PROJEKTNR. 13987

Digitalt Räddningsstöd - allvarlig skadehändelse vid bygg och anläggningsprojekt

Slutrapport

Hans Hedberg,
Umeå Universitet

2024

En utbildningsdag

MID-TERM REPORT

Assisted trauma care for workplace injury events outside hospital - support for laypersons while Waiting for Ambulance

Hans Hedberg
Department of Surgery and Perioperative Care

2024

Mid-Term Report

UMEÅ UNIVERSITET

Acknowledgement

This midterm report has been prepared in unit for anesthesia and intensive care, Department of surgery and perioperative care, Umeå University, Sweden. This research was founded by the Development Fund of the Swedish Construction Industry (SBUF), and Umeå university, Department of surgery and perioperative care.
I would like to thank all the persons who shared their experiences in the project's interview study and thank you to the employees who participated in the study with simulations of serious injury events (90 persons). We thank Jan Eliasson, Arne Falk (NCC), Christer Johansson (Byggföretagen) for initiative and support. Finally, thanks to all companies, organizations, schools, Byggnads and SEKO for cooperation.

We hope that this midterm report inspires safety discussions and continued development of workplaces' preparedness for action in collaboration with society's resources, alarm centers, ambulances, and rescue services.

I would like to thank those who have given me support and learning in this part of my thesis work.

- To my supervisor, Prof, Michael Haney
- To my co-supervisor, Assoc, Prof, Jonas Aléx, Sofia Karlsson
- To the project manager, Assoc, Prof, Pia Hedberg

And thanks to Prof, Veronica Lindström for support for future studies

Abstract

Background: The risks of high-energy injuries at construction sites are significant, and a delayed response from ambulance personnel can have serious consequences. **Study 1** aimed to describe the experiences of personnel being present at serious injury events, participating in first aid measures before the ambulance arrives. **Study 2** aimed to evaluate whether digital video support and associated training, including advanced life-saving measures, have a positive effect on construction site workers/layperson, performing first aid measures during simulations of serious injury events.

Methods: Study 1 employed an interview study with qualitative content analysis. In **Study 2**, a simulation study was conducted with 90 participants from construction sites. Participants were assigned to different groups with various combinations of video calls, preparatory training, or nothing. The primary outcomes measured correct actions to manage blocked airways and stop life-threatening bleeding from lower extremity injuries within 90 seconds.

Results: In **study 1**, nine employees in the construction industry who had been involved in life-saving interventions at serious injury events were interviewed. The results identified an environment where employees needed to quickly transition from their professional roles to being layperson capable of identifying and managing serious injury events. This created stress that the layperson collectively tried to limit but affected them both in the short and long term. In **Study 2**, ninety participants were included in 10 groups of 3 for each of the 4 exposures. Live video support was effective in controlling bleeding, while a first aid course given beforehand did not seem as effective. Video support and the prior first aid course improved bystanders' ability to manage the airway, with the combination being no better than each intervention in isolation.

Conclusions: To reduce the risk of negative stress reactions among laypersons, preparedness is suggested in form of training and/or guidance from ambulance personnel through video calls. Since the effects of training are presumed to diminish over time without regular repetition, guidance through video calls during serious injury events may be a practical way to improve immediate life-saving measures while laypersons wait for ambulance.

Keyword: Construction Safety, Workplace incident, Injury event, Prehospital trauma, First aid training, Layperson, Bystander, First responders, Support, Telemedicine,

Table of contents

Definitions

Layperson: An individual without in-depth knowledge in first aid.

Bystander: A person who witnesses an injury event, often without in-depth knowledge in first aid.

Jaw Thrust: A maneuver to create an open airway by lifting the lower jaw in a form of underbite.

Tourniquet: Constricting device used for uncontrolled bleeding in extremities.

Pelvic sling: A product stabilizing the pelvis in cases of suspected pelvic injury.

Response time: The time from the emergency call, 112 until the ambulance or rescue service arrives and begins their work at the injury scene.

Publications in process

Hedberg H, Hedberg P, Haney M, Karlsson S, Alèx J. "Construction employee's experiences of being involved as a layperson first-aid provider in a serious workplace injury event- a qualitative study". Scheduled to be submitted, February 2024.

Hedberg H, Hedberg P, Alèx J, Karlsson S, Haney M. "Effects of an advanced first aid course or real-time video communication with ambulance personnel on layperson first response for building-site severe injury events: a simulation study". *BMC Emergency Medicine* 24, 2 https://doi.org/10.1186/s12873-023-00917-4

Introduction

In October 2018, two workplace injury events occurred somewhere in Sweden. It was afternoon, and the employee had just returned from their break. At one project site, casting was underway for a dam project in a remote rural area. At another construction site in the heart of a large city, assembly work was taking place on a vault, on the fifth floor. Suddenly, someone from the staff sees something falling, unsure of what fell (both construction sites). Uncertainty arises; was it a person who fell, or was it some material? Materials often fall to the ground; someone might have dropped an object, or an object might have blown away. Someone calls for help, and though it's still unclear if something has happened, others notice that someone is screaming for help. Several from the group have now gathered where a member of the staff called for help.

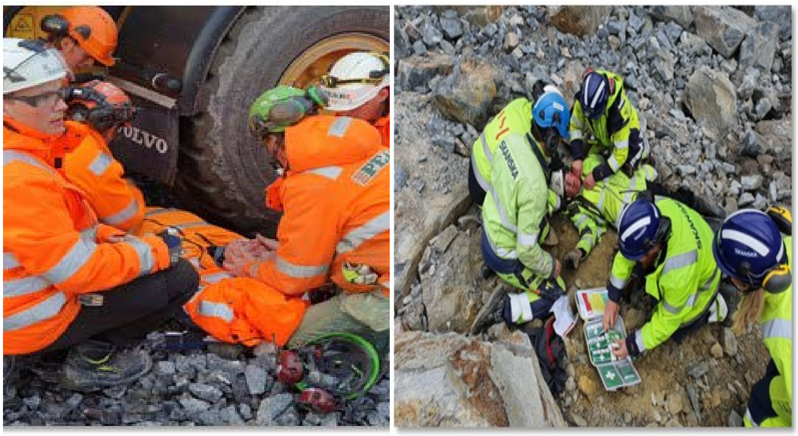
As the employee’s approaches, they see a person lying on the ground at both construction sites. There is blood around the body, pulsating from the leg, while the person is almost blue in the face and makes a strange sound as they try to breathe. Someone from the group calls for an ambulance and simultaneously tries to assist by applying pressure to the bleeding. Confusion arises about whether the person is breathing or not. The group begins to understand and realize that the person felt from a great height, but no one knows how long the person has been on the ground. Some start asking where the ambulance is and when it will arrive. The project in the rural area gets a response from the emergency dispatch: "within 1 hour," and the project in the city gets the response, "Don't know; we have no available ambulance" (it took 90 minutes for the helicopter to arrive at the rural project and 45 minutes for the ambulance to arrive at the city project).

The staff becomes even more stressed; the emergency dispatcher tries to provide support and advice while waiting for the ambulance. Despite this, the staff finds it challenging to understand how to establish an open airway for the injured person. Eventually, the injured person starts breathing but remains unconscious. The staff becomes calmer as the person's face regains color.

The ambulance and helicopter now arrive at the scene, taking over the rescue operation and transporting the injured person to the nearest hospital. Both individuals survived. This real-life injury event serves as a contributing factor to this project. Can lives be saved remotely, and if so, how? What support does a layperson need, and what can they do before professional ambulance personnel arrive at the scene?

Serious injuries with high energy levels pose a significant problem in Europe. Construction sites are identified as a sector with a higher risk of such events compared to other industries (Berglund et al., 2017; Perlman et al., 2016). This is partly due to the varied work environment and the continuously changing risks associated with construction activities. The work environment on construction sites is often characterized by stressful situations (Hansen et al., 2022). To provide a context, in Sweden, approximately 1,000 serious injury events are reported annually (medical leave of absence for thirty days or longer), sometimes resulting in fatalities (M. Stenberg, 2017). This highlights the extent of the problem, and the potentially life-threatening dangers present on construction sites. These types of serious injuries are characterized by sudden events resulting in the release of high energy onto the human body. This high energy primarily affects the injury and secondarily its consequences (Winge et al., 2019). Immediate aspects requiring management arise when serious injuries occur on construction sites. One of the primary actions is to care for the injured person. It is crucial to gain an understanding of the specific situation and the mechanisms behind the injury (Lennquist, 2017). Furthermore, it is necessary to ensure that the workplace is safe to be in and that the execution of peer rescue is time-critical to prevent potential secondary injuries. Immediate life-saving measures must be performed as quickly as possible, as these actions can potentially impact the outcome of the injury (Whilke & Schmidt, 2021; Jansson, 2009; Vikström, 2014; Pham et al, 2017). The initial interventions, integral to all healthcare systems (ATLS 2017; PHTLS 2021), include the competence and ability to effectively manage massive bleeding, ensure an open airway, and provide adequate breathing for the injured person. The examination of the injury, subsequent decisions, and actions follow a specific algorithm and sequence (SC-ABCDE, SX-ABCDE, S-ABCDE) designed to facilitate prioritization and provide guidelines for rapid and adequate treatment. These measures and assessments are crucial to achieving the best possible outcomes and should be performed as simultaneously as possible.

In Sweden, the response time for ambulances has increased over the past decade. In 2021, the average response time for ambulance interventions was 18 minutes for all alarms, primarily reflecting response times in larger urban areas (Hjärtlungfonden, 2022). Extended response times can have significant consequences for prehospital trauma care and the outcome after serious traumatic injuries, especially if other emergency care options are not available (Mell et al., 2017). Early assessments and actions by layperson have proven to be crucial, especially in cardiac arrest situations, cardiopulmonary resuscitation, and serious injury events (Linderoth et al., 2021; Lee et al., 2020; Avest et al., 2019). Laypersons can perform life-saving measures before the ambulance arrives. A study by Bakke et al. (2015) examined 330 prehospital trauma cases and their responses, noting that 35% of layperson had received first aid training. Participants with first aid training tended to perform more accurate and effective measures compared to those without such training (Bakke et al., 2015). Despite these advantages, the knowledge, and skills of first aid-trained layperson decrease within 2–6 months after certification (Andersson et al., 2011).



Participants practice handling an injured person

When individuals without professional competence find themselves in an injury event, the stress they experience can affect their ability to act effectively. A study by Sepahvand et al. (2020) identifies three basic conditions required for a layperson or bystander to intervene in a serious injury event: (a) The person must have personally witnessed the critical situation, (b) the person must accurately assess the situation as an emergency, and (c) the person must then decide to assist the injured individual by taking necessary actions. If a layperson fails to make these assessments, it can negatively impact the rescue effort while waiting for an ambulance. To guide the necessary actions, ambulance personnel providing advice need knowledge of the specific situation and the mechanisms that caused the injury (Lennqvis, 2017). Real-time contact through video calls allows ambulance personnel to gain insights into the specific situation and provide advice and guidance based on their expertise in healthcare and kinematics. Technology, such as communication via video call, can support the assessment and implementation of actions by ambulance personnel (Linderoth et al., 2021; Park et al., 2020; Bakke et al., 2015). However, it is essential that the technology does not negatively impact the working environment and safety of ambulance personnel, especially during emergency response. Driving an ambulance requires skills in maneuvering during emergency response, as well as knowledge and skills in medicine, stress management, and risk assessments, as ambulance care can directly impact the health of the affected individual in case of injury or illness (Becker & Hugelius., 2021). In summary, it's not certain that laypersons involved in workplace injury events have the knowledge, skills, and courage to act, which can lead to secondary injuries for the affected person and negative emotional experiences for the bystander witnessing the injury event. Guidance and support from ambulance personnel can be a way to reduce risks for both the affected individual and the layperson. However, adding technology in ambulance services may affect ambulance personnel's ability during emergency response, and it is not clear if the benefits of advice and guidance from ambulance personnel to laypersons outweigh the impact on the working environment and safety of ambulance personnel.

In 2020, the project "Remote Rescue" financed from SBUF, was initiated and implemented, a collaborative project involving key partners in Swedish construction and civil engineering industry. The project aimed to address the challenges faced by employees in this industry when acting as laypersons in injury events. The main goal was to optimize the opportunities for peer rescue from the time of the injury event until the arrival of ambulance and emergency services. This goal would be achieved by providing training, counseling, and support from an ambulance personnel via a video link. During the project, a care model was developed that included a related checklist/action card and technical support for distance-based assistance. The results identified similar challenges relevant to adjacent industries such as wind power and mining industry, particularly concerning response time and intervention time after a workplace injury events (Hedberg, H, 2020). Several testing and development partners, including NCC, PEAB, SKANSKA, and SVEVIA, actively participated in the project. The digital rescue support was designed to be used before the ambulance's arrival at the injury site, enabling employees/layperson to perform life-saving measures remotely. This digital rescue support consisted of both hardware and software, including integrated three-party video communication linked to a biosensor. The biosensor was used to measure and transmit medical parameters to ambulance personnel, such as respiratory rate, breath sounds, oxygen saturation, blood pressure, heart rate, and electrocardiogram (EKG). This allowed construction employees to, during simulations, perform advanced life-saving measures with guidance and support from a simulated ambulance personnel present remotely via video communication. The results from the project's exercises showed that training combined with technological support can function in real-life situations.

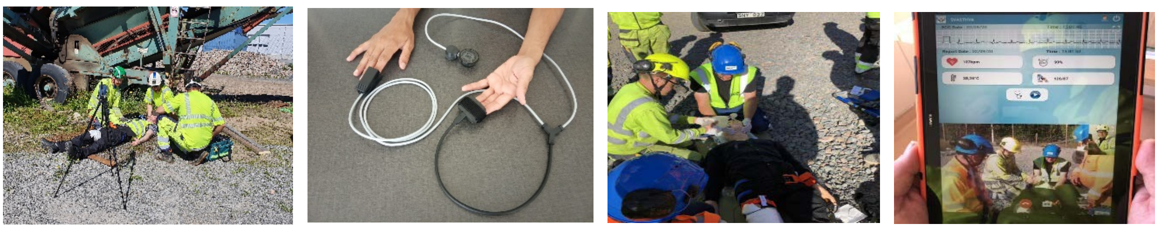


Photo. SBUF 13813 developed prototype, digital rescue support, Biosensor-Video support with associated training.

Study Context

In Swedish construction industry, there exists documented information and statistics offering insights into the most prevalent types of injuries (Table 1). From these data, it is evident that severe injury events are infrequent but still occur frequently enough to underscore the importance of an optimized response from laypersons, persons without professional training, in order to potentially save lives. Ongoing research and thesis work are geared towards cultivating a more profound understanding of the critical process factors influencing the management of serious injury events within Sweden's construction and civil engineering industry.

Table 1. Number of reported injury incidents with sick leave of at least one day. Over 3,000 incidents are reported each year.

Event	%
Handheld machines or tools	17
Body movement with overload	16
Fall to lower level	13
Fall on the same level	12
Objects tipping or collapsing	9
Manual handling	8
Body movement without overload	7
Machinery for processing	7
Vehicles	6
Burn injury, explosion, electricity	2
Other	3

(Statistic; B, Samuelson, 2020)

Aim

The scientific question of this thesis is whether construction employees/Layperson, in the event of a serious injury event, at a construction site, can apply proper life-saving measures with more advanced medical equipment through communication and interaction with ambulance personnel via an interactive rescue support system before ambulance arrives at the site of injury.

Theoretical Perspective

The perspective of this thesis is to describe the actions of laypersons/construction employees during serious injury events connected to guidance through interaction with a remote ambulance personnel. The dissertation is based on the research topic of anesthesia with a prehospital interdisciplinary focus, where the knowledge perspective involves human interaction from both a professional and non-professional social perspective (Rapaport & Ashkenazi, 2020). Providing support and guidance to a layperson through technology can be complex to study. The dimensions of the dissertation focus on the layperson at the injury scene (Bakke & Wisborg, 2017; Bakke et al., 2015; Fischer et al., 2011; Gitte et al., 2021; Hall et al., 2013; Kulnik et al., 2019; Linderoth et al., 2021) in terms of communication, situational awareness, guidance, and perform life-saving measures (Endsley, 1995; Endsley, 2015; Stubbing et al., 2012; Busby & Witucki-Brown, 2011).

Specific aims

- To describe the experiences of construction employees who have been involved as layperson first aid providers in a serious workplace injury event.
- To assess whether digital support video calls and related training have a meaningful impact on first aid in simulated serious injury events.
- To describe and evaluate the ambulance personnel's perspective during driving an ambulance, when using a telemedical system that includes video calls with integrated biosensors in interaction with layperson.
- To describe the experiences of layperson in carrying out life- saving measures with the guidance of ambulance personnel regarding their ability to act and the impact of stress.

Methods

Table 2 shows a summary of the studies included in this thesis (Mid -term)

Tabell 2. Overview of studies I–II

Artikel	Design	Respondents	Analysis	Outcome measures	Progress
I	Semi structured interview study	n=9 participants Individual interviews	Qualitative content analysis	Understanding how employees have experienced and responded to an injury event, both individually and as a group, in the short and long term	Manuscript 2024
II	Simulation study	n=90 participants distributed across four groups, one baseline group, one intervention group, and two control groups. Each group consisted of 10 teams with three participants per team.	Quantitative	Non-professionals' ability to perform advanced life-saving measures in a group, without training and digital support, or with only training, or with only digital support, or with both digital support and completed training	Published 2024-01-07

In this thesis, study 1-2 employed both qualitative and quantitative methods. study 1 applied an inductive method to describe the experiences of the employee, layperson when responding to a serious injury event. Study 2 was deductive, partially built on experiences from previous pilot projects that had not been scientifically evaluated before. In study 1, semi-structured interviews were analyzed using qualitative content analysis. Study 2 utilized a quantitative method where time and implementation were recorded through video observations, and the evaluation was conducted with and without intervention (which involved support in the form of video assistance and training). The results from study 1 and study 2 influence the design of the research question and method for the upcoming study 3 and study 4, which continue in the same research line.

Study 1

In study 1, a qualitative methodology was employed based on the fundamental assumption that responses or truths are subjective and perceived through the observer's perspective, reflecting the complex nature of the surrounding environment (Graneheim & Lundman., 2004). The research method involved the collection of narrative stories through interviews, which were later compiled into an overarching text. This text underwent an analytical process where its meaning was contextualized and interpreted based on the individual life conditions and experiences of the interviewed individuals (Graneheim & Lundman., 2004; Graneheim & Lundman., 2017). The purpose of this method was to understand the experiences of personnel actively participating in injury events and their individual and group-based handling of such injury events.

To conduct the study, semi-structured interviews were used with the participants, where they were asked to share their experiences related to real injury events. The interviews focused on three main aspects of participants' stories: i) the occurrence of the event, ii) the handling of the event, and iii) the time after the event.

Participants were recruited from various construction companies in Sweden and were selected based on their experience with injury events. To be included, it was required that the emergency number 112 be dialed, that an ambulance arrived at the scene, and that the injured person needed ambulance transportation into hospital. A total of nine employees participated in the study, eight of whom were men, and one was a woman. Their ages ranged from 22 to 66 years, and they had worked in the construction industry for varying lengths of time, from 5 to 41 years. None of the participants had a background as e.g working in rescueservices, police, healthcare, military.

To structure the interviews, an interview guide was designed by the authors, based on the specific context to be explored. The interviews began with an open question where participants were encouraged to freely talk about their experiences of providing first aid to one or more colleagues in an injury event. They were asked to describe the entire experience, from discovering the injured person to making the emergency call to 112 and the transportation by ambulance. Follow-up questions were asked if essential information did not emerge, such as questions about participants' thoughts upon arriving at the injured person.

All interviews were recorded and transcribed verbatim. The collected data underwent a qualitative content analysis following the method described by Lindgren et al. (2020), Graneheim & Lundman., (2004); Graneheim & Lundman., (2017). The analysis process initially involved consolidating all text into a common analysis database. Common words and phrases were identified and then grouped as meaningful units. Subsequently, a condensation of the text was carried out with the goal of reducing the scope without losing the essence of the information. The condensed text was further abstracted to achieve a logical level, which was then reviewed against the original meaningful units and the condensed text. Then, the common text fragments were coded and grouped into subcategories, which were then organized into categories describing the results at a descriptive level.

Study 2

Study 2 is a simulation-based study. The research method consists of several components for data collection and analysis (Skivnington et al. 2021; Craig et al., 2013). With cooperation from building companies or training program in northern Sweden, persons consenting to participate in the study were scheduled for test days in groups of 3 persons at a time at their building site. This was presented as a training course and a part of this study. All the groups had the same first day activity with a scenario-based practical assessment without training and then the planned course. After that, half of the groups were recalled for a second assessment after 4-6 weeks, where they were allocated to the treatment groups based on when they scheduled their second assessment. Those that scheduled for the first 10 assessment days were allocated to treatment group 3 and those that were scheduled for the last 10 assessment days were included in treatment group 4. The treatment or exposures were not known to the companies or participants ahead of time. Prospective randomization by lot was not chosen due to challenges for the building companies in scheduling the days, and this minimization method was used to achieve balance for groups and exposures, even if this was not formal block randomization.

Each ‘treatment’ group (of 3 individuals) was planned to comprise one of 10 teams for each ‘treatment’ arm. The treatments or exposures were as follows: Group 1 no course training and no video support during the simulation-based assessment. This same group then later (after the assessment) went further and participated in the training course and had a second assessment 4 to 6 weeks after their course, and this assessment group was called Group 4. Group 2 and Group 3 had video support during the assessment, Group 2 without pre-treatment training course and Group 3 with the completed training course prior to their assessment. All groups had access to standardized medical equipment during the simulation-based assessment, but which was a kit with which no participants had familiarity before the study. All groups participated in a full-scale, high-fidelity simulation-based major injury scenario for assessment where their performance was scored (described below). For the two groups who were allocated to receive the practical training course, the course was completed 4-6 weeks before the simulation-based assessment.

With advertising for participants, and with cooperation of large building companies as well as local builder apprenticeship training programs in Sweden, individuals working on building sites as employees or apprentices were screened and recruited with cooperation of their employers. Not having Swedish language was an exclusion criterion.

For the planning and design of the scenario and simulation, with assessment and data collection, an expert group was formed consisting of anesthesiologist, emergency nurse, ambulance nurse, trauma surgeon and safety experts from the construction industry. The expert group designed a scenario that was realistic for the construction industry workplace environment. The expert group designed a 10-minute scenario with one injured person, 35 years old, previously healthy with multiple injuries caused by falls from 5 meters. The scenario contained 2 critical diagnoses, catastrophic bleeding and occluded airway, where early (first 90 seconds) recognition and treatment of these can be presumed to be potentially life-saving. The premise was that it was going to take a long time for ambulance personnel to arrive on site. The focus was on what the participants would do during the first 10 minutes. The simulation was conducted with the help of a facilitator who had also been the first response course instructor, and a high-fidelity wireless computer operated human patient simulator (HPS) which was preprogramed with pathophysiology parameters specific for this scenario (Table 3). Two behaviors were included in the scenario as secondary elements: a safety check for the injury event place, and systematic head to toe survey and re-evaluation, commonly referred to as SCABCDE, was used to be able to detect other injuries.

Table 3. Scenario- critical diagnoses and assessment preprogrammed and set up in human patient simulator.

Name	Critical diagnosis, assessment	Human patientsimulator	Primary critically outcome
S -Safety	Safe injury- event site expected to be visually assessed 360 degrees		
C - Catastrophic bleeding	Catastrophic bleeding right femoral artery	0.5 liters of 'blood' was out on the ground at the source of bleeding, as well as pulsating bleeding	Direct manual pressure over bleeding source < 60 seconds or Tourniquet <90 seconds
A-B -Airway -Breathing	Blocked airway Apnea without airway management	Simulated chewing gum applied in the upper airway. Recorded sound with signs of blocked airway, released when airway was secured. Cyanosis when blocked airway, blue light in the face, removed when secured airway. Air stream on exhalation at secured airway The chest moves up and down at the open airway, Respiration rate 20/minutes	Inspect the oral cavity, Jaw Thrust< 90 seconds or Oro-pharyngeal airway < 90 seconds
C -Circulation	Hypotension and tachycardia	Heart rate 130/minutes. Blood pressure 70/40 mmHg Pale skin color and simulated sweat. Palpable pulse A, carotid	
D -Disability	Unconscious does not react to pain. Equal pupils on the right and left sides	Does not respond to contact. Does not react to painful stimuli. Pupils same size, responsive and react to light	
E Exposure	Wound injury in the back of head. Inwardly rotated legs. Blood on the legs.	Made-up wound injury back of the head. Legs inwardly rotated	Secondary outcome Examine the entire body head to toe, Pelvic sling in 10 minutes, mean time until completed

The expert group prepared a simulation facilitator`s manual with the aim of standardizing the simulation. The manual described the expected life-saving measures, which were required in order for the injury figure's condition to improve in the simulation. The manual also described types of help the facilitator could supply to the study participants, for example in the case where expected life-saving measures were not addressed, so-called "Lifesaver"(Dieckman et al.,2010) hints could be provided to allow the simulation to progress, even if the participants were unable to demonstrate one or the other critical behavior in the first phase of the scenario.

The video support content and possible interventions were based on a pilot project (Hedberg.,2020). The 6-hour advanced first aid course, along with the medical equipment in the scenario, were developed in this same pilot project. The medical equipment kit was available to all the participants during the simulation-based assessment. This included checklists for field vital sign assessment and as well as instructions for video communication with remote ambulance personnel.

The 6-hour practical advanced first aid course included an emphasis on assessment of the injured party and advanced critical life-saving procedures (direct pressure or tourniquet, jaw thrust, oro - pharyngeal airway, laryngeal mask airway, bag-mask- ventilation, CPR and defibrillation and pelvic sling) with accompanying systematic checklist (SCABCDE). The training course also included introduction of the telemedicine supporting system. The course began and ended with a 10-minute trauma response exercise, event-based training, and participant reflection in groups. The procedures were first introduced through instruction film and instructor demonstration, then the students practiced on a patient simulator, with feedback from the instructor.

The medical kit included biosensors, with the capacity to measure and transmit the following medical parameters: breathing rate, oxyhemoglobin percent or saturation (SpO_2), heart rate, blood pressure, electrocardiogram selected leads, and temperature. The participants had the option to demonstrate the situation using video in the telephone or connecting biosensors. Though not part of this study primary analysis, there was a pre-programmed and for-purpose designed smartphone function available, to connect to a server where medical instrument measurements in the simulation could be transmitted to the simulated ambulance personnel.

Based on direct observation and supported by the video recording of the participant performance during the standardized simulation, participant behaviors were scored using a pre-defined set of outcomes and time intervals. The scenario aimed to present clear signs of immediate life-threatening injuries in order to test for recognition and intervention behaviors, correct or incorrect. The whole scenario included the first 10 minutes of primary systematic prehospital trauma care, though the critical behavior period was defined as the first 90 seconds for 2 categories of primary responses. A detailed scoring protocol was developed which followed the expected measures in the standardized scenario. There were always 2 assessors for the primary and secondary outcomes, though exact times when these outcomes were achieved was confirmed by one assessor using the video recording. The outcomes were simple categories of responses, and agreement was required between assessors on whether or not the outcome was achieved. The assessors were not blinded since they could observe the interventions at the same time as the outcomes were assessed.
Before each group started the simulation-based assessment, the participants were given a standardized short orientation and introduction, including details about the training environment and how the simulator worked. After introduction, each participant completed a pre-assessment registration where they recorded their sex, age, years in the profession, and any resuscitation training they had prior to this

study. The simulation was conducted in a standardized room where the human patient simulator was lying on their back on the floor. Next to the simulator was a medical kit with the above-described equipment, telephone, biosensors, and checklists/action cards. All groups had the same opportunity to use the equipment freely. An instructor conducted the assessment simulation scenario. An emergency nurse acted as 1) simulated emergency call center operator and 2) simulated ambulance nurse for remotely video support. Before the test started, all groups had been informed to simulate a call to the Swedish central emergency alarm phone number/112 on arrival at the scene of injury event. The two groups allocated to receive video support were directly 'called' (telephone) by a simulated ambulance nurse, immediately after the call to 112, and the video distance support was started using the checklist SCABCDE. The scenario/assessment period was stopped at 10 minutes. At this point, the group was asked to report back to the ambulance nurse on what they understood in the scenario, and what they had done as far as resuscitation. There were 2 primary outcomes, both within the first 90 seconds. These were early correct bleeding control by manual pressure within 60 seconds or applied tourniquet within 90 seconds, yes or no, and then correct identification of occluded airway with behavior to manage airway obstruction, also within 90 seconds. Secondary outcomes were assessed within the 10-minute time frame, and these included the following: correct top-to-toe examination finding wound injury in back of the head, also a categorical variable yes or no, time to completion of top-to-toe examination mean in seconds, correct fixation of pelvic injury a pelvic sling, categorical variables, yes or no, and time in seconds to fixating a pelvic fracture with a pelvic sling.

Power calculation for a sample size

After intervention, either training course, ambulance tele-support, or both, the correct response for the critical behaviors was expected to be approximately 90% based on earlier course experience. The expected baseline rate for responses or behaviors from completely unschooled or untutored participants was expected to be not more than 25%. This meant an estimated or anticipated difference in frequencies correct versus incorrect responses or proportions of 0.65, with power to detect a true difference of 80% and a 2-sided 'alpha' of 5% (0.05). This calculation indicates that a minimum of 8 sets of participants or groups should be in each paired analysis. A sample size of 10 for each set of groups was chosen, to allow for dropout.

Data management

A total of 40 simulation assessments were observed and recorded with two cameras and from two angles. Exposures were pseudo anonymized for the assessments, and for the analysis of the videos. The videos and observation protocol were encoded and stored on a server with a coded password to which only primary investigator had access.

Statistical Analysis

Analysis was conducted using IBM SPSS statistics, version 28. Descriptive statistics are presented both at individual level and at group level. Group comparisons for the primary outcome frequencies correct and incorrect were done using the Fisher's exact test, based on the small sample size. For continuous variables where an approximately normal distribution could be assumed, an independent samples standard t-test was used. Maximum time in the assessment scenario was 10 minutes or 600 seconds, and groups that did not complete the expected procedure were assigned 600 seconds for that outcome. Significant differences between groups were identified when the p value was less than 0.05.

Methodological considerations

Study 1

In the field of qualitative research, various methods are used to collect information, such as observing or interviewing participants individually or in groups. The initial steps in analyzing the collected data are similar regardless of the qualitative method used, such as sorting and categorizing information (Graneheim & Lundman, 2004). Qualitative content analysis approach can be both deductive and inductive (Graneheim et al., 2017). The deductive approach involves analysis based on a predetermined model or theory. Inductive approach involves a presupposition-free analysis of texts that can be narratives based on people's experiences. Study 1 took an inductive approach where participants shared their experiences of acting as laypersons in a workplace-related serious injury event. The meaning of content analysis text can be manifest or latent. Study 1 focused on the manifest meaning, that is what the text says, resulting in categories with corresponding subcategories. An important concept in qualitative studies is trustworthiness, which is a summary of various aspects of credibility, reliability, and transferability (Graneheim et al., 2017). The trustworthiness of this study was strengthened by active participation of multiple researchers in the interview process and continuous presence throughout the entire analysis phase. Furthermore, regarding the transferability of the results, it is important to note that the participant sample size was limited. This fact may entail certain limitations regarding the generalizability of the obtained results to a broader population. However, this was compensated for by conducting interviews in a comprehensive and in-depth style, with narratives of experiences highlighting actions in serious injury events. It is also worth noting that the subject addressed in the study could be considered sensitive for the participants, especially considering the uncertainty surrounding right or wrong actions in the described events. This implies a potential risk that participants may not fully share their innermost experiences and reactions to the events, which could impact the credibility and reliability of the presented results.

Study 2

Study 2 encompassed several aspects that could have influenced trust in the conclusions. Due to its smaller cohort, this negatively impacted the precision of our estimates regarding the effects of various exposures on the primary outcome measures. With a smaller sample size, there is an increased risk of false positive or false negative results. Despite being a prospectively controlled simulation study, caution must be exercised in interpreting the results. This represents the initial testing of this type of intervention. We aim to obtain confirmatory results for the intervention's effect by continuing to test different components of the "system," with the goal of identifying the most significant factors and intervention design. This study served as an exploratory first step. The choice to simulate an event is a compromise because it is not feasible to conduct studies and collect data during actual, uncommon events. One aspect of the simulation is the deliberate minimization of confounding factors to create a focused and as clean a situation as possible for study participants. It is a limitation of prospective studies that they may not fully reflect real events. We attempted to enhance understanding of how laypersons may experience this situation through Study 1. These findings will influence the design of future studies.

Ethical Considerations

The research in question obtained approval from the Ethics Review Authority under reference number 2021-05774-01. All participants provided their informed consent before being included in the study. The research work was conducted in strict accordance with the principles established in the Helsinki Declaration, as well as the applicable laws and regulations of the European Union and the World Health Organization (WHO), including the General Data Protection Regulation (European Union, 2016; WHO, 2013). All personal information, including participants' identifying information, audio recordings, and film material, was treated and securely stored. The use of pseudo-anonymization significantly minimized the risk of privacy infringement for the subjects. We analyzed the risk of harm, either in the form of interviews or participation in courses, simulated injury situations, and reactions from laypersons, and found it to be minimal. Awareness of reporting serious incidents can evoke strong emotional reactions. The individuals conducting the interviews had documented experience in dealing with individuals who had previously been involved in serious injury event or other critical events in their lives. After completing the interview, each participant was provided with contact information for the interviewer, who could offer additional support and conversations if desired.

All participants had the right to discontinue their participation in Study I and Study II at any time during the course of the study. It is worth noting that none of the participants considered themselves in need of any form of support after completing their participation in the study.

Results

In study 1, three categories with nine subcategories were identified which illustrated construction employee's experiences of being involved as a layperson first-aid provider in a serious workplace injury event and are exemplified with citations in the results (Table 4).

Table 4. Categories and subcategories illustrated construction employee's experiences of being involved as a layperson first-aid provider in a serious workplace injury event

Categories	Subcategories
Suddenly trying to save lives after realizing the unexpected	Understanding that a serious injury has occurred
	Initiating an own response
	First aid activities own and team
	Inexperience, fear of doing wrong
The importance of collaboration in a chaotic situation	Acting with support from dispatcher
	Support from ambulance and rescueservice
The need for social support and following improvements	Stated desire for early support and later follow-up
	Long-term psychology experience
	Trying to learn from injury event experience

Suddenly trying to save lives after realizing the unexpected

Four factors were highlighted as in the immediate initial acute phase. Understand that a serious injury has occurred, initiating an own response, first aid activities own and team, inexperience, fear of doing wrong affected the initiation of starting some kind of rescue effort.

Understanding that a serious injury has occurred

Attempting to understand what had happened was described as important in the role of laypersons, first responders. Participants highlighted that when a risk escalated into a serious injury event, they described a profound change in their awareness. It became surreal and challenging to grasp the reality of a serious injury event. To comprehend the reality, participants described that they relied on their sensory experiences to understand and create awareness of what has occurred.

As one participant expressed:

"I initially thought it wasn't him who had fallen down; I was convinced that it was some construction material. It felt surreal

Initiating an own response

The participants described how the event created immediate stress with a strong sense of discomfort. The initial thought was an immediate reaction of just wanting to walk away from there. to move away from the scene of the injury event. This thought then transitioned into a desire to help and take responsibility. They described that many colleagues were standing and watching in what they described as chaotic environment. Taking action involved the ability to maintain composure, not hesitate, as the participants described it, to take an initiative, organize and support by thinking steps ahead.

"The feeling was to simply try to assess the situation while also supporting the colleagues who couldn't immediately handle the situation"

First aid activities own and team

The participants described first aid activities as despite their sense of stress they still worked together within their team. Medical measures were initiated and carried out, such as supporting the injured person's breathing, applying initial dressings, and warming the injured person.

“It's difficult to explain how one feels in that particular moment. Certainly, it's uncomfortable, but one do the best you can; after all, you do everything to help someone”

The participants further described that their teamwork in mutual assistance, collectively devising innovative solutions such as constructing a stretcher or moving equipment that was in the way, ensuring an adequate number of colleagues were present, and providing support to each other in the chaotic situation. This teamwork was seen to maintain calm within the group, a calmness that was conveyed to the injured person.

“There were perhaps about 10 colleagues around when this happened, everyone behaved, it was professional considering how people tend to react. It felt really good and safe”

Inexperience, fear of doing wrong

The participants experienced the events as unexpected, something they hadn't mentally prepared for or trained in advance. They described how they lacked experience in assessing and managing these severe conditions, with severe bleeding being particularly challenging. Additionally, they encountered difficulties in understanding how medical materials worked, from opening packages to knowing how to correctly apply pressure dressings for severe bleeding.

“In hindsight, one would have desired some form of training. Some coworkers have received training in cardiopulmonary resuscitation (CPR), however, when it comes to injuries involving extensive bleeding, such as cuts, one is left unprepared”

The condition of the injured person created fear among the first aid responders, which the participants described as a fear of making mistakes and worsening the injury. This fear, as described by the participants, primarily occurred when the injured person was unconscious, when the participants assessed that the airway was blocked and needed to be addressed physically at the scene of the injury. Fear was also described during the encounter and conversation with the injured person, and the fear was related to not wanting to provide incorrect information, something that the participants described as particularly pronounced when they themselves did not know the extent of the person's injuries.

“I hold him so he gets air, I've pulled him out so he can breathe. Then I don't want to do much more because he was pretty bad, I didn't want to move his neck so much”

The importance of collaboration in chaotic situation

The category delineated the participants' experiences of collaboration, both between emergency call dispatchers and ambulance- rescue services. These experiences could be divided into two subcategories, Generating an actionplan with support from dispatcher and Support from ambulance and rescuservices.

Acting plan with support from dispatcher

The collaboration with society's emergency responders began even before the ambulance and rescue service arrived at the scene of the injury event. Participants described this collaboration as commencing when they dialed the emergency number 112. The initial feeling that arose during the conversation with the dispatcher was described as a sense of calm among the participants, a feeling of security simply by knowing that an ambulance was on the way. Furthermore, the participants described a mutual collaboration, where they themselves had a need to receive advice and support from the dispatcher, while the dispatcher needed a clear description of the event's situation and guidance to accurately describe the address and approach route for the ambulance and rescue service personnel. Participants highlighted important factors in collaboration with 112, such as ensuring that mobile coverage was available and, in cases where a fixed address was not available for a construction site, clear coordinates were provided.

"At times, it's just coordinates that matter; you don't have an address, you have coordinates. 'Here' is where you should be working. No fixed address? Then it's difficult to call 112"

The initial sense of calm among the participants quickly turned into a feeling of discomfort on occasions when they had to wait for an extended period for the ambulance to arrive at the scene. Participants described this waiting as compelling, compelling them to continue assisting the injured person during the ongoing emergency call, but now with support and collaboration with the dispatcher while awaiting the ambulance.

"We managed to do quite a bit; we had time to sit with him, we had time to carry him on the makeshift stretcher, to stay inside the barrack for a while, I think it was about 1 hour and 45 minutes before the ambulance personnel arrived"

Support from ambulance and rescue service

When the ambulance arrived at the scene, the participants described it as an overall calmness prevailed. Through this feeling, the participants fully relinquished their responsibility to the ambulance personnel, and a strong desire arose to leave the injury site. The participants understood that their effort was not over even though the ambulance was on the scene. The work had to continue, but now in collaboration with the ambulance and rescue service personnel. This awareness was described as arising through the ambulance personnel's ability to convey calmness. Collaboration with the ambulance personnel was based on communication among each other. The participants described that the calmness and clarity of the ambulance personnel helped them understand what they needed to assist with, and, through their guidance, they executed tasks together.

“He wanted my help, so I buttoned up the collar. I had no idea how tight to fasten it; we did it together. He was good, calm, and easygoing”

The need for social support and following improvements

The participants described how the injury event affected them even afterward, after the injured person was transported to the hospital. The participants described this as, stated desire for early support and later follow-up, long-term psychology experience and trying to learn from injury event experience.

Stated desire for early support and later follow-up

After the injury event, there was a strong urge to unite. Participants referred to this as a check-in, where their main concern was to gauge the well-being of everyone involved and determine if anyone required immediate support or assistance. During this initial period following the injury, the participants noted that they had to rely on each other for support. From this phase where they had to take care of each other, the participants described the need for external support from the company's management organization. The participants described external support as a crisis team responsible for monitoring all individuals involved, providing updates on the injured person's condition, and offering information to family members. When this support was lacking, disappointment arose, a disappointment that it took time to receive support.

“We were disappointed with how we had been handled, that is, from the top, by our management. Yes, it took some time before any support was provided”

When the crisis management team was in place and began functioning, participants described it as a positive experience, having the opportunity to share their stories or be seen.

As one of the participants expressed:

"Then my senior manager called and asked what had happened and how I was doing. Everyone has been concerned about me and asked if I needed someone to talk to"

Long-term psychology experience

Experiences of the injury incident were described by the participants as affecting them both in the short and long term. Returning to their workplace initially felt good, but at the same time, they described that the feeling of the injury event still lingered.

"I felt ice-cold in the head at that moment, not emotionally sensitive to blood, but I've carried this experience with me throughout my entire life"

Participants explained that those particularly vulnerable were the persons who were close to the injured person, those who tried to save lives during the injury event.

"The ones who suffered the most were those who tried to save him, yes, to do something. Yes, it's a trauma that never leaves you, or a memory that never leaves you"

Trying to learn from injury event experience

The injury event generated lessons that the participants described and provided suggestions for new ways to act related to organization and education.

" when you consider that you have to show the way because we are, after all, on a construction site that doesn't have an address, it becomes immediately inconvenient. Perhaps that is something that should be emphasized in the training, that someone needs to be sent out to show the way"

The equipment was also further developed to adapt more serious traumatic injuries and replaced the old equipment. The most important aspect described by the participants was the experience of being present during an injury event.

"To analyze the worst-case scenario, if I put it that way, how do we handle it, who does what, and that's something I take with me, that we need to plan before the worst can happen."

In study 2, data was collected in Northern Sweden between February and June 2022. A total of 90 individual participants completed the study, all in groups of 3. One participant in Group 1, and two participants in Group 2, did not answer the background questions of the survey. Demographics are shown in Table 5.

Table 5. Participant background data

MEASURES	Group 1/4 (n=10) Individuals (n=29)	Group 2 (n=10) Individuals (n=28)	Group 3 (n=10) Individuals (n=30)
Female/Male	2/27	7/21	7/23
Age (mean ±sd)	28±14	40±13	28±14
***Previous Training**			
First aid trauma course	2	2	1
CPR training course	4	5	1
CPR+ defibrillation course	1	1	1

**Previous training was defined as completed training course, First aid trauma course (ABC, ABCDE, SABCDE) within 2 years, Cardiopulmonary training course with or without defibrillator (CPR, CPR+ Defibrillation within 2 years). The youngest person in the study were 18-year-old and the oldest 60 year.*

Primary Outcomes

For the first primary outcome, first without any preparation or training, there were almost no correct behaviors observed for the baseline assessment, for both bleeding control and airway management. Then, concerning interventions, video support by itself with no course preparation (Group 2) was associated with better critical bleeding control compared to those who had neither course or video support (Group 1) (9/10 vs 1/10, p = 0.001) (Table 6). For bleeding control, the pre-treatment course and video support combined Group 3 was not statistically different in performance compared to those that had the course by itself (Group 4) or video support by itself (Group 2) (8/10 vs 5/10, p = 0.35, and 8/10 vs 9/10, p= 1, respectively), and all groups had a high proportion of correct behaviors.

Table 6: Primary critical outcomes (bleeding or airway control < 90")

	Group 1 Baseline	**Group 4** Training course only	**Group 2** Video support only	**Group 3** Video support + training course	***P value***
Bleeding control < 90"	1/10	5/10			*0.14*
	1/10		9/10		*0.001*
		5/10	9/10		*0.14*
		5/10		8/10	*0.35*
			9/10	8/10	*1*
Airway control < 90"	0/10	9/10			*<0.001*
	0/10		4/10		*0.02*
		9/10	4/10		*0.06*
		9/10		8/10	*1*
			4/10	8/10	*0.17*

Group 1 received no telemedicine support and with no course training. This same group then later (after the assessment) participated in the training course and had a second assessment 4 to 6 weeks after their course, and this assessment group was called Group 4.

Concerning airway management responses, only 40% of participants in Group 2 (video support only) correctly managed the airway critical step, despite video support. The course by itself (Group 4) was superior to no course (Group 1) where neither had video support for airway management (9/10 vs 0/10, p< 0.001), but not statistically different from video support by itself (9/10 vs 4/10 respectively, p = 0.06).

Secondary Outcomes

Use of the vital sign biosensors in the scenario by the study participants was zero in groups 1, 2 and 4. Group 3 connected biosensors to the 'injured' in 10/10 groups, but only very late in the 10-minute scenario, and there was no attention for any group concerning biosensor readings. Concerning the head-to-toe examination, in the baseline assessment there was no group that performed this (Table 7). Further, video support with or without a pre-treatment course (groups 3 and 2) was associated with better performance compared to the those with no video support (Group 4) (9/10 vs 2/10, p=0.01; 8/10 vs 2/10, p=0.02, respectively). Time to the outcome event was in line with the frequency comparisons between groups. Concerning the behavior establishing a pelvic sling to limit suspected internal bleeding, the video support plus course group had perfect performance (10/10 groups) while both the course by itself and the video support by itself groups had half or more showing this behavior.

Table 7: Secondary outcomes

	Group 1 Baseline	Group 4 Training course only	Group 2 Video support only	Group 3 Video support + training course	*P value*
Head-to-toe examination (number correct) and Time (mean, sd, seconds)	0/10	2/10			*0.47*
		541 ± 126			
	0/10		8/10		*0.001*
			410 ± 109		
		2/10	8/10		*0.02*
		541 ± 126	410 ± 109		*0.02*
		2/10		9/10	*0.01*
		541 ± 126		288 ± 115	*<0.001*
			8/10	9/10	*1*
			410 ± 109	288 ± 115	*0.03*
Pelvic sling (correct)	0/10	6/10			*0.01*
		450 ± 144sec			
	0/10		5/10		*0.03*
			579 ± 25		
		6/10	5/10		*1*
		450 ± 144	579 ± 25		*0.01*
		6/10		10/10	*0.09*
		450 ± 144		358 ± 54	*<0.001*
			5/10	10/10	*0.03*
			579 ± 25	358 ± 54	*<0.001*

Discussion

Overall discussion

This report aims to present the interim results halfway through the ongoing dissertation work titled " Assisted trauma care in workplace accidents outside the hospital - Support for laypersons while waiting for ambulance. " The report covers two studies conducted in collaboration with companies and organizations in the Swedish construction and civil engineering industry. The overarching scientific goal of the project was to gain a deeper understanding of how personnel/laypersons working in the construction and civil engineering industry experience providing first aid for life-threatening injuries and to study their ability to apply correct life-saving measures at a construction site using new and advanced medical equipment and/or interactive rescue support video calls with ambulance personnel before the ambulance arrives.

The results indicate an environment where individuals transition from being employees on a construction site to quickly trying to identify and understand when a serious injury event has occurred and then taking action to save lives. The construction industry is heavily involved and actively collaborates to minimize the risk of serious injury events. This preventive work is not unique to the construction and civil engineering industry but also occurs in other industries such as wind offshore and oil industry, where these industries focus on building preparedness and resilience to handle serious injury events (Landgraf et al., 2019; Edvin et al., 2021).

Through studie 1 and 2, we have deepened our understanding of how personnel/laypersons, through adequate preparation and support, can minimize the negative consequences of serious injury events. This applies not only to the injured person but also contributes to limiting the short- and long-term stress among the involved laypersons.

Study 1

The study aimed to describe the experiences of construction employees who have been involved as layperson first aid providers in a serious workplace injury event.

The participants encountered uncertainty and challenges when attempting to recognize, comprehend, interpret, and raise awareness of the injury event. The realization of such an event led to a profound shift in their consciousness, and they relied on their sensory perceptions to comprehend the situation and take appropriate actions. According to Perlman et al. (2014), these challenges in recognition and understanding can be attributed to the work environment, where sound and other distractions can impede sensory perception and affect their ability to interpret and understand.

The attempt to act and take responsibility emerged as a significant issue in our results is in according to Sepahvand et al. (2020) that argue that bystanders observe each other on the scene, and if they do not interpret the situation as an emergency, they do not act either. Initially, the study participants experienced discomfort and a fight-or-flight reaction, but they eventually transitioned into a desire to provide assistance and take responsibility. It was noted that individuals reacted differently to the situation. Some participants proactively initiated life-saving measures, while others initially observed the event without taking action. We interpret this variation in responses as a possible form of the bystander effect. According to the bystander effect, the presence of others leads to the diffusion of responsibility, meaning that each of the individuals present does not act because they believe someone else will offer help (Rapaport & Ashkenazi, 2020; Fisher et al., 2011). Our results demonstrate that some participants have the ability to take responsibility for the situation and thus take action. We infer that when other bystanders realize that someone is taking the lead, they also take responsibility and act, which contradicts hesitation related to the bystander effect. We attribute this to the close relationships that existed between the participants and the injured individual, a conclusion also highlighted by Hal et al. (2013).

Insecurity and doubt were common feelings among the participants when caring for a seriously injured individual with life-threatening injuries, as Hal et al. (2013) also highlighted in their study. One possible explanation for this uncertainty, in our view, could be a sense of lacking the right first aid knowledge. In our study, participants provided insights that align with this explanation of inadequate knowledge. They expressed uncertainty about necessary actions in critical life-saving situations, such as handling severe bleeding or an unconscious person. Our results emphasize the idea that knowledge and experience can alleviate laypeople's fears, increase the likelihood of them taking action, and initiating life-saving measures while waiting for an ambulance. This concept is also supported by Kulnik et al. (2019).

Collaboration with rescue personnel began as soon as the participants dialed the emergency number 112. They felt a sense of relief knowing that help was on the way. However, their insecurity grew as they had to wait for the ambulance for an extended period. We interpret that the wait for the ambulance encourage the participants to cooperate with and engage in the advice and support of the dispatcher. The participants described this collaboration as mutual, where they could also support the dispatcher by describing the incident and explaining the location of the injury site to facilitate the arrival of the ambulance.

When the ambulance arrived, the participants experienced an overall sense of calm, and they willingly handed over their responsibilities to the ambulance personnel. The participants shared their experiences of completely trusting the ambulance and rescue services and physically leaving the scene. The participants mentioned that the professionalism and calm demeanor of the ambulance and rescue service personnel encouraged them to stay and assist in ongoing rescue efforts. This interaction between professional and non-professional individuals in emergency situations, as described by Rapaport & Ashkenazi (2020), encompasses two aspects: "professional assistance," where the emergency services personnel take charge and request laypersons to leave the scene, and coordinated assistance, where both parties collaborate to manage the situation.

We believe that in complex environments, such as construction sites, there is a need for coordinated assistance, clearer cooperation between ambulance services, rescue personnel, and employees to enhance the efficiency of rescue operations during serious critical events. We argue that this collaboration requires mutual understanding from both organizations, including builders and ambulance or rescue services. It is especially important for the professional organization, such as ambulance services, to recognize that involved laypersons are vulnerable and may require support.

After the injury event, participants experienced a strong desire to inquire about each other's well-being and seek external support from the company's management team. Some participants also began reflecting on their actions and questioning whether they had done enough or potentially worsened the injury. We believe that this self-doubt can be the onset of inner stress, a common feeling reported in previous studies (Palsgaard-Möller et al., 2014; Brinkolf et al., 2021). The effects of these reactions extended beyond the initial days following the injury event. Several participants shared that the event continued to occupy their thoughts and affect them in the long term. This phenomenon is described by Torun-Mathiesen et al. (2016), who highlight how individuals involved in critical situations outside a hospital setting can experience lasting emotional effects and may struggle to adapt to life after the event.

The injury event subsequently led to suggestions for new ways to organize and educate employees, as well as improve equipment to better handle traumatic injuries, and to prepare the organization for worst-case scenarios. Through this result, we believe that the organization can prepare for the worst by, as step 1, linking risk to an action plan. Step 2 involves adapting training based on the organization's expected needs and challenges, as highlighted in previous research (Burke et al., 2005; Lingard, 2001; Reason, 1998). Our findings also support the need to prepare the organization for what needs to be done after the injury event. Without psychosocial support, the risk of long-term negative consequences for the personnel who acted as first responders in a serious injury event increases our findings respond to several research reports (Palsgaard-Möller et al., 2014; Linderoth et al., 2021; Langraf et al., 2019; Linderoth et al., 2021; Goralnick et al., 2018; Pileman et al., 2020). Through our result, we have been able to describe a group of personnel who were strongly affected by having to participate in the rescue of colleagues who were injured in a serious injury event. We believe that, through this impact, the participants have learned and gained new experiences that we hope have strengthened their ability to have the courage to act if they find themselves in a situation where they need to save lives.

Conclusion

The result shows the challenges for a laypersons ability to switch from being an employee on a construction site trying to understand when a serious injury event has occurred, and then changing roles trying to save lives. Their intervention can potentially affect the individual both in the short and long term after the injury. To prevent short-term and long-term negative stress reactions preparations are required in terms of education in first aid training. We believe that in complex environments, such as construction sites, there is a need for coordinated assistance, clearer cooperation between dispatcher, ambulance services, rescue personnel, and laypersons to enhance the efficiency of rescue operations during serious critical events. A level of understanding from professional organizations is required, to support the layperson in becoming a valuable resource to the emergency personnel and enables them to assist and collaborate effectively by waiting for the ambulance.

Study 2

The main findings were that participants, untrained or unprepared laypersons active in the construction industry, showed a low ability to manage catastrophic bleeding and occluded airway in a 10-minute simulated accident scenario. Participants had a low degree of current practical training in first aid trauma care and lifesaving before entering the study, so the study's possibility to assess effects of training and telemedicine support were good. Preparation or support through either the 6-hour practical training course in life-saving procedures, or medical telemedicine support from distance through realtime video support, or a combination of both, was associated with increased effect in carrying out life-saving procedures while waiting for an ambulance to arrive at the scene of a simulated injury workplace event. These findings are in line with those from Bakke et al. 2013 who found that only 35% of the laymen had a practical training in first aid competences, and that laymen who had documented practical training manage first aid for injuries more effectively than those who did not have documented education (Bakke et al.,2013).

In this simulation-based assessment for a serious workplace injury event, we could see significant improvements in managing a catastrophic bleeding and occluded airway, after practical training or with video support from ambulance personnel. Responses to manage catastrophic bleeding with direct pressure or with a torniquet within 90 seconds were best. Results for managing an occluded airway with video support were better compared to no course or support at all, but not clearly better than for those with the training course.

The effect of a training course/education is expected to decrease over time without recurrent training or repetition (Andersson etal.,2011; Goralnick et al.,2018). For companies in the construction industry, it can be a challenge to dedicate time for regular refresher practical training in advanced first aid procedures. External real-time telemedicine resources to support local layperson responses to serious injury events could be a practical way to improve early response effectiveness even for those who have not had recent first aid courses. The findings here show that support through video calls provides meaningful benefit to layperson performance, independent of preparatory practical training or not.

Practical training combined with video support may provide additional benefit, though this study design was not optimal to assess this.

Several studies have validated the concept of medical support from distance, through a communication-distance solution, telephone, or video system, for instance in connection with CPR, trauma management, or assessment of various medical conditions such as stroke (Linderoth et al.,2021; Lee et al.,2020; Ter Avest et al.,2019; Johansson et al.,2019; Landgraf et al., 2019; Nord-Ljungquist et al.,2015). Nord-Ljungquist et al, 2020 studied dispatcher support to layperson by phone, for CPR before an ambulance arrived (Nord Ljungquist et al.,2015). Those findings showed difficulty in getting layperson to correctly manage an airway blockage, which our results confirm. Landgraf et al, 2019 reported on a telemedical support system with offshore emergency scenarios and quality of medical first response by medical non-professional comparing to medical professionals and found that the supported group required more time to act compared to non-supported (Landgraf., 2019).

In our scenarios/simulation sessions where participants were supported by video, the success rate for managing an occluded airway with the jaw-thrust procedure was not as high as expected. This possibly could be due to the complexity or unfamiliarity with evaluating and managing an occluded airway. We also observed that where the groups had practical course experience, sometimes they focused on the experience they seemed to remember related to the training course, which may have hindered video communication to guide intervention. An interaction between these different exposures could have led to dilution of possible benefit from the combined interventions. These observations are also in line with results from Linderoth et al, (2021), where they concluded that in order to support the layperson by video, dispatchers at the emergency call center-112 must understand the situation in order to best facilitate the layperson in their actions. It appears that video support can change the emergency response, though it is challenging to use this approach to advantage within the context of existing dispatch protocols (Linderoth et al.,2021).

The interaction between dispatcher and layperson is important, but, in addition, interactions between the laypersons on-scene are also important. Teamwork within the groups was observed when there was a video dialogue with ambulance personnel. One layperson needed to focus on the smartphone and film the injured person, while at the same time listen and try to understand the advice from the ambulance personnel, and then communicate this to the laypersons in the team. Specific team non-technical performance, including communication, situational awareness, and distributing workload in the team, was not assessed in this study. Non-technical performance for both layperson and ambulance personnel could be relevant for future testing of a video support system for this type of response.

None of the groups spontaneously connected biosensors (heart rate, pulse oximetry, blood pressure measuring devices) which could transmit signals to the video supporter. Use of these was taught in the course. Even with video support, implementation of vital sign measurement did not come up until bleeding, airway, and even head-to-toe assessment and pelvic sling steps were completed. This meant that measuring and monitoring vital signs (and transmitting) in practice for this scenario came later, if it was done. These biosensor signals were still appropriate for more informed video support, and not only for the ensuing phase. As assessed here, vital signs measurement, or impact on measuring vital signs on the course of video support, could not be assessed. Vital sign assessment should be a priority early in this type of scenario. This could be something that can be emphasized in both training courses and video support tactics.

The study context was based on Swedish construction industry conditions. There are other initiatives that have focused on the effects of collaboration between layperson and professional rescue personnel while waiting for an ambulance or fire brigade. One initiative is the Civil Response Person and In Wait for Ambulance (Nord-Ljungquist.,2020; Pileman et al.,2020). The concept is that individuals with established technical means to receive an 'alarm' can be sent to a nearby accident site as prepared layperson responders before ambulance or fire brigade personnel arrive. Both this alert concept as well as direct two-way interaction have been tested in the community to facilitate layperson responses for early management of critical situations such as cardiac arrest or traffic accidents. Some reported experience is that there is sometimes insecurity among laypersons in these actions when acting by themselves, though not after first contact with ambulance personnel **(**Nord-Ljunquist.,2020**;** Møller et al.,2014). Further research in this area could focus on evaluation of a supporting model including dispatchers, ambulance personnel, and interaction with laypersons, to optimize video support for lifesaving procedures.

Limitations

In this study, participants were inexperienced and untrained in this specific context, including in working or assessment using a full-scale high-fidelity simulator. Working in groups, there appeared to be good immersion into the clinical scenarios, with no difficulty with 'suspension of disbelief' concerning the simulation. The video connection to ambulance personnel used here was a nono-commercial prototype, though commercial products for this purpose are expected to be widely available soon. The study groups were small, meaning that there can be imprecision in estimating effect sizes of the interventions. The preparatory course and the ambulance personnel protocolized communication can be updated and improved prior to future studies of efficacy and implementation. Since the only group that connected the biosensors to the 'injured' was the one that had both the training course and video support with ambulance personnel, there were limitations in assessing how the biosensor-based information might influence behavior. This finding though could inform future study design where biosensor information is central to the study question. The choice to assess learning and behavior related to the interventions using simulated injury events, rather than actual events, is a first step in studying these interventions, given that real-world serious trauma events at building sites are not common and not planned. Still, if and when these types of interventions might be implemented by builder organizations, the practical results will need to be assessed as part of implementation studies.

CONCLUSION

These findings show that for laypersons (here construction industry employees) and first responders in a serious injury scenario during waiting for ambulance , airway management and active bleeding control, are improved by live video support, including if these actions have been trained beforehand.

Conclusion study 1–2

The results indicated a complex environment that requires significant capability from individuals to transition from being a layman employed at a construction site to identifying and understanding when a serious injury event occurs, and then adapting to the role of taking action to save lives. Being compelled to act as a layman in a serious injury event can have lasting effects on the individual. To minimize both immediate and long-term negative stress reactions, well-developed preparation through training is required, along with support and insight from community resources, the emergency dispatch center, ambulance services, and the fire department. Since the effectiveness of training is expected to diminish over time, guidance and support can be provided remotely through video calls to assist a layman in a serious injury event. A counseling model can be specifically developed within emergency medical services, and then evaluated with a focus on the use of video calls and interaction between emergency medical services and layperson.

Future work

Study 1 and study 2 have laid ground for ongoing work on the design of study 3 and study 4.

Study 3:

Describing and evaluating the perspectives of ambulance personnel during driving using a telemedical system containing video calls with an integrated biosensor in interaction with layperson.

Method: The study is descriptive-exploratory using a mix method with the perspective of ambulance personnel using a telemedical system containing video calls with an integrated biosensor in interaction with layperson. The study aims to examine and evaluate the system's usability during driving, and interaction with layperson. It also aims to understand how the ambulance personnel, through video calls, guides the use of the biosensor and gains knowledge of how the ambulance personnel creates situational awareness related to guidance and advice to layperson in performing life-saving measures.

The simulated injury event, like study 2, will be recorded with cameras, and in study 3, we standardize the interaction of layperson with ambulance personnel. An experienced person will act as a layperson to standardize predetermined simulated factors for study.

Mixed-method study (Schoonenboom & Johnson, 2017) where recorded videos from simulations are used for interviews with ambulance nurses (n=12 pairs). Chart stimulated recall technique (Sinncott et al., 2017) will be used to describe their decision-making and the actions of ambulance personnel during driving. Analysis with descriptive statistics and content analysis will be integrated into the discussion of findings to gain knowledge about the situational awareness, decision-making, and interaction of ambulance personnel, as well as how the system affects traffic safety during emergency driving.

Study 4:

In study 4, we plan to maintain the same structure as in study 3, except for fine-tuning ambulance personnel's preparations based on the results of study 3. We aim to identify and enhance potential improvement points in remote support elements. Afterward, we intend to use real construction employees as layperson in simulation. A qualitative study where layperson (n=12) is interviewed to answer questions about their experiences of performing actions with the guidance of ambulance personnel, how layperson perceive their ability to act with support, and how their sense of stress is affected when supported by ambulance personnel during care. The analysis will be conducted using Critical Incident Technique (Flanagan, 1954; Fridlund, 2012; Polit & Tatano- Beck, 2012).

References

Advanced Trauma Life Support® Student Course Manual 9th Edition. Library of Congress Control Number: (2017) 907997 ISBN 78-0-9968262-3-5.

Allvarliga arbetsskador och långvarig sjukfrånvaro. Rapport, AFA-Försäkring. (2023).

Andersson GS, Gaetz M, Masse J. First aid skill retention of first responders within the workplace. *Scand J Trauma Resusc Emerg Med. 2011; 19:11.*

Avest E, Lambert E, de Coverly R, Tucker H, Griggs J, Wilson MH, Ghorbangholi A, Williams J, Lyon RM. Live video footage from scene to aid helicopter emergency medical service dispatch: a feasibility study. *Scand J Trauma Resusc Emerg Med. 2019 May 8; 27(1):55.*

Backteman-Erlanson. S, Jacobsson. A, Öster .I, Brulin.C. Caring for traffic accident victims: the stories of nine male police officiers. *International Emergency Nursing. 2011*;19(2):90-5.

Bakke HK, Steinvik T, Eidissen SI, Gilbert M, Wisborg T. Bystander first aid in trauma – prevalence and quality: a prospective observational study. *Acta Anaesthesiol Scand. 2015 Oct;59 (9):1187–1193.*

Bakke, H. K., & Wisborg, T. (2017). We need to include bystander first aid in trauma research. Scandinavian journal of trauma, *Resuscitation and emergency medicine*, 25(1), 1-3.

Becker J, Hugelius K: Driving the ambulance: an essential component of emergency medical services: an integrative review. *BMC Emerg Med* 2021, 21(1):160.

Berglund. L, Johansson. J, Johansson. M, Nygren. M, Rask. K, Samuelsson. B, Stenberg. M. Risks and safety work in the construction industry, A knowledge compilation based on international research. *Swedish Work Environment Authority, Knowledge compilation 2017:5. Elanders printing house, Sweden AB. (2017).*

Bergrath S, Brookman JC, Beckers S, Felzen M, Czaplik M. Implementation of a full-scale prehospital telemedicine system: evaluation of the process and systemic effects in a pre–post intervention study. *BMJ Open. 2021 Mar 24;11(3).*

Bray. JE, Deasy. C, Walsh. J, Bacon. A, Currell. A,Smith. K. Changing EMS dispatcher CPR instructions to 400 compressions before mouth-to mouth improved bystander CPR rates. *Resuscitation* 2011; 82: 1393–8.

Brinkolf.P, Metelmann.B, Metelmann. C, Baumgarten.M, Scharte. C, Zarbock. A, Hahnekamp. K, Bohn .A. One out of three bystanders of out-of-hospital cardiac arrests shows signs of pathological psychological processing weeks after the incident - results from structured telephone interviews. *Scand J Trauma Resusc Emerg Med. 2021; 29:131*.

Busby, S., & Witucki-Brown, J. (2011). Theory development for situational awareness in multi-casualty incidents. *Journal of emergency nursing*, 37(5), 444-452.

Burke, C.S., Wilson, K.A., & Salas, E. The use of a team-based strategy for organizational transformation: guidance for moving toward a high reliability organization. Theoretical Issues in Ergonomical Science, 6, 509–530. 2005

Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M: Developing and evaluating complex interventions: the new Medical Research Council guidance. *Int J Nurs Stud* 2013, 50(5):587 592.

Dieckmann P, Lippert A, Glavin R, Rall M. When things do not go as expected: scenario life savers. *Simul Healthc*. 2010;5(4):219-25.

Duut MS, Okyere P, Zakariah AN, Donkor P, Mock C: Factors influencing willingness to intervene as bystanders among adult residents living in crash-prone areas in the Ashanti region of Ghana. *Afr J Emerg Med* 2022, 12(4):315-320.

Edwin. K-W, Nielsen. M, Albrechtsen. E. Why Is the Construction Industry Killing More Workers Than the Offshore Petroleum Industry in Occupational Accidents? *Sustainability 2021, 13.*

Endsley, M. R. (2015). Final reflections: Situation awareness models and measures. *Journal of Cognitive Engineering and Decision Making*, 9(1), 101-111.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human factors*, 37(1), 32-64.

Fischer. P, Krueger. JI, Greitemeyer. T, Vogrincic. C, Kastenmyller.A, Frey.D, Heene.M, Wicher.M, Kainbacher.M.. The bystander effect: a meta-analytic review on bystander intervention in dangerous and non-dangerous emergencies. *Psychol Bull. 2011;137 (4):pp 517-37*.

Flanagan, J. F. (1954). The Critical Incident Technique. *Psychological Bulletin*, 5(4),

327–358.

Friberg. M, Jonson. C-O, Jaeger. V,Prytz. E. (2021). The Effects of Stress on Tourniquet Application and CPR Performance in Layperson and Professional Civilian Populations. *Human Factors*. 2023; 65: Pages 495-507

Fridlund, B. (2012). Kritisk incident teknik. I M. Henricson. (Red.). Vetenskaplig teori och metod - från idé till examination inom omvårdnad. (1:a uppl., s. 177-192). Lund: Studentlitteratur.

Goralnick E, Chaudhary MA, McCarty JC, Caterson EJ, Goldberg SA, Herrera-Escobar JP, McDonald M, Lipsitz S, Haider AH. Effectiveness of instructional interventions for hemorrhage control readiness for laypersons in the Public Access and Tourniquet Training Study (PATTS). *JAMA Surg. 2018; 153:791–799.*

Graneheim, U.H. and Lundman, B. (2004), "Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness", *Nurse Education Today, Vol. 24 No. 2, pp. 105-112.*

Graneheim, U.H., Lindgren, B.M. and Lundman, B. (2017), "Methodological challenges in qualitative content analysis: a discussion paper", *Nurse Education Today*, Vol. 56, pp. 29-34.

Halcomb, E. & Hickman, L. (2015). Mixed methods research. Nursing Standard: promoting excellence in nursing care, 29 (32), 41-47.

Hall. A, Wotton.K, Hutton.A. Bystander Experiences at and after a Motor Vehicle Accident: A review of the literature. *Australasian Journal of Paramedicine. 2013;10(4).*

Hansen-Weber. P, Schlynssen. V, Fonager. K, Hjort-Bönnlökke. J, Hansen. CD, and Böggild. H. Association of perceived work pace and physical work demands with occupational accidents: a cross-sectional study of ageing male construction workers in Denmark. *BMC Public Health. 2022; 22:18.*

Hedberg. H. (2020). SBUF 13813. Slutrapport-Livräddning på Distans. https://vpp.sbuf.se/Public/Documents/ProjectDocuments/90f67d07-fa5f-4c56-9bbe-0f61653165fa/FinalReport/SBUF%2013813%20Slutrapport-Livr%C3%A4ddning%20p%C3%A5%20Distans%20SBUF%2013813%20(1).pdf

Jansson, K-Å. (2009). Olycksfall och trauma. I Suserud, B-O & Svensson, L. (red.). *Prehospital akutsjukvård. Stockholm: Liber. s. 375-434.*

Johansson. A, Esbjörnsson. M, Nordquist. P, Wiinberg. S, Andersson. R, Ivarsson. B, Möller. S. Technical feasibility and ambulance nurses' view of a digital telemedicine system in pre-hospital stroke care – A pilot study. *International Emergency Nursing 44 (2019) 35–40.*

Karlsson. S. (2020). Saving lives during major underground mining incidents, Becoming prepared for a collaborative response. Umea University, Department of Surgical an Perioperative Sciences. ISBN: 978-91-7855-257-3.

Kim Y, Groombridge C, Romero L, Clare S, Fittzgerald MC. Decision Support Capabilities of Telemedicine in Emergency Prehospital Care: Systematic Review. *J Med Internet Res 2020;22(12).*

Kulnik. ST, Halter.M, Hilton.A, Baron.A, Garner.S, Jarman.H, Klaasen.B, Oliver. E. Confidence and willingness among laypersons in the UK to act in a head injury situation: a qualitative focus group study. *BMJ Open. 2019;9.*

Landgraf. P, Spies. C, Lawatscheck. R, Luz. M, Wernecke. KD, Schröder. D. Does Telemedical Support of First Responders Improve Guideline Adherence in an Offshore Emergency Scenario? A Simulator-Based Prospective Study. *BMJ Open 2019;9.*

Lee SY, Song KJ, Shin SD, Hong KJ, Kim TH. Comparison of the effects of audio-instructed and video-instructed dispatcher-assisted cardiopulmonary resuscitation on resuscitation outcomes after out of-hospital cardiac arrest. *Resuscitation. 2020; 147:12–20.*

Lennquist, S. (red.) (2017). Traumatologi. Stockholm: Liber.

Lindgren BM, Lundman B, Graneheim U. Abstraction and interpretation during the qualitative content analysis process. *Int J Nurs Stud. 2020.*

Linderoth G, Lippert F, Østergaard D, et al. Live video from bystanders’ smartphones to medical dispatchers in real emergencies. *BMC-Emerg Med. 2021;21:101.*

Linderoth G, Rosenkrantz O, Lippert F, Østergaard D, Ersbøll AK, Meyhoff CS, Folke F, Christensen HC: Live video from bystanders' smartphones to improve cardiopulmonary resuscitation. *Resuscitation* 2021, 168:35-43.

Lingard. H. The effect of first aid training on objective safety behaviour in Australian small business construction firms. *Construction Management and Economics. 2001; 19, pp 611–618*.

Matinrad. N. An Operations Research Approach for Daily Emergency Management. Linköping Studies in Science and Technology. Licentiate Thesis No. 1842 (2019). ISBN 978-91-7685-058-9.

Mell HK, Mumma SN, Hiestand B, Carr BG, Holland T, Stopyra J. Emergency medical services response times in rural, suburban, and urban areas. *JAMA Surg. 2017;152(10):983–984.*

Nielsen. AM, Isbye. DL, Knuddsen-Lippert. F, Rasmussen. RS. Engaging a whole community in resuscitation. Resuscitation, Volume 89, Issue 9, 2012, p 1067-1071.

Nord-Ljungquist. H. Vem har och tar ansvar! – I Väntan På Ambulans (IVPA)-uppdrag i Glesbygdsmiljö. Doktorsavhandling, Institutionen för hälso- och vårdvetenskap, Linnéuniversitetet, Växjö, 2020. ISBN: 978-91-89283-10-7.

Palsgaard-Möller. P, Hansen.CM, Fjordholt.M, Dahl-Pedersen. B, Østergaard. D, Lippert.FK. Debriefing bystanders of out-of-hospital cardiac arrest is valuable. *Resuscitation 85. 2014;pp 1504-1511*.

Park HJ, Jeong WJ, Moon HJ, Kim GW, Cho JS, Lee KM, Choi HJ, Park YJ, Lee CA: Factors Associated with High-Quality Cardiopulmonary Resuscitation Performed by Bystander. *Emerg Med Int* 2020, 2020:8356201.

Perlman. A, Sacks.R, Barak.R. Hazard recognition and risk perception in construction*. Safety Science 64. 2014; pp 22-31*.

Pevnick. JM. Wearable technology for cardiology: An update and framework for the future. Trends Cardiovasc. Med. (2018) 28(2), 144–150.

Pham. H, Pucket. Y, Dissanaike. S. Faster on-scene times associated with decreased mortality in Helicopter Emergency Medical Services (HEMS) transported trauma patients. *Trauma Surg Acute Care Open 2017; 2:1–5.*

PHTLS: Prehospital trauma life support 9th Edition. USA: Jones and Bartlett. Publisher, inc. ISBN (2021) 978-1-284-19872-0

Pileman. S, Grahn. O, Källgården. P. Att förhindra och hantera händelser i socio-ekonomiskt utsatta områden: vidareutveckling och utvärdering av konceptet Civil insatsperson i förort. CARER rapport nr 30 (2020). Linköping Universitet. ISBN: 978-91-7929-705-3.

Polit, D. F. & Tatano Beck, C. (2012). Nursing research - generating and assessing evidence for nursing practice. (9.e uppl.). Lippincott Williams & Wilkins.

Ponsonby. W, Mika. F, Irons G. Offshore industry: medical emergency response in the offshore oil and gas industry. Occupational Medicine 2009;59:298–303.

Rapaport.C, Ashkenazi. I. Better Together: Evolving Social Process between Bystanders and First Responders is a Force Multiplier for Effective Emergency Respons*e. Epidemiol Open J. 2020; 5(1): pp 1-7.*

Reason, J. Achieving a safe culture: Theory and practice. Work & Stress: *An International Journal of Work, Health & Organisations, 1998;12, pp 293–306.*

Regulation, General Data Protection. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46. *Official Journal of the European Union (OJ). 2016;59(1-88):294.*

Ramsell. E. Toward ICT-enabled Co-production for Effective Crisis and Emergency Response. Linkoping Studies in Arts and Sciences No. 799. (2021). ISBN: 978-91-7929-729-9.

Ringh. M, Rosenquist. M, Hollenberg. J, Jonsson. M, Fredman. D, Nordberg. P, Järbert-Petterson. H, Hasselquist-Ax. I, Riva. G, Svensson. L. Mobile-Phone Dispatch of Laypersons for CPR in Out og Hospital Cardiac Arrest. N Engl J Med 2015; 372:2316-2325.

Salo, I., & Lindén, M. Riskperception och interventionsmetoder, Kunskapssammanställning 2015:7, Arbetsmiljöverket. Institutionen för psykologi, Lunds universitet, Mars 2015.

Samuelsson. B. Arbetsskador i Byggverksamhet 2019. BCA-Byggindustrins centrala arbetsmiljöråd. (2020:2).

Samverkan för noll olyckor, Web. https://www.hallnollan.se

Sephavand. E, Khankeh. H, Hosseini. M, Akhbari. B. A concept analysis of the bystander effect in road traffic injuries*:* A hybrid model. *Australasian Journal of Paramedicine. 2020;17.*

Schoonenboom J, Johnson RB: How to Construct a Mixed Methods Research Design. Kolner Z Soz *Sozpsychol* 2017, 69(Suppl 2):107-131.

Sinnott C, Kelly MA, Bradley CP: A scoping review of the potential for chart stimulated recall as a clinical research method. *BMC Health Serv Res* 2017, 17(1):583.

Skivnington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby J, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. *BMJ. 2021;374.*

Stenberg. M. SBUF-Rapport "Bortom Noll". Luleå tekniska universitet Institutionen för ekonomi, teknik och samhälle 2016.

Stenberg. R, Blondin. R, Granberg.TA. Förstainsatsaktörer – Vad är det egentligen? Pilotprojekt för forskning om förstainsatsaktörer (FIA) – forskningsperspektiv och praktiker. CARER Center for advanced research in emergency response. CARER Rapport Nr. 1. (2010), Linköpings Universitet.

Stubbings, L., Chaboyer, W., & McMurray, A. (2012). Nurses' use of situation awareness in decision-making: an integrative review. *Journal of advanced nursing*, 68(7), 1443-1453.

Svenska Hjärtlung Fonden, 2022. Responstid för Ambulanser i Sverige. https://mb.cision.com/Public/545/3645729/823331222070a811.pdf

Svensson. A. Räddningsaktörers tidiga närvaro vid akuta situationer på svensk landsbygd. Doktorsavhandling, Institutionen för hälso- och vårdvetenskap, Linnéuniversitetet, Växjö, 2019. DanagårdLiTHO, 2019.

Tannvik. TD, Bakke. HK, Wisborg. T. A systematic literature review on first aid provided by laypeople to trauma victims. Acta Anaesthesiol Scand 2012; 56: 1222–7.

Torunn-Mathiesen. W, Bjørshol. CA, Braut. GS, Søreide. E. Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims: a qualitative study. *BMJ Open. 2016;6.*

Vikström, T. (2014). Trauma. I Hansson, L-E & Vikström, T. (red.). Akut kirurgi med traumatologi. Lund: Studentlitteratur. s. 59–71.

Vincent. V, Johansson. A, Selling. M, Johansson. J, Möller. S, Todorova. L. Experience of using video support by prehospital emergency care physician in ambulance care - an interview study with prehospital emergency nurses in Sweden. Vicente et al. *BMC Emergency Medicine* (2021) 21:44.

Whilke. G, & Schmidt, R.(red.) (2021). Traumaomvårdnad-vård av svårt skadade patienter. Malmö. Liber.

Winge. S, Albrechtsen. E, Aamnes-Mostue. B. Causal factors and connections in construction accidents. *Safety Science 112. 2019;pp 130-141*.

World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA. 2013;310(20):2191–2194.*

Åkerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Mental fatigue, work and sleep. *J Psychosom Res. 2004;57: pp 427–33.*

I

Preliminary Manuscript 2024-01-09

Construction employee's experiences of being involved as a layperson first-aid provider in a serious workplace injury event- a qualitative study

Author names, affiliations

*Hans Hedberg, PhD-student. Anesthesiology and Intensive Care Medicine, Surgical and Perioperative Sciences, Umeå University, Umeå, Sweden. hans.hedberg@umu.se

Pia Hedberg, PhD. Nursing and Surgical and Perioperative Sciences, Center for Disaster Medicine, Umeå University, Umeå, Sweden. pia.hedberg@umu.se

Michael Haney, MD, Professor, Anesthesiology and Intensive Care Medicine, Surgical and Perioperative Sciences, Umeå University, Umeå, Sweden. michael.haney@umu.se

Sofia Karlsson, PhD. Surgical and Perioperative Sciences, Surgery, Umeå University, Umeå, Sweden. sofia.karlsson@umu.se

Jonas Aléx, PhD. Nursing, Umeå University, Umeå, Sweden. jonas.alex@umu.se

*Corresponding author

Introduction

Workplace-related serious injury events are a well-recognized problem in Europe, with construction sites bearing a higher risk of such events compared to other workplaces (Berglund et al., 2017; Perlman et al., 2016). One explanation for this heightened risk is that construction sites often operate under exposed conditions with varying safety margins and significant time pressure (Hansen et al., 2022). To put this in context, Sweden reports approximately 1,000 serious injury events each year (medical leave of absence for thirty days or longer), some of which result in fatalities (Stenberg, 2017). Serious injury events of this nature occur suddenly, delivering a substantial release of high energy to the human body. This high-energy impact primarily affects the injury itself and can have secondary consequences, for the injured person and for others (Winge et al., 2019).

When serious injuries occur on construction sites, several immediate management aspects occur. It is necessary to gain a comprehensive understanding of the specific situation and the mechanisms underlying the injury (Lennquist, 2017). Time is an important factor. Swift implementation of life-saving measures is essential, as these measures can potentially influence the injury's outcome (Whilke & Schmidt, 2021; Jansson, 2009; Vikström, 2014; Pham et al., 2017). Early assessments and interventions by laypersons, or person without advanced emergency care training, have been shown to be important, especially in situations like cardiac arrest and cardiopulmonary resuscitation, but also in injury events (Gitte et al., 2021; Lee et al., 2020; Avest et al., 2019). Laypersons can perform life-saving measures before the arrival of an ambulance. In a study by Bakke et al. (2015), where 330 prehospital trauma alerts and interventions were observed, it was noted that 35% of laypersons had received first aid training. Those with first aid training tended to perform more accurate and effective actions compared to those without such training (Bakke et al., 2015). It is also worth noting that First Aid administered by laypersons can sometimes be executed incorrectly (Tannvik et al.,2012).

Being involved in a workplace injury event as a layperson can be a stressful experience and can affect their ability to act effectively. Three basic conditions should be met for a layperson to act in the event of an injury: (a) the person must have personally witnessed the injury event, (b) the person must perceive the situation as an emergency, and (c) the person must decide to assist the injured individual by taking action (Sephavand et al.,2020). Acting as a layperson in the event of an injury requires courage, knowledge, and swift action (Duut et al.,2022). Presently, there is limited understanding of how employees in the construction industry reacts and acts when they find themselves in the role of saving a colleague's life during a serious injury event and whether this experience affects them emotionally.

It is not usual that laypersons involved in workplace injury event possess the knowledge, competence, and courage to act. This can lead to secondary injuries for the victim and negative emotional experiences for the layperson who witnessed and acted during the injury event. **This study aims** to describe the experiences of construction employees who have been involved as layperson first aid providers in a serious workplace injury event. Knowledge from this study can increase the understanding of whether and what support employees, layperson first responder may need to mitigate potential negative consequences in the event of a serious workplace injury. Further, this knowledge could also increase the understanding of how dispatchers and rescue personnel (ambulance and emergency services) could interact and cooperate with layperson in events of serious injuries at a construction site.

Method:

Setting

The data collection took place in Sweden 2022 and examined experiences reported by employees in the construction industry who had been involved in an injury event at their workplace.

Design

A qualitative study was conducted with semi structured individual interviews.

Participants and recruitment

Participants were recruited from various construction companies in Sweden and were selected based on their experience with injury events. To be included, it was required that the emergency number 112 be dialed, that an ambulance arrived at the scene, and that the injured person needed ambulance transportation into hospital. A total of nine employees participated in the study, eight of whom were men, and one was a woman. Their ages ranged from 22 to 66 years, and they had worked in the construction industry for varying lengths of time, from 5 to 41 years. Eight of the participants had completed a first aid course within the last three years. None of the participants had a background as e.g working in rescueservices, police, healthcare, military.

Ethical consideration

This study was approved by The Ethics Committee, dnr 2021-05774-01. Participants were informed about the aim of the study, their rights to withdraw their contribution, confidential handling of data, and that all efforts would be made to ensure participants anonymity. Participants provided written informed consent and were also informed that if they wanted to talk with someone after the interviews, they would be provided with details for a contact person.

Data collection

An Interview Guide was created by the authors and was based on the context to be studied, i) when the injury event occurred, ii) management of the injury event and iii) after the injury event. The interviews began with an open question, “Can you tell me about when you performed first aid for one or several colleagues”? “Report freely about what you experienced from the time of discovery of the injured, the emergency call to 112, and to transport by ambulance”. Try to include what you thought, felt and what you did.” Follow up-questions, if these details were not included in the account, included for example, “What did you think when you saw that your colleague was injured?” “What did you do?” “How did you take care of the injured person?” “How did it feel to give your colleague first aid?” Six participants were interviewed live on a digital platform, and three participants in their workplace in a private room without any distractions. After the first interview, two authors discussed the interview guide with the participant, and the questions and process were clarified. All interviews lasted between 35 to 50 minutes and were recorded and then transcribed verbatim.

Data analysis

Interviews were analyzed using a qualitative content analysis method (Granheim and Lundman., 2004., Lindgren et al,2020). The focus of the analysis lay on the manifest content of the interviews. The collected data underwent a qualitative content analysis following the method described by Lindgren et al. (2020). The analysis process initially involved consolidating all the text into a common analysis database (Word-ds). Common words and sentences were identified and grouped into meaningful units. Subsequently, a condensation of the texts was performed with the aim of reducing the volume without losing the essence of the information. The condensed text was further abstracted to achieve a logical level, which was then compared against the original meaningful units and the condensed text. Afterward, the common text fragments from all transcripts were coded and grouped into subcategories, which were then organized into categories describing the findings at a descriptive level. The categories and subcategories are exemplified with citations from the participants in the results.

Results

Three categories with nine subcategories were identified which illustrated construction employee's experiences of being involved as a layperson first-aid provider in a serious workplace injury event and are exemplified with citations in the results (Table 1).

Table 1. Categories and subcategories illustrated construction employee's experiences of being involved as a layperson first-aid provider in a serious workplace injury event

Categories	Subcategories
Suddenly trying to save lives after realizing the unexpected	Understanding that a serious injury has occurred Initiating an own response First aid activities own and team Inexperience, fear of doing wrong
The importance of collaboration in a chaotic situation	Acting with support from dispatcher Support from ambulance and rescueservice
The need for social support and following improvements	Stated desire for early support and later follow-up Long-term psychology experience Trying to learn from injury event experience

Suddenly trying to save lives after realizing the unexpected

Four factors were highlighted as in the immediate initial acute phase. Understand that a serious injury has occurred, initiating an own response, first aid activities own and team, inexperience, fear of doing wrong affected the initiation of starting some kind of rescue effort.

Understand that a serious injury has occurred

Attempting to understand what had happened was described as important in the role of laypersons, first responders. Participants highlighted that when a risk escalated into a serious injury event, they described a profound change in their awareness. It became surreal and challenging to grasp the reality of a serious injury event. To comprehend the reality, participants described that they relied on their sensory experiences to understand and create awareness of what has occurred.

As one participant expressed:

"I initially thought it wasn't him who had fallen down; I was convinced that it was some construction material. It felt surreal

Initiating an own response

The participants described how the event created immediate stress with a strong sense of discomfort. , The initial thought was an immediate reaction of just wanting to walk away from there. to move away from the scene of the injury event. This thought then transitioned into a desire to help and take responsibility. They described that many colleagues were standing and watching in what they described as chaotic environment. Taking action involved the ability to maintain composure, not hesitate, as the participants described it, to take an initiative, organize and support by thinking steps ahead.

"The feeling was to simply try to assess the situation while also supporting the colleagues who couldn't immediately handle the situation."

First aid activities own and team

The participants described first aid activities as despite their sense of stress they still worked together within their team. Medical measures were initiated and carried out, such as supporting the injured person's breathing, applying initial dressings, and warming the injured person.

"It's difficult to explain how one feels in that particular moment. Certainly, it's uncomfortable, but one does the best they can; after all, one does everything to help someone."

The participants further described that their teamwork in mutual assistance, collectively devising innovative solutions such as constructing a stretcher or moving equipment that was in the way, ensuring an adequate number of colleagues were present, and providing support to each other in the chaotic situation. This teamwork was seen as a way to maintain calm within the group, a calmness that was conveyed to the injured person.

"There were perhaps about 10 colleagues around when this happened, everyone behaved, it was professional considering how people tend to react. It felt really good and safe."

Inexperience, fear of doing wrong

The participants experienced the events as unexpected, something they hadn't mentally prepared for or trained in advance. They described how they lacked experience in assessing and managing these severe conditions, with severe bleeding being particularly challenging. Additionally, they encountered difficulties in understanding how medical materials worked, from opening packages to knowing how to correctly apply pressure dressings for severe bleeding.

"Some coworkers have received training in cardiopulmonary resuscitation (CPR), however, when it comes to injuries involving extensive bleeding, such as cuts, one is left unprepared."

The condition of the injured person created fear among the first aid responders, which the participants described as a fear of making mistakes and worsening the injury. This fear, as described by the participants, primarily occurred when the injured person was unconscious, when the participants assessed that the airway was blocked and needed to be addressed physically at the scene of the injury. Fear was also described during the encounter and conversation with the injured person, and the fear was related to not wanting to provide incorrect information, something that the participants described as particularly pronounced when they themselves did not know the extent of the person's injuries.

"I hold him so he gets air, I've pulled him out so he can breathe. Then I don't want to do much more because he was pretty bad, I didn't want to move his neck so much"

The importance of collaboration in chaotic situation

The category delineated the participants' experiences of collaboration, both between emergency call dispatchers and ambulance- rescue services. These experiences could be divided into two subcategories, Generating an actionplan with support from dispatcher and Support from ambulance and rescuservices.

Acting with support from dispatcher

The collaboration with society's emergency responders began even before the ambulance and rescue service arrived at the scene of the injury event. Participants described this collaboration as commencing when they dialed the emergency number 112. The initial feeling that arose during the conversation with the dispatcher was described as a sense of calm among the participants, a feeling of security simply by knowing that an ambulance was on the way. Furthermore, the participants described a mutual collaboration, where they themselves had a need to receive advice and support from the dispatcher, while the dispatcher needed a clear description of the event's situation and guidance to accurately describe the address and approach route for the ambulance and rescue service personnel. Participants highlighted important factors in collaboration with 112, such as ensuring that mobile coverage was available and, in cases where a fixed address was not available for a construction site, clear coordinates were provided.
The initial sense of calm among the participants quickly turned into a feeling of discomfort on occasions when they had to wait for an extended period for the ambulance to arrive at the scene. Participants described this waiting as compelling, compelling them to continue assisting the injured person during the ongoing emergency call, but now with support and collaboration with the dispatcher while awaiting the ambulance.

"We managed to do quite a bit; we had time to sit with him, we had time to carry him on the makeshift stretcher, to stay inside the barrack for a while, I think it was about 1 hour and 45 minutes before the ambulance personnel arrived"

Support from ambulance and rescue service

When the ambulance arrived at the scene, the participants described it as an overall calmness prevailed. Through this feeling, the participants fully relinquished their responsibility to the ambulance personnel, and a strong desire arose to leave the injury site. The participants understood that their effort was not over even though the ambulance was on the scene. The work had to continue, but now in collaboration with the ambulance and rescue service personnel. This awareness was described as arising through the ambulance personnel's ability to convey calmness. Collaboration with the ambulance personnel was based on communication among each other. The participants described that the calmness and clarity of the ambulance personnel helped them understand what they needed to assist with, and, through their guidance, they executed tasks together.

"He wanted my help, so I buttoned up the collar. I had no idea how tight to fasten it; we did it together. He was good, calm, and easy going."

The need for social support and following improvements

The participants described how the injury event affected them even afterward, after the injured person was transported to the hospital. The participants described this as, stated desire for early support and later follow-up, long-term psychology experience and trying to learn from injury event experience.

Stated desire for early support and later follow-up

After the injury event, there was a strong urge to unite. Participants referred to this as a check-in, where their main concern was to gauge the well-being of everyone involved and determine if anyone required immediate support or assistance. During this initial period following the injury, the participants noted that they had to rely on each other for support. From this phase where they had to take care of each other, the participants described the need for external support from the company's management organization. The participants described external support as a crisis team responsible for monitoring all individuals involved, providing updates on the injured person's condition, and offering information to family members. When this support was lacking, disappointment arose, a disappointment that it took time to receive support.

"We were disappointed with how we had been handled, that is, from the top, by our management. Yes, it took some time before any support was provided"

When the crisis management team was in place and began functioning, participants described it as a positive experience, having the opportunity to share their stories or be seen.

As one of the participants expressed:

"Then my senior manager called and asked what had happened and how I was doing. Everyone has been concerned about me and asked if I needed someone to talk to"

Long-term psychology experience

Experiences of the injury events were described by the participants as affecting them both in the short and long term. Returning to their workplace initially felt good, but at the same time, they described that the feeling of the injury event still lingered.

Participants explained that those particularly vulnerable were the persons who were close to the injured person, those who tried to save lives during the injury event.

"The ones who suffered the most were those who tried to save him, yes, to do something. Yes, it's a trauma that never leaves you, or a memory that never leaves you"

Trying to learn from injury event experience

The injury event generated lessons that the participants described and provided suggestions for new ways to act related to organization and education.

" when you consider that you have to show the way because we are, after all, on a construction site that doesn't have an address, it becomes immediately inconvenient. Perhaps that is something that should be emphasized in the training, that someone needs to be sent out to show the way"

The equipment was also further developed to adapt more serious traumatic injuries and replaced the old equipment. The most important aspect described by the participants was the experience of being present during an injury event.

"To analyze the worst-case scenario, if I put it that way, how do we handle it, who does what, and that's something I take with me, that we need to plan before the worst can happen."

Discussion

This study aimed to describe the experiences of construction employees who have been involved as layperson first aid providers in a serious workplace injury event.

The participants encountered uncertainty and challenges when attempting to recognize, comprehend, interpret, and raise awareness of the injury event. The realization of such an event led to a profound shift in their consciousness, and they relied on their sensory perceptions to comprehend the situation and take appropriate actions. According to Perlman et al. (2014), these challenges in recognition and understanding can be attributed to the work environment, where sound and other distractions can impede sensory perception and affect their ability to interpret and understand.

The attempt to act and take responsibility emerged as a significant issue in our results is in according to Sepahvand et al. (2020) that argue that bystanders observe each other on the scene, and if they do not interpret the situation as an emergency, they do not act either. Initially, the study participants experienced discomfort and a fight-or-flight reaction, but they eventually transitioned into a desire to provide assistance and take responsibility. It was noted that individuals reacted differently to the situation. Some participants proactively initiated life-saving measures, while others initially observed the event without taking action. We interpret this variation in responses as a possible form of the bystander effect. According to the bystander effect, the presence of others leads to the diffusion of responsibility, meaning that each of the individuals present does not act because they believe someone else will offer help (Rapaport & Ashkenazi, 2020; Fisher et al., 2011). Our results demonstrate that some participants have the ability to take responsibility for the situation and thus take action. We infer that when other bystanders realize that someone is taking the lead, they also take responsibility and act, which contradicts hesitation related to the bystander effect. We attribute this to the close relationships that existed between the participants and the injured individual, a conclusion also highlighted by Hal et al. (2013).

Insecurity and doubt were common feelings among the participants when caring for a seriously injured individual with life-threatening injuries, as Hal et al. (2013) also highlighted in their study. One possible explanation for this uncertainty, in our view, could be a sense of lacking the right first aid knowledge. In our study, participants provided insights that align with this explanation of inadequate knowledge. They expressed uncertainty about necessary actions in critical life-saving situations, such as handling severe bleeding or an unconscious person. Our results emphasize the idea that knowledge and experience can alleviate laypeople's fears, increase the likelihood of them taking action, and initiating life-saving measures while waiting for an ambulance. This concept is also supported by Kulnik et al. (2019).

Collaboration with rescue personnel began as soon as the participants dialed the emergency number 112. They felt a sense of relief knowing that help was on the way. However, their insecurity grew as they had to wait for the ambulance for an extended period. We interpret that the wait for the ambulance encourage the participants to cooperate with and engage in the advice and support of the dispatcher. The participants described this collaboration as mutual, where they could also support the dispatcher by describing the incident and explaining the location of the injury site to facilitate the arrival of the ambulance.

When the ambulance arrived, the participants experienced an overall sense of calm, and they willingly handed over their responsibilities to the ambulance personnel. The participants shared their experiences of completely trusting the ambulance and rescue services and physically leaving the scene. The participants mentioned that the professionalism and calm demeanor of the ambulance and rescue service personnel encouraged them to stay and assist in ongoing rescue efforts. This interaction between professional and non-professional individuals in emergency situations, as described by Rapaport & Ashkenazi (2020), encompasses two aspects: "professional assistance," where the emergency services personnel take charge and request laypersons to leave the scene, and coordinated assistance, where both parties collaborate to manage the situation.

We believe that in complex environments, such as construction sites, there is a need for coordinated assistance, clearer cooperation between ambulance services, rescue personnel, and employees to enhance the efficiency of rescue operations during serious critical events. We argue that this collaboration requires mutual understanding from both organizations, including builders and ambulance or rescue services. It is especially important for the professional organization, such as ambulance services, to recognize that involved laypersons are vulnerable and may require support.

After the injury event, participants experienced a strong desire to inquire about each other's well-being and seek external support from the company's management team. Some participants also began reflecting on their actions and questioning whether they had done enough or potentially worsened the injury. We believe that this self-doubt can be the onset of inner stress, a common feeling reported in previous studies (Palsgaard-Möller et al., 2014; Brinkolf et al., 2021). The effects of these reactions extended beyond the initial days following the injury event. Several participants shared that the event continued to occupy their thoughts and affect them in the long term. This phenomenon is described by Torun-Mathiesen et al. (2016), who highlight how individuals involved in critical situations outside a hospital setting can experience lasting emotional effects and may struggle to adapt to life after the event.

The injury event subsequently led to suggestions for new ways to organize and educate employees, as well as improve equipment to better handle traumatic injuries, and to prepare the organization for worst-case scenarios. Through this result, we believe that the organization can prepare for the worst by, as step 1, linking risk to an action plan. Step 2 involves adapting training based on the organization's expected needs and challenges, as highlighted in previous research (Burke et al., 2005; Lingard, 2001; Reason, 1998). Our findings also support the need to prepare the organization for what needs to be done after the injury event. Without psychosocial support, the risk of long-term negative consequences for the personnel who acted as first responders in a serious injury event increases our findings respond to several research reports (Palsgaard-Möller et al., 2014; Linderoth et al., 2021; Langraf et al., 2019; Gitte et al., 2021; Goralnick et al., 2018; Pileman et al., 2020). Through our result, we have been able to describe a group of personnel who were strongly affected by having to participate in the rescue of colleagues who were injured in a serious injury event. We believe that, through this impact, the participants have learned and gained new experiences that we hope have strengthened their ability to have the courage to act if they find themselves in a situation where they need to save lives.

Methodological consideration

In the field of qualitative research, various methods are employed to gather information, such as observation or individual and group interviews with participants in the study. The initial steps in analyzing the collected data are similar regardless of the qualitative method used, involving processes sorting and categorizing the information (Granheim & Lundman, 2004). Qualitative content analysis can be both deductive and inductive (Granheim et al., 2017). The deductive approach involves analysis based on a predetermined model or theory, while the inductive approach entails an open-minded analysis of texts, which could be narratives stemming from people's experiences.

The study has an inductive approach. The study focused on the manifest meaning, i.e., what the text explicitly conveys, resulting in categories with corresponding subcategories.

An important concept in qualitative studies is trustworthiness, which is a summary of various aspects of credibility, reliability, and transferability (Graneheim et al., 2017). The trustworthiness of this study was strengthened by active participation of multiple researchers in the interview process and continuous presence throughout the entire analysis phase. Furthermore, regarding the transferability of the results, it is important to note that the participant sample size was limited. This fact may entail certain limitations regarding the generalizability of the obtained results to a broader population. However, this was compensated for by conducting interviews in a comprehensive and in-depth style, with narratives of experiences highlighting actions in serious injury events. It is also worth noting that the subject addressed in the study could be considered sensitive for the participants, especially considering the uncertainty surrounding right or wrong actions in the described events. This implies a potential risk that participants may not fully share their innermost experiences and reactions to the events, which could impact the credibility and reliability of the presented results.

Conclusion

The result shows the challenges for a laypersons ability to switch from being an employee on a construction site trying to understand when a serious injury event has occurred, and then changing roles trying to save lives. Their intervention can potentially affect the individual both in the short and long term after the injury. To prevent short-term and long-term negative stress reactions preparations are required in terms of education in first aid training. We believe that in complex environments, such as construction sites, there is a need for coordinated assistance, clearer cooperation between dispatcher, ambulance services, rescue personnel, and laypersons to enhance the efficiency of rescue operations during serious critical events. A level of understanding from professional organizations is required, to support the layperson in becoming a valuable resource to the emergency personnel and enables them to assist and collaborate effectively by waiting for the ambulance.

References

Andersson GS, Gaetz M, Masse J. First aid skill retention of first responders within the workplace. *Scand J Trauma Resusc Emerg Med. 2011; 19:11.*

Bakke HK, Steinvik T, Eidissen SI, Gilbert M, Wisborg T. Bystander first aid in trauma – prevalence and quality: a prospective observational study. *Acta Anaesthesiol Scand. 2015 ;59 (9): pp 1187–1193*.

Berglund. L, Johansson. J, Johansson. M, Nygren. M, Rask. K, Samuelsson. B, Stenberg. M. Risks and safety work in the construction industry, A knowledge compilation based on international research. *Swedish Work Environment Authority, Knowledge compilation 2017:5. Elanders printing house, Sweden AB. (2017).*

Brinkolf.P, Metelmann.B, Metelmann. C, Baumgarten.M, Scharte. C, Zarbock. A, Hahnekamp. K, Bohn .A. One out of three bystanders of out-of-hospital cardiac arrests shows signs of pathological psychological processing weeks after the incident - results from structured telephone interviews. *Scand J Trauma Resusc Emerg Med. 2021; 29:131*.

Burke, C.S., Wilson, K.A., & Salas, E. The use of a team-based strategy for organizational transformation: guidance for moving toward a high reliability organization. Theoretical Issues in Ergonomical Science, 6, 509–530. 2005.

Fischer. P, Krueger. JI, Greitemeyer. T, Vogrincic. C, Kastenmyller.A, Frey.D, Heene.M, Wicher.M, Kainbacher.M.. The bystander effect: a meta-analytic review on bystander intervention in dangerous and non-dangerous emergencies. *Psychol Bull. 2011;137 (4):pp 517-37*.

Gitte L, Oscar L, Freddy L, Doris Ø, Anette KL, Christian SM, Fredrik F, Helle CC. Live video from bystanders' smartphones to improve cardiopulmonary resuscitation. *Resuscitation. 2021 Nov; 168: pp 35 – 43.*

Goralnick E, Chaudhary MA, McCarty JC, Caterson EJ, Goldberg SA, Herrera-Escobar JP, McDonald M, Lipsitz S, Haider AH. Effectiveness of instructional interventions for hemorrhage control readiness for laypersons in the Public Access and Tourniquet Training Study (PATTS). *JAMA Surg. 2018; 153: pp 791–799.*

Graneheim, U.H. and Lundman, B. (2004), "Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness", *Nurse Education Today, Vol. 24 No. 2, pp. 105-112.*

Graneheim, U.H., Lindgren, B.M. and Lundman, B. (2017), "Methodological challenges in qualitative content analysis: a discussion paper", *Nurse Education Today, Vol. 56, pp. 29-34.*

Hall. A, Wotton.K, Hutton.A. Bystander Experiences at and after a Motor Vehicle Accident: A review of the literature. *Australasian Journal of Paramedicine. 2013;10(4).*

Hansen-Weber. P, Schlynssen. V, Fonager. K, Hjort-Bönnlökke. J, Hansen. CD, and Böggild. H. Association of perceived work pace and physical work demands with occupational accidents: a cross-sectional study of ageing male construction workers in Denmark. *BMC Public Health. 2022; 22:18*.

Kim Y, Groombridge C, Romero L, Clare S, Fittzgerald MC. Decision Support Capabilities of Telemedicine in Emergency Prehospital Care: Systematic Review. *J Med Internet Res 2020;22(12).*

Kulnik. ST, Halter.M, Hilton.A, Baron.A, Garner.S, Jarman.H, Klaasen.B, Oliver. E. Confidence and willingness among laypersons in the UK to act in a head injury situation: a qualitative focus group study. *BMJ Open. 2019;9.*

Landgraf P, Spies C, Lawatscheck R, Luz M, Wernecke KD, Schröder D. Does Telemedical Support of First Responders Improve Guideline Adherence in an Offshore Emergency Scenario? A Simulator-Based Prospective Study. *BMJ Open 2019 Aug 27;9 (8)*.

Linderoth G, Lippert F, Østergaard D, et al. Live video from bystanders' smartphones to medical dispatchers in real emergencies. *BMC-Emerg Med. 2021;21:101.*

Lingard. H. The effect of first aid training on objective safety behaviour in Australian small business construction firms. *Construction Management and Economics. 2001; 19, pp 611–618*.

Mell HK, Mumma SN, Hiestand B, Carr BG, Holland T, Stopyra J. Emergency medical services response times in rural, suburban, and urban areas. *JAMA Surg. 2017;152(10): pp 983-984*.

Möller TP, Hansen CM, Fjordholt M, Dahl-Pederesen B, Østergaard D, Lipper FK. Debriefing bystanders of out-of-hospital cardiac arrest is valuable. *Resuscitation. 2014 Nov; 85(11): pp 1504–1511.*

Palsgaard-Möller. P, Hansen.CM, Fjordholt.M, Dahl-Pedersen. B, Østergaard. D, Lippert.FK. Debriefing bystanders of out-of-hospital cardiac arrest is valuable. *Resuscitation 85. 2014;pp 1504-1511*.

Perlman. A, Sacks.R, Barak.R. Hazard recognition and risk perception in construction. *Safety Science 64. 2014; pp 22-31*.

Pham H, Pucket. Y, Dissanaike S. Faster on-scene times associated with decreased mortality in Helicopter Emergency Medical Services (HEMS) transported trauma patients. *Trauma Surg Acute Care Open. 2017; 2: pp 1–5*.

Pileman S, Grahn O, Källgården P. Preventing and managing incidents in socio-economically disadvantaged areas: further development and evaluation of the concept of Civilian Response Person in Suburbs. *CARER rapport nr 30 (2020). Linköping University. Sweden. ISBN: 978-91-7929-705-3*.

Rapaport.C, Ashkenazi. I. Better Together: Evolving Social Process between Bystanders and First Responders is a Force Multiplier for Effective Emergency Response. *Epidemiol Open J. 2020; 5(1): pp 1-7*.

Reason, J. Achieving a safe culture: Theory and practice. Work & Stress: *An International Journal of Work, Health & Organisations, 1998;12, pp 293–306.*

Sephavand. E, Khankeh. H, Hosseini. M, Akhbari. B. A concept analysis of the bystander effect in road traffic injuries*:* A hybrid model. *Australasian Journal of Paramedicine. 2020;17*.

Tatebe L, Speedy AS, Kang D, Barnum T, Cosey-Gay F, Regan S, LeVon S, Mamta S. Empowering Bystanders to Intervene: Trauma Responders Unify to Empower (TRUE) Communities. *J Surg Res. 2019; 238: pp 255 -264.*

Torunn-Mathiesen. W, Bjørshol. CA, Braut. GS, Søreide. E. Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims: a qualitative study. *BMJ Open. 2016;6.*

Winge. S, Albrechtsen. E, Aamnes-Mostue. B. Causal factors and connections in construction accidents. *Safety Science 112. 2019;pp 130-141*.

Åkerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Mental fatigue, work and sleep. *J Psychosom Res. 2004;57: pp 427–33.*

II

Hedberg *et al. BMC Emergency Medicine* (2024) 24:2
https://doi.org/10.1186/s12873-023-00917-4

BMC Emergency Medicine

RESEARCH
Open Access

Effects of an advanced first aid course or real-time video communication with ambulance personnel on layperson first response for building-site severe injury events: a simulation study

Hans Hedberg[1*], Pia Hedberg[2], Jonas Aléx[3], Sofia Karlsson[4] and Michael Haney[1]

Abstract

Background The risk of high-energy trauma injuries on construction sites is relatively high. A delayed response time could affect outcomes after severe injury. This study assessed if an advanced first aid course for first aid response for laypersons (employees or apprentices) in the construction industry or real-time video communication and support with ambulance personnel, or neither, together with access to an advanced medical kit, would have an effect on immediate layperson vital responses in a severe injury scenario.

Method This was a controlled simulation study. Employees or apprentices at a construction site were recruited and randomly allocated into a group with video support or not, and advanced first aid course or not, and where one group had both. The primary outcomes were correct behavior to recognize and manage an occluded airway and correct behavior to stop life-threatening bleeding from a lower extremity injury. Secondary outcomes included head-to-toe assessment performed, placement of a pelvic sling, and application of remote vital signs monitors.

Results Ninety participants were included in 10 groups of 3 for each of 4 exposures. One group was tested first as a baseline group, and then later after having done the training course. Live video support was effective in controlling bleeding. A first aid course given beforehand did not seem to be as effective on controlling bleeding. Video support and the first aid course previously given improved the ability of bystanders to manage the airway, the combination of the two being no better than each of the interventions taken in isolation. Course exposure and video support together were not superior to the course by itself or video by itself, except regarding placing the biosensors on the injured after video support. Secondary results showed an association between video support and completing a head-to-toe assessment. Both interventions were associated with applying a pelvic sling.

*Correspondence:
Hans Hedberg
hans.hedberg@umu.se

Full list of author information is available at the end of the article

Conclusion These findings show that laypersons, here construction industry employees, can be supported to achieve good performance as first responders in a major injury scenario. Prior training, but especially live video support without prior training, improves layperson performance in this setting.

Keywords Construction Safety, Workplace incident, Prehospital trauma, First aid training, Layperson, Bystander, Telemedicine, Video

Background

Serious high-energy injury events are a risk to construction sites workers, and a higher risk in that compared to other industries [1–2]. This is partly due to the varying work environment and sometimes rapidly changing construction activities. The work environment on construction sites can be stressful for workers [3]. In Sweden, approximately 1000 serious injury events are reported per year, and each year some resulting in fatalities [4].

In the event of severe injury events on construction sites where there is one injured person, there are several immediate aspects needed for good response, including trying to stop catastrophic bleeding if possible and establishing a patent airway if needed. Even before this at an injury event, evaluation and awareness of the situation and mechanism of injury is done, meaning that there is a determination that the site is safe enough to stay deliver peer rescue and prevent injuries to responders [5]. Definitive medical measures then need to be implemented as quickly as possible [6–7]. The first life-saving measures are the same in all healthcare systems and settings [5, 8, 9].

In Sweden, the response time for ambulances has increased by more than two minutes per year over the past 10 years. In 2021, the response time for ambulances was 18 min on average for all alarms [10], though this largely reflects responses in major population centers. A delayed response time will affect the trauma care response and outcomes after severe trauma injury if there is no other care [11]. Laypersons can provide life-saving procedures before the ambulance arrives. Bakke et al., 2015 observed 330 prehospital trauma alarms and responses, and noted that in that cohort 35% of the first-aid providers had participated in a first aid training course. In that report, bystanders with documented first aid training course gave better first aid than those with unknown competence in first aid [12]. Given a long ambulance response time to remote location or where ambulance resources are scarce, live video communication with ambulance personnel may hold promise for supporting layperson at the injury event. Further, if continuous vital sign assessment through biosensors which laypersons could be applied, and then signals received by ambulance personnel, these could inform video support for guidance of laypersons on site [13].

Initial assessments and responses from laypersons have been shown to be of benefit especially in cardiac arrest situation and cardiopulmonary resuscitation, but also in prehospital trauma care [14–16]. Remote consultation for fire brigade or police responders with paramedics or emergency doctors has been described [17–20]. It is not known if remote video support for laypersons in advanced first aid and trauma resuscitation, for example in the event of a remote workplace injury event can be beneficial. Also, for laypersons in remote settings where advanced first aid might be needed, it is not well understood how well an advanced first aid course and access to usual health care system resuscitation equipment might help to facilitate better layperson first responses to a severe injury event.

The general study question was if, for laypersons, a first aid training course or a direct video support system could have benefit on first aid trauma responses during the first 10 min, with focus on catastrophic bleeding and airway management. In a setting where an advanced medical kit is available for first responders, the primary hypothesis was that access to direct video support from remote ambulance personnel would be associated with a higher level of performance in the two immediate layperson critical behaviors, which are correct recognition and behavioral responses to catastrophic bleeding and occluded airway, compared to first responders who did not have remote video support from ambulance personnel. A second hypothesis that the combination of a layperson training course, together with video support from ambulance personnel, would be associated with superior performance with the two critical behaviors compared to either the training course by itself or video support by itself. A third hypothesis was that video support by itself during the layperson first response would be superior to previous training course experience by itself concerning the early critical behaviors. Our objective was to test these hypotheses with actual construction workers or apprentices on site with a simulated major injury scenario using a full-scale human patient simulator, and where groups would have either no beforehand advanced first aid course, or a course by itself, and for direct video support by itself or a combination of the two.

Methods

Study design

This was a controlled simulation study. With cooperation from building companies or training program and sites in northern Sweden, persons consenting to participate in the study were scheduled for test days in groups of 3 persons at a time at their building site. This was presented as a training course and a part of this study. All the groups had the same first day activity with a scenario-based practical assessment without training and then the planned course. After that, half of the groups were recalled for a second assessment after 4–6 weeks, where they were allocated to the treatment groups based on when they scheduled their second assessment. Those that scheduled for the first 10 assessment days were allocated to treatment group 3 and those that were scheduled for the last 10 assessment days were included in treatment group 4. The treatment or exposures were not known to the companies or participants ahead of time. Prospective randomization by lot was not chosen due to challenges for the building companies in scheduling the days, and this minimization method was used to achieve balance for groups and exposures, even if this was not formal block randomization.

Each 'treatment' group (of 3 individuals) was planned to comprise one of 10 teams for each 'treatment' arm. The treatments or exposures were as follows: Group 1 no course training and no video support during the simulation-based assessment. This same group then later (after the assessment) went further and participated in the training course and had a second assessment 4 to 6 weeks after their course, and this assessment group was called Group 4. Group 2 and Group 3 had video support during the assessment, Group 2 without pre-treatment training course and Group 3 with the completed training course prior to their assessment. All groups had access to standardized medical equipment during the simulation-based assessment, but which was a kit with which no participants had familiarity before the study. All groups participated in a full-scale, high-fidelity simulation-based major injury scenario for assessment where their performance was scored (described below). For the two groups who were allocated to receive the practical training course, the course was completed 4–6 weeks before the simulation-based assessment.

With advertising for participants, and with cooperation of large building companies as well as local builder apprenticeship training programs in Sweden, individuals working on building sites as employees or apprentices were screened and recruited with cooperation of their employers. Not having Swedish language was an exclusion criterion.

For the planning and design of the scenario and simulation, with assessment and data collection, an expert group was formed consisting of anesthesiologist, emergency nurse, ambulance nurse, trauma surgeon and safety experts from the construction industry. The expert group designed a scenario that was realistic for the construction industry workplace environment. The expert group designed a 10-minute scenario with one injured person, 35 years old, previously healthy with multiple injuries caused by falls from 5 m. The scenario contained 2 critical diagnoses, catastrophic bleeding and occluded airway, where early (first minutes) recognition and treatment of these can be presumed to be potentially life-saving. The premise was that it was going to take a long time for ambulance personnel to arrive on site. The focus was on what the participants would do during the first 10 min. The simulation was conducted with the help of a facilitator who had also been the first response course instructor, and a high-fidelity wireless computer operated human patient simulator (HPS) which was preprogramed with pathophysiology parameters specific for this scenario (see Table 1). Two behaviors were included in the scenario as secondary elements: a safety check for the injury event place, and systematic head to toe survey and re-evaluation, commonly referred to as SCABCDE, was used to be able to detect other injuries.

The expert group prepared a simulation facilitator`s manual with the aim of standardizing the simulation. The manual described the expected life-saving measures, which were required in order for the injury figure's condition to improve in the simulation. The manual also described types of help the facilitator could supply to the study participants, for example in the case where expected life-saving measures were not addressed, so-called "Lifesaver" [21] hints could be provided to allow the simulation to progress, even if the participants were unable to demonstrate one or the other critical behavior in the first phase of the scenario.

The video support content and possible interventions were based on a pilot project [13]. The 6-hour advanced first aid course, along with the medical equipment in the scenario, were developed in this same pilot project. The medical equipment kit was available to all the participants during the simulation-based assessment. This included checklists for field vital sign assessment and as well as instructions for video communication with remote ambulance personnel.

The 6-hour practical advanced first aid course included an emphasis on assessment of the injured party and advanced critical life-saving procedures (direct pressure or tourniquet, jaw thrust, oro - pharyngeal airway, laryngeal mask airway, bag-mask- ventilation, CPR and defibrillation and pelvic sling) with accompanying systematic checklist (SCABCDE). The training course also included introduction of the telemedicine supporting system. The course began and ended with a 10-minute trauma response exercise, event-based training, and participant reflection in groups. The procedures were first introduced through instruction film and instructor demonstration, then the students practiced on a patient simulator, with feedback from the instructor.

Table 1 Scenario- critical diagnoses and assessment preprogrammed and set up in human patient simulator

Name	Critical diagnosis, assessment	Human patient simulator	Primary critically outcome
S -Safety	Safe injury- event site expected to be visually assessed 360 degrees		
C -Catastrophic bleeding	Catastrophic bleeding right femoral artery	0.5 L of 'blood' was out on the ground at the source of bleeding, as well as pulsating bleeding	Direct manual pressure over bleeding source < 60 s or Tourniquet < 90 s
A-B -Airway -Breathing	Blocked airway Apnea without airway management	Simulated chewing gum applied in the upper airway. Recorded sound with signs of blocked airway, released when airway was secured. Cyanosis when blocked airway, blue light in the face, removed when secured airway. Air stream on exhalation at secured airway The chest moves up and down at the open airway, Respiration rate 20/minutes	Inspect the oral cavity, Jaw Thrust < 90 s or Oropharyngeal airway < 90 s
C -Circulation	Hypotension and tachycardia	Heart rate 130/minutes. Blood pressure 70/40 mmHg Pale skin color and simulated sweat. Palpable pulse A, carotid	
D -Disability	Unconscious does not react to pain. Equal pupils on the right and left sides	Does not respond to contact. Does not react to painful stimuli. Pupils same size, responsive and react to light	
E Exposure	Wound injury in the back of head. Inwardly rotated legs. Blood on the legs.	Made-up wound injury back of the head. Legs inwardly rotated	Secondary outcome Examine the entire body head to toe, Pelvic sling in 10 min, mean time until completed

The medical kit included biosensors, with the capacity to measure and transmit the following medical parameters: breathing rate, oxyhemoglobin percent or saturation (SpO_2), heart rate, blood pressure, electrocardiogram selected leads, and temperature. The participants had the option to demonstrate the situation using video in the telephone or connecting biosensors. Though not part of this study primary analysis, there was a pre-programmed and for-purpose designed smartphone function available, to connect to a server where medical instrument measurements in the simulation could be transmitted to the simulated ambulance personnel.

Based on direct observation and supported by the video recording of the participant performance during the standardized simulation, participant behaviors were scored using a pre-defined set of outcomes and time intervals. The scenario aimed to present clear signs of immediate life-threatening injuries in order to test for recognition and intervention behaviors, correct or incorrect. The whole scenario included the first 10 min of primary systematic prehospital trauma care, though the critical behavior period was defined as the first 90 s for 2 categories of primary responses. A detailed scoring protocol was developed which followed the expected measures in the standardized scenario. There were always 2 assessors for the primary and secondary outcomes, though exact times when these outcomes were achieved was confirmed by one assessor using the video recording. The outcomes were simple categories of responses, and agreement was required between assessors on whether or not the outcome was achieved. The assessors were not blinded since they could observe the interventions at the same time as the outcomes were assessed.

Before each group started the simulation-based assessment, the participants were given a standardized short orientation and introduction, including details about the training environment and how the simulator worked. After introduction, each participant completed a pre-assessment registration where they recorded their sex, age, years in the profession, and any resuscitation training they had prior to this study. The simulation was conducted in a standardized room where the human patient simulator was lying on their back on the floor. Next to the simulator was a medical kit with the above-described equipment, telephone, biosensors, and checklists/action cards. All groups had the same opportunity to use the equipment freely. An instructor conducted the assessment simulation scenario. An emergency nurse acted as (1) simulated emergency call center operator and (2) simulated ambulance nurse for remotely video support. Before the test started, all groups had been informed to simulate a call to the Swedish central emergency alarm phone number/112 on arrival at the scene of injury event. The two groups allocated to receive video support were directly 'called' (telephone) by a simulated ambulance nurse, immediately after the call to 112, and the video distance support was started using the checklist SCABCDE. The scenario/assessment period was stopped at 10 min. At this point, the group was asked to report back to the ambulance nurse on what they understood in the scenario, and what they had done as far as resuscitation. There were 2 primary outcomes, both within the first 90 s. These were early correct bleeding control by manual pressure within 60 s or applied tourniquet within 90 s, yes or no, and then correct identification of occluded airway with behavior to manage airway obstruction, also within 90 s. Secondary outcomes were assessed within the 10-minute time frame, and these included the following: correct top-to-toe examination finding wound injury in back of the head, also a categorical variable yes or no, time to completion of top-to-toe examination mean in seconds, correct fixation of pelvic injury a pelvic sling, categorical variables, yes or no, and time in seconds to fixating a pelvic fracture with a pelvic sling.

Power calculation for a sample size

After intervention, either training course, ambulance tele-support, or both, the correct response for the critical behaviors was expected to be approximately 90% based on earlier course experience. The expected baseline rate for responses or behaviors from completely unschooled or untutored participants was expected to be not more than 25%. This meant an estimated or anticipated difference in frequencies correct versus incorrect responses or proportions of 0.65, with power to detect a true difference of 80% and a 2-sided 'alpha' of 5% (0.05). This calculation indicates that a minimum of 8 sets of participants or groups should be in each paired analysis. A sample size of 10 for each set of groups was chosen, to allow for dropout.

Table 2 Participant background data

Measures	Group 1/4 (n = 10) Individuals (n = 29)	Group 2 (n = 10) Individuals (n = 28)	Group 3 (n = 10) Individuals (n = 30)
Female/Male	2/27	7/21	7/23
Age (mean ± sd)	28 ± 14	40 ± 13	28 ± 14
*Previous Training			
First aid trauma course	2	2	1
CPR training course	4	5	1
CPR + defibrillation course	1	1	1

*Previous training was defined as completed training course, First aid trauma course (ABC, ABCDE, SABCDE) within 2 years, Cardiopulmonary training course with or without defibrillator (CPR, CPR + Defibrillation within 2 years). The youngest person in the study were 18-year-old and the oldest 60 year

Data management

A total of 40 simulation assessments were observed and recorded with two cameras and from two angles. Exposures were pseudoanonymized for the assessments, and for the analysis of the videos. The videos and observation protocol were encoded and stored on a server with a coded password to which only primary investigator had access.

Statistical analysis

Analysis was conducted using IBM SPSS statistics, version 28. Descriptive statistics are presented both at individual level and at group level. Group comparisons for the primary outcome frequencies correct and incorrect were done using the Fisher's exact test, based on the small sample size. For continuous variables where an approximately normal distribution could be assumed, an independent samples standard t-test was used. Maximum time in the assessment scenario was 10 min or 600 s, and groups that did not complete the expected procedure were assigned 600 s for that outcome. Significant differences between groups were identified when the p value was less than 0.05.

Ethical consideration

The study was approved by the Swedish Ethical Review Authority (document number 2021-05774-01). All participants provided informed consent before entering the study.

Results

Study participation-description

Data was collected in Northern Sweden between February and June 2022. A total of 90 individual participants completed the study, all in groups of 3. One participant in Group 1, and two participants in Group 2, did not answer the background questions of the survey. Demographics are shown in Table 2.

Primary outcomes

For the first primary outcome, first without any preparation or training, there were almost no correct behaviors observed for the baseline assessment, for both bleeding control and airway management. Then, concerning interventions, video support by itself with no course preparation (Group 2) was associated with better critical bleeding control compared to those who had neither course or video support (Group 1) (9/10 vs. 1/10, $p=0.001$) (Table 3). For bleeding control, the pretreatment course and video support combined Group 3 was not statistically different in performance compared to those that had the course by itself (Group 4) or video support by itself (Group 2) (8/10 vs. 5/10, $p=0.35$, and

Table 3 Primary critical outcomes (bleeding or airway control < 90″)

	Group 1	Group 4	Group 2	Group 3	*P value*
	Baseline	**Training course only**	**Video support only**	**Video support + training course**	
Bleeding control < 90″	1/10	5/10			*0.14*
	1/10		9/10		*0.001*
		5/10	9/10		*0.14*
		5/10		8/10	*0.35*
			9/10	8/10	*1*
Airway control < 90″	0/10	9/10			*< 0.001*
	0/10		4/10		*0.02*
		9/10	4/10		*0.06*
		9/10		8/10	*1*
			4/10	8/10	*0.17*

Table 4 Secondary outcomes

	Group 1	Group 4	Group 2	Group 3	*P value*
	Baseline	**Training course only**	**Video support only**	**Video support + training course**	
Head-to-toe examination (number correct) and Time (mean, sd, seconds)	0/10	2/10			*0.47*
		541 ± 126			
	0/10		8/10		*0.001*
			410 ± 109		
		2/10	8/10		*0.02*
		541 ± 126	410 ± 109		*0.02*
		2/10		9/10	*0.01*
		541 ± 126		288 ± 115	*< 0.001*
			8/10	9/10	*1*
			410 ± 109	288 ± 115	*0.03*
Pelvic sling (correct)	0/10	6/10			*0.01*
		450 ± 144 s			
	0/10		5/10		*0.03*
			579 ± 25		
		6/10	5/10		*1*
		450 ± 144	579 ± 25		*0.01*
		6/10		10/10	*0.09*
		450 ± 144		358 ± 54	*< 0.001*
			5/10	10/10	*0.03*
			579 ± 25	358 ± 54	*< 0.001*

8/10 vs. 9/10, p = 1, respectively), and all groups had a high proportion of correct behaviors.

Group 1 received no telemedicine support and with no course training. This same group then later (after the assessment) participated in the training course and had a second assessment 4 to 6 weeks after their course, and this assessment group was called Group 4.

Concerning airway management responses, only 40% of participants in Group 2 (video support only) correctly managed the airway critical step, despite video support. The course by itself (Group 4) was superior to no course (Group 1) where neither had video support for airway management (9/10 vs. 0/10, p < 0.001), but not statistically different from video support by itself (9/10 vs. 4/10 respectively, p = 0.06).

Secondary outcomes

Use of the vital sign biosensors in the scenario by the study participants was zero in groups 1, 2 and 4. Group 3 connected biosensors to the 'injured' in 10/10 groups, but only very late in the 10-minute scenario, and there was no attention for any group concerning biosensor readings. Concerning the head-to-toe examination, in the baseline assessment there was no group that performed this (Table 4). Further, video support with or without a pretreatment course (groups 3 and 2) was associated with better performance compared to the those with no video support (Group 4) (9/10 vs. 2/10, p = 0.01; 8/10 vs. 2/10, p = 0.02, respectively). Time to the outcome event was in line with the frequency comparisons between groups. Concerning the behavior establishing a pelvic sling to limit suspected internal bleeding, the video support plus course group had perfect performance (10/10 groups) while both the course by itself and the video support by itself groups had half or more showing this behavior.

Discussion

The main findings were that participants, untrained or unprepared laypersons active in the construction industry, showed a low ability to manage catastrophic bleeding and occluded airway in a 10-minute simulated accident scenario. Participants had a low degree of current practical training in first aid trauma care and lifesaving before entering the study, so the study's possibility to assess effects of training and telemedicine support were good. Preparation or support through either the 6-hour practical training course in life-saving procedures, or medical telemedicine support from distance through realtime video support, or a combination of both, was associated with increased effect in carrying out life-saving procedures while waiting for an ambulance to arrive at the scene of a simulated injury workplace event. These findings are in line with those from Bakke et al. 2013 who found that only 35% of the laymen had a practical training in first aid competences, and that laymen who had documented practical training manage first aid for injuries more effectively than those who did not have documented education [12].

In this simulation-based assessment for a serious workplace injury event, we could see significant improvements in managing a catastrophic bleeding and occluded airway, after practical training or with video support from ambulance personnel. Responses to manage catastrophic bleeding with direct pressure or with a torniquet within 90 s were best. Results for managing an occluded airway with video support were better compared to no course or support at all, but not clearly better than for those with the training course.

The effect of a training course/education is expected to decrease over time without recurrent training or repetition [22–23]. For companies in the construction industry, it can be a challenge to dedicate time for regular refresher practical training in advanced first aid procedures. External real-time telemedicine resources to support local layperson responses to serious injury events could be a practical way to improve early response effectiveness even for those who have not had recent first aid courses. The findings here show that support through video calls provides meaningful benefit to layperson performance, independent of preparatory practical training or not. Practical training combined with video support may provide additional benefit, though this study design was not optimal to assess this.

Several studies have validated the concept of medical support from distance, through a communication-distance solution, telephone, or video system, for instance in connection with CPR, trauma management, or assessment of various medical conditions such as stroke [14–17, 24, 25]. Nord-Ljungquist et al., 2020 studied dispatcher support to layperson by phone, for CPR before an ambulance arrived [25]. Those findings showed difficulty in getting layperson to correctly manage an airway blockage, which our results confirm. Landgraf et al., 2019 reported on a telemedical support system with offshore emergency scenarios and quality of medical first response by medical non-professional comparing to medical professionals, and found that the supported group required more time to act compared to non-supported [24].

In our scenarios/simulation sessions where participants were supported by video, the success rate for managing an occluded airway with the jaw-thrust procedure was not as high as expected. This possibly could be due to the complexity or unfamiliarity with evaluating and managing an occluded airway. We also observed that where the groups had practical course experience, sometimes they focused on the experience they seemed to remember related to the training course, which may have hindered video communication to guide intervention. An interaction between these different exposures could have led to dilution of possible benefit from the combined interventions. These observations are also in line with results from Linderoth et al., 2021 [14], where they concluded that in order to support the layperson by video, dispatchers at the emergency call center-112 must understand the situation in order to best facilitate the layperson in their actions. It appears that video support can change the emergency response, though it is challenging to use this approach to advantage within the context of existing dispatch protocols [26].

The interaction between dispatcher and layperson is important, but, in addition, interactions between the laypersons on-scene are also important. Teamwork within the groups was observed when there was a video dialogue with ambulance personnel. One layperson needed to focus on the smartphone and film the injured person, while at the same time listen and try to understand the advice from the ambulance personnel, and then communicate this to the laypersons in the team. Specific team non-technical performance, including communication, situational awareness, and distributing workload in the team, was not assessed in this study. Non-technical performance for both layperson and ambulance personnel could be relevant for future testing of a video support system for this type of response.

None of the groups spontaneously connected biosensors (heart rate, pulse oximetry, blood pressure measuring devices) which could transmit signals to the video supporter. Use of these was taught in the course. Even with video support, implementation of vital sign measurement did not come up until bleeding, airway, and even head-to-toe assessment and pelvic sling steps were completed. This meant that measuring and monitoring vital signs (and transmitting) in practice for this scenario came later, if it was done. These biosensor signals were still appropriate for more informed video support, and not only for the ensuing phase. As assessed here, vital signs measurement, or impact on measuring vital signs on the course of video support, could not be assessed. Vital sign assessment should be a priority early in this type of scenario. This could be something that can be emphasized in both training courses and video support tactics.

The study context was based on Swedish construction industry conditions. There are other initiatives that have focused on the effects of collaboration between layperson and professional rescue personnel while waiting for an ambulance or fire brigade. One initiative is the Civil Response Person and In Wait for Ambulance [27–28]. The concept is that individuals with established technical means to receive an 'alarm' can be sent to a nearby accident site as prepared layperson responders before ambulance or fire brigade personnel arrive. Both this alert concept as well as direct two-way interaction have been tested in the community to facilitate layperson responses for early management of critical situations such as cardiac arrest or traffic accidents. Some reported experience is that there is sometimes insecurity among laypersons in these actions when acting by themselves, though not after first contact with ambulance personnel [27, 29]. Further research in this area could focus on evaluation of a supporting model including dispatchers, ambulance personnel, and interaction with laypersons, to optimize video support for lifesaving procedures.

Limitation

In this study, participants were inexperienced and untrained in this specific context, including in working or assessment using a full-scale high-fidelity simulator. Working in groups, there appeared to be good immersion into the clinical scenarios, with no difficulty with 'suspension of disbelief' concerning the simulation. The video connection to ambulance personnel used here was a nono-commercial prototype, though commercial products for this purpose are expected to be widely available soon. The study groups were small, meaning that there can be imprecision in estimating effect sizes of the interventions. The preparatory course and the ambulance personnel protocolized communication can be updated and improved prior to future studies of efficacy and implementation. Since the only group that connected the biosensors to the 'injured' was the one that had both the training course and video support with ambulance personnel, there were limitations in assessing how the biosensor-based information might influence behavior. This finding though could inform future study design where biosensor information is central to the study question. The choice to assess learning and behavior related to the interventions using simulated injury events, rather than actual events, is a first step in studying these interventions, given that real-world serious trauma events at building sites are not common and not planned. Still, if and when these types of interventions might be implemented by builder organizations, the practical results will need to be assessed as part of implementation studies.

Conclusion

These findings show that for laypersons (here construction industry employees) and first responsers in a serious injury scenario during the wait for ambulance arrival, airway management and active bleeding control, are improved by live video support, including if these actions have been trained beforehand.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12873-023-00917-4.

Supplementary Material 1

Acknowledgements

The authors thank all involved participants, companies and school coordinating invitation and scheduling the participants. The project would not have been possible without your support. The authors will also thank Par Suneson, Department of Nursing, Umea University with the technical support during the data collection.

Author contributions

Study conception and design was performed by: HH, PH, JA, SK, MH. Data collection was performed by: HH, PH. Analysis and interpretation of data was performed by: HH, PH, MH. Writing was performed by: HH, MH. Reviewing by: HH, PH, JA, SK, MH: Editing was performed by: HH, MH.

Funding

Funding sources include The Development Fund of the Swedish Construction Industry (SBUF) funded the study (ref,13987), the Medical Faculty of Umeå University, Sweden, and the Department of Anesthesiology and Intensive Care Medicine at the University Hospital of Umeå. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Open access funding provided by Umea University.

Data Availability

The simulation and assessment protocol is available as a supplemental file. The dataset is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study has been approved by the Swedish Ethical Review Authority (document number 2021-05774-01). All participants provided informed consent before entering the study. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not Applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Anesthesiology and Intensive Care Medicine, Surgical and Perioperative Sciences, Umeå University, Umeå, Sweden
[2]Nursing and Surgical and Perioperative Sciences, Center for Disaster Medicine, Umeå University, Umeå, Sweden
[3]Nursing, Umeå University, Umeå, Sweden
[4]Surgical and Perioperative Sciences, Surgery, Umeå University, Umeå, Sweden

Received: 21 June 2023 / Accepted: 11 December 2023
Published online: 07 January 2024

References

1. Johansson J, Berglund L, Johansson M, Nygren M, Rask K, Samuelson B, et al. Occupational safety in the construction industry. Work. 2019;64(1):21–32.
2. Perlman A, Sacks R, Barak R. Hazard recognition and risk perception in construction. Saf Sci. 2014;64:22–31.
3. Hansen-Weber P, Schlynssen V, Fonager K, Hjort-Bønløkke J, Hansen CD, Bøggild H. Association of perceived work pace and physical work demands with occupational Accidents: a cross-sectional study of ageing male construction workers in Denmark. BMC Public Health. 2022;22(1):18.
4. Stenberg M, Beyond Zero -A, Health-Promoting. Construction Industry. SBUF, Knowledge compilation. 12441. (2017). https://www.sbuf.se/projektresultat/projekt?id=638703f6-fecc-4ef9-ba75-ec5bbbfa4718.
5. PHTLS. : Prehospital trauma life support 9th Edition. USA: Jones and Bartlett. Publisher, inc. ISBN. 978-1-284-19872-0. 2021.
6. Tatebe L, Speedy AS, Kang D, Barnum T, Cosey-Gay F, Regan S, et al. Empowering bystanders to intervene: Trauma Responders unify to empower (TRUE) communities. J Surg Res. 2019;238:255–64.
7. Pham H, Pucket. Y, Dissanaike S. Faster on-scene times associated with decreased mortality in Helicopter Emergency Medical Services (HEMS) transported trauma patients. Trauma Surg Acute Care Open. 2017;2:1–5.
8. Advanced Trauma Life Support®. Student course manual 9th Edition. Libr Congress Control Number: 2017907997 ISBN 78-0-9968262-3-5. 2017.
9. TNCC Provider Manual 8th Edition. Jones and Bartlett. Authors, ENA, ISBN-13: 9781284180701. 2020.
10. Swedish Heart Lung Foundation., 2022. Response time for Ambulance in Sweden. https://mb.cision.com/Public/545/3645729/823331222070a811.pdf.
11. Mell HK, Mumma SN, Hiestand B, Carr BG, Holland T, Stopyra J. Emergency medical services response times in rural, suburban, and urban areas. JAMA Surg. 2017;152(10):983–4.

12. Bakke HK, Steinvik T, Eidissen SI, Gilbert M, Wisborg T. Bystander first aid in trauma – prevalence and quality: a prospective observational study. Acta Anaesthesiol Scand. 2015;59(9):1187–93.
13. SBUF., 2020 A Case report. Life Saving on Distance. https://vpp.sbuf.se/Public/Documents/ProjectDocuments/90f67d07-fa5f-4c56-9bbe-0f61653165fa/FinalReport/SBUF%2013813%20Slutrapport-Livr%C3%A4ddning%20p%C3%A5%20Distans%20SBUF%2013813%20(1).pdf.
14. Linderoth G, Rosenkrantz O, Lippert F, Østergaard D, Ersbøll A, Meyhoff CS, et al. Live video from bystanders' smartphones to improve cardiopulmonary resuscitation. Resuscitation. 2021;168:35–43.
15. Lee SY, Song KJ, Shin SD, Hong KJ, Kim TH. Comparison of the effects of audio-instructed and video-instructed dispatcher-assisted cardiopulmonary resuscitation on resuscitation outcomes after out of-hospital Cardiac Arrest. Resuscitation. 2020;147:12–20.
16. Ter Avest E, Lambert E, de Coverly R, Tucker H, Griggs J, Wilson MH, et al. Live video footage from scene to aid helicopter emergency medical service dispatch: a feasibility study. Scand J Trauma Resusc Emerg Med. 2019;27:1–6.
17. Johansson A, Esbjörnsson M, Nordquist P, Wiinberg S, Andersson R, Ivarsson B, et al. Technical feasibility and ambulance nurses' view of a digital telemedicine system in pre-hospital Stroke care – A pilot study. Int Emerg Nurs. 2019;44:35–40.
18. Kim Y, Groombridge C, Romero L, Clare S, Fitzgerald MC. Decision support capabilities of Telemedicine in Emergency Prehospital Care: systematic review. J Med Internet Res. 2020;22:12.
19. Vincente V, Johansson A, Selling M, Johansson J, Möller S, Todorova L. Experience of using video support by prehospital emergency care physician in ambulance care - an interview study with prehospital emergency nurses in Sweden. BMC Emerg Med. 2021;21(1):44.
20. Bergrath S, Brookman JC, Beckers S, Felzen M, Czaplik M. Implementation of a full-scale prehospital telemedicine system: evaluation of the process and systemic effects in a pre–post intervention study. BMJ Open. 2021;11.3.
21. Dieckmann P, Lippert A, Glavin R, Rall M. When things do not go as expected: scenario life savers. Simul Healthc. 2010;5(4):219–25.
22. Andersson GS, Gaetz M, Masse J. First aid skill retention of first responders within the workplace. Scand J Trauma Resusc Emerg Med. 2011;19:1–6.
23. Goralnick E, Chaudhary MA, McCarty JC, Caterson EJ, Goldberg SA, Herrera-Escobar JP, et al. Effectiveness of instructional interventions for Hemorrhage control readiness for laypersons in the Public Access and Tourniquet Training Study (PATTS). JAMA Surg. 2018;153:791–9.
24. Landgraf P, Spies C, Lawatscheck R, Luz M, Wernecke KD, Schröder D. Does telemedical support of First Responders improve Guideline Adherence in an Offshore Emergency scenario? A Simulator-based prospective study. BMJ Open. 2019;9(8):e027563.
25. Nord-Ljungquist H, Brännström M, Bohm K. Communication and protocol compliance and their relation to the quality of cardiopulmonary resuscitation (CPR): a mixed-methods study of simulated telephone-assisted CPR. Int Emerg Nurs. 2015;23(3):254–9.
26. Linderoth G, Lippert F, Østergaard D, Ersbøll A, Meyhoff CS, Folke F, et al. Live video from bystanders' smartphones to medical dispatchers in real emergencies. BMC-Emerg Med. 2021;21:1–10.
27. Nord-Ljungquist. Who has and takes responsibility! – Waiting for an ambulance (IVPA) assignment in a rural environment. Doctoral thesis, Department of Health and Caring Sciences, Linné-University, Växjö, Sweden. ISBN: 978-91-89283-10-7. 2020.
28. Pileman S, Grahn O, Källgården P. Preventing and managing incidents in socio-economically disadvantaged areas: further development and evaluation of the concept of Civilian Response Person in Suburbs. CARER report nr 30. Linköping University. Sweden. ISBN: 978-91-7929-705-3. 2020.
29. Møller TP, Hansen CM, Fjordholt M, Dahl-Pedersen B, Østergaard D, Lippert FK. Debriefing bystanders of out-of-hospital Cardiac Arrest is valuable. Resuscitation. 2014;85(11):1504–11.

Publisher's Note