Local-specific resource planning for mass casualty incidents

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ABSTRACT

In the situation of mass casualty incidents in Germany the questions that always remain are what and how much resources are needed to provide the best response. Furthermore, there are many local-specific constraints that exist, such as the density of hospitals nearby, what their surgery capacities are like, the distance between the local rescue bases and the incident scene as well as the level of preparedness of first responders. This paper describes an organisational approach to elaborate the specific tactical strategies that take part in preparedness planning. Furthermore, this paper will give insight and explore a simulation information system to support local medical response managers in elaborating those strategies in an office environment.

Keywords

Mass casualty incident, preparedness planning, resource management, simulation, user interface design

INTRODUCTION

A mass casualty incident (MCI) is an emergency with a large number of injured or affected persons that cannot be managed with regular emergency medical services (DIN13050 2009). In creating an efficient plan that includes how much staff would be needed and the deployment of resources for MCIs shows to be challenging due to the large amount of resources required. From practitioner's point of view, it is easy to see shortcomings regarding the awareness of the actual availability of resources during a crisis situation. In addition, the relation between the actual needed and available resources is often left unclear. Also, the medical incident commanders that are involved in ambulance organisations desire resource planning across existing administrative boundaries that allows elaborating and establishing flexible concepts for a suitable use of human and technical resources to develop realistic local concepts in cooperation with neighbouring districts (German Red Cross 2012).

From a strategic point of view, Germany is prepared insufficiently on MCIs (BBK 2010). Germany's states are responsible for disaster protection. In standard rescue procedures, ambulances are supposed to arrive after a particular period of time, called help period (BBK 2010). This key performance indicator (KPI) covers the time between the notification of an alarm and the arrival of the unit on site (Hilgers and Schwieren 2010). However, this KPI does not apply for mass casualty incidents.

We understand resource management as the interactions between actors and how they affect each other including the steering and governance of crisis response actions and resources such as vehicles, personnel and equipment. Based on that, we define resource planning as the elaboration of local-specific tactical strategies in the preparedness phase. In this paper we suggest an organisational approach for resource planning by local-specific preparedness strategies. Further, we describe a simulation application that supports medical response managers in elaborating flexible and local-specific strategies for mass casualty missions. In order to generate valid results, data from Red-Cross real-life exercises are planned to be utilized for validation and calibration. The application is currently under development and will be evaluated within the CRISMA project. In the following, we will start with the status quo on mass casualty missions and related work on simulation approaches and proceed with methodical explanations. This section is followed by the explanation of the organisational concept of local-specific preparedness strategies for MCIs. Further, we describe the context of use and the user interface of the application, followed by technical realisation aspects and a conclusion.

STATUS QUO MASS CASUALTY PROCEDURES AND RELATED WORK

The operational response for a mass casualty incident is characterized by the treatment and transportation of patients. This procedure is always constrained by available and usable emergency service resources (Hellmich 2010). The German states agreed on some common structures and operational-tactical recommendations on various administrative levels. E.g. the Fire Brigades Service Regulation 100 intends to serve as the basis for common crisis management structures at operational-tactical level. Among other regulations it defines the leading procedure as the three steps “identify (investigation /control)”, “planning (assessment /decision)” and “giving commands” (Schäfer 1998). Additionally there are local-specific response keywords linked to resource deployments in the so called order of alarm and action (OAA).

Within Germany’s emergency medical services (EMS) the mass casualty mission is controlled by two roles operating on site, the chief emergency physician (CEP) and the medical incident commander (MIC). The CEP guides the medical incident commander and the emergency medical services. The CEP forms his operational picture of the situation and decides whether to request additional rescue personnel/technical support or not. Further he coordinates the planning of primary medical care, in particular by triaging patients and assigning treatment priorities. Also the priority and type of patient evacuations as well as the assignment of appropriate hospitals and emergency shelters is decided by the CEP (Dirks 2006). The on-site triage of patients during a mass casualty incident is done by the MIC and his paramedic teams with their team leaders, e.g. using the mSTaRT process. Further, the MIC is coordinating the efficient delivery of patients to appropriate hospitals and affected to appropriate shelter. Thus the MIC copes with logistics, while the CEP coordinates medical care and takes decisions on tactical procedures that are constrained by availability and preparedness of first response units and hospital capacities (Kanz et al. 2006). Although they prepare their missions in training courses, field exercises and table top exercises the procedures often lack of concrete strategies for local conditions.

Several simulation tools were developed and were practically applied in research and industry to support crisis management and civil protection for preparedness planning as well as for training (Jain 2003). Simulation systems for response processes are either used in an interactive manner for training purposes or in a calculative manner for planning purposes. Business process modelling has already been applied to mass casualty missions and enabled practitioners for defining and changing workflows and benefiting from the visualisation (Rose, Peinel and Arsenov 2008). The MobiKat information system for strategic planning and operative use allows users to simulate and calculate ambulance arrivals on site and the patient transportation to hospitals taking into account local-specific constraints. It aims at vehicle logistics and routing and is capable of taking into account road closures (Danowski 2010). We focus on the on-site processes and take into account available staff. We also aim at logistics calculations for vehicle arrival and patient transportation times.

METHOD

In the development of interactive information systems, ethnographic field work is crucial to understand the end users behaviour and language by observing them in their working environment. We participated in training exercises of first responders (Max and Sautter 2013) and gained insights for a user-centred design and development approach (Sautter, Engelbach and Frings 2012) and for the requirements engineering according to the viewpoint framework (Sterling and Taveter 2009). Ideas and needs of users gained through systematic interviews and workshops with several CEPs and MICs provided rich input. The organisational concept as well as the requirements engineering and the user interface designing profited from these internal and external participants with crisis management backgrounds. Goal models, organizational models, domain models for requirements engineering and a resource management concept were elaborated that model actors, resources and environment for mass casualty missions. The context analysis yielded user profiles and tasks, considering also the environmental conditions such as time and concentration constraints. For designing user interfaces paper and digital mockups constitute a flexible method enabling designers to easily add, delete or adapt features according to user feedback. In an iterative process user interfaces have been designed and discussed regularly with potential users. The resource management simulation model is based on a disaster management meta-modelling approach (Othman et al. 2013). The model includes incident influences, the capabilities constrained by resources and attributes of the environment. In order to prepare the modelling of mass casualty missions, a concept was developed that describes the involved entities (actors, resources, and environment) as well as their interaction.

LOCAL-SPECIFIC PREPAREDNESS STRATEGIES

Preparedness in local communities needs to take into account regional conditions and critical infrastructures as e.g. concert halls or train stations. Risks of potential incidents can be mitigated by choosing particular infrastructures and conditions as part of crisis scenarios for targeted trainings and exercises. In the following we suggest a further measure for a targeted improvement of local resilience. The organisational status quo for mass casualty missions in Germany shall be enhanced by additional functionalities of the chief emergency physician (CEP) and the medical incident commander (MIC) during the preparedness planning phase. In addition to currently performed trainings and other preparedness activities they can elaborate local-specific strategies and recommendations especially for mass casualty missions. Such strategies for tactical decisions are for instance:

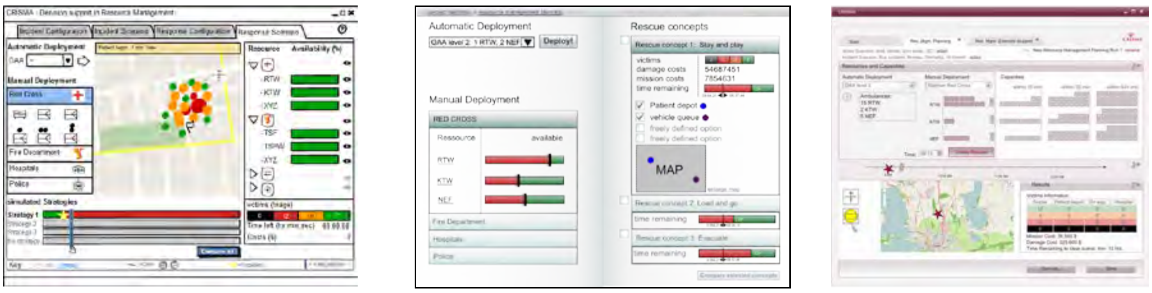
- Carry the most critical 10 patients to hospitals immediately, the 11th needs to be treated on-site first
- Stabilize patients as much as possible before transportation, as ways to hospitals tend to be long
- Start pre-triage process without tactical areas in order to not bind leading personnel for each tactical area due to few immediate available personnel

As a prerequisite they need to assess regional infrastructures and perform calculations with their local resource constraints. Such regional constraints are for instance the number of beds in nearby hospitals (within 50 kilometres) and their surgery-capacities for badly injured, the number of available emergency medical services (EMS) resources, the distance of the corresponding rescue bases to the potential incident scene and the distance from the hospitals to the incident scene.

Modelling and simulation systems can provide an essential contribution to the elaboration of such strategies as they can easily perform calculations on the basis of local constraints. Virtual mass casualty missions can be assessed by so called key performance indicators (KPI). We understand key performance indicators as characteristics and relevant aspects of a mass casualty scenario. Examples are: time until all patients are pre-triaged/triaged, time until red-triaged patients are away from the incident scene, time until care measures start or time until the last patient is transported to the hospital. The consideration of these local KPIs in simulation runs allows a region-specific replication and an incorporation of the lessons learned as preparedness measures into the daily work. Thus it is possible to develop better tactical schemas that lead to improved operations, training and resource planning.

CONTEXT OF USE AND INTERACTION CONCEPT

This paragraph describes the context of use for an information system-support of the elaboration of local-specific strategies. The CEF, the MIC and other team leaders of emergency medical services organisations should elaborate local-specific strategies detached of daily operational activities in a quiet environment on a desktop computer. This familiar environment can help to ensure that the user feels comfortable, which in turn has an influence on his mental concentration and the effectiveness of working. In Germany the mentioned roles are mostly voluntary personnel with high expertise in crisis management and civil protection, while their IT usage skills can differ and are more likely on an average level. These aspects need to be considered for an easy to learn as well as an easy to use interaction concept. Also, the expected usage is of short duration (no full time job). Despite of these boundary conditions the end user workshops and interviews identified that this user group has a high envisioned usage frequency of the resource planning application as they act on altruistic motivation.



(a) First iteration **(b) First iteration** **(c) Second iteration**

Figure 1: Mockups of the resource planning tool

The mockups designed in the first iteration (cp. Figure 1 a and b) followed the interaction principle that the user first models an incident in order to characterize the scenario he/she has to respond to. Afterwards the user can define different response strategies (e.g. use an advanced medical post and a vehicle queue) for this specific scenario, determine the location of the advanced medical post and/or the vehicle queue as well as set the main key performance indicators (KPI) he/she wants to investigate by simulating the different response strategies. Continuing, the user can start the simulation in a new tab by selecting those strategies he would like to simulate and compare. The result calculation starts with the first resource deployment by the user that can either be manual or automatic by choosing a response keyword of the order of alarm and action (OAA). Each selected response strategy is represented by a navigable timeline that visualizes the end of the response based on the previously selected main evaluation indicator (e.g. all patients removed from scene). The parallel display of the timelines and the focus on one indicator provides a quick overview of the effectiveness of the different strategies without an information overload. Nevertheless, results of other evaluation indicators for each strategy can be displayed separately by clicking on the related timeline.

The mockups designed in the second iteration (cp. Figure 1 c) followed the interaction principle to manipulate the simulation at runtime. While the world scenario (e.g. 9am, winter, 5cm snow) and the incident scenario (e.g. bus accident, Germany, 19 injured) are defined beforehand, the response strategy is defined during the simulation run and can be adapted at every time. This drastic chance of interaction is based on user feedback. Workshops revealed that the response in real life is more flexible and the system should support such behaviour. The manual deployment has been extended by the declaration of the time of arrival of the resources at the incident site. As opposed to the previous concept the user is able to place the patient depot and/or the vehicle queue when and wherever he/she wants. Each manipulation by the user is marked on the timeline to provide a quick overview about all interventions that have been made.

SIMULATION MODEL AND REALISATION

The resource management model represents involved entities of mass casualty missions like actors, resources, and environment as well as their way of interaction. Human factors are taken into account reflecting real world situations. For example, in the triage process, stress as well as an insufficient skill level of a first responder may lead to erroneous patient categorisation. The concept is based on the processes of a local EMS organisation; adaptions may be needed for other organisations and regions.

The agent-based simulation platform that will be applied allows defining different types of spatial agents (Meriste et al. 2005). We intend to use agents to represent objects of interest (OOI) such as patients and ambulances. Patient-agents can behave according to scenario-specific health or injury patterns. Also ambulance-agents can simulate transporting patients and necessitate of being refuelled after some time in service. The realization of the application will be integrated into an architecture that facilitates persisting simulation runs as world states for analysis and comparisons. It further provides means for representing both initial crisis scenarios and model-generated mass casualty mission timelines. KPIs of mass casualty missions are represented by either single existing measures or aggregating functions of several values within a world state (Dihé et al. 2013).

An exercise-support application for mass casualty field exercises that allows gathering and analysing exercise data is currently under development. Data from mass casualty field exercises like e.g. a bus accident scenario (Max and Sautter 2013) shall be gathered and analysed using the solution. In order to obtain valid results of the resource planning application and to obtain a high end user acceptance, a validation and calibration for those mass casualty processes that take place on site (needed time for triage, care and stretcher transportation) is envisioned. As calibration we understand “the process of tuning a model to fit detailed real data” (Carley 1996).

CONCLUSION AND OUTLOOK

Adequate resources as well as tactical strategies in the management of a mass casualty mission are often unclear. In this paper we described the responsibilities of a chief emergency physician (CEP) and a medical incident commander (MIC). We designed an organisational concept that describes how they can elaborate and specify mass casualty strategies for their regions. The context of use and the interaction concept describe how a modelling and simulation system can support the strategy development. Finally, the progress of simulation model development and architecture integration as well as the intended validation is outlined. Currently the resource management simulation model is developed in form of an agent-based simulation model, which will first be tested in a training application and afterwards adapted for the resource planning application.

Beyond the described context of use in the office environment, practitioners envision a context of use in the command vehicle as to use the resource planning tool for interactive decision support during exercises and real missions. In order to utilize gained insights on a tactical and an operational level, a similar approach could be altered for elaborating long-term investment decisions. Aggregated indicators could facilitate long-term mass casualty preparedness decisions for local municipalities and districts.

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