ALARM: A Modular IT Solution to Support and Evaluate Mass Casualty Incident (MCI) Management

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ABSTRACT

ALARM is a modular IT-solution to support emergency medical service (EMS) providers and rescue staff in mass casualty incident response and training. Seven modules were implemented, covering the entire process from preliminary triage, treatment support and resource management to tactical information and registration. Communication technology is used to close information and documentation gaps. The system uses medical algorithms and telemedicine to improve patient treatment. The ALARM system generates logs automatically including procedural time stamps and outcome factors such as triage and transport categories. This allows an objective analysis and comparison of missions and opens a new approach to evidence based MCI management and training.

Keywords

ALARM, Drill, Mass Casualty Incident (MCI), Mission Report, Performance Indicators, RFID, START, Tactical Worksheet, Telemedicine, Triage

INTRODUCTION

Mass Casualty Incidents (MCI) with many injured patients represent a great challenge to rescue and medical staff. These complex situations are characterized by multiple variables such as cause, time, place, type of injuries and number of casualties that are not known in advance and require specific responses. There are some common factors however: The first phase of large-scale emergencies with many casualties is characterized by scarce resources. Casualties outnumber helpers, vehicles and other equipment. This leads to a situation where standard care cannot be provided and triage is mandatory. Furthermore, MCIs often lack timely and precise information needed for adequate emergency response (Johnson and Calkins, 1999).

By introducing new concepts and innovative IT- and communication technologies, ALARM aims at the following improvements:

- Quick and precise information for rescue and command staff
- Implementation and evaluation of medical algorithms to standardize medical diagnosis and treatment
- Increasing effectiveness and quality of medical care
- Improved resource management
- Autonomous, stable communication
- Quick and easy generation of analysis reports

Status quo

When a MCI occurs, responding units have to manage medical and organizational tasks that are not part of their daily routine and that they might have to carry out for the first time: Information on the incident has to be gathered and provided to the dispatch center. Patients have to be categorized according to severity of injury and urgency of treatment and transport. The results are documented with pen and paper and tagged to the respective patient. Carbon copies are carried back to provide documentation and are counted and analyzed manually by the time they reach the field command. At the same time, treatment areas and logistic structures have to be established. Communication is conducted via radio, often on different frequencies for different sections. This results in leading officers handling multiple radios in synchronous communication mode (Oestern, Huels, Quirini and Pohlemann, 2000). With current standards, a thorough documentation of the processes is impossible and failure-prone. Most reviews are based on narrative reports. Thus, it is difficult to compare missions objectively and to create structured reports and analyses, which in turn, makes it hard to improve mission performance based on evidence.

ALARM SOLUTION OVERVIEW

The ALARM project´s solution aims at improving communication in mass casualty incidents, speeding up data transmission and making information seamlessly available to personnel on scene, in control rooms and hospitals. An integrated service delivery platform is the core component of ALARM which supports categorization and identification of patients, dynamic resource management, telemedical expertise and thorough documentation for quality assurance and simulation. The solution components are redundantly distributed into a local and a remote strategic management platform. All information is mirrored between platforms which enhances availability. By using intelligent ad-hoc network technologies, information flow on-site is independent of existing infrastructure that might be damaged and put out of service. All information assessed is also written on radio-frequency identification (RFID) tags that stay with the patient at all times. An important aim of the project is defining emergency medical performance indicators in MCI. Through these indicators it should be possible to measure and compare the efficacy of IT-supported patient care and resource management and to draw evidence based, objective conclusions to analyze missions in post-processing and even on-the-fly. The modules of the newly built solution, as well as the developed concepts are evaluated in a demonstration room and in field tests. Feasibility and usability of the system is tested by fire fighters, rescue personnel and emergency physicians in a series of MCI drills.

Approach

A scenario of a passenger train accident with at least 30 injured was chosen to display current procedures, structures and technical equipment. Our approach is based on working in line with processes currently in use at the Berlin Fire Department. An analysis of prevailing processes, roles and responsibilities, applied technologies, perceived limitations and a thorough literature review was performed. Project partners and stakeholders created requirements and process documents. A large scale training drill was organized to show processes currently implemented. The drill was analyzed by narrative expert interviews. A solution concept was designed and subsequently implemented. The modules of the solution were tested in a series of drills with professional rescue personnel. Iterative optimization was achieved by implementing identified and approved changes as a result of each drill.

In Germany, the triage and documentation in MCI is paper-based which leads to several limitations. The information flow is slow. Often, information is not up to date or even gets lost due to the given conditions. Information has to be transferred between several media (copying handwritten paper tags) which is time-consuming and failure-prone. Often, information at tactical level is incomplete or unavailable (Lenert, Kirsh, Griswold, Buono, Lyon, Rao and Chan, 2011).

A system that is used for daily work will subsequently work in MCI. Electronic emergency protocols today are implemented on tablet solutions. First responders arriving on scene of an MCI should be able to use the same hard- and software to triage patients that they use in everyday work. In MCIs, a great number of victims may be scattered across a large area (Fischer, Wafaisade, Bail, Domres, Kabir and Braun, 2011). Since devices have to be carried long ways and rescue staff has to be able to climb obstacles we chose a lighter handheld format for preliminary triage. In our project, tablet form-factors were only used in the treatment area and for command staff on scene.

HANDHELD BASED TRIAGE APPLICATIONS

Two types of standard industrial handhelds were chosen to show a hardware independent approach and to find usability differences: Ikon 7505 (Psion Teklogix, London, England) and IT-800 RGC-05 (Casio, Tokyo, Japan). Both devices feature 94mm diagonal touchscreen user-interfaces with the operating system Windows Mobile Professional 6.x (Microsoft, Redmont, USA). The touchscreen is designed for outside use and can be operated wearing gloves. Both handhelds have RFID reader/writer integration, Wifi IEEE802.11b/g and GPS capability.

Paramedic´s and Physician´s Triage

START is a widely used triage algorithm for MCI, developed in the USA (Benson, Koenig and Schultz, 1996). In preparation of the soccer world championship in Germany in 2006 the Berlin Fire Department introduced a modified and translated version, the paper based mSTART algorithm. For the paramedic´s triage we implemented a slightly altered "modified simple triage and rapid treatment" (mSTART) algorithm. Asking a maximum of seven questions concerning vital parameters, mSTART assesses the status of a patient and assigns one of four urgency-of-treatment categories: Immediate = red, delayed = yellow, minor = green and deceased = black (Kanz, Hornburger, Kay, Mutschler and Schäuble, 2006). We enhanced mSTART by adding questions regarding gender and age (adult vs. child) which are both critically relevant for identification and medical treatment. We then refined the paper version of mSTART and simplified questions by eliminating all double negative phrasing.

When patients are triaged by a physician, a body-check algorithm developed for MCI is used. It consists of 20 questions quickly assessing the patient´s status from head to toe (Bubser, 1998). Additionally, the physician chooses the urgency category, the hospital type and the mode of transportation for each patient.

RADIOFREQUENCY- IDENTIFICATION (RFID) TAGS

In line with other projects (Inoue, Sonoda, Oka and Fujisaki, 2006; Williams, 2007, Jokela, Simons, Kuronen, Tammela, Jalasvirta, Nurmi, Harkke and Castren, 2008) we implemented passive RFID tags: MIFARE Classic (NXP Semiconductors, Eindhoven, Netherlands) with 4 kilobytes capacity. They have low maintenance, are cost-efficient and read/writable. In passive RFID tags, the reader unit transmits the energy to access the RFID transponder. Information is stored permanently on the tags. Unlike active tags, passive tags do not use a battery that deteriorates over time when stored (HIBCC, 2005). For a consistent documentation and as a backup the results assessed in each step of triage and treatment stay with the patient. They are written on RFID tags which are clipped to the wrist of the patient. Two basic parameters of information are visible on the RFID tags for quick orientation of triage and transport teams: The patients ID number which serves as a unique identifier in the system for tracking and the latest triage result represented by a colour label attached to the tag. Patients categorized as "immediate" and "deceased" are also marked with warning tape in red-white or black-yellow respectively for faster orientation of following teams.

AD-HOC, LOCAL AND STRATEGIC MANAGEMENT PLATFORM

The information gathered by the triage application on the mobile devices has to be transmitted to a superordinate instance to enable processing and distribution of the information to where it is needed. In an MCI, there are numerous users: On-scene staff, dispatch center, hospitals, telemedicine center and police registration system which provides information to relatives. In ALARM, a software network module was developed which allows the mobile devices to create an ad-hoc Wi-Fi network between each other. Within this network, the *Local Platform* provides various services for sending, receiving, processing and storing data for the mobile clients. The *Local Platform* is able to communicate with its remote counterpart, the *Strategic Platform*, via a gateway which controls several different wireless connections over UMTS, GPRS/EDGE and satellite. The information forwarded to the *Strategic Platform* can then be used by the different remote network nodes using the *Strategic Platform* service API.

TABLET COMPUTER BASED APPLICATIONS

We chose two types of standard tablet computers F5v (Motion, Austin, USA) with 264mm diagonal pen-touchscreen already in use in pre-hospital emergency management. Tactical staff used J3500 (Motion, Austin, USA) with 307mm diagonal touchscreen. Both devices use the operating system Windows 7.x (Microsoft, Redmont, USA) and Wifi IEEE802.11b/g capabilities, while only the F5v has RFID reader/writer and GPS integration.

Telemedically supported Patient care in the Treatment Area

The physician´s triage lead to short treatment instructions depending on injury patterns. Paramedics inside the treatment area scan RFID tags and treat patients according to the displayed treatment instructions. They can request support by a telemedical emergency physician. Basic functionality is audio communication and sending photos of injuries. He supervises the treatment by the paramedics and can answer occurring medical questions. The telemedical physician has access to strategic and tactical information gathered in the field and can integrate it into treatment and transport decisions. If needed, the paramedic can send a set of live vital data of the patient (blood pressure, heart rate, respiratory rate, peripheral oxygen saturation, expiratory carbon dioxide level and electrocardiogram) to the telemedicine center using a Corpuls c3 (Stemple, Kaufering, Germany) monitor. When the treatment of the patient is finished, all procedures are documented and confirmed by the paramedic.

Resource Management

The system logs all arriving vehicles for patient transport. The ID, the type and the location of the vehicle is tracked. There is a predefined list of EMS vehicles on duty in the Berlin area. New vehicles can also be fed into the system. While the patient is in treatment the transport dispatcher inquires the target hospital and assigns the patient to an ambulance. On arrival, he coordinates the ambulance crews to transport a patient to a designated hospital. All steps are tracked within the system and sent to local and strategic management platform.

Tactical Worksheets

Via the *Tactical Worksheets* near real time information is provided to the incident command staff. All relevant information is gathered and processed by the *Local Platform* and forwarded to the mobile client, a multi-touch tablet application. The UI of the *Tactical Worksheets* was designed to be concise and easy to operate at the same time. It consists of four quadrants: (1) a geo-referenced map of the incident location with instalments and hazards, (2) notifications, tasks, personal notes and reminders, (3) available vehicle and staff resources and (4) patient overview with triage categories.

EXPERT INTERVIEWS

Experts (emergency physicians, n=5; paramedics, n=14) were asked to evaluate technical support before and after the drill. The feedback was given using a 10 cm visual analogue scale (VAS) with a range from “agree” (= 0 cm) to “disagree” (= 10 cm). The technical support system was rated as “helpful” before the drill (median VAS 1.6). The median rating changed to VAS = 1.1 after the first experience with the ALARM solution. The opinion that IT support could lead to a better overview did not change. When asked to evaluate the telemedical support at the treatment area before and after the drill, paramedics rated IT support 1.9 and 1.5 respectively. In contrast, emergency physicians rated the telemedical support 1.6 before and 4.4 after experiencing the ALARM solution during the MCI drill.

CONCLUSION

This study gives an overview of the ALARM solution – a modular telemedical IT solution to support emergency medical staff in mass casualty incident (MCI) response and training. The chosen scenario is a passenger train accident with at least 30 injured. The project was developed from the perspective of processes currently in use in Berlin, Germany. It is a modular approach which makes alteration possible. Hardware independency was shown by using various standard hardware. The system integrates triage algorithms for preliminary and physician’s triage. It features remote treatment advice, documentation and triage decisions by telemedical emergency physicians. All assessed information is logged in the system for full documentation of all processes with quick information distribution to all levels involved. With the ALARM system it is possible to improve mission performance by comparing mission objectives and creating structured reports and analyses in post-processing or on-the-fly. While the overall feedback of the ALARM solution was rated as “very helpful” (determined by a strong agreement and an improvement of the median VAS score after a first experience during a MCI drill compared to beforehand), the telemedical ALARM solution at the treatment area was rated controversial depending on the user’s profession and role.

ACKNOWLEDGMENTS

The ALARM project is sponsored by the German Federal Ministry of Education and Research (contract/grant number 13N10109). The sole responsibility for the content of this paper is with the authors.

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