Participatory User Centered Design Techniques for a Large Scale Ad-Hoc Health Information System

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ABSTRACT
During mass casualty incidents, an enormous amount of data, including the vital signs of the patients, the location of the patients, and the location of the first responders must be gathered and communicated efficiently. The Advanced Health and Disaster Aid Network (AID-N) used participatory design methods to develop an electronic triage system that changed how emergency personnel interacted, collected, and processed data at mass casualty incidents. Through a collaboration between computer scientists, biomedical engineers, usability analysts, paramedics, and medical doctors, AID-N constructed scalable algorithms to monitor a large numbers of patients, an intuitive interface to support overwhelmed responders, and an ad-hoc mesh network that maintained connectivity to patients in ad-hoc, chaotic settings. This paper describes an iterative approach to user-centered design that allows for the collection of a massive amount of data and presents this data in a clear and understandable format to the user.

Categories and Subject Descriptors
H.1.2 [**Information Systems**]: User/Machine Systems – *human factors, human information processing.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Embedded medical systems, participatory design, triage.

1. INTRODUCTION
Response to mass casualty incidents (MCIs) poses numerous challenges to the emergency medical services (EMS) community. The rapid and accurate triage of patients is a critical step of the response process and triggers a chain of events that should result in efficient resource allocation. Responders conduct initial triage at the incident by attaching red, yellow, green or black colored paper tags to patients based upon assessed priority. Each responder periodically reports their triage counts to a triage officer. Triage officers then delegates this information to other officers and the incident commander, who each in turn uses this critical initial information to coordinate on-site treatment resources, transport vehicles, and off-site care facilities for the patients.

For years, responders performed these critical tasks with paper triage tags, clipboards, and voice communication (telephones and hand-held radios). This workflow, however, has proven labor intensive, time consuming, and prone to human error. As a result, the management of the ongoing disaster by on-site and off-site medical teams can be easily and quickly overwhelmed. Officers may be forced to coordinate personnel and transport vehicles with insufficient information from responders in the field. Receiving hospitals must prepare for the incoming patients without any prior information on the number of patients expected or the types of injuries. To make matters worse, patients with minor injuries often depart the scene without notifying the response team and create an organizational headache for the EMS officers coordinating the resources. In an understaffed response team, patients with significant injuries may deteriorate and remain undetected while waiting for transport.

In collaboration with EMS, we developed a patient monitoring system to address the unsolved problems discussed above. We used an iterative participatory design process to understand the workflows, problems, and needs of various user groups of our technology. Furthermore, we created a system of embedded medical devices, light-weight algorithms, central server, and mobile personal servers to address these needs.

Details of the hardware and software of the Advanced Health and Disaster Aid Network (AID-N) can be found in [16]. A summary of the system infrastructure is described below. Lightweight embedded medical systems called electronic triage tags (E-tags) continuously track patient locations and monitor their vital signs through medical sensors (pulse-ox, electrocardiogram (ECG), blood pressure). These low-power devices automatically form a wireless ad-hoc mesh network that continuously transmits data to a base station. The reconfigurable and self-healing components of the mesh network ensure connectivity even when no previous infrastructure is available. The base station continuously collects the vital signs of the patients, prioritizes the patients for transport, and alerts the first responders of critical changes. When an 802.11 connection is available, the base station downloads the patient's vital signs to a central server. During secondary triage, first responders gather a patient's background information (e.g. name, address, allergies) with a mobile personal server and

HealthNet'07, June 11, 2007, San Juan, Puerto Rico, USA.

associate this information with data from the central server. In AID-N, responders managing the scene can access information on the patient's location, data, vital signs from anywhere.

2. RELATED WORK

Technology has previously been combined with triage through the use of barcodes, tag readers, passive RFID tags, hand-held computers, and geolocation to collect data about the mass casualty events [5][7][14]. The AID-N electronic triage system differs from these approaches [17][14] by using low power 802.15.4 communication, instead of 802.11, on ultra-low power embedded hardware. Other work [4][15] developed biomedical sensors for preventive health monitoring, but AID-N specifically used itera-tive user design to build a system for large disaster applications.

Related work has also described how information is commonly misunderstood in health applications and expressed the need to extract useful information when a massive amount of data is available [19][13]. AID-N addresses this problem by using participatory design methods to ensure that the right type of data is gathered and displayed to the user.

3. METHODOLOGY

In collaboration with emergency response personnel in the Washington DC Metropolitan area, we used a user-centered and iterative design process similar to [3][18]. As shown in Table 1, our sampled user community comprised of over 50 emergency medicine providers from various ranks, in three counties in the DC Metropolitan area: Arlington County, VA, Montgomery County, MD, and Baltimore County, MD.

To gain insight into the first responders' line of work, we interviewed five paramedics, observed fire and police dispatchers at the Montgomery County Emergency Operations Center, attended a MCI table top exercise at Baltimore County, and participated in ambulance ride-alongs at five fire stations in Arlington County. Through observations of responders in their routine roles, as well as questionnaires about hypothetical MCI scenarios, we created a user task flow chart for MCIs (Figure 1).

We also accumulated a list of user needs from our initial investigations and compiled them into a survey. We then consulted more users and asked them to rank each need/problem along a continuum of importance. We then built prototypes of envisioned solutions and asked users for feedback through interviews and round-table discussions. During these demonstrations, we discovered additional user needs which were not articulated by our users in the initial interviews or surveys. Furthermore, we discovered user concerns in the new technologies that lead to additional needs that did not exist before. We integrated the new user feedback and suggestions into each additional version of our prototype. We repeated four cycles of these user feedback sessions and rapid prototype development.

In this paper, we describe the baseline needs extracted from initial investigations with users. We then describe three iterations of prototypes that were developed using user-centered design. We then list additional user needs discovered when we demonstrated the prototyped solutions. Following the description of user needs, we summarize the key design principles in our technological designs. Finally, we describe users' concerns on issues that the new technologies introduced.

Table 1: Data sources for soliciting user feedback

Understanding user workflows
Interviews
4 medics (at Fire, Police, and EMS Expo)
Field Studies
60 hrs of ambulance ride-alongs (Arlington, Montgomery [1])
2 site-visits to emergency operations center (Montgomery, Baltimore [20])
2 MCI exercise observations (Baltimore, Prince George's [2])
Identifying and ranking user needs
Surveys
6 medics (Arlington County)
6 medics (Arlington, Montgomery, and Baltimore)
Discovering additional user needs through prototype demonstrations
Interviews
3 medics (2 Arlington County, 3 Baltimore County, 1 Montgomery County)
2 nurses (Suburban Hospital)
5 physicians (3 Suburban, 1 Maryland, 1 military [10][8])
3 MCI experts ([9][11][12])
Round-table discussions
10 responders in Baltimore County
15 responders in Arlington County
6 responders in Montgomery County

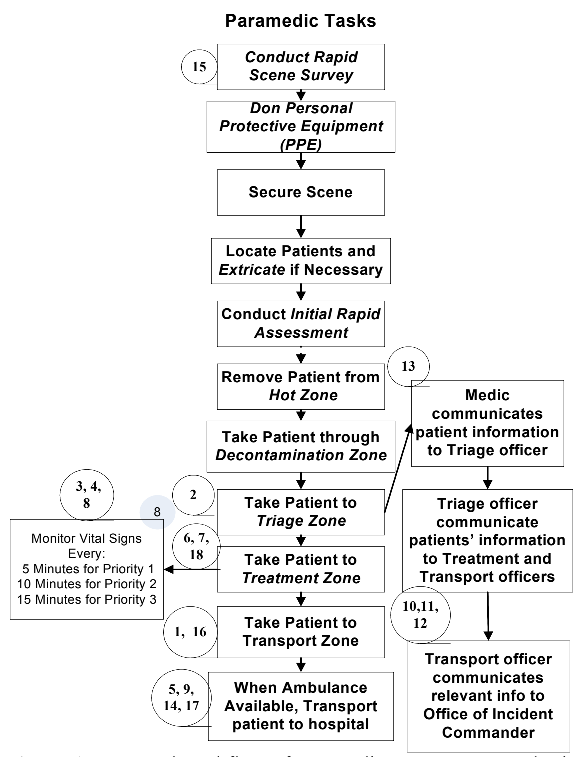

Figure 1: Expected workflow of paramedics at a mass casualty incident response. Numbers denote problems ("needs") the medics experience in the task referred to in Needs Analysis Section.

4. ITERATIVE DESIGN PROCESS

Our user interfaces evolved through multiple iterations of rapid prototyping and user feedback. Initial iterations gathered input from a broad range of EMS personnel, technologists, and usability experts through cognitive walkthroughs, usability reviews, and round table discussions. Final rounds of iterations used interviews to focus upon individual user needs. Each iteration and its implication on our design are described below. The scope of this paper covers the design decisions for the electronic triage tag and patient monitoring software. The final discussion section summarizes the design principles that we learned and followed for the overall system. The following section describes methodology for two key aspects of our design: 1) vital signs monitoring and 2) usability engineering.

Our first prototype contained three LEDs to indicate priority levels, a push button to set the triage color, and a pulse oximeter sensor to continuously monitor heart rate and blood oxygen concentration. Medics would strap the E-tag on the patient's neck or arm (like they would do with a paper tag), place the pulse oximeter sensor on the patient's finger, and push a button on the E-tag to set the triage color. As each E-tag is turned on, it self-configures into a wireless mesh network and transmits patient data to a monitoring laptop or PDA.

Upon completion of an initial prototype, we attended the 2005 Fire, Rescue, and EMS Expo and conducted cognitive walkthroughs with five technology exhibitors with prior EMS experience [12]. Feedback on the software focused on improving the adaptability and customizability for patients, and user preferences. Feedback on the E-tag focused on two major problems: 1) limited visibility of LEDs under bright sunlight 2) lost of triage status if the E-tag loses battery power. Medics also suggested that patients may accidentally push the button and unknowingly re-triage themselves to a new priority level.

Feedback from cognitive walkthroughs of the first prototype prompted the following changes in the second prototype:

- Software: Customizable detection algorithms for each patient allowing users to set preferences (e.g. font size, alert modes).
- E-tag: An LCD display on the E-tag and colored insert card.

In the second E-tag prototype, we removed the push button and used a colored insert card to set the triage color. This prevented the patients from accidentally changing their triage colors by toggling the button. Two additional benefits of the colored paper is that it is not battery-depended, and it maintains visibility under bright sunlight. The colored card contained four triage colors (black, red, yellow, and green) and the prototype displayed the proper triage color depending on the card orientation. When a paramedic inserts the prior side of the card, the E-tag triggers the appropriate LED to light up.

In the second round of development, cognitive walkthroughs were conducted with two experienced user interface designers, two medical informaticians, and three groups of EMS providers in a round-table format. We gathered feedback on the layout, font and image sizes, and wording of components in the interface. Medics focused upon the misuse, learnability, and accessibility of the E-tag. Unfortunately, the medics found the colored-card insert to be troublesome to handle and disliked the idea of having more than one component to keep track of.

Key changes in the third prototype are:

- Software: Alerts and status codes were changed to commonly accepted color codes (pink=stable, blue=critical)
- E-tag: The card-insert feature was removed and password button added to keep patients from re-triaging themselves.

5. NEEDS ANALYSIS

In surveys, we asked users to rank needs on a continuum of 0-7 based upon how often they experienced the problem (0 = never a problem, 3 = sometimes a problem, and 7 = always a problem). We also demonstrated our prototypes to our target users through interviews and round-table discussion. While analyzing the electronic triage tags, users ranked how well these technological solutions would affect their workflow and identified additional properties that the new system should contain.

Problem 1. The task of recording patient medical history, allergies, and pre-existing conditions is essential, but too time-consuming during a disaster. (Rating: $\overline{X}$= 3, s=0.63) *Solution:* Handheld devices upload information from wearable patient records and transmit that information to the EMS officer.

Problem 2. I have trouble reading information from triage tags (e.g. text rubbed off or illegible. (Rating: $\overline{X}$=3.2, s=0.89] *Solution:* Handheld devices allow medics to input and review patient information in text form.

Problem 3. Paper triage tags provide little room for manually recording important information, such as medication details and treatments. (Rating: $\overline{X}$=3.32, *s*=1.21] *Solution:* Handheld devices allow medics to record patient assessments and transmit it to a remote patient medical record database.

Problem 4. I am in the treatment area and I need to monitor a large number of patients waiting to be transported. This can be challenging in a mass casualty situation. (Rating: $\overline{X}$=4.53, *s*=0.84] *Solution:* E-tags transmit vital signs to mobile patient monitoring station, which in turn analyzes vital signs for abnormalities and alerts medics of critical conditions.

Problem 5. It is not always clear where patients have been transported to. (Rating: $\overline{X}$=4.7, *s*=0.81] *Solution:* E-tag track patients by associating the patient location with the location of the base station or PDA (GPS-equipped).

Problem 6. The tremendous amount of paperwork that I need to complete **after** the disaster. (Rating: $\overline{X}$=5.54, *s*=0.83] *Solution:* Patient information is uploaded through to a database to allow for automated report generation.

Problem 7. (off-site personnel) My bird's-eye view of the disaster scene is degraded due to insufficient and out-of-date information. (Rating: $\overline{X}$= 4.67, *s*=0.57] *Solution:* Website show real-time patient vital signs and locations.

Problem 8. (Medics) Communicating patient information to the incident commander is not efficient. (Rating: $\overline{X}$=3.14, STD=1.54] *Solution:* Patient information (e.g. triage status, location, assessment) is displayed on web portals for commanders.

Problem 9. (Medics) Communicating patient information to the receiving hospital is not efficient. (Rating: $\overline{X}$=3.0, STD=0.89] *Solution:* Websites allow hospital staff to access real-time vital signs and transportation progress of patients who are en route to their facility.

Problem 10. (Medics) As an arriving ambulance to an incident, it is hard to know where to retrieve my patient. (Rating: $\overline{X}$= 1.67, STD=1.03] *Solution:* Handheld devices show maps annotated with the locations of patient, providers, ambulances, and designated zones. Medics can locate a patient setting their triage tag to buzz or blink.

Problem 11. (Medics) Private ambulance companies take patients from the scene without permission from the transport officers. (Rating: $\bar{X}=$ 0.67, STD=0.82] *Solution:* Transport officers can designate patients that should be transported by remotely triggering the E-tag to blink. Any patients who are taken off the scene without authority would be easily identified by their non-blinking tag.

6. USER INTERFACE DESIGN

The following section summarizes key design decisions for the user interface (UI) in regards to the E-tag, vital sign monitoring, and patient management. A summary of the design principles discovered and implemented through our iterative design process is presented in Table 2. The final AID-N system displays the triage status, vital signs, location tracking, information display, and alarm signaling. Four colored LEDs (red, yellow, green, blue) on the tag are used to designate triage colors (red, yellow, green, black). An amber-colored LED designates contaminated patients during hazmat emergencies. The E-tags were designed with consideration for colorblind medics. The LED colors are placed in order of priority with a priority number labeled next to it. Therefore, the medic has three modes for identifying the priority level: color, position, and label. An instruction card is on the back of the E-tag for medics unfamiliar with the devices.

Table 2: User interface design principles form Mass Casualty Incident patient monitoring systems

Principle	Application to emergency medical response applications
Learnability	Provide guidance for tasks: Display descriptive text when cursor hovers over a button.
	Provide visual feedback to users' actions: Use a marker to indicated when a patient's electronic tag is turned off
Familiarity	Use familiar workflow terms: label users with common terms such as "triage officer", "staging area"
	Match the system with current practices: Integrate systems to in non-disruptive ways to promote use during routine ambulance runs.
	Use common conventions for symbols, abbreviations, and text: Label with roman numerals commonly printed on paper triage tags.
Simplicity	Hide unnecessary functionality: Tabs and menus hide action buttons.
	Provide non-redundant information: Deploy an overview pane that shows essential vital signs while hiding other details.
	Provide all-inclusive devices: Avoid using loose parts on wearable devices which may be lost or forgotten.
Accessibility and Customizability	Enable customizable language, font, and font size.
	Provide multiple types of alarms: Incorporate alarms that can be displayed on the software, buzz on E-tag, blink on E-tag, or be turned off.
	Consider patient physiological differences: provide multiple pulse oximeters (e.g finger, ear, pediatric).
	Allow manual override of automation: auto-adjust alarm parameters for each patient, but allow users to adjust parameters or turn off alarms
Minimize Hazards and Errors	Prevent user mistakes: Use a password button on the electronic tag to prevent patients from triaging themselves. Hide on/off button inside rigid case protector so it is not easily flipped.
	Minimize false alarms: Auto-adjust vital signs monitoring thresholds by considering patient physiological differences (e.g. age, medical history) and environmental conditions
	Eliminate, protect against, or warn against hazards: Breakaway lanyards a used to attach E-tags around the neck to prevent choking.
Failsoft	Plan for failures: Continuously save state of the system. If the computer crashes, users can restart from previously saved states.
	Plan for unreliable networks: Incorporate ad-hoc wireless mesh networking capabilities.
	Provide backups: print a writeable over on the back of E-tags, so it can be used as a paper-triage tag in the event the E-tag fails to operate.
Wearability	Consider weight, size, and battery-life: minimize the footprint of the E-tag to reduce storage space requirements, ease medics' load, and provide for patient comfort.
	Ensure water-resistance: devices must be water-resistant to decontamination procedures

The design process identified vital signs to be measured, useful medical sensors, and scalable algorithms for vital sign trends analysis. Based upon current protocols and discussions with paramedics, candidate vital signs are: 1) temperature, 2) pulse, 3) blood pressure, 4) respiratory rate, 5) oxygen saturation, 6) peripheral vascular perfusion, 7) mental status, and 8) electrocardiography. We narrowed this list of candidates based upon the performance of available sensors. To appraise sensor performance, we gathered a large list of noninvasive sensors and weighed each sensor upon the following criteria: 1) ease of use, 2) portability, 3) wearability, 4) ruggedness, 5) power consumption, and 6) capability of providing continuous vital sign data. Those that best fit these criteria were a blood pressure cuff, pulse oximeter, and a two-lead electrocardiogram. Next, we conducted an anonymous survey of six medics with over 90 years of combined exerience to assess the importance of the candidate vital signs to user needs. Respondents were asked to rank vital signs on a 7 point likert scale. Our results indiated that the pulse rate and oxygen saturation were rated to be the most important vital signs. Based upon this analysis, we decided to use pulse oximeter as the primary sensor for the electronic tag. We also implemented a wireless blood pressure cuff as a separate module that could be applied to patients who required an additonal level of monitoring.

We developed vital signs analysis algorithms based upon published detection methods implemented by existing patient monitoring products. Paramedics and physicians were queried to determine which vital sign trends should be detected. To stimulate discussion, the interviewees were supplied with a list of the hypothetical cardiovascular and respiratory complications and asked them to review how they would detect these conditions using vital sign trends.

The patient management user interface displays summary panels for all patients that contain the patient ID, triage color, wireless connection strength, and latest vital signs. All the patient summary panels are listed in one scrollable panel, sorted by priority and waiting time. When a paramedic clicks on a patient summary panel, that patient's vital sign graphs are displayed in a graph area. This dashboard approach allows the user to maintain an overview of all patients while drilling down to the details of a single patient.

When an anomaly is detected in the patient vital signs, an alert appears on the user interface. All current alerts are listed inside a panel, making multiple alerts easy to manage. The paramedic can locate a patient in trouble by selecting a "Ring Patient Audio" feature, which will sound a buzzer and blink the lights on the patient's electronic tag.

Throughout our iterations of user feedback sessions, we were cognizant of any concerns that the emergency medical response community had in regards to our technology. Below, we present a list of recurring concerns expressed by the user community on the developing technologies and how we addressed each concern.

Concern 1 - *Training*: The medics may forget how to use the system after using it only once, since disasters do not occur frequently. *Solution:* AID-N was integrated with Michaels ambulance software and can monitor patients in routine ambulance runs.

Concern 2 - *Maintenance*: The technology may be idle for prolonged periods of time and should not require continual maintenance. *Solution:* Most software components developed in Web 2.0 technologies. The software is maintained and tested at the server and all software updates are transparent to the user.

Concern 3 - *Reliability*: System must function even if the existing telecommunication infrastructure is damaged. *Solution:* We used redundancy and provided devices with multiple communication paths through an ad-hoc mesh network of devices.

Concern 4 - *Cost*: System cost must be low enough to support mass casualties. *Solution*: We selected low cost components in the E-tag hardware (e.g. low-cost IEEE 803.15.4 radio, disposable pulse-ox, and ECG sensor modalities).

Concern 5 - *Differences in vital statistics between patients. Solution:* Customizable alerts that adjust thresholds based on patient age, height, and preexisting patient records.

Concern 6 - *Medic Habits*: All devices must be durable enough to sustain repeated drops, easy to carry, and simple to use. *Solution*: We following a user-centered design process by working in close collaboration with the EMS staff to address their needs and incorporate their feedback in our designs.

Concern 7 - *Pulse Oximeter:* Patients in shock or in cold environments may not register an accurate heartrate and oxygen saturation on the pulse-ox. *Solution*: The E-tag provides multiple pulse-oximeter sensor options (e.g. finger clip, finger wrap, toe wrap, and ear clip attachment) to be used for a wide range of environments and patients [21].

7. IN-SITU USABILITY STUDY

AID-N was tested in a simulated mass casualty event. The drill brought together EMS, the public health department, a hospital, and a public school which was set up as an auxiliary care center. Two groups of eight responders operated on two parallel triage, treatment and transport areas. There were ten patients on each team, who played out a custom pre-scripted series of injuries and conditions. One EMS group used traditional tools (control group) consisting of the following: 1) paper triage tags, 2) clipboards and pencils, and 3) handheld radios. The other group operated with our system of: 1) electronic triage tags with vital sign sensing, location tracking, and wireless ad hoc mesh networking capabilities, 2) a laptop that monitors patient for critical physiological changes, 3) a website and central server that delivers real-time information to off-site response team members, 4) handheld devices for capturing patient data relevant to follow-on treatment.

All patients were triaged at the incident and held on scene for 22 minutes, due to a delay in transport. Upon arrival of a transport vehicle, responders made decision to transport the highest priority patients to the hospital, and the remaining patients were moved to a temporary treatment center. Our hypothesis was that the electronic group would demonstrate increased access to real-time patient information and reduced communication burden.

The electronic team reassessed the vital signs of patients more frequently than the paper group ($r = 0.642$, $p < .01$, $n = 22$). Although the team using the electronic equipment received only 10 minutes of training prior to the start of the drill, responders commented that the E-tags were extremely easy to use. The time for responders to triage all 10 patients and report the triage information to the incident commander was 8 min 40 sec in the electronic group and 9 min in the paper group. The E-tags did not hinder responders' speed of operation, while the amount of information being collected and communicated increased because the electronic team gained an added benefit where patient vital signs were automatically captured by the motes. Patient photos and details were captured by PDAs. This information was successfully transmitted to members of the electronic group who were located off-site of the disaster (hospital emergency department nurse, public health official).

The high first responder to patient ratio in this simulation made it unnecessary for providers to continually check their patients' vital statistics because patients were in easy view. In real-life settings where the provider to patient ratio is much lower and patients cannot be watched so closely, the increased efficiency and thoroughness of the E-Tag system could alert providers to patient status changes the providers might otherwise miss. The system was also able to reduce the communications burden of some key personnel. The incident commander and transport officer in the E-tag group conducted fewer radio calls (command: 34 times; transport 15 times) than the incident commander and transport officer in the paper group (command: 42 times; transport: 20 times). However, group membership was not correlated with radio call frequency ($r = 0.142$, $p = 0.601$, $n = 16$).

8. DISCUSSION

Our user-centered approach allowed us to understand the users, their work flows, and their problems. This process made it possible to design solutions that address the urgent needs in the emergency response community with technological solutions. During the initial interview phase, we discovered 12 major needs. Following several rounds of demonstration of prototyped solutions where six more needs (50% additional) were discovered. Although our iterative process unearthed additional needs beyond our initial results, the list of needs we have reported is by no means finalized. Through more iterations, more needs will likely be discovered. Nevertheless, through multiple iterations of user feedback, we have identified many significant user needs. With each iteration, we reevaluated our old needs and added additional needs.

Prototype demonstrations were a tremendously valuable method for the discovery of user needs. By seeing the possible solutions, our users saw new possibilities in their line of work and realized more gaps and shortcomings in their workflows.

During our surveys, we identified that many situational-specific problems. Problem 16, for example, (unauthorized transport of patients by private ambulance companies) was rated as a severe problem by medics present at a particular disaster but rated as non-problem by medics who had not experienced that disaster.

We also identified conflicting needs between the paramedics and upper level officers, often during the round-table discussions when multiple stakeholders (front line paramedics, officers, and incident commanders) were able to discuss their concerns with the technology together. For instance, incident commanders valued GPS tracking of the members as a means to ensure the safety of their team members. In contrast, front-line medics did not value the GPS, viewing the added burden of carrying a GPS receiver as unnecessary and unrelated to triage and stabilization of patients. As a compromise, the PDA recorded and transmitted the location of each medic only when they view/modify a patient record on their PDA.

Due to the chaotic nature of emergencies, our system faces the difficulty of operating in situations that challenge instrumentation designed for use in the controlled environment or clinical situations. Furthermore, these new technologies warrant changes to the workflow of the EMS processes. For instance, through the in-situ study, we discovered that while the electronic triage system more efficiently gathered more information on the patient's vital signs, the electronic triage device shifted the medic's attention away from the patient. During the post-drill debrief, patients noted that medics would often approach them to read their vitals off the E-tag but did not spend time in looking at the patients. Keeping the needs of the patient in the forefront of the system is essential in correctly analyzing the patient's condition. Further development of workflows to efficiently use the new tools as well as training is necessary steps to ensure the effective utility of our system.

A massive amount of data was collected during the mass casualty incident. Further methods need to be designed to analyze this data after the incident to improve the procedure during mass casualty incidents. A combination of stress, limited resources, and time pressures can overwhelm the users. Providing the emergency personnel with useful information to aid their decision making process is invaluable in reducing worker burnout.

9. CONCLUSIONS

Recent events in global terrorism, military conflicts, and natural disasters raised international concern on casualty care and suggest that there will be increasing demand for efficient field triage solutions in the future [6]. We presented a design centered approach that created an electronic triage system for mass casualty events. An iterative, user centered design process resulted in a system that changed how medics interacted and how information was collected, distributed, and displayed. A qualitative and quantitative analysis of the system was done to evaluate how well our electronic triage system fit their needs, improved their workflow, and changed how the medics interacted with each other and the technology.

In AID-N, the continuous update of information not only provided medics with real-time updates of the patient's status, but also captured more data about the mass casualty incident. This investigation indicated that additional data is beneficial only if it is presented in an understandable format to the first responders. In addition, a massive database of information about the triage event will enable one to more clearly understand what exactly occurs during these events and allow one to further optimize the triage process.

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