain Rescue Service

The Austrian Mountain Rescue Service (ÖBRD) is a legally recognized, independent and non-profit rescue organization dedicated to providing assistance in alpine and rough terrain. With around 13,000 voluntary and honorary members, the mountain rescue service carries out around 10,000 missions every year, including search and rescue operations for missing or injured persons as well as preventative safety measures.

The ÖBRD works closely with the alpine police, air rescue and other organizations and is integrated into the disaster control plans of the federal states. The primary goal is to prevent accidents and to protect human life and minimize the risks in the mountains (1,2).

1.1.1. Founding and development of the mountain rescue

After numerous accidents in the mountains, a tragic accident on 8 March 1896 on the Reißthalersteig on the Rax was the cause for the founding of the world's first alpine rescue organization. An avalanche buried the three Viennese mountaineers Josef Pfannl, Max Schottik and Fritz Wannieck during a snowstorm and could only be rescued days later due to the bad weather conditions.

Dr. Heinrich Pfannl, Josef's brother, not only took part in the search operation, but also played a significant part in the subsequent discussions about the need for an organized alpine rescue system. The first meeting at the Austrian Tourist Club took place on April 10, 1896, at which the Green Cross was already being considered as a symbol. On April 24, engineer Franz X. Kleinwächter proposed the formation of a voluntary rescue team to the Austrian Alpine Club in Vienna. A committee consisting of Heinrich Krempel, Franz Kleinwächter and Theodor Keidel then invited various Alpine clubs to join in.

On 22 May 1896, the “Alpine Vienna Rescue Committee” was founded in Vienna, which was later officially registered and recognized as the “Alpine Rescue Committee Vienna” (ARAW). It was the first organized rescue service for mountaineers and mountain hikers worldwide. The operational area initially included the mountains and national parks in upper Styria. In the following years, other mountain rescue organizations were founded in Austria and abroad based on the Viennese model (2,3).

1.1.2. Development in the 20th century

From 1896 to 1912, Heinrich Krempel led the ARAW, after which Rudolf Hamburger took over the leadership. During the First World War, some mountain rescuers lost their lives and their equipment was lost. At the same time, new rescue techniques were developed during the war in the Dolomites.

In the interwar period, the work of the ARAW became increasingly difficult, but the Alpine clubs continued to support the local offices. In 1922, Adolf Noßberger took over the management and introduced standardized training and founded new local bases. In 1938, the ARAW was incorporated into the German Mountain Rescue

Service. During the Second World War, the mountain rescuers were assigned auxiliary police duties. After the war, the Alpine Rescue Committee was reactivated in 1945 by the Club “Friends of Nature” (Naturfreunde). The first rescue course took place in 1946 on the Hochschneeberg. In 1946, the “Austrian Mountain Rescue Service” (ÖBRD) was founded, and in 1947, the independent Vienna/Lower Austria local base was established. A significant milestone occurred in 1948 with the International Mountain Rescue Conference in Obergurgl, which led to the founding of the International Commission for Alpine Rescue, now comprising 143 organizations from 41 countries. In 1949, the ÖBRD was registered as a nationwide working group and association. Today, it is the umbrella organization of the seven regional associations of Lower Austria/Vienna, Upper Austria, Styria, Salzburg, Carinthia, Tyrol and Vorarlberg with a total of 291 local offices (2,3).

1.2. Human Factors

Human Factors (HF) is an interdisciplinary concept that deals with the relationships between people, technology and organization from a systemic perspective. It encompasses the scientific consideration of human capabilities, limitations and behavior in complex systems. The term originally comes from aviation and has established itself primarily in the field of emergency and rescue medicine, as similar challenges exist here regarding to communication and susceptibility to errors. The focus is on the following factors:

- Error occurrence
- Teamwork
- Communication (4)

1.2.1 Human Factors in Mountain Rescue Operations

In an alpine rescue operation, numerous factors affects the safety and effectiveness of the operation. Approximately 60% to 80 % of all mountain rescue accidents are caused by human error (5).

Factors influencing human behaviour during a rescue-operation are:

- **Communication:** Unclear or delayed communication can lead to unsystematic procedures. A widely recommended strategy is the use of closed-loop communication, which ensures feedback and reduces misunderstandings.
- **Stress and fatigue:** both have major impact on the thinking and decision-making process.
- **Teamwork:** Effective teamwork is essential to achieving common operational goals and requires regular joint training and trust within the team. It is also important to feel secure in the team and to trust each other.
- **Overconfidence and lack of self-reflection:** These traits pose a risk to individual and team safety.
- **Competence and experience:** Rescuers must be aware of their limitations and avoid operating outside their capabilities (5).

1.3. Communication

1.3.1. Effects of poor communication

Communication errors often occur when responsibilities are handed over. In particular, problems arise during shift changes and when handing over patient information, if information is passed on incompletely, inaccurately or misleadingly. This often leads to misunderstandings and incomplete communication of important details, which significantly increases the likelihood of errors and incidents. Typical sources of error are language and cultural barriers between those involved, as well as time pressure and high workloads. In addition, there is often a lack of structured handover protocols or clearly defined guidelines, which further deteriorates the quality of communication. Inadequate training and a lack of communication skills also contribute to the problem.

The consequences of such communication deficiencies are serious. Incomplete or incorrect handovers significantly increase the risk of wrong decisions and avoidable errors. Important information, e.g. about symptoms, vital signs or measures carried

out - can be lost, leading to delays in subsequent measures and negative effects on teamwork. Communication problems during handover can therefore lead directly to treatment errors and poor care.

Targeted measures are required to overcome the communication problems of patient handover. These include the development and implementation of structured handover schemes as well as the use of checklists and standardized protocols. In addition, the training of communication techniques through regular training and simulations is of high importance. The use of modern communication tools, such as text-based platforms with documentation functions, can also help to improve the quality and reliability of handovers (6).

1.3.2. Role of structured Communication

Although a standardized format does not necessarily change the content of the handover, it helps to create a shared mental model between the teams involved. This reduces interruptions, increases confidence in the handover and improves the process overall.

Interruptions caused by parallel activities reduce the quality of the handover. Clear rules, such as an undisturbed speaking time of 60 seconds for the handover, can improve communication and strengthen team spirit. The handover must remain short, structured and limited to the essential information - in particular, vital signs, obvious injuries, mechanism of injury and measures taken (7).

The importance of structured communication training in prehospital care is further supported by evidence from clinical education research. A quasi-experimental study examined the effects of a simulation-based handover training program on nursing students and found statistically significant improvements in the knowledge of the participants, self-efficacy, and overall handover performance (8). Although the study was conducted in a clinical setting, the results are highly relevant to mountain rescue, where clear, structured, and reliable communication is equally critical. These findings underscore that simulation-based training not only enhances individual competencies but also contributes to overall patient handover safety and efficiency. In the context of mountain rescue, this supports the argument for integrating structured communication tools and educational simulations into standard training protocols.

1.4. Communication in Emergency Medicine: General Principles and Relevance in Mountain Rescue.

1.4.1. Core Principles of Team Communication

Effective communication is a core competency in emergency medicine, where quick, error-free information transfer directly influences patient outcomes. Structured techniques such as closed-loop communication are central to this effort. This approach ensures that messages are not only sent but also clearly received and acknowledged, minimizing the risk of omission, misinterpretation, or procedural error. Closed-loop communication involves a three-step process:
1: the sender communicates a message to the intended receiver (when possible, utilizing the name),

2: the receiver acknowledges receipt and seeks clarification if necessary, and

3: the sender verifies that the message has been correctly interpreted, thereby closing the loop (9).

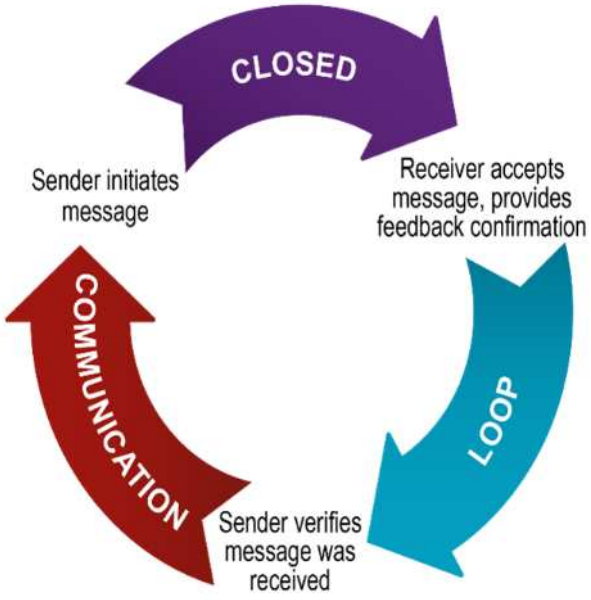

Figure 1: Illustration of Closed-Loop Communication (10)

In parallel, Crew Resource Management (CRM), originally developed in aviation, has been widely adopted in healthcare and emergency medical service (EMS) to improve non-technical team skills. CRM emphasizes leadership, task management, decision making, situational awareness, and mutual support. These principles are particularly relevant in unpredictable, high-risk environments such as alpine rescue.

CRM training has also been shown to fundamentally improve the behavioural performance and safety culture of emergency response teams (11).

The 15 CRM principles adapted for alpine rescue operations emphasize proactive planning, early requests for help, effective resource utilization, and continuous reassessment of the situation (see Table 1). Of particular relevance are the guidelines: "Communicate clearly and effectively," "Use all available information," and "Prevent and detect fixation errors. These rules have been formally incorporated into mountain rescue curricula by the Austrian Mountain Rescue Service and are considered standard practice in CRM-oriented training (12).

Table 1: The 15 CRM principles of the mountain rescue service

1. Know your tasks and responsibilities	9. Maintain an overview (situational awareness)
2. Recognize critical situations early	10. Question your decisions regularly
3. Stay within your competencies	11. Communicate clearly and effectively
4. Plan ahead	12. Use all available information
5. Set priorities	13. Avoid and recognize fixing errors
6. Ask for help early	14. Actively support others in the team
7. Use resources efficiently	15. Take care of yourself and your team (team resources and self-care)
8. Act calmly, thoughtfully and in a structured manner	

(12)

1.4.2. The Role of Stress and Cognitive Load

Medical emergency situations, especially in alpine environments, are often associated with high levels of psychological stress and cognitive load. Under such conditions, rescuers may experience tunnel vision, reduced situational awareness, and impaired communication. These effects are particularly pronounced in high-stakes scenarios, where time pressure and unpredictable dynamics increase the likelihood of human error.

To address these challenges, simulation-based training has proven to be an effective strategy. Such training environments provide a realistic yet controlled environment in which participants can practice critical skills without compromising patient safety. Simulation allows for repeated exposure to stressful scenarios, enabling learners to improve decision-making, develop structured communication patterns, and enhance their ability to handle high-pressure situations (13).

Sustaining efficient communication under cognitive load is essential in high-stress situations like mountain rescue, where responders face challenging conditions like bad weather, physical exhaustion, and inadequate infrastructure. This need is met by simulation-based training (SBT), which allows for repeated practice in authentic situations, strengthening routines, improving teamwork, and lowering anxiety. Better communication performance during actual operations is a result of these enhancements (13).

The findings of Elendu et al. (2024) underscore the pedagogical value of simulation not only for technical procedures, but also for the development of non-technical skills such as communication, leadership and team dynamics. Integrating such training into mountain rescue education could therefore significantly improve operational safety and effectiveness (13).

1.4.3. Role understanding and nonverbal communication

In alpine emergencies, clear roles and trust are essential for effective teamwork. However, in contrast to the structured hierarchy of clinical teams, mountain rescue groups are often assembled on an ad-hoc basis. Communication must therefore be explicit and respectful, facilitating safe delegation of responsibility despite different professional backgrounds.

Nonverbal communication, such as hand gestures, body alignment and eye contact, also plays an important role in noisy or visually limited environments. Thus, training in both verbal and nonverbal communication improves coordination and fosters a common mental model, which is essential for safety in high-risk missions (14).

The ÖBRD explicitly addresses these challenges in its official training manuals. It emphasises the importance of situational awareness, repeated reassessment and the use of checklists or memory aids under stress. These tools not only reduce cognitive load, but also serve to standardise communication, even among team members with different levels of experience or familiarity with each other (15).

1.4.4. From clinical to alpine environments

While structured handoff schemes such as I-PASS or ISOBAR have proven effective in clinical settings, where teams work in controlled environments with stable infrastructure, their direct applicability to alpine rescue scenarios is limited. Mountain rescue operations take place under fundamentally different conditions: extreme weather, difficult terrain and often a lack of access to comprehensive medical resources. Communication is further complicated by environmental factors such as wind, cold, darkness and distance, which can severely hamper verbal exchange. In addition, the team composition is often ad-hoc and heterogeneous, including volunteers from non-medical backgrounds who may be unfamiliar with clinical communication standards.

One particularly prominent example of these challenges is the concept of tactical alpine medicine as presented in the official instruction manual of the Austrian Mountain Rescue Service (ÖBRD). In "red zones," which are hazardous areas such as exposed ridgelines or avalanche-prone slopes, safety always comes before medical assistance. Treatment can only begin when it does not increase the risk to the rescue crew. In these circumstances, communication must be prompt, targeted, and situation-specific because time, visibility, and team collaboration are all limited. The ÖBRD emphasizes the value of shared situational awareness and recommends the use of simple memory aids and standardized procedures, even in stressful situations or when team members are unfamiliar with one another (12).

Because of these organizational and environmental limitations, communication tools must be robust, user-friendly, and flexible enough to respond to actual outdoor emergencies. Current clinical models frequently make assumptions about stable medical infrastructure and a shared professional background, which are uncommon in alpine operations. In order to ensure the reliable transfer of crucial information,

tools and communication strategies used in these settings must take into account diverse teams, harsh environments, and scarce resources.

In response to these limitations, this project initiated the development of a new field-oriented handover scheme. The resulting structure, presented in chapter two, has been specifically designed to meet the unique needs of alpine rescue. It provides a mnemonic, context-sensitive tool for the efficient transfer of patient and situational information, even under adverse conditions.

1.4.5. Implications for training and system integration

Given the critical role of communication in alpine rescue, the integration of structured communication training into mountain rescue training is essential. Evidence from simulation-based training in health care shows that such programs can significantly improve communication skills, decision-making, and teamwork performance in high-stress environments (13,16). These findings suggest that educational interventions, especially those that incorporate simulation, role-playing, and scenario-based learning, are highly effective in preparing emergency rescue personnel for complex and dynamic emergency situations.

Training approaches should combine Crew Resource Management (CRM) principles with field-specific content, including verbal communication strategies, nonverbal interaction, and competent use of communication technologies. Simulation-based training provides a realistic and safe environment to practice these skills before applying them in real-world missions (11).

In addition, standardizing communication formats between different stakeholders, such as mountain rescue teams, helicopter crews, and emergency physicians, could significantly improve interoperability and patient safety. The newly developed handover tool could serve as a unifying tool within and between organizations by ensuring consistent information flow and shared situational awareness.

1.5. Definition: Handover

A handover is the transfer of patient care responsibility from one individual or team to another. Effective handover ensures that critical information – including interventions and contextual details – is communicated clearly and efficiently. However, this process, often involving unfamiliar professional groups, can be prone to misunderstandings due to differing expectations and communication styles (17).

To address these challenges, handover is increasingly recognized as a structured and standardized method for transferring not only information but also responsibility during changes in patient care. It involves sharing knowledge about the patient's condition, treatment, recent changes, and the ongoing care plan, including uncertainties and contingencies. The aim is to ensure continuity of care despite changing teams or providers. Lack of clarity in the transfer of responsibility and authority can result in serious errors. Therefore, a structured patient handoff is essential. It should include the following:

1. Clearly transferring responsibility and accountability, ensuring the receiver acknowledges the transfer.
2. Providing clear, unambiguous information, especially when uncertainty exists.
3. Using appropriate communication channels and confirming understanding.
4. Receiving acknowledgment from the receiver before relinquishing responsibility.
5. Allowing opportunities for questions, review, and evaluation of the situation for safety and quality (18).

1.6. Example of a Structured Handover Assessment Tool

To be completed by Assessor Complexity of case: low ☐ medium ☐ high ☐

Retrieval: yes ☐ no ☐ Call number_____Assessor code_____

PLEASE TICK APPROPRIATE JUDGMENT	***Not performed competently***	***Able to perform under firm direction***	***Able to perform under modest direction***	***Able to perform under minimal direction***
Identifies self and position	*Requires direct prompting to elicit name and position*	*Introduces themselves as an afterthought during handover or after a subtle hint.*	*Incompletely introduces themselves prior to commencing handover*	*Introduces themselves and their role prior to commencing handover*
Identifies main problem	*Unable to identify the main problems*	*Identifies and prioritises the main problems after extended prompting*	*Identifies and prioritises the main problems with a few further questions being needed*	*Identifies and prioritises the main problems*
Gives appropriate history	*The history is unstructured, or contains significant extraneous information.*	*The key features of the history are elicited but frequent clarification by questioning is required*	*The key features of the history are elicited with only a few further questions being required*	*A comprehensive focused history is delivered*
Gives appropriate examination/observations	*The examination is omitted, or significant parameters suggested by the problem and history are missing*	*The key features of the examination are reported but frequent clarification by questioning is required*	*The key features of the examination are reported with only a few further questions being required*	*A focused examination is reported*
Makes logical assessment	*No credible assessment given*	*The assessment correlates the problem, history and examination, and the context of the encounter after much questioning*	*The assessment correlates the problem, history and examination, and the context of the encounter after minimal questioning*	*The assessment fully correlates the problem, history and examination, and the context of the encounter*
Makes a clear recommendation	*No credible recommendation is made*	*A credible recommendation is agreed after extended questioning by the receiver.*	*A credible recommendation is agreed after a few further questions by the receiver*	*A credible recommendation is provided*
Global Rating How confident am I that I received an accurate picture of the patient?	*Not at all confident*	*I am confident but required extended questioning on several aspects*	*I am confident but required some further questioning*	*I am confident and required little or no questioning*
Ungraded observation of additional factors impacting the quality of the handover	*Please Comment*			

Figure 2: Clinical Handover Assessment Tool (19)

In structured handover training, especially in medical education and emergency simulation, handover quality is increasingly assessed using multidimensional tools. These assessment grids focus not only on whether information is transmitted, but also on how well rescuers can demonstrate clinical reasoning, structure, and situational awareness.

Figure 1 illustrates a commonly used handover assessment tool in clinical simulations that breaks down handover performance into domains such as self-identification, problem recognition, history taking, and clarity of recommendations. This underscores the multifaceted nature of handover communication and the high standards required in professional emergency care settings.

In alpine rescue scenarios, where such formal tools are typically not used, these standards are rarely applied. This thesis addresses this gap by investigating whether similar structured approaches can improve communication quality even in non-clinical, high-stress environments such as mountain rescue.

In reviewing existing handover tools, it becomes evident that while many offer useful frameworks, their application to alpine rescue scenarios is limited. Tools such as ISOBAR and I-PASS are primarily designed for intrahospital communication or structured team handoffs in clinical settings (20,21). Their strengths lie in their detail and their ability to promote a shared mental model among care providers. However, in high-stress, unpredictable environments such as mountain rescue, these tools may prove too complex or ill-suited due to the lack of time and the often minimal overlap between the handing-over and receiving teams (22).

Prehospital tools like ATMIST or PAVISAR consider some of these challenges, offering a more concise structure with a focus on vital signs, mechanism of injury, and critical measures taken (23,24). Still, they do not fully consider environmental hazards, resource limitations, or the non-medical background of many mountain rescuers. Furthermore, while schemes like SINNHAFT incorporate elements of decision prioritization and teamwork, they are currently used inconsistently and without national standardization (25).

1.7. Presenting existing handover tools

To bring structure to the handoff of a patient, mnemonic devices are often used as memory aids to ensure no important information is overlooked. Several well-known schemas will be presented in the following chapter:

1.7.1. ISOBAR

Table 2: ISOBAR-Scheme

Symbol	Criteria	Contents
I	Identification	Patient's data: Age, Sex
S	Situation	Emergency event, Emergency diagnosis
O	Observation	Vital body functions are stable/ unstable, ABCDE
B	Background	Additional information, Pre-existing conditions, SAMPLER
A	Assessment	Actions, upcoming measures
R	Recommendation	Request

own representation based on (26)

1.7.2. ATMIST

Table 3: ATMIST-Scheme

Symbol	Criteria	Contents
A	Age	
T	Time	Exact time or approximate time when the incident occurred
M	Mechanism	How the injury was sustained
I	Injuries	Begin with significant, life-threatening injuries, followed by less critical injuries
S	Sign	Vital signs of the patient
T	Treatment	Treatment given

own representation based on (24,27)

In addition to the ATMIST schema (Table 3), there is a modification of this schema called IMIST-AMBO. Instead of the A-age and T-time there is I, which stands for the identification of the patient. The acronym AMBO stands for allergies, medications, background history and other information (28).

1.7.3. I-PASS

Table 4: I-PASS

Symbol	Criteria	Contents
I	Illness Severity	Is the patient: Stable, “watcher”, unstable
P	Patient Summary	Summary statement, if necessary, also include: event leading up to admission or care transition, hospital course or treatment plan, ongoing assessment, contingency plan
A	Action list	To-do list, Pending results/consults, Timelines and ownership
S	Situation awareness and contingency planning	To know what is going on and plan for what might happen
(S)	Synthesis and Summary by the receiver	Summarization of what was heard by the receiver, Time to ask questions Restates key actions/to-do items

Own representation based on (21,29)

1.7.4. SAFE-PT

The mnemonic SAFE-PT aims to ensure that all pertinent patient details are included, with a focus on red flags and issues requiring immediate attention.

Table 5: SAFE-PT

Symbol	Criteria	Contents
S	Situation	Patient ID and Background
A	Assessment	Chief complains, Provisional diagnosis and actions taken
F	Follow-up	Referrals, Recommendations
E	Event	Red flags
P	Pending	Procedures/ Labs
T	Team	Incoming and outgoing

Own representation based on (30)

1.7.5. SINNHAFT

Table 6: Sinnhaft

Symbol	Criteria	Contents
S	Start	Maintain calm! avoid potential manipulation or activity on the patient. Communication within the team!
I	Identification	Gender, age and surname
N	Emergency event *	What? Suspected diagnosis and main symptom How? cause of the emergency When? time of the accident/event Where? Location
N	Emergency priorities **	Prioritization of the signs and symptoms with the ABCDE-Scheme, including pathological examination findings, as well as abnormal vital parameters
H	Actions ***	Conducted actions: Dosage/Time/Extent, Effect, or consciously omitted actions
A	Anamnesis	Medication, allergies, infections, former diseases, particularity, organizational
F	Conclusion ****	Repeat of the important information by the receiving staff: Identification, emergency event, emergency priority, action
T	Team questions	The receiving personnel have the possibility for additional essential questions

Own representation based on the table (25)

* Emergency event: translated from the German word: Notfallereignis

**Emergency priorities: translated from the German word: Notfallpriorität

***actions: translated from the German word: Handlungen

****conclusion: translated from the German word Fazit

1.7.6. PAVISAR

To ensure consistency in preregistration at hospitals, handover of emergency patients and interhospital transports, the Tyrol EMS, along with all collaborative system partners, has developed guidelines including all relevant emergency medical information and the CRM criteria (23).

Table 7: Pavisar

Symbol	Criteria	Contents
P	Patient-Data	Patient data (name, birthday, insurance-card)
A	accident (Type and location of the accident)/ emergency event	Scenario, mechanism of injury, initial Assessment (possible interruption for immediate intervention, CPR)
V	Injuries, suspected diagnoses *	Vital functions (e.g. ABCDE), main diagnosis
I	Intubation, other measures	Actions taken and therapies administered. relevant Therapies (e.g., thrombolysis)
S	Symptoms, Red Flags	Anamnesis (e.g. Sampler), potential infections, patient decree
A	Contact person**	Contact information for relatives, general practitioner
R	Readback, follow-up questions	Lack of information? Review and confirmation

Own representation, a fusion of the two figures from (23)

*Injuries: translated from the german word: Verletzungen/ Verdachtsdiagnose

**Contact person: translated from the german word: Ansprechperson

1.8. Need for a standardized handover

Communication failures are widely recognized as a leading cause of preventable adverse events in healthcare. The Joint Commission has reported that over 70% of sentinel events involve communication errors as a root cause (31). These risks are particularly pronounced during patient handovers, where incomplete, ambiguous, or poorly timed communication can jeopardize patient safety. To address this,

structured communication strategies and standardized handover protocols are strongly recommended to enhance patient safety and ensure continuity of care (32,33).

The application of the structured handover scheme ISOBAR resulted in a notable improvement in the information exchange between emergency room personnel and the ambulance service, according to a study by Nuernberger et al. (2025). The medical team was able to remember around 20 percent more key information 15 minutes after the handover. The number of queries also fell by around 30%. The increased awareness of the importance of high-quality communication within the team was more important than strict adherence to the order of the protocol. The study findings underline that the structured approach and increased awareness of high-quality communication are more decisive for successful handovers than strict adherence to the protocol structure (34).

Despite the availability of numerous handover templates such as ISOBAR, I-PASS or ATMIST, no standardized handover tool currently exists for the Austrian Mountain Rescue Service. As a result, handovers vary greatly and each emergency worker chooses an individual approach. In practice, this means that important information can be passed on inconsistently or be even completely overlooked. As the previous comments on human factors and the frequent communication problems during handovers show, this poses a considerable risk of errors, loss of information and delays. A standardized, easy-to-use handover scheme is therefore urgently needed to standardize handover processes, avoid communication gaps and ultimately improve the quality and safety of patient care. This gap forms the basis of this thesis, which aims to develop and test a structured handover tool specifically tailored to the Austrian Mountain Rescue Service.

During the course of this thesis, a new handover tool - PEAKS - was developed specifically for use in mountain rescue. This structured, field-oriented scheme builds on established clinical principles while adapting to the unique conditions of alpine rescue. Its structure and evaluation are discussed in detail in the following chapters.

1.8.1. Methodical approach

To evaluate the effectiveness of the newly developed handover tool, a simulation-based exercise was conducted with prospective mountain rescuers. Participants

performed handovers both with and without the structured tool (PEAKS), allowing direct comparison of communication quality.

1.8.2. Delimitation

This thesis focuses exclusively on the communication process during patient handovers in mountain rescue scenarios. Clinical outcomes or the accuracy of medical decision-making are not part of the research. The simulation scenarios used were entirely fictional and did not involve real patients; they served solely to evaluate the structure and clarity of the handover process under realistic training conditions.

1.8.3. Practical relevance

The development and implementation of a standardized handover scheme holds substantial practical relevance for mountain rescue operations in Austria. The alpine environment is characterized by challenging terrain, extreme weather conditions, and often long response times. These factors demand a particularly high level of coordination and clear communication among rescuers. In practice, however, handovers within the Austrian Mountain Rescue Service are currently conducted without a uniform protocol, relying instead on the individual approach of each rescuer. This variability increases the risk of critical information being omitted or misunderstood, especially under stress or time pressure.

A structured handover tool provides a practical solution to this issue by ensuring that all rescuers follow a common framework for communicating vital information. This includes patient status, interventions performed, and environmental or situational hazards. Such a tool can also serve as a valuable training instrument during rescue courses, offering clarity to both novice and experienced rescuers. Simulation-based training using standardized communication models has been shown to improve handover performance and confidence (34). In addition, the incorporation of human factors such as stress, fatigue, or teamwork dynamics into the handover process promotes safer and more effective communication in the field (4).

Furthermore, structured handovers can help reduce hierarchy-based communication gaps between team members of varying experience levels, enabling all participants to contribute essential information. Especially in situations where mountain rescuers collaborate with clinical personnel such as emergency physicians or helicopter crews, a clearly structured format increases interoperability

and minimizes ambiguity. The lack of structured trauma treatment algorithms in mountain rescue education, reinforces the need for practical tools like standardized handover schemes that can improve care continuity in real-world missions (35).

1.8.4. International context

The importance of a standardized handover protocol extends well beyond Austria and reflects a broader international challenge in mountain emergency medicine. Rescue missions often involve collaboration between teams from different regions or countries, especially in cross-border incidents or large-scale disasters. Inconsistent communication strategies, differing documentation practices, and variation in training levels can lead to delays, misunderstandings, and even adverse outcomes for patients (36,37).

The International Commission for Mountain Emergency Medicine (ICAR MEDCOM) has long recognized these issues and has published evidence-based guidelines and best-practice recommendations to improve operational consistency (36,37). These efforts highlight the necessity for shared standards in international cooperation, where alignment in handover processes can make a significant difference in time-sensitive rescue operations.

Additionally, skill disparities between rescue personnel from different systems have been documented as a major issue (35). A standardized communication protocol can serve as a baseline across varying educational backgrounds, facilitating consistent performance and reducing preventable errors. Research has also shown that structured handovers promote better retention of critical data and reduce the cognitive load on rescuers, especially during high-stress scenarios such as avalanche responses or mass casualty events (38).

The potential of a standardized handover scheme goes beyond operational use: it can serve as an educational and evaluative tool to enhance the overall quality of training, teamwork, and care delivery across national borders. By implementing such a protocol, countries and organizations could collectively improve the interoperability and efficiency of alpine rescue operations, ultimately contributing to safer outcomes for patients in extreme environments (39,40).

2. Methods and materials

2.1. Study Design and Objectives

This diploma thesis is based on a simulation-based crossover study, conducted in cooperation with the Department of Anaesthesia and Intensive Care Medicine at the University Hospital of Graz and the Styrian Mountain Rescue Service. The study aimed to examine whether the implementation of a structured handover scheme specifically designed for alpine rescue operations could improve the quality of verbal patient handovers. The central objective was to determine whether structured communication helps reduce the loss of critical patient-specific information.

Each participant completed two simulated patient handovers: one using a free, unstructured approach, and one using the newly developed PEAKS handover scheme. The performance of both handovers was evaluated using a standardized checklist (see Appendix 3: Checklist), which measured the completeness and clarity of transmitted information.

The research project received ethical approval from the Ethics Committee of the Medical University of Graz on 13 December 2024 (EC No.: 1127/2024). No real patients were involved, and all scenarios were entirely fictional.

2.2. Development of the PEAKS Handover Scheme

Pre-hospital emergency medicine is a highly specialized field that already relies on established handover schemes in various areas to ensure structured and efficient communication between emergency services. There are numerous standardized models in intensive care, emergency medical service, hospital handovers and others, that help to communicate relevant information clearly and completely. Examples include well-known handover schemes such as SBAR (Situation, Background, Assessment, Recommendation), MIST (Mechanism, Injuries, Signs, Treatment), or ATMIST (Age, Time, Mechanism, Injuries, Signs, Treatment), which have proven their value in various emergency medical contexts.

However, to this day there is no single standardised handover scheme tailored to the specific needs of mountain rescue. The specific challenges of this field - including inaccessible terrain, extreme weather conditions and long transport times - require specific adaptations of existing concepts or the development of new, customized solutions.

The aim of this work was to design a new handover scheme that would meet the specific needs of the mountain rescue service. Special attention was given to the development of a memorable and practical mnemonic that is easy to learn and use. To ensure this, three different schemes were developed, based on proven models from emergency medicine, but specifically adapted to the circumstances and challenges of the mountain rescuers.

Table 8: PEAKS

Symbol	Criteria	Contents
P	Patient information	Name, Sex, Age, Patient history (insurance-card/number), medical history, red flags
E	Event	Accident/emergency situation, altitude, location, time, temperature, medical history + Red flags
	Evaluation	Vital functions (ABCDE) and vital signs, condition and injuries
A	Action taken	Immediate actions and treatment, transport
K	Key findings	Detailed description of the injury or illness
S	Summary	Summary and Situation awareness

Table 9: GLACIER

Symbol	Criteria	Contents
G	General information	Name, Sex, Age, Patient history (insurance card/number, medical history + Red flags
L	Location	Location + time of the accident, altitude, temperature
A	Assessment	Assessment: Vital parameters; condition (stable/unstable) , ABCDE
C	Care provided	Current measures and treatment + transport
I	Injurie/ Illness	
E	Event	Red flags
R	Resume	Summary + Situation awareness

Table 10: ALPINE

Symbol	Criteria	Contents
A	Assessment	Vital parameters; condition (stable/unstable), ABCDE
L	Location	Location + time of the accident, altitude, temperature
P	Patient information	Name, Sex, Age, Patient history (insurance card/number,
I	Injury/ Illness	
N	Needed information	Current measures and treatment + transport
E	Events	Red flags

Due to the fact that the first handover-scheme was considered the best designed and the mnemonics were also very suitable for mountain rescue team, the Peaks handover-scheme was chosen.

PEAKS	
Personal-information	Name, age, gender, red flags, medical history, (medications, allergies) insurance number/ insurance data
Event **E**valuation	Cause of the accident/ emergency situation, altitude, position, temperature, environmental influences Vital functions (ABCDE) and vital parameters, general condition and appearance of the patient, injuries Examinations (MDS, trauma check,...)
Action taken	Immediate actions and treatment, (wound car, oxygen therapy, defibrillation and number of shocks, administration of medication) transport
Key findings	Detailed description of the injury or illness.
Summary and **S**ituation awareness	Point out the most important information, include relevant facts not previously mentioned.

Figure 3: PEAKS

2.3. Simulation and Data Collection Procedure

As part of the winter basic training course, 30 mountain rescue trainees voluntarily participated in the simulation study. The procedure was pseudonymized, and no conclusions could be drawn about individuals or their specific performance. Participants were divided into groups of five and assigned to one of two fictional emergency scenarios:

- **Scenario 1:** The patient had collapsed on a ski slope, the cause of the fall was unknown. On arrival, the mountain rescue team found the patient in cardiac arrest. Immediate resuscitation measures were initiated, including chest compressions, ventilation and defibrillation with an automated external defibrillator (AED). Following return of spontaneous circulation (ROSC), the patient was prepared for transport, with appropriate thermal management using warming packs.
- **Scenario 2:** The patient had fallen off-piste and was lying in the snow when the mountain rescue team arrived. To provide the team with an optimal working environment, the patient was moved onto the ski slope. The patient had suffered a head injury, which caused confusion and nausea. He also had a trauma on his shoulder and severe pain in the upper arm/shoulder area. The

focus was on correct patient positioning to stabilise circulation, possible immobilisation of the injured shoulder using a triangular bandage and final stabilisation in a vacuum mattress. Thermal management was provided using a rescue blanket and warming packs.

Each group performed two handovers per scenario:

- An initial handover without structured guidance
- A second handover after a brief introduction to the PEAKS scheme

In both instances, participants handed over the patient verbally to a designated person representing an emergency physician. All information was recorded and evaluated using a scoring system based on a predefined gold standard.

2.4. Study population and study design

A simulation-based crossover study was conducted as part of a practice-oriented basic winter training program of the Styrian Mountain Rescue Service. The aim was to investigate the influence of a newly developed structured handover scheme (PEAKS) on the quality of verbal patient handover. The study design comprised two handovers per participant:

- Handover 1: without using a structured scheme
- Handover 2: using the PEAKS scheme

The following hypotheses were formulated to test the effect of the structured handover using the PEAKS scheme:

- H0 (null hypothesis): There is no difference between handovers with and without the new scheme.
- H1 (alternative hypothesis): There is a significant difference between handovers with and without the new scheme.

The study was conducted with 30 participants consisting of prospective mountain rescuers of the Styrian Mountain Rescue. Each person carried out a simulated patient handover to a person who represented an emergency doctor in the setting. A brief introduction to the PEAKS scheme was given between the two handovers. In addition, a pocket card of the PEAKS scheme was distributed (Figure 3:PEAKS),

which could be used during the second handover. The handovers were evaluated using a standardized evaluation form with a scoring system from 0 to 4 based on a previously defined gold standard. See Appendices 1 and 2 for the timely outcomes of the individual handovers and the gold standard.

2.5. Evaluation Criteria

To compare handover quality, a 4-point scoring system was developed for both scenarios. The maximum score was awarded when all critical elements of the gold standard were communicated. A score of 0 indicated the omission of all relevant information. The comparison allowed objective analysis of whether the PEAKS tool improved information completeness.

2.6. Data Analysis

The data collected from the handovers were compiled in an Excel spreadsheet. Analysis was performed using IBM SPSS Statistics 29. The number of correctly communicated information points was evaluated per participant for both the structured and unstructured handovers. Descriptive statistics and inferential analysis (e.g., Wilcoxon signed-rank test) were used to examine the significance of observed differences.

2.7. Inclusion and Exclusion Criteria

Inclusion criteria:

- Minimum age of 18 years
- Active membership in the Austrian Mountain Rescue Service

Exclusion criteria:

- Refusal to participate in the study

2.8. Potential Sources of Bias

Despite efforts to ensure objectivity, several sources of bias may have influenced the results:

2.8.1. Observer bias:

The evaluation of handovers using checklists was performed manually, which may have introduced subjective judgment, especially when interpreting the clarity or completeness of information.

2.8.2. Hawthorne effect:

Participants may have altered their behaviour due to awareness of being observed, potentially improving performance in both handover types regardless of the intervention.

2.8.3. Learning effect:

As the structured handover always followed the unstructured one, participants might have already improved due to repetition, independently of the scheme itself.

2.8.4. Small sample size:

With only 30 participants, generalizability to all mountain rescue members is limited.

2.8.5. Group dynamics and information leakage:

As the handovers were performed sequentially within a group setting and not in isolated rooms, it is possible that participants overheard previous handovers or discussed aspects of the scenario between rounds. This could have led to an unintended exchange of information and influenced the quality of subsequent handovers.

2.8.6. Professional Background:

The participants came from different professional fields (e.g., paramedics, intensive care nurses, physicians), some of whom may already have had experience with structured patient handovers. This prior knowledge may have positively influenced the quality of both unstructured and structured handovers, potentially skewing the results in favour of the intervention.

2.8. Ethical and Practical Considerations

The scenarios used in this study were entirely fictional and designed for educational and research purposes. No real patients were involved. The aim was solely to evaluate communication structure and information transfer in simulated handovers.

The results of this study aim to support the further development of communication training within mountain rescue services and may serve as a foundation for introducing a nationally standardized handover scheme.

3. Results

The findings of the simulation-based study assessing the PEAKS handover scheme's impact are presented in this chapter. The analysis sheds light on the efficacy of the new communication tool by comparing unstructured and structured handovers in terms of information completeness, consistency, and statistical significance. The Appendix (Appendix 1) contains the punctual outcomes of each individual handover.

3.1. Results of the handover quality

3.1.1. Mean values of the transmitted information

At the first handover (without PEAKS), the mean value of the correctly transmitted patient-specific information was 2,51 points (SD = 0,83).

At the second handover (with PEAKS), this value increased significantly to 3,59 points (SD = 0,45). The lower standard deviation in the second handover indicates a more consistent quality of information transfer.

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Handover 1	2,5083	30	,82984	,15151
	Handover 2	3,5933	30	,44755	,08171

Figure 4: T-Test

3.2.2. Correlation of handovers

The paired sample correlation between the two conditions is r = 0,458 (p = 0,011). This indicates a moderate positive correlation between performance in the two handovers - participants who performed better in the unstructured handover also tended to perform better with PEAKS.

Paired Samples Correlations

		N	Correlation	Significance One-Sided p	Significance Two-Sided p
Pair 1	Handover 1 & Handover 2	30	,458	,005	,011

Figure 5: Paired Sample Correlation

3.2.3. T-Test for mean difference

The mean difference is -1,085, which indicates that, on average, more patient-specific data was correctly transmitted with the new scheme.

The t-test resulted in a t-value of -8,021 with df = 29, indicating very strong statistical evidence for a difference between the groups.

The calculated significance p<0,001 means that the probability of a random result is very low. Thus, the new scheme leads with high certainty to an improved handover. The 95% confidence interval of the mean difference is between -1,36167 and -0,80833, which means that the null hypothesis can be excluded.

Paired Samples Test

		Paired Differences					t	df	Significance One-Sided p	Significance Two-Sided p
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper				
Pair 1	Handover 1 - Handover 2	-1,08500	,74094	,13528	-1,36167	-,80833	-8,021	29	<,001	<,001

Figure 6: Paired Sample Test

3.1.4. Effect size

The organized handover utilizing PEAKS has a very large effect, as indicated by the calculated effect size of d = 1,46 according to Cohen. Even after Hedges' modification, the value for d = 1,43 stays constant. These findings show that using the PEAKS scheme improves the quality of information transfer in a way that is both practically important and statistically significant.

Paired Samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval Lower	Upper
Pair 1	Handover 2 - Handover 1	Cohen's d	,74094	1,464	,940	1,977
		Hedges' correction	,76082	1,426	,915	1,925

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Figure 7: Paired Samples Effect Sizes

3.1.3. Graphical representation of the distribution of the data

A boxplot and a bar chart were created to visualise the differences between the two handovers.

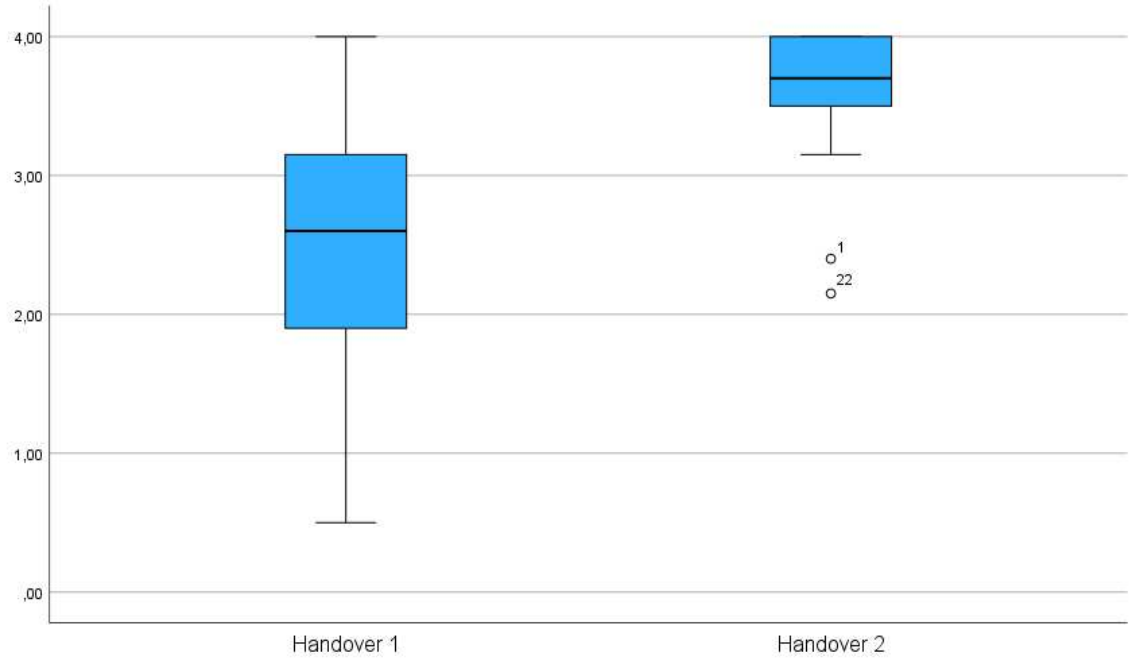

Figure 8: Distribution shown in a boxplot

Boxplot diagram: The boxplot shows that the values for handover 1 (without PEAKS) have a greater spread. The median line is lower than for handover 2 (with PEAKS), which means that, generally, less patient-specific data was handed over correctly in the first condition. In addition, there are larger differences between individual participants in handover 1, while the values in handover 2 are closer together, indicating a more uniform handover. This indicates that the standardised scheme makes the handover more consistent.

Bar chart: The bar chart shows the mean difference between the two conditions. Handover 2 has a significantly higher mean number of correctly transmitted patient-specific data than Handover 1. This visual representation supports the previously reported descriptive statistics and emphasises the positive effect of the PEAKS scheme.

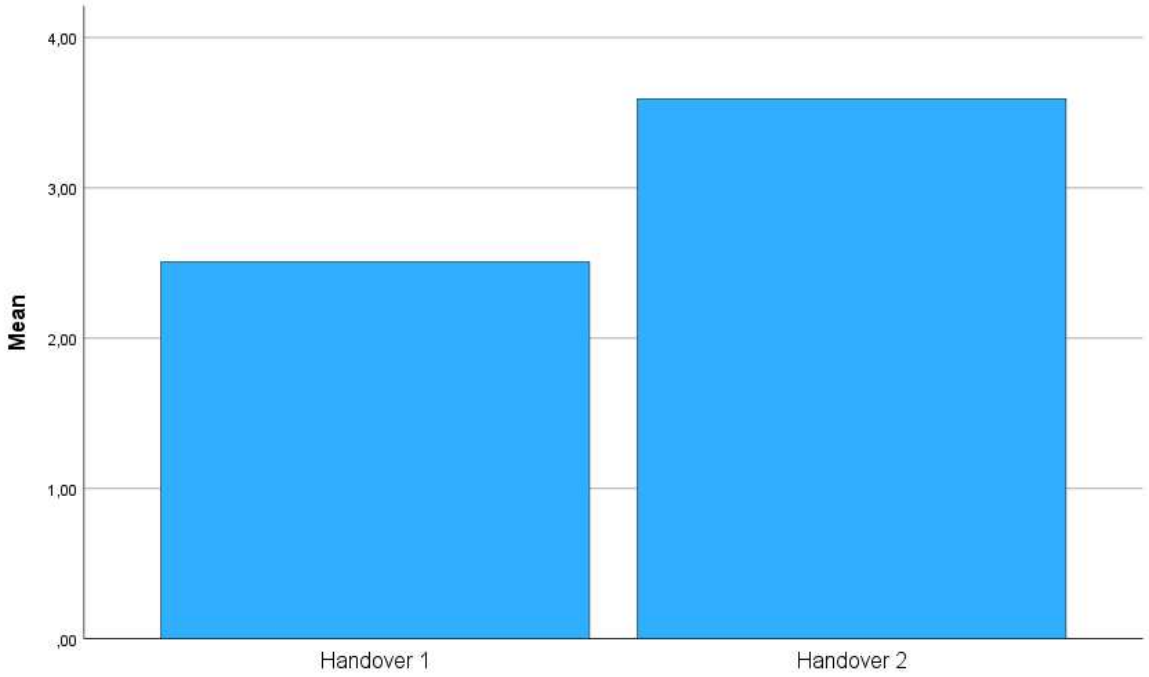

Figure 9: mean value shown in a bar chart

3.1.5. Interpretation of the results

The results show a significant improvement in the quality of the transfer through the implementation of the PEAKS transfer scheme.

The significant difference between the means shows that more patient-specific data is correctly transferred with the new scheme.

The large effect size confirms that the difference is not random but represents a significant improvement in practice.

The narrow confidence interval shows that the results are reliable and not influenced by random variation. The moderate correlation between the transfers indicates that there are still individual differences between the subjects, but that a significant improvement has been achieved with the new scheme.

4. Discussion

4.1. Interpretation of the results and answer to the research question

The results of the simulation-based crossover study clearly show that the introduction of the PEAKS handover scheme led to a statistically and practically significant improvement in the quality of verbal patient handovers in alpine rescue scenarios. The comparison of structured and unstructured handovers shows a consistent trend: participants using the PEAKS protocol provided more complete, accurate and consistent information.

The increase in the mean score from 2,51 to 3,59 points highlights a measurable gain in the amount and precision of information conveyed. This difference is not only statistically significant ($p<0,001$) but also supported by a large effect size (Cohen's $d = 1,46$), which reinforces the practical relevance of the findings. The lower standard deviation observed during structured handovers indicates that participants performed more consistently, suggesting that the PEAKS framework serves as an effective guide to help standardize communication across different skill levels and backgrounds.

Furthermore, the moderate correlation ($r = 0,458$) between the two handovers suggests that individuals who initially performed better were also more proficient with the structured approach, but the standardized protocol increased the overall quality of the handover regardless of individual baseline skill. This suggests that PEAKS may act as an equalizing tool, reducing the performance gap between paramedics with different levels of experience.

The results answer the central research question in the affirmative: the implementation of a structured handover scheme, which was specifically developed for mountain rescue, leads to a significant improvement in the quality of verbal handovers. The observed improvement is not only statistically verifiable, but also of high practical value, especially in the context of alpine emergencies, where communication barriers and environmental stressors often challenge information transfer.

In summary, PEAKS provides a clear, memorable, and effective structure that facilitates accurate and complete handovers. Its successful use in the simulation environment demonstrates its potential as a training tool and operational aid within the Austrian Mountain Rescue Service and possibly beyond. These results justify further efforts towards formal implementation, continuous evaluation, and wider dissemination of the PEAKS handover scheme.

4.2. Practical experience and subjective feedback from participants

As part of the study, some participants were also asked qualitative questions about their perception of the PEAKS handover scheme after the simulation. The informal feedback was mostly positive. In particular, younger rescuers without a medical background felt more confident and structured in performing the handover thanks to the scheme. They reported that the diagram helped them to keep track of relevant information and to reduce uncertainty. It was also noted that the scheme provided good guidance in stressful situations where structured communication is particularly challenging.

This feedback underscores the practical benefits of the PEAKS scheme, particularly for first responders without extensive emergency medical experience. The simple and memorable format seems to be particularly suitable for supporting less experienced team members and improving team communication. This confirms the relevance of a standardized handover structure not only from a theoretical but also from a user perspective.

4.3. Comparison with existing literature

The results of this study are consistent with the existing literature on the effectiveness of structured handovers in emergency and rescue medicine and for the first time add a specific contribution from the Alpine context. Numerous publications already indicate that structured handovers lead to a significant improvement in the transfer of information and reduce the risk of incorrect or faulty care. For example, the work of Nuernberger et al. (2025) shows that the use of the

ISOBAR scheme in pre-hospital emergency medicine improves the memory performance of medical staff and, at the same time, reduces the number of necessary queries. These findings are also reflected in the present study, in which a significant increase in correctly transmitted information and a more homogeneous transmission quality were achieved by using the newly developed PEAKS scheme.

At the same time, the work confirms the demand of the International Commission for Mountain Emergency Medicine (ICAR MEDCOM) for standardized, evidence-based handover formats for alpine emergency operations (36,37). The development and successful testing of a scheme specifically designed for mountain rescue represents a practical implementation of these recommendations and closes an existing research gap.

This study also agrees with previous research findings regarding the influence of human factors. For example, Lazarovici, Trentzsch and Prückner (2016) emphasize that factors such as stress, team dynamics and experience are decisive for the quality of communication. The PEAKS scheme appears to be able to cushion precisely this influence: Less experienced mountain rescuers stated that the structured approach helped them to communicate safely and fully under pressure. This speaks for the practical effectiveness of the tool, especially in exceptional situations, which are typical for alpine rescues.

This assessment is also supported by the subjective feedback from the participants in the study: In informal feedback following the simulation, younger mountain rescuers without a medical background in particular described the PEAKS scheme as helpful and relieving. It helped them to systematically record relevant information and reduce uncertainties during the handover. It was emphasized several times that the scheme provides orientation, especially in stressful situations. This qualitative feedback underlines not only the high practical suitability of the scheme, but also its potential role as a training tool for new or inexperienced emergency personnel.

Furthermore, the study is directly related to the findings of Kornhall and Martens-Nielsen (2016), which emphasize the importance of clear and consistent communication in relation to avalanche operations. In that study can be seen that structured handovers not only improve the quality of information transfer but can also support decision-making processes in stressful situations. The positive

development of handover quality observed in this study impressively confirms this assumption, even under simulated conditions with limited resources.

In addition, the present study can be linked to studies by Podsiadło et al. (2017) and Nagody-Mrozowicz & Halemba (2021), who see structured handovers not only as a means of communication, but also as a pedagogical tool. According to them, standardized schemes contribute to the training and competence development of emergency teams. The added value of the PEAKS scheme is also evident here: the memorable format is particularly suitable for teaching.

Overall, it can be stated that the present results not only confirm the existing scientific findings, but also supplement them with practical, empirical data from the specific field of alpine rescue. The work thus makes a valuable contribution to the further development of evidence-based communication standards in mountain rescue.

4.4. Critical Reflection and Limitations

While the results of this study indicate a significant improvement in the quality of rescues using the PEAKS scheme, several methodological and contextual limitations must be considered when interpreting the results.

First, the simulation-based design, while beneficial for standardization and control, only approximates real-world alpine rescue conditions. Factors such as terrain complexity, adverse weather conditions, limited team resources, and time-critical decision making were not fully replicated. As a result, the external validity of the results is limited, and their generalizability to actual rescue operations must be approached with caution.

Second, the sequence of handovers - with the structured (PEAKS) handover always following the unstructured one - introduces a potential learning or training effect. Participants may have improved in the second handover simply because of increased familiarity with the scenario or through self-correction of previously omitted points. This design choice, while pragmatic, may have artificially inflated the observed effect of the intervention.

Furthermore, observer bias cannot be ruled out. Although scoring was based on predefined checklists, subjective interpretation, especially in borderline cases, may have influenced the outcome. A blinded scoring protocol or independent raters could reduce such bias in future studies.

Another limitation is the small sample size (n = 30) and the homogeneous training context. All participants were recruited from a single regional mountain rescue course, which limits the representativeness of the study population. In addition, pre-existing medical knowledge varied, as some participants had professional experience as paramedics or nurses. This prior familiarity with structured communication likely influenced their baseline performance and may have made it easier for them to apply the PEAKS model effectively.

The Hawthorne effect must also be considered: participants knew they were being observed, which may have led to artificially improved behaviour during both handovers. While this is a common issue in simulation studies, it underscores the need for real-world validation to assess the scheme's effectiveness under operational stress and distraction.

Lastly, information leakage between participants - due to group-based simulation rounds and limited isolation - could not be entirely ruled out. Although efforts were made to minimize this risk, prior exposure to the scenario may have affected the second performance of later participants within the same group.

Taken together, these limitations highlight the need for further field-based studies with larger, more diverse populations and randomized handover orders. Only through repeated and varied application in real-life contexts can the true practical value and robustness of the PEAKS scheme be confirmed.

4.5. Implications for practice and training

The results of this study suggest that the PEAKS handover scheme has strong potential for practical implementation within the Austrian Mountain Rescue Service. Given the significant improvement in information completeness observed in the simulation and the positive feedback from the participants, it is reasonable to

conclude that PEAKS can make a meaningful contribution to communication safety in alpine emergencies.

One of the main advantages of PEAKS is its simple structure and intuitive design, which makes it particularly suitable for rescuers without a clinical background. Since many volunteer mountain rescuers lack formal training in emergency medicine or structured communication protocols, the use of a clearly defined handover scheme can reduce uncertainty and improve consistency in verbal exchanges.

For training purposes, PEAKS can be integrated into the standard curriculum of basic and advanced mountain rescue courses. Practical tools such as laminated pocket cards, scenario-based simulations, and e-learning modules could support learning and retention. In addition, the inclusion of PEAKS in regular refresher training would help reinforce correct use and ensure long-term integration into daily practice.

Beyond internal training structures, PEAKS also has potential for cross-organizational standardization. Since mountain rescue operations often involve other emergency services, such as helicopter crews, alpine police, and emergency physicians, a common language and framework for handovers can improve interoperability and reduce the risk of miscommunication at critical interfaces. In this way, PEAKS could serve as a bridge between alpine and clinical EMS systems, promoting a more seamless transition of patient care.

Furthermore, the implementation of PEAKS supports patient safety goals by reducing the likelihood of omitted or incorrect information during handovers. By establishing a standardized communication process, rescue teams can ensure that essential data - such as vital signs, injuries, and interventions - are consistently conveyed, even in high-stress and time-sensitive environments.

Taken together, these findings point to a strong practical relevance of the PEAKS scheme for both training and operational settings. The structured format not only improves communication quality but also offers a low-threshold entry point for less experienced team members, thereby contributing to a more resilient and reliable mountain rescue system.

4.6. Outlook and future research

The results of this study highlight the potential of the PEAKS handover scheme as a practical and effective communication tool for mountain rescue scenarios. However, while the controlled simulation setting allowed for a structured evaluation, the applicability of the findings to real-world operations remains limited and needs to be critically examined. The artificial setting of the simulation, the predictability of the scenarios, and the awareness of being observed likely influenced participants' behaviour-raising the question of whether similar results would be achieved under real-world mission conditions with environmental stressors, time pressure, and unforeseen complications.

As a result, future research should focus on the implementation and evaluation of PEAKS in real-life rescue missions. This includes observational field studies that analyse how the program performs under the physical, emotional, and organizational demands of actual operations. Such studies would provide insight into the practical usability and long-term effectiveness of PEAKS when integrated into existing mountain rescue workflows.

In addition, longitudinal studies are needed to assess knowledge retention and skill transfer among rescuers. It remains to be seen whether rescuers will continue to use the system after the initial training phase, or whether its use will decline over time without repeated exposure. This is particularly relevant for volunteer organizations such as the ÖBRD, where the frequency of training may vary and members often come from non-medical backgrounds.

Another area of future interest is the interprofessional applicability of the PEAKS program. Although it was designed with mountain rescuers in mind, it could be adapted and tested for use in interdisciplinary settings, including collaboration with helicopter emergency services, prehospital emergency physicians, and alpine police. If the tool proves effective across organizations, it could serve as a basis for interoperability and uniform training standards in alpine emergency care.

From a broader perspective, the system may also be of value to the international mountain rescue community. Organizations such as ICAR and ICAR MEDCOM provide a suitable platform to further develop and possibly standardize communication protocols across borders. Given the frequent collaboration between

rescue teams from different countries, especially in the Alpine region, a harmonized tool such as PEAKS could significantly improve patient safety and operational efficiency.

However, it must be critically acknowledged that the success of any standardization effort depends not only on the content of the tool, but also on user acceptance, cultural adaptability and integration into existing structures. Resistance to change, different training philosophies and varying levels of medical knowledge among international rescuers may pose challenges to widespread implementation. Therefore, comparative studies with existing tools such as ATMIST, ISOBAR or SINNHAFT should be considered to determine context-specific advantages or limitations of the PEAKS framework.

Finally, with the growing importance of digital documentation tools and mobile applications, future research could explore how systems such as PEAKS could be digitally supported - for example, through integration with emergency services apps or voice-guided handover checklists. Such innovations could further improve the reliability of communication, especially in harsh weather conditions where verbal communication may be impaired.

In conclusion, although the PEAKS handover system has shown promising results in controlled training environments, its effectiveness in real-world scenarios, long-term integration, and potential for widespread standardization have yet to be fully determined. Extensive field testing continued user-focused refinement and coordinated efforts across organizations will be critical to realizing its full potential in mountain rescue.

4.7. Communication in a multi-professional context

In alpine emergency situations, several organizations and professional groups often work together, including mountain rescue, air rescue, emergency doctors, the fire department, police or a rescue organization. This multi-professional collaboration poses particular challenges for communication. Different training backgrounds, technical language, and understanding of roles and priorities can lead to misunderstandings, especially in stressful situations(41). A uniform and clearly

structured form of handover, such as the PEAKS scheme, can create a central interface at which information is passed on in a standardized way, regardless of the professional background of the person taking over.

The literature shows that standardized communication formats in multi-professional teams can lead to a significant increase in safety. For example, Patterson et al., (2012) recommend consciously using shared communication tools in emergency care to promote a shared mental model. The ICAR MEDCOM Guidelines also emphasize the need for “interdisciplinary handover tools” in the cross-border alpine rescue context (37). The PEAKS scheme offers a practicable basis for this: it is easy to understand, self-explanatory and can be used both in training and in operations across professions.

4.8. Sustainability and implementation of the PEAKS scheme

The long-term effectiveness of a new handover tool depends largely on its integration into training, organizational structures and everyday practice. Studies on comparable communication schemes such as I-PASS or ISBAR show that although the initial introduction can bring about improvements, a sustainable effect can only be achieved through continuous training, feedback loops and institutional support (43,44).

For the PEAKS scheme, this means that it should not only be presented in courses, but actively integrated into training scenarios, regularly evaluated and discussed in debriefings. Integration into digital training formats - for example, in the form of e-learning modules or interactive simulations - offers additional potential for scaling. The use of pocket cards or checklists in real operations can also contribute to long-term establishment. Institutional backing is crucial here: PEAKS can only become effective as a uniform standard if specialist areas such as air rescue, emergency medical systems and the ÖBRD work together on its introduction.

4.9. Conclusion

This chapter: Discussion has explored the development, evaluation, and broader relevance of the PEAKS handover scheme in the context of alpine emergency medicine. Through a simulation-based study, it has been shown that structured communication significantly improves the completeness and consistency of patient handovers between mountain rescue personnel. The scheme showed particular benefits for less experienced rescuers, reinforcing its pedagogical and practical value.

Compared to established clinical handover tools, PEAKS stands out for its adaptability to challenging environmental conditions, its mnemonic design, and its relevance to non-clinical rescue settings. The integration of human factors, the emphasis on communication under stress, and the consideration of non-verbal and technological aspects further support its real-world applicability.

However, limitations such as the artificial nature of the simulations, a small sample size, and possible observer effects highlight the need for further field validation. The chapter also highlights the importance of standardized training, inter-organizational collaboration, and sustainable implementation strategies to ensure long-term effectiveness.

Taken together, the results presented here provide strong evidence that structured, context-specific handover models such as PEAKS can play a central role in improving communication, safety, and coordination in mountain rescue operations.

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5. Appendix:

As a non-native speaker of English, I utilised the DeepL Write and Scribbr paraphrasing tools to assist with grammar and the reformulation of phrases to enhance comprehension and clarity.

Handover 1	Handover 2	Difference (H2-H1)
1,5	2,4	0,9
3,5	4	0,5
4	4	0
3	3,15	0,15
3,05	3,5	0,45
3,3	4	0,7
2,65	3,65	1
2,5	3,8	1,3
2	3,8	1,8
2,9	3,15	0,25
3,2	3,65	0,45
3	4	1
2,5	4	1,5
3,15	3,8	0,65
1,75	4	2,25
3,25	3,65	0,4
3,35	3,55	0,2
2,4	3,5	1,1
1,65	3,8	2,15
2,4	3,8	1,4
2,65	3,3	0,65
0,5	2,15	1,65
3,05	3,8	0,75
1,9	3,3	1,4
1,65	3,3	1,65
1,25	3,5	2,25
3,5	3,5	0
2,15	4	1,85
1	3,75	2,75
2,55	4	1,45

Appendix 1: selective results of the individual handovers compared with the goldstandard (Appendix 2)

Goldstandard Übergabe 1: Atemkreislaufstillstand
Identifizierung: mit Name und Alter, Geschlecht
-> 0,5 Punkte

Event: Unfallhergang (Sturz/ zusammengesackt auf der Piste) optional mit Begleitperson
-> 0,5 Punkt

Evaluierung: ABCDE-> Atemwege frei, keine Atmung, Atemkreislaufstillstand
1,5

Prozedere/ Aktionen: CPR mit Defi + Schocks; Lagerung, Wärmeerhalt und Abtransport
1,5

Goldstandard Übergabe 2: Commotio und Schulterverletzung
Identifizierung: mit Name und Alter, Geschlecht
-> 0,5 Punkte
Event: Unfallhergang (Sturz in steilem Gelände, unbeobachtet)
-> 0,5 Punkte
Evaluierung: allgemeiner verwirrter Zustand, keine örtliche Orientierung, Verletzung Arm und Kopf, Abarbeiten des ABCDE-Schemas (Atemwege frei, normaler Kreislauf, Sauerstoffsättigung (->folglich O2-Gabe), grober Neurologischer Status, Exposure (Verletzungen und Körpertemperatur))
-> 2 Punkte

Prozedere/ Aktionen: Lagerung, Wärmeerhalt und Abtransport, O2-Gabe, weitere Aktionen
-> 1 Punkt

Appendix 2: Goldstandard

Beeinflussung der alpinen Übergabe der Bergrettung an Notärzte*innen – Einführungsversuch eines Übergabe-Schemas

Checkliste:

Teilnehmer-Code: _____

	Übergabe 1	Übergabe 2	Notizen
Identifikation Person			
Event			
Evaluierung			
Prozedere Aktionen			
Zusammenfassung			

PEAKS-Schema Version 1: 05.05.2024

- Identifikation: Name, Alter, Geschlecht, Medizinische Vorgeschichte, Red flags, Medikamente, Allergien, Versicherungsnummer
- Event: Unfall+Unfallhergang/Notfallsituation, Höhe, Position, Temperatur, Umwelteinflüsse
- Evaluation: Vitalfunktion (ABCDE) und Vitalparameter, generelle Zustand und Erscheinungsbild des Patienten/der Patientin, Verletzungen Untersuchungen (MDS, Traumacheck,…)
- Prozedere : Maßnahmen die ergriffen wurden: Wundversorgung, Sauerstoffgabe, Defibrillation und wie oft, Medikamentengabe, Abtransport
- Zusammenfassung: Hervorheben der wichtigsten Informationen, Einbringen von vorher nicht erwähnten, relevanten Fakten. Detaillierte Beschreibung der Verletzung oder der Erkrankung.

P Patients information: Name , Sex , Age , Patient history (insurance-card/number) medical history, red flags

E Event : accident/emergency situation , altitude , location , time, temperature
medical history + Red flags
Evaluation: vital functions (ABCDE) and vital signs, condition and injuries

A Action taken: immediate actions and treatment, transport

K key findings: detailed description of the injurie or illness

S Summary and Situation awareness

Appendix 3: Checklist

Case Report: Untersuchung der Effektivität eines neuen Übergabeschemas für die Bergrettung an den Notarzt/die Notärztin

Einleitung: In diesem Fallbericht wird die Effektivität eines neuen Übergabeschemas für die Bergrettung an den Notarzt/die Notärztin untersucht. Dabei werden die Auswirkungen der Übermittlung von wichtigen Fakten im Vergleich zu einer Situation ohne Übermittlung betrachtet. Die Studie zielt darauf ab, zu untersuchen, ob das neue Übergabeschema zu einer verbesserten Übermittlung wichtiger Informationen führt und ob die Reliabilität der übergeben Fakten besser ist im Vergleich mit dem Protokoll der Bergrettung.

Übergabe : Vorlage

	Übergeben (herkömmliche Methode	Übergeben (neues Schema)
Essenzielle Information 1	**Ja** ☐ **Nein** ☐	**Ja** ☐ **Nein** ☐
Essenzielle Information 2	**Ja** ☐ **Nein** ☐	**Ja** ☐ **Nein** ☐
Essenzielle Information 3	**Ja** ☐ **Nein** ☐	**Ja** ☐ **Nein** ☐
Unterschiede zwischen Protokoll und Übergabe		

Fakten als relevant vs. irrelevant übergeben: Im neuen Übergabeschema werden relevante Fakten, die für die Behandlung des Patienten von Bedeutung sind, übermittelt. Dazu gehören unter anderem die Identifikation des Patienten, die Situation und der Unfallhergang, die Art des Unfalls, die Symptome/Verletzungen, „red flags“ sowie die durchgeführten Maßnahmen und Behandlungen. Irrelevante Fakten, die keinen direkten Einfluss auf die Behandlung haben, sollten diesbezüglich nicht übergeben werden.

Primärer Endpunkt (essenzielle Fakten): Der primäre Endpunkt dieser Studie ist die Übermittlung von essenziellen Fakten, die für die Behandlung des Patienten von entscheidender Bedeutung sind. Dazu gehören die im oberen Absatz genannten Informationen über die Identifizierung des Patienten, die Verletzungsart, den Zustand des Patienten bei der Ankunft, relevante Vorerkrankungen und die durchgeführten Ersthilfemaßnahmen.

Sekundärer Endpunkt (Reliabilität der Übergabe im Vergleich zu den wahren Fakten): Der sekundäre Endpunkt befasst sich mit dem Vergleich zwischen dem Protokoll der Bergrettung (welches während des Einsatzes erstellt wurde) und den Fakten die tatsächlich übergeben wurden. Hierbei wird ermittelt, ob die wichtigsten Daten/Fakten, welche im Protokoll dokumentiert, auch übergeben wurden. Wiederum wird verglichen, ob es Unterschiede gibt, bezüglich der Übergabe mit oder ohne Schema.

Diskussion: Die Untersuchung der Daten wird zeigen, ob das neue Übergabeschema zu einer signifikanten Verbesserung der Übermittlung wichtiger Fakten führt. Dies kann dazu beitragen, dass der Notarzt alle relevanten Informationen erhält, um eine schnellere und genauere Behandlung zu ermöglichen. Darüber hinaus wird festgestellt, ob sich das neue Übergabeschema auf die Übergabezeit auswirkt und durch das Einhalten der vorgegeben Punkte, es zu einer schnelleren Faktenübermittlung kommt, wodurch es zu eine folglich effizienteren Patientenversorgung kommt. Die Ergebnisse werden zeigen, ob das neue Übergabeschema ein wirksames Instrument zur Verbesserung der Kommunikation zwischen Bergrettungsteams und Notärzten/Notärztinnen ist.

Appendix 4: Case-Report