Process Improvement and Consumer-Oriented Design of an Inter-Organizational Information System for Emergency Medical Response

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Abstract

This research employs Information Systems Design Theory (ISDT) to design, develop, and assess an inter-organizational information system for Emergency Medical Services (EMS). This research takes both a goal-oriented process improvement and consumer-oriented approach to systems design. While IS development has a rich history of focusing on improving organizational processes, the consumer-oriented approach aims to incorporate socio-psychological considerations of users. System goals include 1) improve patient information exchange from emergency responders to emergency department practitioners, and 2) develop the system in a manner that users believe to be ethical and otherwise intrinsically motivating to use. Data collection, system requirements, and system design and kernel theories are presented, design propositions are evaluated, and implications discussed on the role of consumer-oriented approaches in the development of multi-organizational, multi-consumer information systems.

1. Introduction

Consumer-oriented approaches to IS development are on the rise in the healthcare domain [2, 3, 4]. Motivated by the need to increase patient safety and quality of care, health information systems have largely been developed to improve the efficiency and effectiveness of health care processes and support decision making for practitioners [28, 29]. While process efficiency has long been an important motivator for IS development, IS professionals must increasingly take into account a wide range of other end-user socio-psychological motivations, such as relational, ethical, and enjoyment factors. Characterized by a close association between users and system developers as co-creators, consumer-oriented approaches focus on innovating, designing and developing information services that users *want* to use. Consumer-oriented approaches lend themselves to a customizable and service oriented design, as opposed to stand alone software products, that can address a potentially wide range of needs across many user types [26, 27].

We posit that a consumer-oriented approach may be useful in combination with goal-oriented process improvement objectives. As such, we have taken both approaches in the development of an IT artifact for multi-organizational Emergency Medical Services (EMS). We aimed to develop a system to 1) meet the business process goals of organizational leaders, and 2) to meet the consumer needs of the people on the "front lines", motivated by socio-psychological factors. We have taken a design science [1] approach to develop CrashHelp, a mobile and web-based information service for use by various emergency medical practitioners involved in the end-to-end continuum of emergency patient care.

While information systems design theory (ISDT) has been used extensively as a research framework, gaps remain in terms of how to employ it within the consumer-oriented development approach, and when eliciting requirements from distinct and different user types across different yet cooperating settings. Our driving research question is: *How can a consumer-oriented information system be developed to achieve both a set of desired business process goals and a set of consumer goals?*

2. Background: EMS information systems

Information technology is generally viewed as a key "enabler" of coordination and decision making. Health Information Technology (HIT) has been found to help improve the quality of patient hand-offs, lead to decreased errors of omission, and reduce risk of patient injury during the transition of care [13] [14]. Past research identifies the potential role of HIT in significantly reducing emergency medical response

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times [7, 8] and improving the care provided to the injured at varying points across the inter-organizational continuum of emergency care [9, 10] [6, 11, 12, 15, 16]. However, emergency department (ED), trauma center, and other health practitioners typically receive little contextual information about a patient and his/her related emergency incident information from pre-hospital emergency responders at or before a patient enters the hospital. This is largely due to the dynamic, fast-paced, and stressful emergency environment that does not allow for timely data capture [6, 30, 33]. There are currently no examples of IS artifacts that address this gap. Thus, researchers have applied design theory in this project to address the needs of EMS practitioners in this regard.

This research focuses on developing a set of tools aimed at addressing the needs of different types of consumers across the emergency medical service chain. The first application is a mobile wireless application that enables emergency responders to collect incident and patient information. The second is an application that displays information collected by emergency responders in a visually oriented interface for emergency department (ED) and hospital physicians and nurses. The goal of the cross-organizational (pre-hospital + hospital) system is to enable better emergency medical response decisions. To accomplish this goal, researchers must understand the operational and socio-psychological needs of the information consumers.

3. Consumers of EMS IS

What, or who, is a consumer of EMS information systems? The definition of a consumer has been construed broadly [27]. In this research, we identify a consumer as someone who provides, interacts, manipulates, and uses EMS information. We view these users as "consumers" for several reasons. First, the system under development is positioned to be an innovative and web-based service [26]. Second, while users represent certain specific job functions, many are only loosely associated with a specific organization. Third, the users of the system play a paramount role in determining whether or not the system will be used. These types of users are highly resistant to change and must participate in system design if the system is to be used. Finally, we view these consumers as being critical to the creation of content (producers) that will be valuable to their peers (consumers).

Consumers of EMS information systems include any individual involved in an emergency event from beginning (patient medical onset) through response, medical treatment, and patient outcome – as presented in the Time-Critical Information Services (TCIS) framework (see Figure 1). These roles may include 911 operators, paramedics, fire fighters, emergency medical technicians (EMTs), law enforcement officers, nurses, physicians, surgeons, patients, bystanders, and others. While we envision many opportunities for various consumer types to use EMS information, to date the development of CrashHelp has focused on a select few user types for purposes of scope and practicality. The information consumers in this study include paramedics, EMTs, and emergency department nurses, physicians, and surgeons. It is important to note that these users span two traditionally disparate, yet cooperating institutions – pre-hospital emergency response and hospital emergency medicine (emergency department, trauma, etc.).

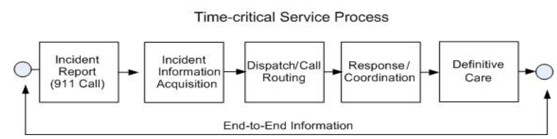

Figure 1. Time-critical service process

3.1 Consumer driven theory for EMS: ethics in healthcare organization

Health care providers deliver health services based on several varying motivations including economic, legal, political, organizational, and managerial goals. Ethics in Healthcare Organization maintains that the top priority in all health care organizations should be first and foremost a focus and concern for the patient [20]. In short, health care professionals should be driven by a desire to help, to do the "right thing" for a patient. This core socio-psychological priority became apparent in prior work by the research team [7, 9, 10] and is the foundational consumer oriented goal for CrashHelp. That is, CrashHelp must be designed to address an intrinsic need, or motivation, to care for people, combined with personal satisfaction from using the system, including a belief that using the system will indeed help a patient. As such, consumer requirements must be well understood in order to design and deliver a service that will be embraced. Here, consumer emotional responses to an information service play a significant role [34].

3.2 Socio-psychological motivations to use IS

Socio-psychological theory has focused a great deal of attention on *intrinsic motivation,* or the motivation to engage in an activity primarily for its own sake, because the activity itself is interesting, engaging, or in some way satisfying. Theorists have proposed that intrinsic motivation is made up of several interrelated active components including interest, excitement, elation, happiness, surprise, and fun [35, 36, 37]. To what degree do these components also carry over to the use of IS by EMS professionals?

Prior research indicates that many emergency medical professionals are highly motivated intrinsically. For both pre-hospital (EMTs) and hospital (physicians, nurses) personnel, this intrinsic motivation is characterized by a desire to help people. Physicians have long been known to be motivated by the need to help others [31][25]. Intrinsic motivation is perhaps most apparent with EMTs, whom are highly satisfied with their jobs [23], rate their peers high in terms of professional integrity, empathy, and patient advocacy [23], yet earn annual salaries that are far lower than most other health care professionals [6]. They also experience a high degree of health and safety hazards, experiencing a fatality rate that is more than twice the National average for all job positions and is comparable with Fire and Law Enforcement jobs [6]. Furthermore, approximately 36% of EMTs nationwide are volunteer workers. This number is as high as 50% - 70% in some states. Indeed, a National longitudinal study showed that most EMTs entered their profession for the purpose of helping others by providing medical care [24].

What is less clear is the role that technology can play in enacting these intrinsic motivations. For example, we found that the EMS culture is highly resistant to technology change, generally, and that any action or process that is perceived to be a distraction from patient care is unacceptable and vigorously resisted [7][10]. However, we also found enthusiastic support to perform IS related tasks that are believed to help patients. Turning to artifact design, we have sought to apply these intrinsic motivation concepts to the analysis and design of the CrashHelp prototype.

4. Research approach and methodology

This study employed a multi-method research approach. First, transcripts and findings from prior phases of research were data-mined and analyzed including interviews and observations with EMS practitioners across two case studies [7, 10], quantitative performance data analysis and group interviews on EMS performance information [21], and EMS IS architecture analysis [32].

Second, a subsequent phase of interviews were held with pre-hospital and hospital EMS practitioners from one of the case study locations previously studied to validate and inquire more specifically about the desired features of a cross-organizational EMS information system. Interview transcripts from all phases were assimilated, analyzed, and categorized into a set of information challenges and needs across each of the dimensions of the TCIS framework.

An information system design theory (ISDT) approach was then employed, based on the findings, to infer how an artifact might function and to identify the underlying theoretical drivers for developing a prototype system [1, 38]. Table 1 shows the ISDT framework used to formulate findings into design elements for the prototype. As shown, this analysis was used to establish the meta-requirements, meta-design, kernel theories, and testable design product propositions. The meta-requirements in Table 1 illustrate the class of goals to which the theory applies. The meta-design describes the class of artifacts to meet the meta-requirements.

We applied several kernel theories for governing design requirements including: Continuity of patient care (i.e., patient centered process improvement), Ethics in Healthcare Organization (and intrinsic motivations) [20], Wide Audience Requirements Engineering (WARE) method [5], consumer-oriented information system design, and agile development methods [19]. Testable design product propositions are illustrated to test whether the meta-design satisfies the meta-requirements. Findings from qualitative evaluation are presented in the evaluation section below.

The ISDT presented herein is dedicated to the development of knowledge useful to both research and practice [17]. The goal of the research is to afford EMS practitioner decision makers information not previously accessible, in a manner not previously delivered, while producing a technological artifact aimed to extend scientific knowledge about how consumers across multi-organizational systems use such information [18]. In this manner, the research team was able to design, analyze, and improve the system in a structured way that satisfied both design outcomes and the prescriptions and disciplines of this theory-based framework.

4.1. Data collection, analysis and ISDT development

As noted above, researchers analyzed and applied findings from multiple research phases to formulate an ISDT. A wide range of requirements elicitation methods were used across research phases including observations and context focused interviews in real work settings, group discussions and elicitation, cognitive techniques such as scenario development, and prototyping, scenario-building / storyboarding, and drew from WARE methods to address needs of a wide audience of users [5, 41]. Feedback was obtained from a wide range of potential consumer types, stakeholders, and researchers to inform the usability, success factors, and value proposition of the CrashHelp model. These were held in a group interview format that included the following stakeholder types: ED physicians (4), trauma physician (1), EMTs and paramedics (6), EMS Administrators (4), EMS Operations Managers (2), Public Health Administrators (3), medical informatics researchers (3), injury prevention researchers (3), and EMS IT Managers (3).

Participants were presented the CrashHelp model and then asked open ended questions about the validity of the system problem and need, the perceived value of CrashHelp, the desired improvements for the system to provide value to each type of practitioner, and how the system could be modified to improve patient care.

Findings from across research phases helped elicit the meanings, needs, issues, and benefits of an open, standardized, integrated, secure, and private information sharing environment. These findings were utilized in the design of the CrashHelp prototype design described in the following section.

Table 1. ISDT Design Elements

Design element	Description
Meta-requirements	- Support end-to-end EMS operational processes - Support practitioner socio-psychological needs to provide good patient care - Reduce the negative health impacts of motor vehicle crashes - Humanize the EMS response - Support patient decision making for EMS practitioners
Meta-design	- Capture patient information relative to an emergency incident - Visualize information, as desired by users, to make patient health care decisions - Provide means for communicating with EMS personnel about a patient and incident - Provide means for communicating priority health indicators - Provide ways to assist non-technical users to visualize patient outcomes - Provide means to customize information views for users - Provide flexibility in use of hardware devices
Kernel theories	- Process Improvement, Continuity of Care - Ethics in Healthcare Organization - Wide Audience Requirements Engineering (WARE) method - Consumer-oriented information systems - Agile development method
Testable design product propositions	- CrashHelp will be perceived by EMS practitioners as helpful to patients. - CrashHelp will improve EMS health care delivery processes - CrashHelp will improve EMS patient health outcomes -It is possible to display spatial data and key clinical indicators in a consumer-oriented display -It is possible to provide EMS incident and patient profiles -It is possible to provide real-time incident and patient status

6. CrashHelp prototype design

Past research findings indicated that a system to facilitate information exchange between pre-hospital and hospital environments in a way that accompanies a patient at the ED does not exist. Therefore, the design science approach was deemed suitable to this project and an IT prototype system was developed (dubbed CrashHelp).

The prototype was designed to integrate information regarding EMS responses and hospital treatment of motor vehicle crash (MVC) patients within the Mayo Clinic trauma jurisdiction.

From the outset, the goal of CrashHelp was to design a system that consumers would want to use. The operational goal was to enhance decision making, help reduce emergency response times, and improve the quality of healthcare. Within this set of goals, the design considered how such a system could embrace or at least leverage the intrinsic interests of consumers in the system.

6.1 Requirements for CrashHelp prototype

We envision CrashHelp to eventually include an array of rich, interactive, visual and multi-media information such as maps, two-way video streaming, interaction between actors in real time, and potentially a social networking context. To date, we have developed only those features and services that we have elicited from consumers.

Findings were synthesized and generalized into guiding principles, based on specified kernel theories, to meet process improvement goals and consumer socio-psychological goals as follows:

Process Goals:

- ***The system must facilitate information hand-off*** *at* or *before* the patient hand-off to the ED. Responses included: "We have to find a way to get it [information] to the ED on time. There has to be some way to resolve this." (ED Physician)

Consumer-oriented Goals:

- ***The system must have a visual display*** and user friendly look and feel similar to what can be experienced on the latest hand held device apps, multi-media, social networking, and location based apps. It must not take long to enter information. Responses included: "I'll take a picture of an accident with my own personal cell phone and show it when I get there [to the ED]." (Paramedic)

"I want to have some way to see a picture and then, you know, let the medics in the field know what I think. Like, move in closer [with the camera] or ask a question [to a patient]." (Trauma Surgeon)

- ***The system must provide value added context*** to decision makers at the ED/Trauma Center in a way that can be visualized and consumed quickly and easily. Responses included: "I think the basic information, the context of what happened on scene helps out the most. We need that." (Director, Trauma)

"…picture says a thousand words…it could help us know if we should assemble our [trauma] team or not."

- ***The system must allow customizable information services*** for a variety of EMS information consumers. Responses included: "I want to see what I want to see. I think most clinicians are that way." (ED Physician)

- The system must humanize the EMS response. In direct reference to the intrinsic interests of consumers of the system, our research has indicated that EMS personnel want to know what happened to the patients they treated – not necessarily because of organizational accountability, but because they "care". Responses included: "If I want to go back and see what happened [to a patient I cared for] I pretty much have to call someone [at the hospital] who's really not supposed to tell me but you know, I know them and they tell me. Did she live? Did she go home?" (EMT).

Consumer-oriented and process improvements goals:

- ***The system must interfere in the least possible way with care processes*** and practices. Responses included: "I don't have time to enter all that [patient] information. If I have a choice between stopping profuse bleeding and messing around with a laptop, the choice is pretty obvious." (Paramedic)

"We already give a verbal snapshot to the doc. If I could just…record it and let him listen whenever he wanted to, then I wouldn't have to wait. I could get back out on the street faster." (EMT)

Consumer design features were identified to embed within the software application. These included:

- End-to-end patient information that can be viewed in the system from the start to finish of an EMS incident.
- A multi-organizational view of the system and use by practitioners. A common operating picture (COP) is important for many organizations and user types.
- Many consumer types including dispatch, EMS, ED, trauma, and public health oversight organizations.
- Visualization of a range of data, images, video, and audio from a range of devices (e.g., mobile phones, other EMS software), quickly consumable for a fast paced environment.

Functions were identified and analyzed in an iterative agile development manner using pre-factoring and model-driven refactoring [22]. The following are the functional requirements:

- Data Capture – utilize handheld, mobile technologies to capture digital voice, video, images, and GPS data for display and easy access in the ED.
- Incident Map – visually display spatial data about an incident for situational awareness and decision support.
- EMS Incident Profile – visually display patient information including multi-media information along with key clinical indicators (i.e., age, response time).
- EMS Incident Detail – allow drill-down on an incident to display gallery of image, video, digital voice files pertaining to a specific patient and incident.

Also the following consumer-oriented requirements were defined:

- Multimedia Content - Content can be created, used, visualized, and manipulated by consumers
- Web-based – Information can be accessed and viewed based on web-based design principles, that is, to allow for flexibility in the use of information and accessibility for a wide range of users.
- Interoperable Services – Middleware technology provides a means for integrating and routing information securely and privately between devices and interfaces. It allows for flexibility in creating a

range of configurable information services, enables configurable interface visualizations, and facilitates interaction with other services and applications. The middleware allows for any compatible device to securely interoperate.

- Open Development Platforms – As much as possible, software is built using open (i.e., open source) and standardized technologies to increase accessibility of the system to the widest range of users, allowing them to choose the devices they want to use.
- Security – Identification, authorization, and authentication of users, secure data transfer, encryption and decryption are required for transmitting and saving patient data as required by HIPAA rules. A key challenge exists in balancing this requirement with the consumer need for usability.
- Data standardization - Data standardization is required for integrating data into a larger information network. The National Emergency Medical Services Information System (NEMSIS) standards as well as others (e.g., NTDS, HL7) provide frameworks for standardizing CrashHelp data.

6.2 CrashHelp prototype components

Drawing from the requirements above, the CrashHelp system was developed utilizing a range of current and emerging concepts and technologies including Web 2.0, geographic information system (GIS) Mashups, web services, dashboards, and multi-media mobile applications. CrashHelp has two primary interfaces utilized by end-users, 1) a hand held device for paramedics to collect information at a crash site, and 2) a web-based application to visualize integrated information at the ED. A set of server-side applications and databases are used to integrate, aggregate, and "mash-up" information for viewing in the web-based application.

The CrashHelp Prototype consists of four components: handheld application, middleware, ED Dashboard, and ED application (see Figure 2).

The handheld application for use by EMTs and paramedics was developed using the Java programming language on the Google Android operating system. The application for use in the ED for physicians, nurses, and administrators can be accessed using any device running a standard web browser. The Android application enables EMTs to collect data for a crash incident and patient, take a picture of the scene, record audio notes, and capture video for the incident. Basic patient data, GPS location and EMT contact information are also collected. These data are then sent to the CrashHelp database (See Figure 2).

The middleware plays a role for integrating between devices and interfaces. It facilitates security capability when transmitting data to and from devices and interfaces, such as the ED Dashboard. The ED Dashboard visualizes EMS data captured by EMTs and paramedics utilizing map, picture, audio, and video inputs.

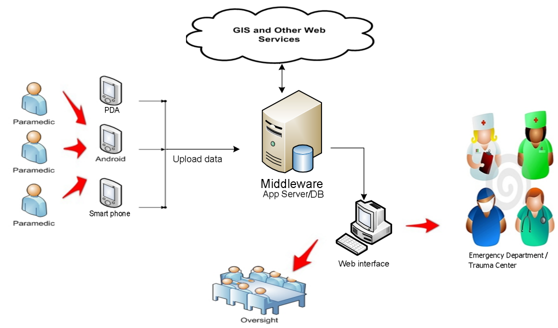

Figure 2. CrashHelp System Architecture

The ED Application displays incident and patient information collected from the Android application, as well as from other potential data sources such as computer-aided dispatch, trauma registry, and patient care record systems. CrashHelp displays the patient and incident information on a map. Detailed incident information can be displayed from the initial screen. Location information is also aggregated from Google and Microsoft web services to provide mapping, street level, and "bird's eye views" of an incident location. The CrashHelp system architecture is illustrated in Figure 2 above.

7.3 The mobile, handheld application

The handheld mobile application was developed for paramedics and EMTs to use at a crash site. The first user screen allows creation of a new incident (Figure 3 below). Simple navigation then allows the user to take pictures, video, or digital audio, record basic patient information (i.e., name, age, gender), and send the data along with GPS coordinates, name of the medical attendant, and phone number of the device to the system server.

6.4 ED dashboard

Once incident information has been sent to the CrashHelp server, it can be accessed in the emergency department via a standard web browser. Web services can be created at the Java Glassfish middleware for consumption based on what the user wants to see. The prototype (Figures 4-5) displays an example simplified list of incidents within a web browser. Incident status, map view and location of incident, estimated time of arrival and distance to arrival, patient demographics, and priority indicators are shown. From this dashboard list view, a detailed view can be drilled down on.

Figure 3. Mobile Application Screen Shots

The web application provides users (doctors and nurses) an interface to the system with the following information :

- **Incident Information:** Time/date of incident, Estimated distance and time of arrival and Incident number (from dispatch)
- **Patient Information :** Age, name , gender for all patients
- **Media Display** : images, audio and video that were taken at the incident scene by paramedics.
- **Map View :** Locations of incidents and ambulances on the map in near-real time.
- **Priority Indicators:** information such as patients' age, number of patients in an incident, and arrival time are used to calculate severity level scores for prioritizing how and where an incident is displayed in the interface.

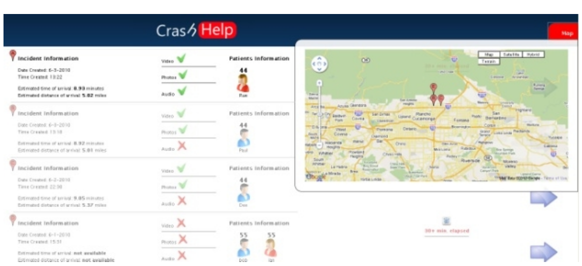

Figure 4. ED Dashboard with Map

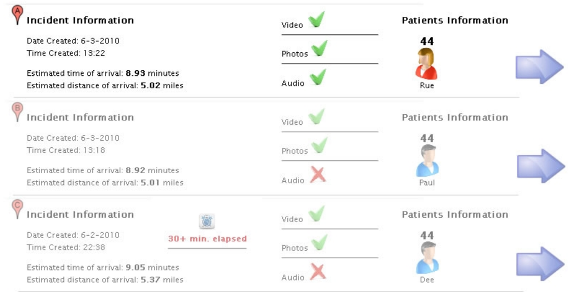

Figure 5. Close-up of ED Dashboard View

The detailed ED dashboard view displays a picture gallery, video and audio gallery, and detailed map view with estimated ambulance routing information of each incident as collected by EMTs. It also displays a Microsoft Virtual Earth map, and a Google Street View map (see Figure 6).

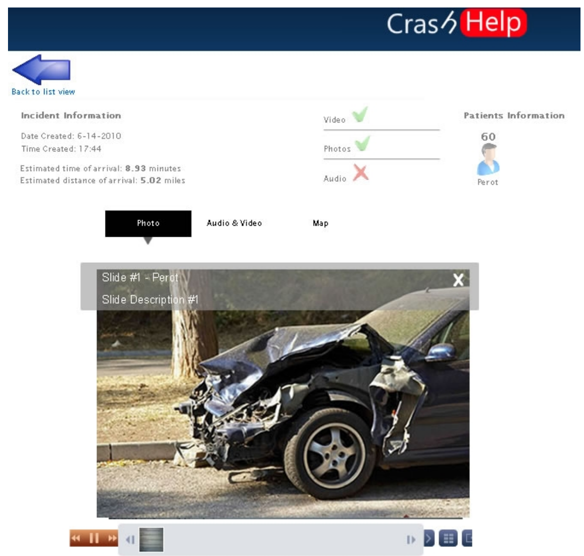

Figure 6. Detailed View with Picture

6.5 ED application

Some consumer types want to visualize incident information at an oversight level. As such, web services allow for a configurable, web based map view along with aggregate data. Figure 7 displays current (near real-time) aggregate incident information using graphical gauges. Users are able to view information such as the average age of all incident patients, the average response time of all EMS units, and allows for integration of data from other sources, such as the average injury scores as assessed by health practitioners including the glasgow coma score (GCS). An interactive map displays the locations of current incidents and related resources (e.g., hospitals) in the Rochester, Minnesota region. A user may select an icon to view more detailed information about each resource. A user can select from different base map configurations, Google or Microsoft. When the user selects an incident icon, the system allows a user to "drill down" and display detailed incident information.

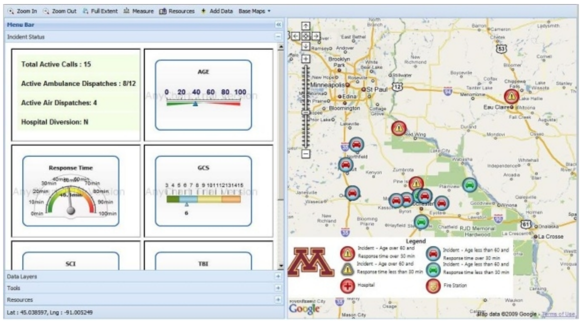

Figure 7. Aggregate View for Oversight

Similarly, when a Fire Station or Hospital symbol is selected, detailed information about that resource are displayed. Various icons represent combinations of age and response time indicators to represent "alerts" to practitioners.

6.5.1 Data layers for analysis and oversight

The ED Application provides detailed resource information such as incidents, fire stations and hospitals, cell phone service areas, locations of traffic cameras, fatal crash hot-spot statistics, and current weather information. These features allow for post-incident analysis, training, and medical reviews across incidents. When a user selects a view of incidents, hospitals, fire stations or traffic cameras, the CrashHelp system displays a resource icon on the map. When a user selects a view of cell phone service areas, fatal crash hot spots, or current weather, the CrashHelp system displays colored area boundaries.

7. CrashHelp evaluation

Several themes from qualitative analysis emerged when the prototype was presented to EMS stakeholder groups. These groups included academics from the Public Health Informatics program at the University of Utah; EMS practitioners and researchers from the Federally sponsored Inter-Mountain Injury Prevention and Control research center; practitioners and policy makers from two State level EMS Agencies (Minnesota and Utah); practitioners from an EMS professional organization (EMS Safety Foundation), and practitioners from the case study location (Mayo Clinic Medical Transport).

First, the visual "list" view and GIS graphical display combined with performance indicators and dashboard gauges were viewed as valuable for providing situational awareness about the emergency and trauma system service demands, for providing important information for making timely emergency care decisions for individual patients, and for Quality Assurance / Quality Improvement activities during post incident reviews. Additionally, the GIS interface was viewed as a user-friendly platform for accessing needed information. The "YouTube"-like display and function of photo and video galleries was appreciated and spurred discussion about the potential value of "mining" emergency pictures and video for educational purposes.

The ability to capture and display pictures, video, and voice recordings along with time and location information was viewed as potentially the most significant feature of the prototype. While EMTs continue to be wary of the time it takes to use technology during an emergency, there was significant interest, particularly from younger EMTs, to take pictures and video. Younger EMTs felt the handheld device and application followed trends from industry technology companies (e.g., iPhone, YouTube). Older EMTs likewise thought the younger EMTs would think the device was "cool." These features were viewed as valuable for enabling ambulance teams to "get back out on the street faster" and for affording trauma teams the information needed to help determine when to assemble a trauma team (or not) prior to patient arrival. Most believed the multimedia information could be helpful to provide better patient care.

Participant discussions also revealed the value of minimizing the amount of manual data capture required out in the field. Simply capturing age, gender, name, incident number, and injury level indicators were thought to be "good enough." This data together with location, image, voice, video, and automated emergency response time stamps were believed to be highly useful. Many participants continued to look for ways to reduce the number of clicks and touches in the interface and believed the application functionality needed to be scaled back even further.

The prototype elicited discussion about potential interactive features, such as communicating between users at an incident location and the hospital. Though several ideas were discussed (e.g., 2-way video conferencing), users were unsure how such features could be incorporated into CrashHelp. Most importantly, both in-the-field emergency response technicians and emergency room doctors expressed strong interest in establishing a direct communication between them, and valued the opportunity to give and receive information. Finally, participants believed an important next step would be to further develop and pilot the application and evaluate its ability to enable timely and quality information handoff across pre-hospital and hospital settings.

8. Implications and next steps

We believe that this study has contributed to research and practice. In terms of research, it illustrates a multi-method approach to analyzing and developing an ISDT drawing upon both emerging consumer-oriented approaches and more traditional goal-oriented, process improvement approaches. The use of ISDT as a guiding framework enforced the systematic inclusion of "hard" and "soft" factors in the design. The hard factors included the quantitative analysis approach to requirements gathering and process improvement. The soft factors included the consumer-oriented approach and interaction with stakeholders motivated by socio-psychological needs.

From a methodological perspective, a contribution of this research is an illustration of the use of multiple research methods to iteratively design, develop, and prototype an innovative system for the exchange of information across a traditionally disparate multi-organizational setting. The next important step is to determine if and how these expressed desires to utilize the system can be translated into actual utilization and satisfaction thereof. Plans for such testing are underway.

In terms of practice, this research offers an ISDT for a new type of IT system; an inter-organizational, consumer-oriented information system for EMS drawing generally from social-psychological aspects rooted in healthcare ethics and intrinsic motivation. An ISDT is an important contribution as it guides system developers and sets an agenda for academic research. The paper also offers guidelines for developers of information systems that involve exchanging sensitive information and data visualization in near real-time settings. Finally, the paper presents a set of development tools (middleware) and methodologies that provided the CrashHelp team with sufficient flexibility to build a highly customizable and consumer-oriented system.

Future work may consider expanding the design of this system to include other consumer types. For example, patients and bystanders are important emergency medical actors. CPR instructions to bystanders over the phone have been associated with a 50 percent improvement in the odds of survival compared with cases in which no CPR is administered before the arrival of EMS [39, 40]. How could these consumer types interact with information during emergency scenarios? Second, while this research elicited consumer responses using a variety of methods, much work is required to discover the most appropriate mix of methods for multi-organizational consumer-oriented design. Future research should seek to evaluate the utility of other robust approaches.

9. Acknowledgements

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