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Information Capturing in Pre-Hospital Emergency Medical Settings (EMS)

Kerstin DENECKE[a,1], Lea MEIER[a], Jan G. BAUER[a],
Matthias BENDER[a], Christopher LUEG[a]
[a] *Bern University of Applied Sciences, Bern Switzerland*

Abstract. Emergency medical situations are characterized by high physical, cognitive and mental demands on the paramedics on the ground. Studies suggest that crucial information such as treatments administered to patients is often documented retrospectively, during patient transport or once a patient is handed over to an emergency department. Information access may also be surprisingly difficult (e.g. patient medical history). In this paper, we focus on supporting in situ information capturing and report on a realistic laboratory-based study involving experienced paramedics that we used to explore the specific requirements and constraints of supporting in situ information capturing. Specifically, we focused on ways to use audio and visual data capture methods and how they need to be designed to better support paramedics without interfering with their work. We then use the resulting information centric perspective to argue for a roadmap towards smart emergency medical services.

Keywords. Emergency medical service, information systems, emergency communication, emergency documentation, EMS, paramedics

1. Introduction

Emergency medical service (EMS) providers play a crucial role in identifying, treating and transporting patients suffering from time-critical emergency medical conditions. In particular when following the Franco-German model of EMS delivery, patients are treated on site which requires complex clinical judgements [1]. In this context, EMS providers perform urgent actions such as the initial assessment of patients in need and treatment as required (vital signs, intravenous fluids, cardiac monitoring, and stabilization). The decision making leading to interventions requires comprehensive medical knowledge of the physiology and pathology of the human body as well as any pharmacological knowledge of drugs to be administered. Appropriate documentation is required, including documenting the patient's initial condition, the care provided by first responders and EMS providers, the status of the patient during the ambulance transport and responses to any treatment [1,2]. A number of studies [3-5] identified a range of problems that are likely to occur over the course of this complex and time-sensitive process and that may impact on the quality and completeness of the information collected. Common mistakes include insufficiently communicated details of the medical intervention on-site [3-5] or an undocumented initial condition of the patient [6].

[1] Corresponding Author: Kerstin Denecke, Bern University of Applied Sciences, Institute for Medical Informatics, Quellgasse 21, Biel, Switzerland; E-mail: kerstin.denecke@bfh.ch.

Elements such as prehospital hypotension, Glasgow Coma Scale score, and other prehospital vital signs [4] or key elements of the history (witnesses, predisposing factors, and post-event symptoms) and physical examination [5] are not recorded consistently. Some of these problems can be attributed to the fact that EMS personnel may have to remember key information in the above-mentioned stressful setting and only gets to document information once a mission is completed or even towards the end of their shifts [7]. To address these issues, digital protocols become increasingly available in EMS, for example the Medical-Pad provided by Tech2Go (https://www.tech2go.de). Some of these systems allow for automatic data capturing from medical devices such as ECG. Speech recognition technology [8] and the use of body worn cameras [9] have been explored, but research in this field is still in its infancy.

In this paper, we report on a realistic laboratory-based study involving experienced paramedics that we used to explore the specific requirements and constraints of supporting in situ information capturing. We present our study design and discuss our findings. We also use the resulting information centric perspective to argue for the need for a roadmap towards smart emergency medical services, and conclusions regarding possible concerns to be addressed.

2. Exploring Options for Real-Time Data Capturing during EMS Delivery

The Medical Informatics *Living Lab* at the Bern University of Applied Sciences in Biel, Switzerland brings together expertise in a range of relevant IT (information systems, process design, human centred design), clinical experiences as well as substantial, hands-on EMS experience. We collaborated with local EMS providers to set up a laboratory based study that helps us to probe the suitability of different in situ data capture methods (audio, visual) and how they could be designed in such a way that they fit paramedics' ways of working without interfering too much with their work practices.

2.1. Experimental Setup

The study was designed around medical emergencies using SimMan, an advanced patient model that can be programmed to simulate medical cases of varying complexity. Two conditions requiring interventions were designed, anaphylactic shock (scenario 1) and a low-back injury (scenario 2). Visible injuries and pain zones were marked on the SimMan by images or text. A skilled research assistant was present on site and adapted the vital signs of SimMan during the study as to simulate the patient's responses to treatments administered. A mission was considered to be completed once the "patient" was stabilized and considered ready for transport by the paramedic team. Each of the teams of paramedics had to handle both cases in the same order with a 10 minutes break in between. We implemented the Wizard-of-Oz method [10], a method used for evaluating technology, interaction methods, and technology acceptance without the need to put the actual technology in place. In this particular study, the Wizard-of-Oz method enabled paramedics to document a situation or a particular aspect thereof (e.g. the visual impression of a wound) by using voice commands to "activate" in situ data capturing. The corresponding audio or visual recording was then administered by the research assistant standing in for the actual technology. Once the teams completed each of the two EMS deliveries, paramedics and researchers met to review and discuss the video recordings of the earlier EMS missions. In these reviews, participants were encouraged to discuss their use of the "live" documentation feature and also whether they would have preferred different types of recordings (different angle, duration, close-up, wide-angle) or even different media (e.g. a voice recording instead of video recording or video recording where a photograph was taken).

2.2. Data Collection

We recruited as participants four experienced, active, male paramedics between 32 and 41 years old (average 36.5 years) from EMS providers based in the Swiss Canton of Bern. Their work experience ranged between 4 and 12 years (average 8.25 years). Following the Franco-German model of EMS delivery they were to form teams of two. Participants were made aware that the experimental setup was realistic in the sense that be provided standard EMS equipment and that fully engaging in the EMS delivery would likely lead to physical exertion and physical stressors. Participants wear body worn GoPro cameras attached at chest level that documented the EMS delivery roughly from their point of view. As explained earlier, participants could also, at any point in time, "activate" documenting by picture/video/audio recording. This feature did not use the body worn cameras but would allow "free form" data capturing as per participants' specifications. Data collected included number of audio/video/photo recordings requested during the course of the live experiment, the number of audio/video/photo recordings requested while watching the footage, reasons for requesting media as recalled by participants, additional data needed (e.g. data transfer from medical devices such as ECG). Data regarding live recordings was then compared to data recording requests as they emerged during the review.

3. Data analysis and interpretation

In terms of duration it took the two teams between 6.85 and 8.50 minutes to have "patients" suffering from anaphylactic shock and a low-back injury stabilized and ready for transport which is in line with what our own EMS experienced personnel who designed the scenarios expected. The following data requests were made during the course of the experiments (see Figure 1): Audio recordings were requested most (n=13), followed by taking a picture (n=8). Some video recordings were taken during the mission (n=3) to document the overall situation. Participants asked only rarely (n=1) for transmitting data via external interfaces (e.g. vital parameters from monitoring systems to the documentation record). When reviewing the footage captured during the live events the paramedics would have preferred to use different data capturing methods: In general, more audio recordings were requested (m=22) when reviewing the recording than were requested during EMS delivery. Some video recordings were replaced by other media during the review (m=2). While watching the recording they asked more for data collection via external interfaces (m=8). The scatterplot (see Figure 2) shows that audio recordings were mainly used for documenting the medical history and administered medications during the mission and afterwards. Pictures were largely requested for documenting wounds and for medical documentation (for example, the documentation dossier of the nursing service). The video recordings were exclusively requested for recording the overall situation.

We looked into reasons why there were these differences between Wizard-of-Oz enabled data capturing during the course of the live event and changes to the way recordings were made during the retrospective review. One reason is that participants realized that audio recordings would not only help them remember certain aspects but that audio recordings could also be used to transfer data directly to an electronic version of the emergency protocol, via speech-to-text processing, therefore replacing the need for manual data entry. Paramedic participants explained that sometimes, it is difficult to verbalize an emergency situation in a way that all parties can understand the overall situation and surroundings. A video recording could help and was requested in the live event. However, during discussions, participants changed their opinion and preferred taking pictures of the overall situation instead of the initially requested video recording. A reason given for this is that pictures might be more meaningful and, more importantly, provide relevant information at a glance without having to watch a video. During the course of the live event, vital values were documented using audio (paramedics reading the values aloud) or photos (taken of medical devices). During the review paramedics would have preferred to have used audio only if this allowed them to have the data directly entered into an electronic version of the emergency protocol, via speech-to-text processing.

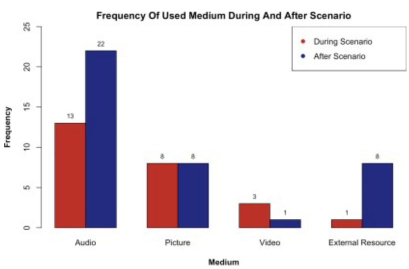

Figure 1. Comparison of requests during and after the scenarios

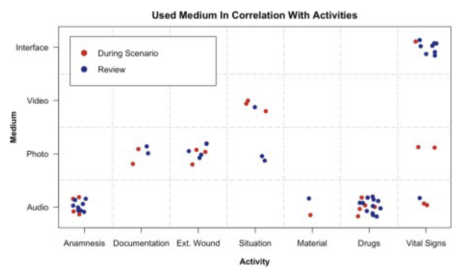

Figure 2. Scatterplot of requests during and after scenario correlated with documentation activities.

4. Discussion and future work

In this paper, we described a study to probe usefulness of different data recording approaches during EMS missions. There is some evidence that incident documentation in EMS could be supported by speech-to-text technology that would allow to enter data directly into the electronic emergency protocol which is needed for documentation purposes and for hand-over to emergency department staff. It is believed that this could help ease the problem of gaps or errors in documentation which are often due to retrospectively collected data. We would expect this to improve both timeliness and correctness of documentation. Ho et al. argue that body worn cameras could help increasing documentation accuracy [9]. While our research supports this observation, we also observed that user acceptance is a critical issue in this context. Participants recognized the benefits of a video recording including increasing their personal security during a mission. However, they were also keenly aware of potential legal ramifications. They know just too well that in emergency situations, decisions regarding treatments may need to be made in a split second and they may include non-standard treatment methods. A potential solution against the fear of after-mission misinterpretations of recordings might be that the recordings are only made available afterwards if paramedics explicitly agree or can add explanations to avoid misunderstandings by not involved persons. We conclude, there are use cases for video recording in EMS settings, but research is still necessary to find solutions that are accepted by the paramedics and do not hamper the working process.

Given the results of the study, we envision an intelligent rescue environment that supports real-time documentation, direct data capturing from devices, and electronic data transfer to the hospital information system. Further, paramedics have to be equipped with intelligent devices that automatically scan the environment for upcoming risks (like dropping material, changing environment due to weather changes) and provide intelligent decision support as needed, possibly involving services like a telemedicine approach via video guidance [11]. We are currently developing and evaluating a novel system that allows to capture data in a digital EMS protocol using speech recognition technology specifically designed for Swiss EMS and look into its integration with medical devices to enter vital signs into the protocol automatically and to implement data transfer using the CDA-CH RESP standard. In future, we will include methods for ontology mapping (e.g. mapping to a medical ontology [12]) and natural language understanding to make our voice user interface more powerful. Relying upon communication standards and medical ontologies will help in ensuring semantic interoperability. Our research clearly shows the need for acceptance (see also [11]) and that we keep in mind that we don't fall into the trap of designing interfaces that are more suitable for patient, logical, rational humans than for EMS staff who get tired, irritated, or distracted [13].

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