A knowledge-based system to support emergency medical services for disabled patients

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Abstract. This paper illustrates a knowledge based system devoted to help nurses and volunteers of Emergency Medical Services (EMS) in dealing with disabled patients during an emergency.

Keywords: emergency medical services, decision support systems, knowledge-based systems, disabled patients, Web-based systems, mobile devices

1 Introduction

Being able to promptly and accurately choose a proper course of action in the field is a crucial aspect of emergency response. To guarantee that, emergency medical services (EMS) heavily rely on predefined procedures, on which first responders are specifically trained. The procedures are necessarily thought for the most frequently occurring cases. As a result, they may not be optimal and require additional knowledge for special cases, such as the various types of disabilities. To the best of our knowledge, no research has been devoted to using knowledge based systems for helping EMS nurses and volunteers in dealing with disabled patients. This paper focuses on a system that provides recommendations in the field for such cases.

2 Requirement Analysis and Knowledge Acquisition

We started our project by conducting focus groups that involved: (i) EMS physicians and nurses, (ii) rehabilitation clinicians specialized in disabilities, and (iii) representatives of various italian associations of disabled persons[1]. We summarize in the following the main findings that emerged from the focus groups:

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[1] Association of the Blind and Visually impaired (UICI), Association of the Deaf and Mute-Deaf (ENS), Autism association (PROGETTO AUTISMO FVG), Dystrophy Association (UILDM), Regional Council of the Disabled (CONSULTA FVG), Spilimbergo Center for the Motor Disabled (PROGETTO SPILIMBERGO).

- Although knowing the general class of (sensory, motory, cognitive) disability to which the patient belongs already allows to provide some disability-related advice, for each class there are a large number of descriptive attributes (e.g., detailed anatomical descriptions of motor disabilities) that would allow the system to provide advice which is tailored to the single patient. Therefore, the system needs a detailed representation of the patient's disabilities that comprises all those attributes. From this point of view, our work shares some similarities with the problem of generating personalized information using medical records that has been explored in non-emergency domains [1].
- Since every second counts in EMS operations, it is not conceivable to acquire the detailed description of patient's disabilities during the emergency: the information is needed beforehand, also taking into account that determining the value of the different attributes can require considerable time to an experienced clinician.
- The disabled person and her family should be actively involved in the management of the information stored in the system: although some attributes can be provided only by doctors, allowing the disabled to access their full record and keep some personal fields up-to-date contributes to build trust in the system and make patients aware (for privacy and legal reasons) of the data stored about them and who can access it.
- The system should provide advice to the phone operators of the EMS center (to help them choose which team and which ambulance is most appropriate to the context) as well as to the EMS first responders on the field (to provide advice about the course of actions to take). For this reason, the system should run on desktop as well as mobile devices, and the mobile interface should take into account peculiar limitations of mobile data visualization [2].
- An important contextual factor to be taken into account is the severity of the emergency which is formalized by EMS with standard codes (e.g., the standard employed by all Italian EMS is based on 4 codes of increasing severity: white, green, yellow, red). As severity increases, the system should restrict the number of recommendations, focusing on those which are crucial to preserve life.
- The advice provided to different classes of medical first responders (physicians, nurses, volunteers) should not necessarily be the same.

After the analysis of requirements, the knowledge acquisition process has been organized to take advantage of three different kinds of knowledge sources:

- Available general documents about safety response concerning the disabled, produced by different organizations, e.g. the National Department of Firefighters in Italy and the Center for Development and Disability in the US [3]. The analysis of such documents allowed us to derive basic rules about how to communicate and behave with blind, deaf, mute people or people with mental disorders, and how to transport motor-impaired persons in emergency situations such as fires or underground train evacuations. This knowledge was not specific to EMS so it was reviewed with clinicians to adapt it to the EMS context, e.g. some recommendations were considered to be trivial for professional EMS personnel.
- Expert knowledge, provided by the medical authors of this paper (an EMS physician and two clinicians specialized in disabilities). Each expert analyzed the problem from a different perspective, the acquired rules were formulated in natural language in a draft document and we carried out periodical panel meetings

involving all the experts to review the individually proposed rules. These panel meetings helped point out and correct some differences in the terminology used by the different experts. Changes in rules were typically made to reconcile the clinical approach of thoroughly reasoning from very precise diagnoses with the EMS approach where priority is given to preserve life, stabilizing the patient and transporting him quickly and safely to the hospital. When the two approaches could not be reconciled, the rule was rejected: it would indeed be impossible on the field to carry out evaluations which require considerable time and are technically more appropriate for a hospital environment.

- Knowledge acquired from representatives of the associations of disabled persons. Semi-structured interviews were carried out to gather information about previous experiences (if any) as EMS patients or let them imagine (as a role-playing exercise) being rescued and think about which kind of first responders' actions should be avoided or should be undertaken to make the whole operation more acceptable and comfortable to them. This was especially useful to more thoroughly investigate communication-related and social aspects of the interaction between first responders and disabled patients (e.g., ways to appropriately get the attention of a deaf person, verbal expressions that should be avoided with blind persons,…). The acquired knowledge was always submitted to the previously mentioned panel meetings for final approval.

Table 1. Main GEM II elements and values for a guideline that applies to a motor disability.

Identity	*GuidelineTitle*	First Aid of Motor Disabled Patients – Forearm impairment - Transportation
Developer	*DeveloperName*	Physical Medicine and Rehabilitation Institute "Gervasutta"
	Sponsor	118 Regional Emergency Medical Service, Udine Hospital
Purpose	*Main Focus*	Transport of Motor Disabled people
	Exception	none
	Objective	Prevent transport injuries and provide comfort
Intended Audience	*Users*	nurses, volunteers, physicians, relatives
	Care Setting	red, yellow, green, and white emergency codes
TargetPopulation	*InclusionCriterion*	Motor disabled people
Knowledge Components	*Conditional Recommendation*	IF (b710.s7103="Moderate Impairment" OR b710.s7103 = "Complete Impairment") THEN (avoid forced movement of b710)
	ActionType	Transportation
	Recommendation Strength	4

3 The Knowledge Based System

Identifying and representing all the impairments of each disabled patient to generate guidelines for EMS operations is a challenging task because severely disabled patients can be affected by many different and unrelated conditions which are not taken into

account by general disability stereotypes (e.g., blind, deaf, …). To represent patient's disabilities, we started from the ICF international standard of the World Health Organization (WHO) for measuring health and disability, and defined a specific Disabled User Profile (DUP) for the EMS context. The DUP is described in detail in [4].
The knowledge base has been represented using the GEM II document model [5]. For example, Table 1 shows a guideline that applies to motor disabilities where the impairment is located on the patient's forearm (b710 is the ICF code for Mobility of joint functions and s7301 is the ICF code for Structure of Forearm). The table shows only the GEM elements and values that are more important in this example. From the GEM II documents, we derive rules in the format executable by Drools (jboss.org/drools), a Rule Management System based on the well-known RETE algorithm. We included the knowledge base into a Web system we developed with the Jboss framework (jboss.org).

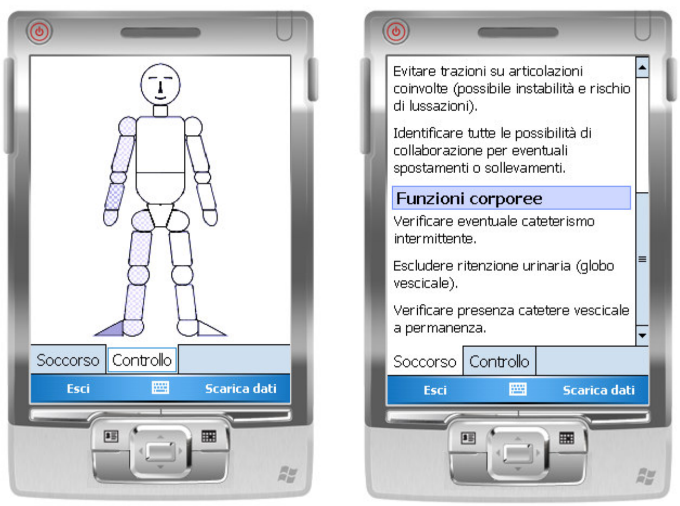

Figure 1. The screen of the Web interface devoted to motor control representation.

The first step in using the system is to fill the DUP for the considered person, through a Web interface. The personal data section of the DUP can be filled by the disabled person or her relatives. The medical sections have instead to be filled by the general practitioner or the specialists who follow the disabled person.

The second step concerns the emergency call. When the phone operator in the EMS center receives the call, the system first tries to match the calling number with the DUP database to automatically display the caller's personal data on the phone operator's screen. If caller's automatic identification fails, the system provides the phone operator with a quick search functionality to retrieve the right DUP from the typical information that is requested anyway during an emergency call. When the phone operator dispatches an ambulance to the emergency destination, she assigns that DUP to that ambulance run.

The third step concerns sending system recommendations to the first responders. Since each ambulance run has an associated team of first responders, assigning the

DUP to that ambulance run will enable the members of that team to read the system's recommendation from their mobile devices. Figure 1 shows two screens of the mobile interface used in the field: the screen on the left shows the motor control graphical representation for the considered patient, the screen on the right displays the recommendations, organized into sections and ordered according to their Recommendation Strength. Team members can thus examine recommendations while traveling to the emergency destination, so that they do not need to use the mobile device when they reach the patient.

6 Conclusions

At the time of writing, the project has entered a validation phase: each member of a pool of clinicians, who were not involved in the focus groups and in the expert panel, is now separately entering DUPs of real patients into the system. Each considered patient case is given to every involved clinician, to detect possible misunderstandings in the DUP forms as well as analyze consistency among clinicians in filling the DUP. Moreover, these clinical cases are being used to have the EMS physicians and nurses assess the usefulness of the recommendations provided by the system.

We have also started an exploration of using the DUP and the knowledge base for training purposes. In particular, we aim at integrating them in a serious game [6] to provide visual realism and user immersion in simulated EMS training scenarios.

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