Practitioner-Centered, Long-Term Testing of an ICT-based Triage System for Emergency Management

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ABSTRACT

Triage in emergency response refers to determining the priority of victims based on their need for treatment and medical intervention. Today, triage is performed by the use of paper-based triage tags. Communication about patients' status is mainly carried out over radio or through handwritten notes. This practice makes it challenging for emergency personnel to keep an overview of the number, location, and medical status of victims, and to distribute information between personnel. Although technological solutions to ease the triage process exist, the methods used to test these solutions are somewhat limited. This paper reports our plans and preparations for a practitioner-centered, long-term testing of an ICT-based triage system. The system uses electronic devices to tag patients and communicate their status to relevant incident operators, providing a common operational picture for both on- and off-site personnel. The technologies (eTriage and Master) that are to be used during the testing are presented.

Keywords

Common operational picture, electronic triage, emergency management, long-term testing, mass casualty

INTRODUCTION

When crisis strikes, it is vital for emergency responders to rapidly establish an overview of the situation, and ensure that victims receive the medical attention and care they need as quickly as possible. Inefficiency in the handling of casualties can have devastating consequences and, in a worst case scenario, result in the loss of human lives. For keeping an overview of involved victims, paramedics perform triage and sort victims into different triage categories. Triage refers to the process of determining the priority of victims based on their needs for treatment and medical intervention. Although varying from county to county (Jentsch, Ramirez, Wood, & Elmasllari, 2013), typical triage categories in an emergency response setting are: *minor* (green) – with no life threatening injuries, *delayed* (yellow) – victims with serious injuries but who will survive without medical attention for the next hour, *immediate* (red) – victims who need immediate medical attention to survive, and *lifeless* (black) – dead or victims who are not likely to survive even with medical attention.

In today's practice, triage is usually carried out by attaching paper-based tags to the victims, the tags reflecting the victims' individual triage category and an initial diagnosis given by a paramedic (Jentsch, et al., 2013). This current method of performing triage often falls short in terms of helping responders keep an overview of the number of victims involved, victims' location, and changes in their medical conditions (Holzman, 1999). Practitioners have expressed the need for new technology to support the triage process and the establishment of a common operational picture between the different parties operating an incident (Eide, Haugstveit, Halvorsrud, Skjetne, & Stiso, 2012). Although several technological solutions for this purpose have been developed over the past 10-15 years (Jentsch, et al., 2013), the methods used to test the solutions have been somewhat limited; conducted over short time spans and lacking in realism. There is a need for this type of technology to be tested in long-term (weeks or months), practitioner-centered trials, where it is used in real-world situations involving real patients.

This paper reports our plans and preparations for a practitioner-centered, long-term testing (LTT) of an ICT-based triage system that uses electronic devices to tag patients and communicate their status to relevant incident operators, thus providing a common operational picture for both on- and off-site personnel. We hypothesize that the use of electronically supported triage systems for emergency management can enhance situational awareness (e.g. for first responders, incident commanders, operations centers, hospitals, etc.), improve individual monitoring and treatment, streamline logistics and transportation of patients, and generally increase efficiency of emergency response operations. The research is carried out as part of the EU project BRIDGE, where the aim is to develop technical solutions to support interoperability in large-scale emergency management.

PREVIOUS RESEARCH ON ICT-BASED TRIAGE SYSTEMS

The advantage of technology to support the management of crisis events has been studied by several researchers, also in regard to electronic triage (Adler et al., 2011; Nestler, Huber, & Klinker, 2009). One common aim of the technology that has been or is being developed for this purpose is to ease the communication and information flow between both on- and off-site responders operating an incident. Today, information sharing is mainly supported through radio and phone communication, face-to face interaction, and handwritten notes (Eide, Haugstveit, Halvorsrud, & Borén, 2013). In a hectic and dynamic environment where increasing demands are put on response personnel, these methods for sharing of information are both time consuming and prone to errors.

Several electronic solutions for supporting the triage process and keeping an overview of victims have been developed during the past decades (Jentsch, et al., 2013; Nestler, et al., 2009). Among the existing electronic solutions for triaging victims, some devices make use of barcode tags readable by electronic scanner devices (Gao & White, 2006; Inoue, Sonoda, Oka, & Fujisaki, 2006; Lenert, Palmer, Chan, & Rao, 2005), others displaying the triage category through LEDs directly on the triage device (Gao & White, 2006), and still others are equipped with sensors and GPS (Adler, et al., 2011). Current information systems for sharing of data obtained through the electronic triage devices usually include a list of triaged victims and their related data (Killeen, Chan, Buono, Griswold, & Lenert, 2006). However, several of these devices are designed for scanning triage barcode tags attached to victims, thus the information is only available for on-site responders with access to the scanner device. The more general systems for providing a common operational picture usually do not support the display of victim data directly, but rather are used for resource tracking and allocation.

While there is a large body of research on developing ICT-based systems for supporting the triage process and related information sharing, the methods used to test these solutions are somewhat limited. Most studies have involved short testing sessions, often in controlled settings or as part of a training exercise (Killeen, et al., 2006; Martín-Campillo, Mart, Yoneki, & Crowcroft, 2011). To our knowledge, no studies have applied a long-term, practitioner-centered approach to test solutions for electronic triage within the emergency management domain. While testing over short training sessions can generate valuable input, we believe that for obtaining more valid knowledge and results, such systems should be tested over a longer period of time, in different and natural situations, and on a number of patients with various types of injuries and varying needs for medical treatment. The LTT will generate knowledge of how the technology is adapted in emergency responders' normal work settings. From experience within the BRIDGE project, we know that if technology is to serve its intended purpose during extreme situations, the operators of the technology have to also use it on a daily basis.

ELECTRONIC SYSTEMS FOR EMERGENCY MANAGEMENT ASSISTANCE

Before elaborating on the LTT, we will introduce the two main technologies that are to be used during the testing, namely *eTriage* and *Master*. Both are technologies that have been developed within the BRIDGE project, and are to be seen as prototypes.

eTriage is an electronic device for triaging of patients. It consists of a case (9,5 x 7,5cm) equipped with an on/off button, three LED lights for displaying the triage category (green, yellow, and red), sensors for measuring skin temperature and activity level, and GPS for tracking location. The eTriage is attached to the patient by a Velcro bracelet fitted to the eTriage device. When started, the device will through SMS send information to a central database, and the data will be visible in the Master system. The eTriage device will follow the victim from the incident site, through transportation, and to the hospital. Figure 1 shows the eTriage prototype that is to be used during the LTT.

Figure 1. eTriage prototype to be used during the LTT.

The Master is a command and control information system for use in emergency management. It assists commanders and other central actors in keeping a common operational picture of the situation. During the LTT, Master will be used to enable operators of the medical emergency operations centers to keep an overview of the patients that have been triaged using the eTriage bracelet. Each patient is given a unique ID in the system, and updates about the patients (i.e. location, status, temperature, activity level, etc.) are received every minute.

Master comes with several different modes for viewing the data obtained through the eTriage device, including tables, lists, maps and graphs. A location-based view is also available (see Figure 2), where patients are listed in different columns depending on their current location (i.e. on scene, under transport, or delivered at the hospital). The map view (see Figure 3) enables users to view patients directly on the map by means of icons showing their status, ID, location, and geographical position.

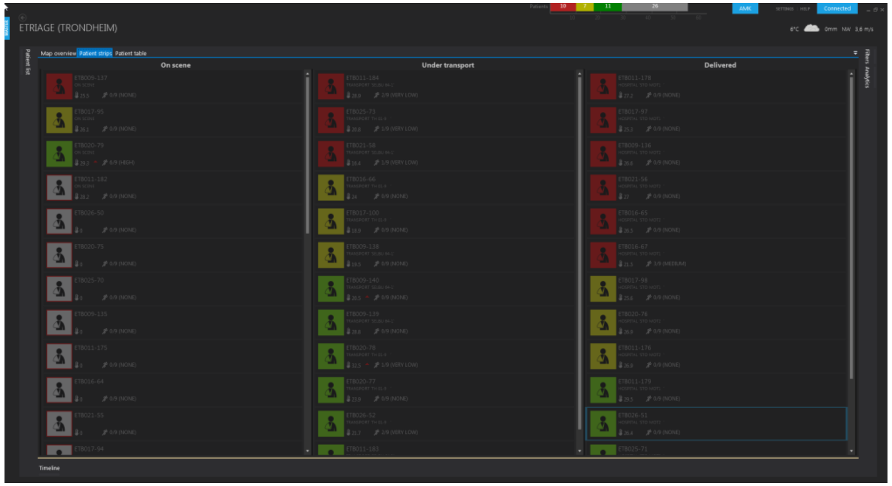

Figure 2. Location-based view in the Master.

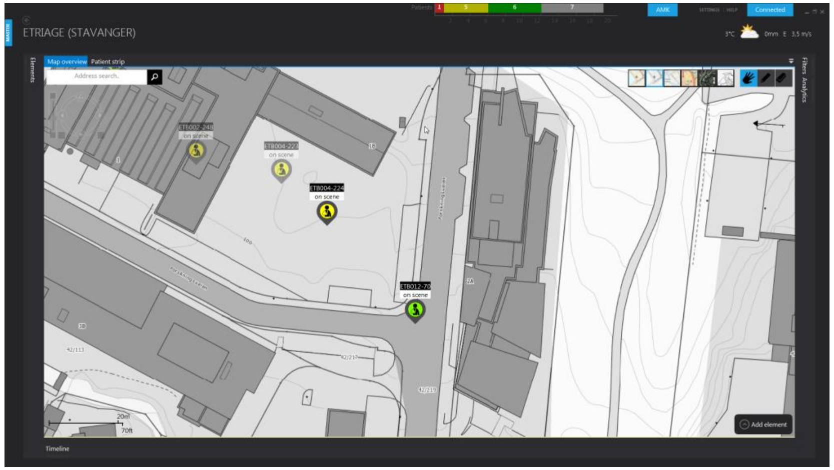

Figure 3. Map view of the Master displaying triaged patients.

Figure 4. Sensor data (activity level and skin temperature) displayed in the Master.

Clicking on a patient brings up a window showing additional patient information (see Figure 4). In this window, users can view and edit a textual description of the patient, and also look at graphs showing how the temperature and activity level of the patient has changed over time. Information about the status of the bracelet (e.g. network signal, GPS signal, battery) is also provided.

The system will alarm its users if the activity level or skin temperature of a patient fall/rise to a very low/high level. During the testing period, this alarm is designed to be unobtrusive (i.e. no blinking and sound are used) so that it will not interfere with the operators normal tasks. In an operational setting however, one might consider a more attention-demanding approach.

In addition to the above, Master also provides mechanisms for filtering out patients based on their status, and on whether the patient is active or inactive (i.e. if the patient's bracelet has been turned off). Users may also delete inactive patients from the system, and view summarized information about current patients (e.g. number of patients by status) using graphs and tables (see Figure 5).

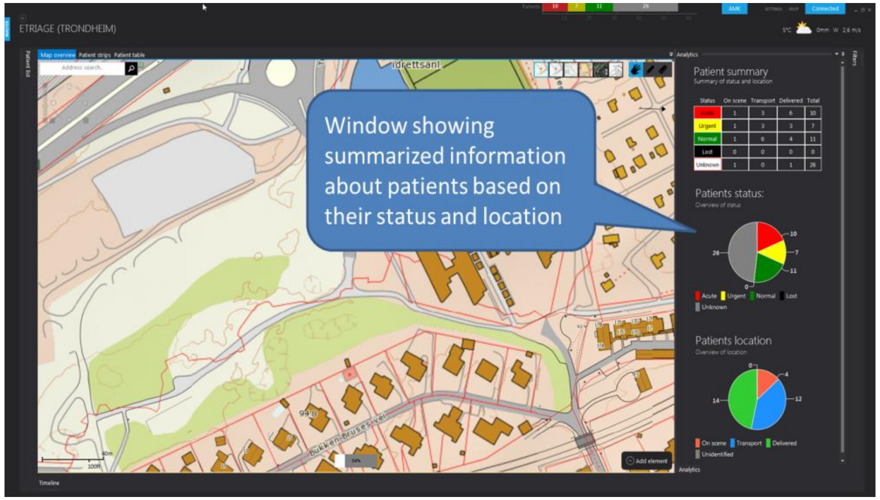

Figure 5. Summarized information about patients.

The information can be presented on different devices, such as PCs, tablets, and smartphones, making it available both on and off the incident site.

LONG-TERM TESTING OF ETRIAGE AND MASTER

The purpose of the LTT is to test, over a period of 6 weeks, how the technology can support medical emergency responders in the process of performing triage, and in establishing a common operational picture of the situation. The LTT will take place between February and April of 2015, in two Norwegian cities; Stavanger and Trondheim, where paramedics and operators of the medical emergency operations centers will use the technology on a daily basis. Informed consent will be collected from all participants prior to the study.

In each city, two ambulances will be equipped with three eTriage devices each. These will be attached to every patient the ambulances transport, regardless of the type of incident the response involves. We expect that the devices will be used on more than 1000 patients during the test period. Of course, should an actual and critical incident occur, exceptions can be made. The trial shall not in any way inflict delays to the handling of any situation. The medical emergency operations center in the respective cities will be equipped with the Master system running on separate computers. Through the Master, the operators of the emergency operations center will be able to keep an overview of patients' status all the way from the scene of the incident, to the arrival at the hospital.

Preparations

For people to accept technology, the perceived usefulness and usability of the introduced technology is of high importance (Davis, 1989). If the technology does not work properly, it can affect people's motivation for using the technology, and thus the data and results of our study. Therefore, much effort has been put into mediating factors that can interfere, and possibly ruin, the trial.

As a preparation for the LTT, a pilot study has been conducted. Pilot studies have proven to be highly useful when designing larger study, by giving an indicator of potential pitfalls, testing out study procedures (van Teijlingen & Hundley, 2001), and in our case, making sure that the technology functions as it should. The pilot was set up as a one day mini-trial in one of the actual environment where the LTT will take place. One ambulance was equipped with an eTriage device, and the medical emergency operations center with the Master system. The pilot study was particularly helpful in providing input on issues that needed to be addressed, related e.g. to the functioning of the eTriage devices, the device's robustness, and the transmission of information to the Master. We also got valuable feedback from end-users on how the eTriage data preferably should be displayed in the Master.

In addition, the pilot study provided important input to how we best can give instructions to and train participants on how to use the technologies. Training is an important aspect for people to adapt new technology into their work processes, and for the technology to produce enhanced productivity and satisfaction (Furnham, 2005). All who participate in the LTT will receive a thorough introduction to the purpose of the study, and be given training in how to operate the technology. Manuals for the eTriage device and the Master system have been developed in close collaboration with end-users, and technical support will be provided throughout the testing period.

Collection of data

The data collection will be divided into two main phases, described next. The technology will also be part of a large-scale, mass casualty emergency exercise involving all emergency agencies and several other response organizations.

Phase one will span a 1-2 weeks period where the main aim is to collect data on the functioning and technical aspects of the technology. The logged information that the eTriage devices send to the Master will during these first weeks be continuously monitored by individuals in our research group as well as by a few dedicated people at the medical operations center, with the purpose of detecting potential errors in the system. The intent of phase one is also to gives room for the participants to properly learn how to use the eTriage devices and the Master system within their actual work environments. The participants will be encouraged to provide any input to the system that they notice. Between phase one and two, there will be a couple weeks without the use of the technology, so that issues that might appear can be addressed.

Phase two of the testing, lasting 4 weeks, will concentrate on gathering participants' more general experiences with using the technologies. Observations of paramedics and operators of the medical emergency operations center interacting with eTriage and Master in their own work environments in real-time will be undertaken. Through the observations, we expect to obtain knowledge and insights that are hard to obtain by other methods, such as the patients' and paramedics' reactions when using the eTriage (Crandall, Klein, & Hoffman, 2006; Njå & Rake, 2008). In addition, we will conduct semi-structured interviews with selected participants. The interview will focus on gaining knowledge of participants' experiences with using the system during daily work, with emphasis put on the technologies' ability to support the triage process, provide a common operational picture, and increase effectiveness. In particular, the paramedics will be asked to report on the eTriage device's ease and speed of use (e.g. starting the eTriage device, setting the triage category, restarting and cleaning the device, charging and battery capacity), while the operators of the medical operational center are asked to answer questions regarding the Master system (e.g. the reception of data from the eTriage devices, reliability of the data, and the ease and intuitiveness of using the system). The interviews will be conducted after the LTT has ended, when the participants have gotten to use the technology over several weeks. Patients will not be interviewed and personal data such as name, age and gender will not be registered.

Finally, the technology will be tested during a large-scale, mass casualty emergency exercise involving the different emergency agencies and other response organizations. The purpose is to test the technology under a more hectic situation than the LTT might provide, and to test the functioning of the technology when more 10-20 eTriage devices are to be used in the handling of one concrete incident. We will study the use of the technology both on- and off-scene. Since the exercise in addition to the eTriage devices will also include current practices of performing triage, we will be able to observe and collect data on the different methods used, and make comparisons.

CONCLUSION AND FUTURE RESEARCH

This paper has presented our research efforts to conduct a practitioner-centered, long-term testing of technology for performing electronic triage and for obtaining a common operational picture during emergency situations. The research is an important step towards gaining better insight to the emergency management domain, and the implications of introducing new technology to this environment. The method involving testing over several weeks in the everyday environments of emergency responders, combined with testing of the technology during a mass casualty training exercise, enable for obtaining knowledge from use during different situations, and on a number of patients with various types of injuries and varying needs for medical treatment.

We believe that the LTE will serve as a basis for future research within the field, and provide valuable input to advancements of the technologies introduced in this paper, as well as to other similar technologies. There is still much that can be done to make the technologies easier and more intuitive to operate. In an environment characterized by stress, time constrains, and uncertainty, this might be of particular importance. Furthermore, there is potential for electronic triage devices to include different types of sensors for measuring patient vital signs such as pulse and blood pressure. There is also a need to investigate how the devices' physical designs and visualization of data best can support the work of the personnel using them. In addition to gaining insight to these needs for advancements, we will gain knowledge as to how such long-term testing should be set up and conducted in the future.

We recognize the limitation of only testing the technology within specific cities chosen for this study. Comparable studies have to be conducted in order to achieve a more comprehensive understanding of mechanisms and issues that might exist within other teams operating under different organizational structures. However, we believe that the presented plans and preparations can serve as a starting point for similar future studies within the domain. In particular, there is a need to investigate how the technology can support the overall management of emergency situations, including other emergency agencies and organizations involved. For example, could the police and fire services, often arriving early at the incident site, use electronic triage for initial triaging, thus through an information system provide vital information to paramedics on their way to the scene? And if so, could that benefit the management of the incident and contribute to more efficient handling of patients, thus save lives? In addition to the technology being used for emergency response, it can in future studies also be interesting to explore if and how such technology can be adapted to other domains, for example for monitoring elderly and/or sick persons living at home or in institutions.

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