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RESEARCH REPORT

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Improving Emergency Response to Motor Vehicle Crashes: The Role of Multi-media Information

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16. Abstract

The motivation for this study is to reduce the adverse impacts of trauma caused by motor vehicle crash (MVC), including rural regions, where crashes account for a high percentage of trauma injury and death. One key aspect of reducing adverse effects of MVCs is to improve emergency medical services (EMS)—that is, to increase the efficiency and effectiveness of emergency and transportation services to respond, clear the scene of the crash, provide patient care, and take a patient to the correct hospital. The study centered on a 6-month demonstration of a multi-media (voice, video, pictures, data) EMS application ("CrashHelp") in the greater Boise area. For the pilot test period, 1,513 CrashHelp reports, 306 digital images, and 1,121 voice recordings were sent by 81 paramedics to 8 hospital emergency departments (EDs). EMS and ED staff generally thought the system was easy to use, captured useful information, and could play a role in enhanced clinical decision-making. The voluntary nature of the pilot program did result is some inconsistency of use over time and this limited the extent to which the information was utilized. In summary, when the system was used it was found to be helpful. Therefore, future efforts should focus on protocols and procedures that would allow for easy integration of multi-media information in the workflow of crash response and subsequent hospital care.

17. Key Words CrashHelp; Hospital Emergency Departments; Ambulances; Emergency Response Time, Emergency Medical Services		18. Distribution Statement Copies available online at http://itd.idaho.gov/highways/research/	
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List of Acronyms

CAD	Computer aided dispatch
CERS	Center for Excellence in Rural Safety
CGU	Claremont Graduate University
DOT	Department of Transportation
ED	Eemergency department
EMS	Emergency medical services
FHWA	Federal Highway Administration
ePCR	Electronic patient care record
ITD	Idaho Transportation Department
ITS	Intelligent Transportation Systems
MVC	Motor vehicle crash
PSAP	Public Safety Answering Point
TMC	Traffic Management Center

Executive Summary

Introduction

Motor vehicle safety is a key focus area in the Idaho Transportation Department's (ITD's) strategic plan. In 2012, 184 fatalities occurred on Idaho roadways. The economic cost of Idaho's fatal crashes was estimated at $2.3 billion, accounting for approximately 50 percent of the total economic cost of Idaho crashes in 2012. The total economic cost of crashes per person in Idaho was $1,454. The Idaho Transportation Department, Office of Highway Safety, continues to lead efforts to improve highway safety and reduce fatalities through the "Four E's" of highway safety: enforcement, engineering, education, and emergency response. Due to Claremont Graduate University's experience in using technology to enhance emergency response to motor vehicle crashes (MVCs), ITD supported this research project that centered on a 6-month demonstration and evaluation of a multi-media EMS application ("CrashHelp") in the greater Boise area.

"CrashHelp" for EMS

The motivation of this study is to reduce the adverse impacts of trauma caused by MVCs. One key aspect of reducing adverse effects of MVCs is to improve emergency medical services (EMS)—that is, to increase the efficiency and effectiveness of EMS and transportation services responsible for responding to MVCs, clearing the scene of the crash, providing on-scene patient care, and transporting a patient to the appropriate hospital. The CrashHelp System is a combination of mobile and web-based information systems aimed at helping EMS field personnel (i.e., ambulance crews consisting of emergency medical technicians (EMTs) and paramedics) to more efficiently capture essential incident and patient information and to securely transmit that data to Emergency Department (ED) and Trauma Center medical staff (see Figure 1).

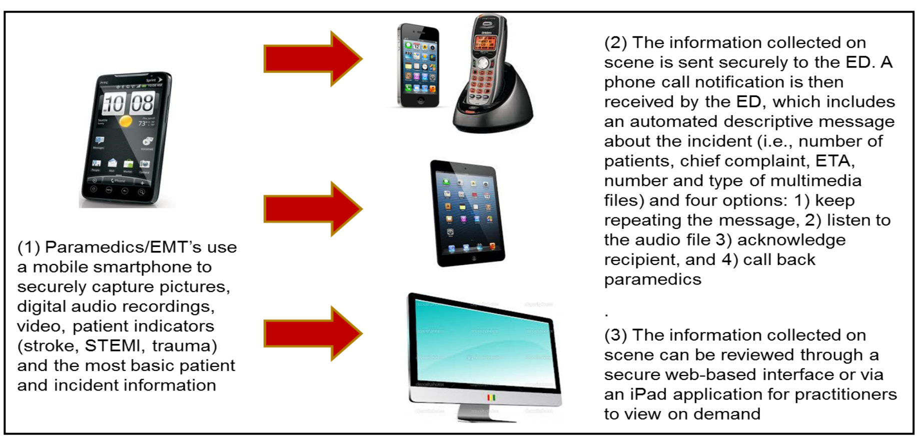

Figure 1. CrashHelp Functional Components

CrashHelp Idaho Design

This Idaho pilot test utilized version 2.0 of CrashHelp. The new (2.0) version of the system was developed to meet the following requirements:

- The system must allow paramedics to capture multi-media information through a user friendly interface similar to what can be experienced on the latest hand held device, multi-media, social networking, and location based applications.
- The system together with the user, must transmit information in a timely manner at or before the patient arrives at the ED.
- The system must have an easy to use visual capability to display the information that was sent by paramedics to ED personnel.
- The system must be capable of capturing and securely sending basic patient information including: age, date of birth, gender, name, incident location Global Positioning System (GPS), patient indicators (i.e., chief complaint of the patient or primary impression of the paramedic), and critical interventions (i.e., immobilized patient, cardiac pacing).
- The system must allow ED users to visually drill-down on an incident record through a graphical user interface to display multi-media details including a gallery of images, video, and digital audio files pertaining to a specific patient and incident.
- The system must immediately notify the ED users when a new incident is sent by a paramedic unit via a text message, email, or automated phone call.
- The system must provide health industry standard data, device, storage, and network transmission security; as well as application availability.

Six Month Evaluation

The live pilot testing began in November, 2012 and ended in May, 2013. A mixed-method approach of quantitative and qualitative analysis was employed. Quantitative usage data was collected throughout the duration of the pilot to assess frequency of use, the amount of time it took personnel to use the system, and overall technical performance. For the pilot test period, 1,513 CrashHelp reports, 306 digital images, and 1,121 voice recordings were sent by 81 paramedics to 8 hospital EDs. Tables 1 and 2 show the total number of incident records sent by EMS to hospitals and recorded in the system, and the number of images, video and audio files attached and associated with those incidents. As shown, EMS attached a proportionately large number of images (pictures) and audio files to incident records. Very few video files were transmitted. For the pilot study, the majority of incidents were sent to hospitals that typically receive the largest number of patients in the Boise metropolitan area.

Table 1. Number of Audio, Video, and Image Files Sent Using CrashHelp

Number of Files	File Type
1,121	Audio
306	Image
5	Video
1,432	**Total**

Table 2. Number of CrashHelp Reports Sent to Each Hospital

Number of Reports	Medical Center
406	St. Alphonsus-Boise
280	St. Lukes-Boise
235	St. Lukes-Meridian
231	West Valley
214	St. Alphonsus-Nampa
100	St. Lukes-Nampa
31	St. Alphonsus-Eagle
13	Ada County Paramedics Non-Transport*
3	St. Alphonsus-Nampa Health Plaza
1,513	**Total (100%)**

** Ada County Paramedics-Non-Transport: Used by Ada County Paramedics when a record was created, but transport is not needed or declined by patient*

Qualitative data were collected through a series of group interviews with practitioners who used the system at least once during the pilot. Interviews were held in person and/or via a conference call. EMS and ED medical staff generally thought the system was easy to use, captured useful information, and could play a role in enhanced clinical decision-making for incidents presenting long transport times. In general, participants noted, that the advantages of the secured asynchronous communication that the system provided over the traditional radio communication including**:** allowing paramedics to record audio at their own convenience and not have to wait for the ED to respond before talking; allowing charge nurses to repeat listening (reprocess) the audio recording, as many times as needed; allowing for multi-tasking, whereas paramedics could essentially record information when convenient to them, and charge nurses could view it when convenient for them. Most participants agreed that pictures can provide important insight into a patient's condition. For example, one paramedic explained that taking a picture was helpful in validating the patient's trauma condition and therefore expediting the trauma activation process*: "*We had a vehicle crash and roll-over that involved 9 people. We took pictures and sent them in and it helped the ED prepare for what was about come in." ED staff had similar observations: "Telling us that the driver was, you know pinned, and in pain just wasn't the same thing as seeing it in the picture they [EMTs] sent us [the ED]. It just made it way more obvious that there were serious injuries and so we acted pretty quickly to that.*"*

Challenges

The voluntary nature of the pilot program did result in some inconsistency of use over time and this limited the extent to which the information was utilized. The pilot suggested that it is challenging for EMS practitioners to make use of the technology in time-critical patient care situations. When the system was used it was found to be helpful. Future efforts should focus on protocols and procedures that would allow for easy integration of multi-media information into the workflow of crash response and subsequent hospital care. Mandatory usage would allow for a closer understanding of the clinical value of the system. Additionally, a business model and stakeholder analysis would be important to determine the long-term sustainability of the system. Finally, future research should aim to assess the impact of using the CrashHelp system on patient outcomes.

Chapter 1
Introduction

Introduction

Motor vehicle safety is a key focus area in the Idaho Transportation Department's (ITD's) strategic plan. In 2012, 184 fatalities occurred on Idaho roadways. The economic cost of Idaho's fatal crashes was estimated at $2.3 billion, accounting for approximately 50 percent of the total economic cost of Idaho crashes in 2012. The total economic cost of crashes per person in Idaho was $1,454. The Idaho Transportation Department, Office of Highway Safety continues to lead efforts to improve highway safety and reduce fatalities through the "Four E's" of highway safety: enforcement, engineering, education, and emergency response. Due to the research team's experience in using technology to enhance emergency response to crashes, ITD supported this research project for a 6-month demonstration and evaluation of a multi-media EMS application ("CrashHelp") in the greater Boise area.

The motivation for this study is to reduce the adverse impacts of all motor vehicle crash trauma, especially the ones occurring in rural regions, where crashes account for a high percentage (81 percent) of trauma injuries and death. One key aspect of reducing adverse effects of MVCs is to improve EMS—by increasing the efficiency and effectiveness of emergency and transportation services to respond, clear the scene of the crash, provide patient care, and take a patient to the appropriate hospital.

Through prior work, the Center for Excellence in Rural Safety (CERS) research team at Claremont Graduate University (CGU) identified several critical gaps. These included the need to more seamlessly communicate patient and incident information from EMS to hospital EDs and to other agencies responsible for highway operations. Evidence from literature described in the following sections of this report suggests that this information could significantly impact patient care. Yet, to date there has been limited work in Intelligent Transportation Systems (ITS) or other EMS research to address these gaps.

Consequently CERS-CGU research team has developed a software system called CrashHelp. CrashHelp is a Smartphone application that enables emergency responders to collect multi-media information about a crash site and crash victim's on-scene and send that information directly to EDs. This provides hospitals with advanced notification of crash severity and related information that can be used to prepare for the patient's arrival. With seed funding from U.S. Department of Transportation (DOT) through CERS and related ITS Institute program, the application was tested in 2011 for 3 months in the greater Boise area. The initial 3-month pilot included Canyon County and Ada County Paramedics and 6 hospitals including St. Alphonsus-Boise, St. Alphonsus-Nampa, St. Alphonsus-Eagle, St. Lukes-Boise, St. Lukes-Meridian, and West Valley Medical Centers. While initial results were very positive, including over 780 record transmittals, 500 pictures, and 500 voice recorded descriptions by EMS personnel, there was a significant need to continue the testing and evaluation of CrashHelp to help determine practitioner value of the technology across medical providers.

This report discusses findings from a subsequent Phase II testing period. While Phase I provided an initial proof of concept, Phase II research aimed to investigate technical performance of the system as well as its perceived value by emergency practitioners. Project objectives are discussed below.

Project Objectives

The goal of the project was to field test the CrashHelp mobile application in Idaho. This included testing the use and value of transmitting multi-media information from EMS personnel at MVC sites to stakeholders, including hospitals and highway operations. Specific project objectives included:

1. Continue enhancing CrashHelp software features and overall functionality including increasing simplicity of use, security, privacy of information, etc.
2. Continue CrashHelp field test evaluation for the Boise region into Phase II for an additional 6 months. This work will validate the technology and allow for future evaluation.
3. Test use of CrashHelp in one rural field location, as possible through extension of current CrashHelp implementation organizations and consider a future broader rural demonstration.
4. Continue enhancing CrashHelp software features and overall functionality including increasing simplicity of use, security, privacy of information, etc.
5. Evaluate CrashHelp outcomes at the conclusion of the Phase II field test, including implications for EMS, transportation (operations) and healthcare stakeholders.

Background: Motor Vehicle Crashes and Emergency Medical Services

Road traffic injuries are a major public health challenge that requires concerted efforts for effective and prevention.(1) In the United States, 34,080 motor vehicle fatalities occurred in 2012.(2) The economic cost of MVCs in the U. S. during 2008 is estimated at $290 billion, approximately 2 percent of the gross domestic product. Medical and emergency service costs are roughly 15 percent of this total.(1) Past research demonstrates that timely emergency medical response to MVC's can significantly reduce the likelihood of death, disability, and economic consequences.(3-5) This may be especially important in rural areas where emergency response times and the subsequent time for a MVC's patient to reach definitive care (i.e., a final destination hospital) is traditionally longer. While U.S. Census figures show that 21 percent of Americans live in rural areas. The Federal Highway Administration (FHWA) has found that about 57 percent of highway deaths occur on rural roads. Thus, a disproportionately large number of fatal crashes occur in areas where timely emergency response is needed the most, yet often difficult to come by. CrashHelp and other technological advances may help to enable more timely and efficient emergency responses for serious crashes in rural and remote locations.

Emergency response consumers need access to accurate, timely, and comprehensible information.(6,7) Patient and incident information is used at various points in time by telematics service providers (e.g. OnStar), 911 dispatchers, first responders, EMS, ED personnel, trauma physicians, crash analysts, medical specialists, and public health organizations (e.g., public health surveillance, injury prevention and control studies). However, information among these agencies is typically not shared across the incident response and care continuum.[8] For example, patient care information collected by paramedics at the scene of a MVC is not always forwarded to an ED doctor upon patient arrival at the hospital.[9] As the patient makes their way to the hospital, critical data that could aid in saving their life is often misplaced, forgotten, or otherwise not reported.[10,11]

CrashHelp: Mobile and Web Technologies to Improve Emergency Responses to Motor Vehicle Crashes

As noted above, one critical information gap is the need to more seamlessly communicate patient and incident information from EMS to "hospital" EDs, including trauma center providers. Working with practitioners at local, state, and national levels, researchers developed "CrashHelp" and conducted a Phase I pilot test for 3 months in Boise, Idaho. CrashHelp is an integrated set of technologies used to address the information and communication gaps described above. CrashHelp leverages a mobile application and SmartPhone capabilities to allow EMS to:

- Capture digital images.
- Record video and audio.
- Collect basic patient information.
- Provide timely notification to hospitals.
- Send the collected information to the appropriate ED.

The mobile application utilizes commercial 3G/4G wireless networks to securely transmit the information to CrashHelp's middleware subsystem, which immediately sends messages to designated ED nurses via pager, email and/or phone. The transmitted data can be accessed using a secure web application interface in the ED (see Figure 2). Upon logging into the web application, ED nurses can browse the newly sent incident and notify paramedics that the incident was received and reviewed. The web application allows ED personnel and EMTs to exchange text messages, if further communication is needed. Furthermore, the web application interface combines location-based services, cloud-computing storage, visualization toolkits and web-services technologies enabling incident records to be visualized in list, map and detailed views via an easy to use interface. Below, we provide a more in-depth literature review and background into the need for improved communications between EMTs and ED personnel.

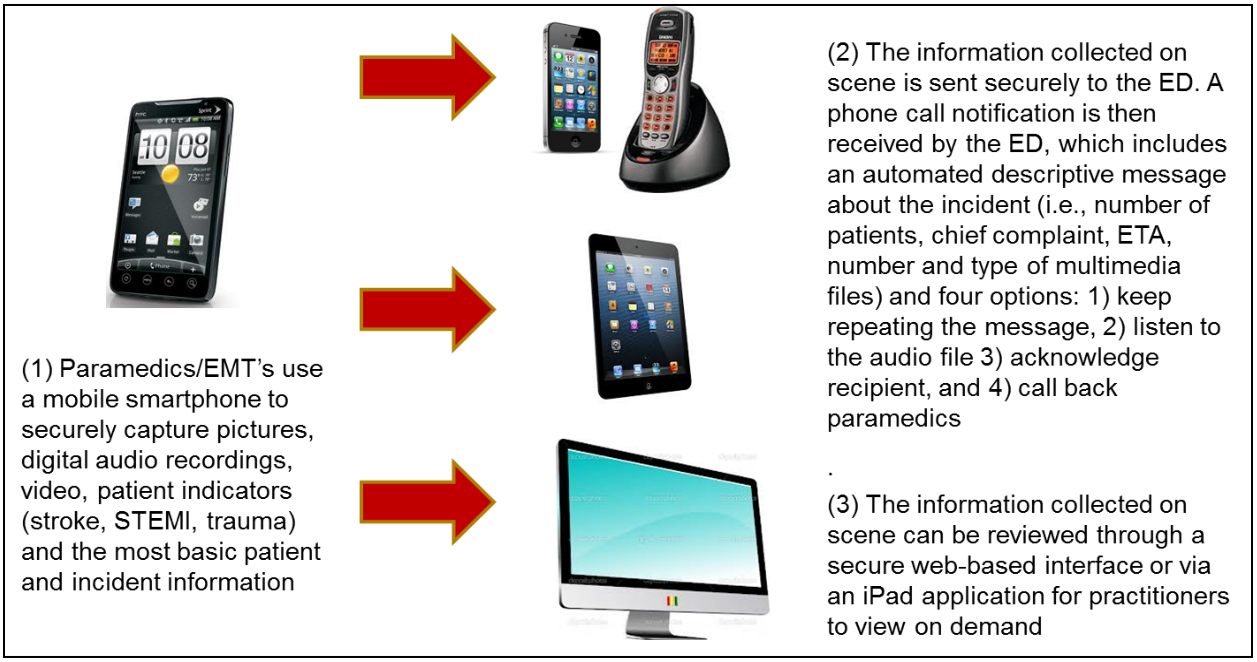

Figure 2. CrashHelp Functional Components

Background: Handoff of Motor Vehicle Crash Patients from Emergency Medical Services to Emergency Departments

The transfer of patient care and responsibility from one care provider to the next is referred to as patient handoff, or handover.[(12)] Transfer of accurate and timely information during patient handoff is a critical clinical and organizational process to ensure continuity of care, and to secure patient safety.[(13)] Communication failures in patient handoff have been cited as a major cause for nearly 70 percent of medical errors in healthcare.[(14)] The communication challenges are further magnified in fast-paced, short-stay, and critical care environments such as the ambulance or ED.[(15-19)] The nature of the communication process in emergency medical settings is complex and cognitively taxing for clinicians, further increasing information handoff challenges.[(20)]

Handover in EMS is likewise a challenging endeavor. EMS provides pre-hospital emergency medical care and/or transportation to a hospital ED. During an emergency medical incident, communication typically ensues between EMS and ED medical staff prior to and/or during patient transport and arrival at the medical facility. This information exchange is essential to the decision-making process for healthcare practitioners and for achieving positive health outcomes for patients.[(21)] Prior research has identified significant challenges to efficient, accurate, and complete information handover for communicating pre-hospital patient information to EDs for the purposes of point of care decision making including:

- Limited time for paramedics to collect and transmit data on scene or enroute using electronic patient care record (ePCR) systems.
- Limited number of tools in the field for paramedics to collect value-added multi-media information[22]
- Often fragmented communications or lack of information exchange standards and practices.[21]
- Significant reliance on the use of synchronous two-way voice radio communication technologies.[23, 24]
- Frequently missed, unreported, or incorrectly reported verbal or written information to the ED especially for more severe medical incidents or with multiple victims.

Several research reports have highlighted this challenge. For example, an analysis of over 22,000 EMS transports across a California County showed completion of a pre-hospital ePCR took an average of 39 minutes, 42 seconds (median 33 minutes, 59 seconds) after EMS arrival and patient handoff to an ED.[22] In emergency medical settings, written and verbal information is often forgotten, misplaced, omitted, or unreadable.[25-27] Often the patient will arrive at the ED in advance of a comprehensive electronic record.[28] For example, in 1 study, necessary information such as patient's name (only reported 67.6 percent of the time) was not included in the verbal report.[29] In another study, verbal information handoffs occurred for only 44 percent of patient handoffs.[18] Additionally, communication and information problems have been sited to be responsible for 70 percent and 20 percent of adverse events in healthcare institutions in the U.S., respectively. The true extent to which delays in patient information handover occurs across the U.S. is unclear.

In short, the development of the CrashHelp system was driven by:

- Inefficiencies found in EMS information handoff through prior research efforts, including the existing electronic tools being used.
- The potential benefits of using multi-media information to supplement EMS reports to the ED.

With the rapid advancement of commercial wireless networks (3G/4G) and the emergence of high-capability SmartPhones and mobile devices, many in industry and research are motivated to explore new approaches to collect and transmit voice and non-voice information. While a variety of commercial software applications have recently been introduced to the EMS marketplace, there has been an insufficient amount of research-based development and testing. CrashHelp was designed to address the information handoff challenges in the EMS handoff described above and to provide tools needed by EMS practitioners to improve responses to MVC trauma patients. The ultimate goal is to increase survivability and reduce economic and disability consequences. The field demonstration and evaluation of the system's usefulness was conducted in Boise, Idaho and the rural areas outside of the metropolitan area.

Background: Relationship Between Motor Vehicle Crash Clearance Operations and Emergency Medical Services

While improved communications across EMS and ED providers may improve MVC trauma outcomes, another goal of this study was to explore how such communications may affect related motor vehicle crash clearance operations. According to research sponsored by the American Association of State Highway and Transportation Officials (AASHTO) in cooperation with the FHWA, quick clearance is the practice of rapidly and safely removing temporary obstructions from the roadway. This can include MVCs, as well as other road obstructions such as debris or loose animals. Traffic clearance operations vary by state, however most involve multiple agencies/stakeholders with various and specific roles. In many states, these stakeholders include the Department of Transportation (DOT), law enforcement, private towing companies, road users/drivers, elected officials, fire department, EMS, medical examiner, and Animal Control.[30] Today traffic clearance operations interact with first responders and EMS in several ways, some of which are described below.

In many cases, public safety answering points (PSAPs) and/or traffic management centers (TMCs) are responsible for facilitating communication with multiple agencies and can dispatch personnel and equipment according to quick clearance procedures. Across the U.S., information is shared between agencies via phone, teletype, video, email, computer aided dispatch (CAD), cell phones, and radio including shared radio frequencies or car-to car frequencies.[31] In San Diego, California, for example, a TMC run by the California Transportation Department (Caltrans) receives information from electronic sensors in the pavement, freeway call boxes, video cameras, 911 calls, officers on patrol, Caltrans highway crews, ramp meter sensors, earthquake monitors, motorist cellular calls, and commercial traffic reporters.[32] On the Caltrans website users can check traffic conditions on a live map. In Ada County, Idaho, the TMC can control traffic signals from a desktop computer.[33] They also have incident cameras located on the freeway system whose feed can be sent directly to the police and media through a fiber optic communications network. There are also feeds to the State Communications center. Information is displayed on monitors and desktop computers and received from various sources and locations. Information is then disseminated as needed to appropriate agencies. Indeed, technology use through a TMC has become an important feature for traffic crash clearance operations and associated interactions with first responders and EMS.

The purpose of implementing these technologies is to improve responder safety, and facilitate safe, quick clearance and prompt, reliable interoperable communications.[34] Several recent projects illustrate how EMS/first responder operations interact with transportation operations for crash clearance. For example, the Redding Responder Field Test, funded by Caltrans in California, allows users to capture, annotate, and transmit incident images.[35] Weather information, maps, and aerial photos are automatically connected to the multi-media information. Users are able to “sketch” on photos and maps to provide more accurate and easily understood information in picture form. A responder can sketch directly on a photo where pavement deficiencies are located for maintenance to view. This allows exact location of incidents or needed fixes. The Redding Responder is looking to add in frequently used forms, more space for incident descriptions, and checkboxes to facilitate better information sharing. The test results from that project found that the system was very useful for facilitating meaningful communication between responders and the TMC. While the system used personal computers in the vehicles, it was suggested that mobile devices be used in the future. Multi-media may be an important component of successful programs allowing users to see incidents and problems in plain view instead of trying to explain them via phones or email. Exploring the communication and technology interface between traffic safety operations and emergency response activities for MVC incidents is still an on-going research endeavor. This project also explored how a system like CrashHelp might interface or be used by traffic safety professionals to improve coordination across agencies. Such understanding could lead to better system-wide planning that will improve responses to MVCs and overall traffic safety.

Prior Research: CrashHelp Pilot Phase I

In 2004, researchers at CGU in collaboration with the University of Minnesota's Center for Excellence in Rural Safety and Intelligent Transportation Systems Institute began investigating the role that information technology plays in enhancing EMS across the continuum of patient care. This work evolved into the design and development of CrashHelp in 2010. The first version of CrashHelp was pilot tested in the Fall of 2011 for 3 months in the Boise metropolitan area. This area was selected as a test site due to its prior record as a location for testing and implementing traffic safety and emergency response innovations. Agencies, ambulance providers, and hospitals were supportive of testing CrashHelp across the metropolitan area. The goal was to provide a working concept of operations to demonstrate system functionality, technical performance, and acceptance from practitioners. Results from Phase I included excellent technical performance and acceptance with over 800 record transmittals, 500 pictures, and 500 digital/audio recorded descriptions by EMS personnel. In general, CrashHelp use increased as medics and ER nurses saw each other using it. Medics reported that CrashHelp was easy to use and provided several potential benefits, including improved communications to the ED. ED nurses noted several potential benefits, including the utility of pictures and audio recordings. However, the research team received a great deal of feedback on the functionality of the system. For example, EMS practitioners described needed changes in the mobile application workflow. ED nurses expressed the need for an improved method to receive emergency notifications, and an improved interface within the ED for viewing CrashHelp information. As such, several improvements were planned to help facilitate seamless communications in the future. These were implemented for the project described herein and are described further below.

Chapter 2
Research Process and Methodology

As mentioned in the previous section, there was an initial 3-month pilot test (Phase 1) prior to the present study. Phase 2 of the pilot test was conducted in the Boise area inclusive of the following participating organizations: Ada County and Canyon County Paramedics, Homedale Ambulance, St. Alphonsus-Boise, St. Alphonsus-Nampa, St. Alphonsus-Eagle, St. Lukes-Boise, St. Lukes-Meridian, St. Lukes-Nampa Medical Centers, St. Lukes Health Plaza Emergency Department, and the West Valley Medical Center. Prior to Phase 2 live field testing, meetings were held with leadership from each organization and approval was secured to conduct pilot testing. Phase 2 tasks included the following:

Task 2.1: Software design and development occurred to enhance the CrashHelp application based on feedback from Phase 1.

Task 2.2: Pre-pilot implementation and testing. Several practitioners from Canyon County Paramedics, West Valley Medical Center, and St. Lukes-Nampa, and St. Alphonsus-Nampa Medical Centers participated in the initial testing in August 2012. This was to assess functional performance of CrashHelp. Enhancements were made to the system as a result in preparation for live field testing.

Task 2.3: Training and implementation. Both in-person and web-based training sessions were conducted in September and October 2012 for each participating ambulance provider organization. Hands-on training sessions lasted approximately 1 hour. A video recorded training session was distributed via the Adobe Connect web-based education and training system to participants that could not attend live sessions. A separate set of on-site training sessions were held for hospital staff. Training lasted approximately 1 hour. One charge nurse for each organization was designated to train the ED staff that could not attend live sessions. Training materials, including user guides, quick reference guides, and login information were distributed to participants. Technical implementation guides and documentation were distributed to information technology staff at each participating organization.

Task 2.4: Live field testing. The live pilot testing began on November 1, 2012 and ended May 31, 2013. Every medic unit at each ambulance agency was equipped with one Motorola Droid X or Casio Commando Android SmartPhone activated on the Verizon 3G/4G network. User names and passwords were created and distributed to each paramedic and ED managers/directors to provide access to the web application in each ED. Phone, email, and web-based support were offered to participants throughout the duration of the pilot. General system administration, security monitoring, and some technical assistance by the research team occurred throughout the pilot in order to maintain operational performance. Paramedics and nurses alike were not required to use the system at any time. Paramedic participants used CrashHelp system in tandem with their standard protocols and policies to use radios and cell phones to make a verbal report to a receiving hospital for each incident. Practitioners were invited to participate in the test and provide feedback to the research team. All participants were asked to stop using the system at any time they felt that the system interfered with patient care. Quantitative usage data was collected throughout the duration of the pilot to assess frequency of use, time of use, and technical performance. Data collected included: mobile application errors, data transmission errors, server errors; time-stamps for the collection of each data point, including for pictures, video, audio recordings, and data; the start time for creating a new record, the start time for transmitting a record, and the time of completion for a record transmittal.

Task 2.5: Participant qualitative evaluation. All paramedics and ED staff that used CrashHelp were invited to participate in a qualitative evaluation. This evaluation was to assess practitioner perspectives on the value of mobile multi-media information for improving EMS communications. Qualitative data was collected through a series of group interviews with practitioners who used the system at least once during the pilot. Participants were asked a series of questions in order to understand their perceptions about the utilization, usability, perceived value and challenges of the system and use of multi-media information in EMS communication processes and decision-making.

A summary list of questions asked during these interviews is provided in Appendices A and B. A list of group and semi-structured interview participants is shown below in Table 3. The interviews were conducted from May 22 to June 15, 2013. Interviews were recorded and notes were taken by at least one member of the research team for each interview. Data was aggregated, categorized, and summarized in the results section of this report.

Organization	Participant Description	Number of Participants
Ada County Paramedics	Paramedics	12
	Paramedic Field Supervisor	2
Canyon County Paramedics	Paramedics	7
	Paramedic Field Supervisor	1
Homedale Ambulance	Paramedics	3
	Paramedic Field Supervisor	1
Saint Alphonsus-Boise	Charge Nurse	1
	ED Supervisor	1
Saint Alphonsus-Nampa	Charge Nurses	3
Saint Lukes-Boise	Charge Nurse	1
	ED Supervisor	1
Saint Lukes-Meridian	Charge Nurses	3
Saint Lukes-Medical Plaza	Charge Nurse	1
Saint Lukes-Nampa	Charge Nurses	3
West Valley Medical Center	Charge Nurses	2
	ED Supervisor	1
Total Organizations: 10	**Total Paramedic Participants**	26
	Total ED Participants	17

Interviews were not conducted with St. Als Eagle due to scheduling conflicts.

Table 3. Interview Participants

While ITD did not use CrashHelp, researchers also sought to understand how the use of CrashHelp might impact motor vehicle crash clearance operations and how the system might be enhanced to provide benefits in the future. A group interview was held on May 23, 2013, with 4 ITD transportation safety professionals to gain insight on the issue. Results from this discussion can be found below (See page 24).

Chapter 3
Results

System Design Enhancements and Software Development

Phase II of the Idaho pilot test utilized version 2.0 of CrashHelp from the initial proof of concept test conducted in 2011.

The system was developed to meet the following requirements:

- The system must allow paramedics to capture multi-media information through a user friendly interface similar to what can be experienced on the latest hand held device, multi-media, social networking, and location based applications.
- The system together with the user, must transmit information in a timely manner at or before the patient arrives at the ED.
- The system must have an easy to use visual capability to display the information that was sent by paramedics to ED personnel.
- The system must be capable of capturing and securely sending basic patient information including: age, date of birth, gender, name, incident location Global Positioning System (GPS), patient indicators (i.e., chief complaint of the patient or primary impression of the paramedic), and critical interventions (i.e., immobilized patient, cardiac pacing).
- The system must allow ED users to visually drill-down on an incident record through a graphical user interface to display multi-media details including a gallery of images, video, and digital audio files pertaining to a specific patient and incident.
- The system must immediately notify the ED users when a new incident is sent by a paramedic unit via a text message, email, or automated phone call.
- The system must provide health industry standard data, device, storage, and network transmission security; as well as application availability.

The above requirements were built into the CrashHelp system utilizing a range of current and emerging concepts and technologies including web services, encryption, and multi-media mobile applications. The system has 3 primary components:

1. A mobile SmartPhone application for paramedics and EMS to collect basic patient and incident information.
2. Enterprise middleware component to support data processing, security, and integration using web services.
3. An ED web application for hospital practitioners to be notified of and view emergency patient and incident information (see Figure 3).

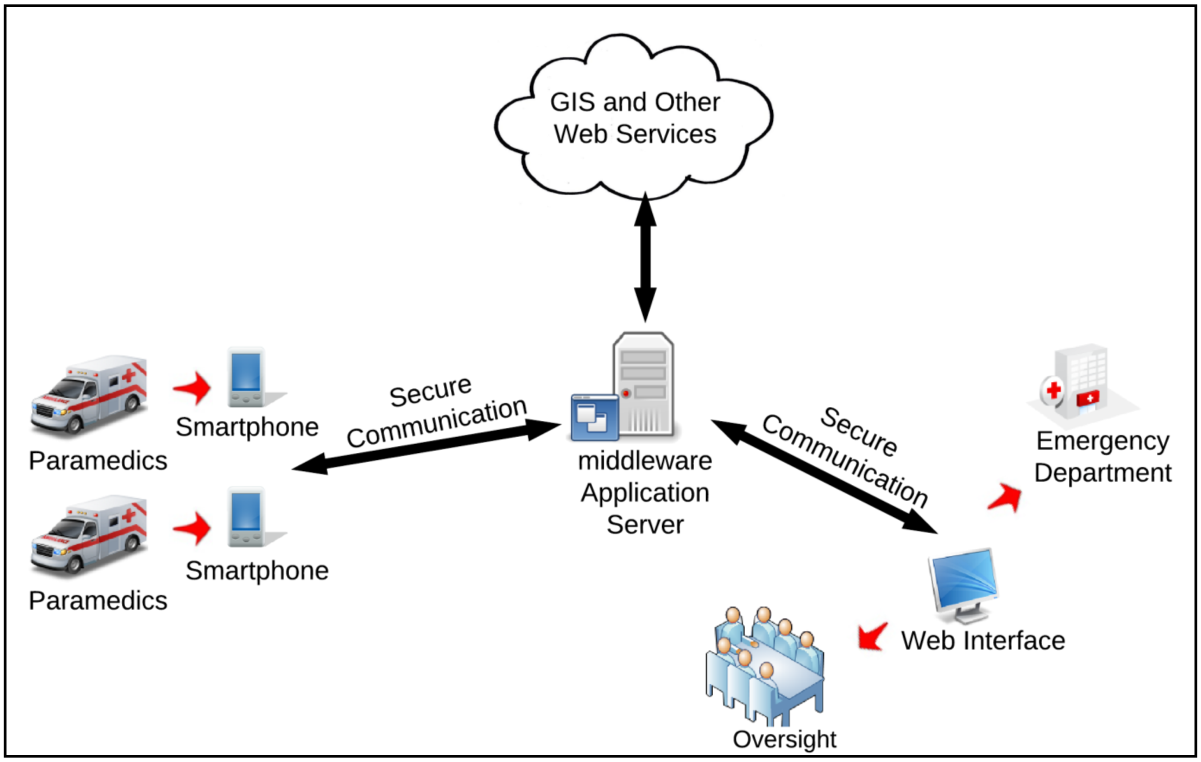

Figure 3. CrashHelp Architecture Overview

Figure 1 provides an overview of CrashHelp's functional components. The mobile application for paramedics does not require any specific types of data to be collected prior to notifying a receiving ED. The reason for no mandatory fields is to accommodate data entry while avoiding the risk of the system interfering with patient care processes. Further, this allowed researchers to assess how EMTs and ED users would use the system given the freedom to collect incident data without predefined protocols. Only basic demographic data (i.e., name, gender, age, date of birth), a short checklist showing the chief complaint (i.e., Cardiac Arrest, Brain Attack/Stroke, Chest Pain, General Medical, Level 1 Trauma (highest priority), Level 2 Trauma, Level 3 Trauma (lowest priority), Respiratory Arrest, Seizure, ST segment elevation myocardial infarction **(**STEMI)), and interventions that matter to the ED (i.e., Cardiac Pacing, continuous positive airway pressure (CPAP), biphasic positive airway pressure (BiPAP), Immobilized, Intubated/Artificial Ventilation, Psychiatric/Combative) are captured and sent. Pictures and audio recordings can also be captured and sent.

Upon sending the data, notifications are automatically sent via text message and automated phone call to pre-selected providers in the ED. Pictures, audio recordings and patient data can be accessed through a web interface or iPad application. ED practitioners can then send acknowledgements and other communications to paramedics via text messages. Mobile applications and device security, automated geo-location and mapping services, and administration features are also built in.

The CrashHelp version 2.0 that was implemented during Phase II of the Boise pilot test included the following modifications prior to implementation:

- Improved Android device security.
- iPad application for use in the ED.
- Improved data transmission reliability.
- Ability to send automated phone call notifications to a receiving ED about an incoming patient.
- Extensive log files for evaluating system usage.
- Miscellaneous bug fixes.

Usage

A goal at the outset of the project was to explore whether the system would be used and how it might be used. For the pilot test period, 1,513 CrashHelp reports, 306 digital images, and 1,121 voice recordings were sent by 81 paramedics to 8 hospital ED as shown in Tables 1-5.

As previously noted, participation in this study was voluntary. Paramedics were not required to use CrashHelp by their respective organizations. Similarly, each of the features within CrashHelp was optional. For example, there were no mandatory data entry fields, nor were there requirements that a multi-media file be captured or transmitted. The only mandatory aspect of the system was that medics enter a predefined unique identification number prior to sending an incident record. This was required for security and identification purposes. Results showed that the 81 paramedics that participated represent 52 percent of the total population of 157 paramedic transport employees that were invited to participate across EMS transport providers in the Boise Idaho area. More than half of the 81 participants (n = 42) sent a minimum of 10 CrashHelp records during the test period. Table 4 shows the paramedic usage tiers. At the high end of usage, there were 2 participants that sent a total of 127 CrashHelp records each, and a total of 6 participants that sent over 50. Several paramedics that did not use the system, and managers at the ambulance agencies, provided the following reasons for non-participation:

- Lack of interest in using new technologies – e.g., non-SmartPhone users.
- Lack of belief that such technologies could make a difference for patients.
- Lack of organizational policy requirement to use the system – i.e., they would use it if required.
- Lack of interest in participating in a short-term project that would “go away” at completion.
- Belief that using the system in parallel to existing communication processes would be too time consuming – i.e., they were willing to use one system, but not two at the same time.

Table 4. Number of Paramedics that Sent CrashHelp Reports per Usage Tier (Percentage of Total Participants)

Usage Tier	Canyon County	Ada County	Homedale Ambulance	Total
20 or more	8	13	0	21 (26.0%)
Between 10 and 19	8	13	0	21 (26.0%)
Between 2 and 9	9	13	2	24 (29.6 %)
1 record	6	7	2	15 (18.5 %)
Total	31 (38.0%)	46 (56.7%)	4 (5%)	81

Overall, participation across paramedic providers was generally representative of the size and volume of the provider and provided an adequate experience base to further understand the potential value of using the CrashHelp system.

Tables 5-8 shows the total number of incident records sent by paramedics to hospitals and recorded in the system, and the number of images, video and audio files attached and associated with those incidents. As shown, paramedics attached a proportionately large number of images (pictures) and audio files to incident records. Very few video files were transmitted. For the pilot study, the majority of incidents were sent to hospitals that typically receive the largest number of patients in the Boise metropolitan area (see Table 6).

Table 5 shows the distribution of incident records sent by each paramedic provider. Interviews and feedback with participants during and at the end-of-the-pilot revealed that Canyon County Paramedics participated more at the outset than Ada County Paramedics due to

- Medic units having past experience using SmartPhones on the job (SmartPhones were new to Ada County medics).
- Strong support and enthusiasm from upper management that included a self-created “train the trainer” program.
- The hospitals serviced by Canyon County decided to significantly engage in the pilot project.

Table 5. Number of CrashHelp Reports Sent Per Ambulance Provider

Number of Reports	Ambulance Provider	Average Number of On-Duty Medic Units
883	Ada County Paramedics	11
616	Canyon County Paramedics	7
14	Homedale Ambulance	1

Table 6. Number of CrashHelp Reports Sent to Each Hospital

Number of Reports	Medical Center
406	St. Alphonsus-Boise
280	St. Lukes-Boise
235	St. Lukes-Meridian
231	West Valley
214	St. Alphonsus-Nampa
100	St. Lukes-Nampa
31	St. Alphonsus-Eagle
13	Ada County Paramedics Non-Transport*
3	St. Alphonsus-Nampa Health Plaza
1,513	**Total (100%)**

** Ada County Paramedics-Non-Transport: Used by Ada County Paramedics when a record was created, but transport is not needed or declined by patient*

Table 7 shows the distribution of patients across a range of patient indicators. Indicators are optionally selected via a drop down menu by paramedics using CrashHelp application prior to sending incident records to hospitals. These selections are intended to provide information to the ED about the type of medical condition/chief complaint of the patient as described by the patient and/or family, friend, or bystander and/or the professional opinion of the medic about the primary medical issue facing the patient. Many of the incidents (18.2 percent) did not include a textual patient indicator as many medic participants elect to report patient indicators using the CrashHelp audio recording feature. However, the table shows what the medics entered voluntarily. As described in the following sections describing practitioner perspectives, using CrashHelp may have the most significant impact for the most severe patients, including those exhibiting:

- Trauma Level 1
- Trauma Level 2
- Trauma Level 3
- Motor Vehicle Crash
- Brain Attack/Stroke
- Cardiac Arrest
- Seizure
- STEMI

These medical issues accounted for 10.7 percent of the total incidents where a patient indicator was reported. While it is also important to note that the large majority of incidents reported were not for critical patients, these numbers are generally representative of the proportion of severe patients transported by EMS versus those that are considered less severe and/or non-emergency. According to qualitative feedback from participants, the reasons for not entering a patient indicator included:

1. Doubts that the ED would find such information valuable or that ED practitioners would look at the information at all.
2. A lack of awareness by some medics that the feature existed in the application.
3. An inability to enter the information due to the need to care for the patient instead in a time critical situation.

Exploring what information was collected and sent to EDs is a step towards understanding overall usage by participants. The following sections provide further insight into usage through analyzing interview and focus group feedback from participants.

Table 7. Number of Incidents Grouped by Incident Indicator Type

Number of Incidents	Indicator Type
552	General Medical
172	Ground Level Fall
116	Chest Pain
79	Shortness of Breath
76	Abdominal Pain
67	Other Trauma
52	Seizure
37	Motor Vehicle Crash
29	Level 3 Trauma
21	Brain Attack
10	Minor Trauma
7	Level 2 Trauma
5	Cardiac Arrest
5	STEMI
5	Level 1 Trauma
4	Respiratory Arrest
1	Stroke
276	No Indicator Selected
1,513	**Total**

Practitioner Perspectives

In addition to usage statistics, EMS and ED participants were interviewed to assess perceptions on the use of CrashHelp. Interviews were held in person and/or via conference calls. The dimensions assessed for EMS and ED participants (respectively) are presented below along with summary findings from the interviews.

In general, participants discussed how using CrashHelp enabled thought processes and potentially led to augmented decision-making to expedite patient care processes such as:

- Transfer of patient to higher level-of-care facility.
- Pre-registration of patient at hospital prior to arrival (registration must occur prior to care).
- Order diagnostics and medical evaluation (e.g., labs, radiology, medications).
- Assemble a specialty medical team (e.g., Trauma, stroke).

Challenges to using CrashHelp included:

- The most urgent incidents, where CrashHelp could potentially provide the most value for medical decision making, are often the most difficult to capture information due to the time-critical nature of the emergency.
- The voluntary nature of the usage led to some concerns about whether the ED would fully utilize the information if provided.
- As medics were also encouraged by management to call-into the ED during the test period, there was some resistance due to having two (audio) processes run simultaneously.

During the pilot, over 306 images, 1,121 digital audio recordings, and 5 video files were transmitted (see Table 8). These are discussed below.

Table 8. Number of Audio, Video, and Image Files Sent Using CrashHelp

Number of Files	File Type
1,121	Audio
306	Image
5	Video
1,432	**Total**

Images

Paramedics took the following types of pictures: crash damages from outside the vehicle, crash intrusion into the vehicle, damaged windshields, damages as seen from inside of the crashed vehicle, unused seat-belt restraints and motorcycle helmets, the surrounding crash site (e.g., vehicle at a distance, vehicle close up, depth of ditches, and existence and length of skid marks), severe patient injuries, immobilized patients, blood pools, paper EMS run reports, medication bottle descriptions, and screen shots and printouts of patient EKG and vital signs. Several participants discussed how images were utilized throughout the pilot. For example, charge nurses explained how pictures, taken effectively to portray the severity of an automobile crash, impacted which facility a patient would be sent to, and what kind of attention they would need to receive prior to arrival to the ED.

Most participants saw value in the use of effective pictures in combination with the mobile application. Most participants agreed that pictures can provide important insight into a patient's condition if taken effectively. For example paramedics explained that taking a picture was helpful in validating the patient's trauma condition and therefore expediting the trauma activation process.

> *"We had a vehicle crash and roll-over that involved 9 people. We took pictures and sent them in and it helped the ED prepare for what was about come in."*
>
> *"I had an incident where the person was shot in the shoulder with a shotgun. I knew that reporting a patient getting shot in the shoulder through audio may not sound very critical, so I took a picture of the patient's exploded shoulder. I think the picture was very helpful, because as I arrived with the patient to the ED department, I found the trauma team waiting and ready to take the patient."*
>
> *"Telling us that the driver was, you know pinned, and in pain just wasn't the same thing as seeing it in the picture they [EMTs] sent us [the ED]. It just made it way more obvious that there were serious injuries and so we acted pretty quickly to that."*

Many images did not provide value as per participant responses because the photos were low quality, or did not provide context that would impact clinical decision-making. Participants discussed a need to define protocols for effective picture taking that could be included in training initiatives. Participants also agreed that using a SmartPhone application to capture and send pictures provided a more secure, timely, and permanent way to communicate those pictures than using a standalone digital camera or personal SmartPhone owned by a medic. While the overall use of the mobile SmartPhone application and web interface in the ED was perceived to provide actionable value as described above, several participants also described perceived value for each of the other media types. Findings in this regard are discussed below.

Video

Only five on-scene recorded videos were taken by paramedics to communicate different types of incidents and patient circumstances. According to participants, video could potentially be effectively to capture a patient assessment in certain situations, such as for stroke.

However, compared to the digital images use, the number of videos was relatively small. Participants explained this was due to the time required for capturing and then encrypting a video file on the mobile device, and then sending it over a 3G network. While researchers limited the size of the video files for faster transmission, the strength of mobile network signals and speed of the 3G network may limit the use of the video recording feature. As such, some of these challenges may be alleviated with a faster 4G network but that would depend on the range of receptivity through Boise as well as the rural regions of Idaho.

Audio Recording

Paramedics recorded a large number of audio files (n=1,121). The information recorded generally included the same (or similar) information typically reported over the radio to the receiving hospital including: patient demographics, patient condition, relevant incident details, and on-scene interventions and medications. Several participants explained that the system provided the following benefits:

- Asynchronous communication - allowed them to record audio at their own convenience and not have to wait for the ED to respond before talking.
- Information permanence – Charge nurses explained how they valued the ability to replay the audio recording, as many times as needed, especially for critical incidents.
- Multi-tasking – Participants explained how CrashHelp enabled efficient data entry and multi-tasking. Medics could essentially record information when convenient to them, and charge nurses could view it when convenient for them.

"I would walk the CrashHelp [iPad] over to the doc if I thought it was important enough so he could hear what the medic was saying and see pictures and stuff. I could just, you know keep replaying it cause it was recorded and I thought that several times it was pretty good that we had that available."

"The [CrashHelp] report was already with some pictures from the crash even before the helicopter came so we sent all the stuff to the hospital and it was pretty good to be able to send that over there and let them know that a pretty significant trauma was coming their way."

Most participants related significant perceived value in the use of voice recordings in combination with the mobile system. As noted above, several participants did explain that beyond a pilot, there should be only one audio transmittal and, if possible, this would combine synchronous and asynchronous elements. For example, EMTs could record and send an audio file to ED personnel, but in the case more information is needed, there should be a "push to talk" button for a synchronous real time communication.

The following sections provide additional information as it pertains to key evaluation metrics and use by EMS and ED participants.

Emergency Medical Services Participants

Performance: Improved information collection by on-scene EMS personnel.

- CrashHelp was viewed as beneficial for communicating information for incidents with long transport times.
- CrashHelp was viewed as less beneficial for short transports, such as those conducted in town.
- Collecting information via the digital audio recording feature was viewed as easier to use than entering data into a SmartPhone screen.
- Some pictures were viewed as valuable, such as for (MVC) trauma. Participants were not convinced that having a photo would change patient care.

Performance: Improved communication between EMS and ED (EMS perspective).

- Communication via CrashHelp was more valuable for longer transports as prep time increases significantly. Knowing patient information prior to arrival enabled readiness in the ED, such as assembling a stroke, cardiac, and trauma team.
- Information was securely transmitted using CrashHelp.

- Information generally arrived to the ED prior to patient arrival, though the advanced arrival was less for short runs.
- ED staff liked receiving patient information in order to pre-register a patient prior to arrival. Paramedics found it challenging to collect data due to time constraints and thus future work is needed to further increase the usability and efficiency of using the system.
- ED staff reported the utility of CrashHelp for reporting severe injuries and stroke cases prior to patient arrival, especially for cases that prompt registration and ordering labs/radiology prior to patient arrival.
- Both EMS and ED staff noted that consistency of use would result in greater utilization of information by ED.

Performance: Easy to use and functional mobile application for EMS personnel (i.e., does not inhibit EMS communication processes above and beyond current communications practices).

- Several technical issues were discovered during the first few months of the project including software bugs that caused the application to freeze or crash. This experience prompted several participants to discuss the need for better pre-pilot testing in the future.
- While most participants thought the mobile application was user-friendly, it was generally not perceived to be usable enough for the most time-critical and severe incidents (e.g., Trauma Level 1). In those settings, communication is generally limited to only the most essential exchanges of information and CrashHelp was not perceived to be as useful for those cases without first being modified. Suggested modifications such as providing a special form to enter trauma information and adding a mechanism for phone notifications to trauma physicians have been noted.
- Challenges to usability included: font sizes were too small for some participants; the screen size of the SmartPhone was too small for some participants; utilization of an Android application was more difficult for some iPhone users; wireless coverage is occasionally insufficient in rural areas, which was blamed for several record transmission delays. Usability relating to the user interface may be resolved by allowing EMTs greater flexibility to choose the type and size of SmartPhone or tablet computing devices to use. Wireless coverage challenges were largely dealt with by the research team by designing CrashHelp to function with or without a wireless signal – with the application only sending data when connected to the wireless carrier. The remaining connectivity challenges are the result of a lack of wireless carrier infrastructure in some rural and remote areas, which can be overcome as infrastructure expands into these areas.

Emergency Department Participants

Performance: Improved communication between EMS and hospital organizations.

- CrashHelp audio records sent by medics were listened to by nurses in the ED, and were often replayed to brief other nurses and physicians on duty; the latter cannot be done with radio communication. Using the audio helped to improve information completeness and accuracy.
- The digital audio report, patient demographic data, medic unit information, procedures performed (e.g., IV established, fluids infusing, medication administered), and medic unit distance from hospital was useful for the ED to be aware, understand, and make decisions prior to patient arrival.

- The preferred method of receiving CrashHelp information in the ED was using a mobile device (i.e., iPad). This enabled fast and efficient retrieval of information, and the ability to easily carry CrashHelp information to other ED staff. This was perceived as a major improvement over a desktop web-based access to the same information.
- In general, pictures, text messaging, and videos were less useful to the ED. These features were useful for some incidents, such as using pictures for certain trauma cases.

Performance: Improved notification times for rural and remote MVC trauma patients.

- Participants felt that CrashHelp enabled earlier notification of rural and remote EMS incidents to the EDs because information was received sooner than typical, and more complete information could be transmitted (i.e., patient name) due to CrashHelp enabling secure communication vs. non-secure radio communications.
- For the pilot study, rural areas had relatively infrequent MVCs, which affected the ability to robustly test its value in this regard.
- CrashHelp enabled faster information retrieval of essential patient information at the hospital. For example, patient medical history, medications, and prior surgeries could be looked up in the hospital EHR prior to patient arrival to enable faster registration, admissions, and ordering radiology exams.

Performance: Improved decision-making by hospital medical personnel (for MVC trauma). This could include decisions about patient care, resource mobilization, or resource utilization (e.g., transfers to higher level of care).

- Receiving CrashHelp records enabled faster resource mobilization for some incidents at the ED for such processes as: room preparation, making referrals to higher levels of care, looking up patient information in the hospital database, registering the patient, ordering labs/radiology, and calling/assembling specialty medical practitioners.

Performance: Easy to use and functional web-based application for ED/Trauma Center.

- The web interface used by the ED provided patient information, medic unit information, incident information, and medic unit status information in a clear, easy to read, and usable format.
- The web interface provided easy access and retrieval of multi-media information (digital audio, pictures, videos) for the ED.
- In general, the audio call-in was viewed as easier to use than accessing the website, which affected the extent to which the latter was used.

Other results.

- CrashHelp could potentially serve as a quality assurance validation tool, because the system shows what information was transmitted for each incident and could thus determine when an incident is missing essential information such as Glasgow Coma Score, Lowest Blood Pressure, etc.
- The radio remains the basic communications alternative by which CrashHelp is considered. There were numerous areas where the multi-media element of CrashHelp (noted above) was perceived to be a definite "value-added." Conversely, for instances such as very short general medical runs, the status-quo radio was perceived to be adequate for the situation.

Finding the optimum combination between a call-in and a multi-media transmittal appears to be the best long run benefit for rural areas.

Motor Vehicle Crash Clearance Operations

As mentioned previously, ITD's safety and operations experts met with the research team to discuss implications of the CrashHelp system on MVC clearance operations. Discussions produced the following potential applications:

- CrashHelp information could be useful for a TMC to help determine the severity of an incident and thus help determine an approximate duration of time to clear an incident. For example, in cases where a major Trauma Level 1 incident occurred, crash clearance often takes longer. Such information could be valuable for internal operations, as well as for communicating to the public.
- CrashHelp information, in the aggregate, may be useful to re-create case scenarios to aid in planning for more effective and efficient crash clearance in the future. For example, CrashHelp pictures, audio, patient information, EMS route, and GPS location together with maps and other relevant information could help create case-based reasoning for responding to certain types of traffic crash emergencies and aid in coordinating with other responders.
- In rural areas, a CrashHelp-like application may be useful for transportation professionals to report a crash or a high-risk situation that may cause a crash (e.g., road debris).
- Mobile applications more generally may be useful for reporting a wide range of traffic safety issues by traffic safety professionals. Pictures provide a mean to communicate visually what words or data may not be able to clearly convey. Such applications could be beneficial to traffic safety professionals for documenting in the field.

Discussions with ITD staff revealed a sense of agreement that data collected by CrashHelp could potentially provide value to traffic crash operations, particularly if integrated in existing command and control environments (e.g., PSAPs, TMCs). More generally, multi-media information, collected by field personnel, could potentially enable improvements for internal traffic operations as well as for communicating a range of information to the public.

Challenges to Address for Future Viability of CrashHelp

While Phase II of the pilot test demonstrated the system's functionality and perceived benefits to EMS and emergency care practices, the evaluation also found significant challenges to address. In general, the pilot suggested that it is challenging for EMS practitioners to make use of the technology for every type of emergency incident due to the time-critical nature of caring for and transporting patients. When the application was used, it was noted to be helpful and provide several benefits. Yet, there is a need to further assess how such technologies could be further integrated into emergency care processes in a manner that does not hinder the primary focus of EMS – to care for patients. Several specific challenges are discussed below.

First, the amount of time required encrypting a video file on the mobile device and then sending it through a 3G network was far too extensive. Video, when sent, was often not received by the ED prior to ambulance and patient arrival. The use of a 4G network may reduce some of these issues, as well as implementing a more “real-time” video stream directly to the ED, as opposed to capturing an entire video file on the device prior to sending. These features should be explored in future implementations as there exists significant time vs. security tradeoffs to be considered.

Second, in some cases, pictures may have been a distraction to ED practitioners as they viewed and tried to determine how to interpret the value of some photos. For example, a picture of a broken arm, photo of a wound taken from a non-descriptive angle, or images of a minor medical condition were described by participants to be of little or no value to ED decision-makers. The pilot test revealed a need to develop protocols on the types and quantity of pictures to capture and send to the ED.

Third, a significant challenge was the need to integrate CrashHelp into EMS and ED workflows. The challenge is that each organization varies in its work flows. For example, at some hospitals, EMS notifications are sent directly to charge nurses. In other hospitals, EMS notifications (i.e., radio calls) are first received by an operator who then keys the information into a computer and forwards that information on to a charge nurse or other appropriate medical practitioner(s). It was challenging for hospitals using the latter workflow to integrate CrashHelp into their workflow. Similarly, each organization desires CrashHelp information to be sent and integrated into their existing patient care record or ePCR. Each organization has a different system that would require separate data integration efforts. In any case, future studies should focus on understanding the range of methods whereby multi-media SmartPhone information could “fit” within an existing EMS or ED workflow. The question of how the EMS and ED workflow might be improved, modified, or eliminated through incorporating such new functionality needs yet to be answered.

Fourth, EMS and ED work is protocol and policy driven. As such, medics, and to some degree charge nurses, follow mandated policies and procedures for many of the decisions that are made – including the technologies that are used. The use of CrashHelp was not mandated, and thus participants lacked motivation to consistently use the system—those that liked it, used it all the time. Those that were doing it because there were encouraged tended to have declining usage over time. If a system like CrashHelp is to succeed, then it would likely need to be formally written into a mandated policy and procedures manual – much like the use of ePCR that are used today in many locales.

Fifth, consumers of personal SmartPhones, many of whom are EMS practitioners, have quickly become used to having access to a wide range of highly functional applications for personal use. As such, many of these same people had high expectations for the CrashHelp application. They expected new and extensive features to be included in the EMS application described herein. These expectations needed to be managed due to:

1. Very high priority to keep data secure and private vs. end-user desires for “cool” but unsecure features.
2. The need to ensure software stability to eliminate as many errors as possible during the research project.
3. Research project cost constraints.

Users were enthusiastic about using the application and the potential for many new features including:

- Automated notifications (e.g., text messages).
- Automated transcription of voice recorded files to text.
- iPhone and iPad apps to view data in the ED,
- Integration of data into ePCR.
- New web-based “views” of the data for other users (e.g., for traffic crash clearance operations), etc.

Managing the expectations of participants was an ongoing challenge that was peripheral, yet related to the research objectives of this project.

Sixth, we found that many participants did not know about some of the CrashHelp features and thus did not use them. While the research team provided general training and training materials at the beginning of the project, getting the system to be used by a wide array of participants within their work setting requires hands-on and in-person professional level training geared to specific workflow situations. Furthermore, while classroom training was useful for paramedics, hands-on training at the desk/workspace of each ED staff member would be most effective.

Seventh, the cost to implement and maintain CrashHelp did not seem to be a major impediment against participating organizations continuing to use the system. Those organizations that already have wireless 3G/4G contracts with a commercial wireless provider were even less concerned about cost. However, since CrashHelp is a system used by both paramedic transport organizations and hospitals across a region, there is some debate about whom should pay (i.e., ambulance providers, hospitals, government EMS agency).

Finally, a challenge faced in this inter-organizational setting was one of information “providers” vs. “consumers.” The paramedics were the primary information providers during this pilot test. Paramedics were more motivated to send incident records as they learned that nurses were consuming them. On the other hand, the nurses wanted to use the system more as they learned that paramedics were capturing and sending records. Hospitals where the most number of incidents were sent and used (e.g., between Canyon County medics and West Valley Hospital), many of the medics and nurses had expressed their perspectives to each other and had “practiced” its use several times in a simulated setting. This created an environment where both sides became more regular users of the system.

Research Limitations

This research has some limitations, some of which are embedded in the discussion above. These should be addressed in future research. In terms of value of the system, the technical performance, usage, and the perception of practitioners were reported. While these are useful measures for studying a new innovation, future work should seek to assess system benefits by quantifying patient health outcomes that were reached as a result of using CrashHelp. This may be achieved by linking patient information in the CrashHelp system with patient outcomes as reported in hospital and public health/EMS registry data systems. This would not be a simple feat for this project considering the permissions required from the number of organizations that participated in the project (i.e., 8 hospitals, 3 ambulance providers). Nevertheless, understanding clinical benefits is an important future research need.

Conclusion

Mobile communication systems have become an inseparable part of everyday life and its utilization is rapidly moving into industry. This research investigated the potential of mobile applications within the EMS industry, with a focus on on-scene multi-media information and its use for all responses and a particular interest in MVC response. The pilot generally demonstrated that such an application can be of value in delivering more robust information in advance of patient arrival to a hospital. The major challenge, of course, is moving from “can” be of value to “will” be of value. For such systems to have consistent and empirical value claims they need to be tightly interwoven into the EMS and ED workflow. Phase II of the pilot, by logistical necessity, was a voluntary element to the EMS response. As such, some of the medics gravitated toward using it and some did not; some of the hospitals gravitated toward using it and some did not. So, while the multimedia application showed promise (with some caveats), delivering on that promise will require thoughtful workflow implementation with clear protocols for use by EMS and ED staff.

Such additional efforts appear to be quite warranted, as broadband capacity is sure to grow over the next decade. For example, within public safety, there is a major new program called “FirstNet” which has been established by Congress in 2012 and will provide some $7 billion in funds to bring broadband applications to public safety communications (Law, Fire, EMS). As FirstNet Board Member Kevin McGinnis recently noted: “We will be able to bring portable diagnostic devices to trauma patients, and virtual doctors to EMTs and their patients in isolated, prolonged transport situations.” The potential applications enabled by a nationwide public safety broadband network are just beginning to emerge.(36) In short, the time is right to consider applications such as demonstrated in this pilot research. We believe the findings reported here are positive stepping-stones for such advances.

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Appendix A
EMS Specific Interview Questions

- How did you use the CrashHelp application? (at the scene, enroute, at hospital, etc.)
- How did you use CrashHelp to communicate with the ED, particularly with regards to the audio, pictures and video?
- How easy or hard was it to use the CrashHelp features?
- What aspects of the CrashHelp application were particularly useful in collecting and reporting information and which were not useful? For example:
  - Taking pictures
  - Recording digital audio
  - Communicating location and/or estimated time of arrival
  - Communicating basic patient data (demographics)
  - Reporting chief complaint / patient indicators / patient interventions
  - Reporting EMS unit information
  - Text messaging and receiving acknowledgements
- What challenges were there in collecting information and communicating with the ED using CrashHelp?
- Thinking of its use in collecting and communicating information to the ED, how useful do you think it *is* or *could be* in:
  - Helping you deliver patient care?
  - Helping the ED deliver patient care?
  - When answering the above, think specifically in terms of:
    - trauma incidents.
    - rural, long distance transports.
    - Other patient conditions or incident scenarios?
- In your opinion, how does a system like CrashHelp impact communications, particularly with the issue of communicating:
  - Accurate information
  - Complete information
  - Clear, understandable information
  - Shareable information
- In general, what benefits and challenges do you see in using mobile devices in the future in EMS?
- To what extent did you feel that the information collected and sent via CrashHelp was secure (i.e., could not be viewed or "hacked" by unauthorized individuals)?
- What improvements would you suggest to make CrashHelp more successful?
- What do you think are major challenges or limitations to using such a system to connect EMS to the ED?
- Aside from the system itself, do you have any other observations that you would like to share about the pilot project more generally?

Appendix B
Emergency Department Specific Interview Questions

- How did you use the CrashHelp application in the emergency department?
- How easy or hard was it to use the CrashHelp features?
- How useful was the notification service of CrashHelp, whether using the phone or web, in helping you prepare for patient care?
- In regards to its functions, which features were useful and which were not useful?
    - Pictures
    - digital audio
    - estimated time of arrival
    - map of EMS unit
    - basic patient info (demographics)
    - chief complaint / patient indicators / patient interventions
    - EMS unit information
    - Text messaging / Acknowledge incident
- How does using CrashHelp compare to communicating with EMS via the radio and/or phone call communications?
- Thinking of its use in receiving information in advance from EMS, how useful do you think it ***is*** or ***could be*** in helping the ED make pre-arrival preparation decisions? Think specifically in terms of:
    - trauma incidents.
    - rural, long distance transports.
    - Other patient conditions or scenarios?
- How does a system like CrashHelp impact EMS communications, particularly with the issue of communicating:
    - Accurate information
    - Complete information
    - Clear, understandable information
    - Shareable information
- To what extent did you think about or determine that the information was secure (i.e., could not be viewed or “hacked” by others)?
- What do you think are major challenges or limitations to using such a system to connect EMS to the ED?
- What improvements would you suggest to make CrashHelp more successful?
- Aside from the system itself, do you have any other observations that you would like to share about the ***pilot project*** more generally?