Improving IT Enabled Continuity of Care Across Pre-Hospital and Hospital Settings

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Recommended Citation
Schooley, Benjamin Ph.D.; McClintock, Rondalynne M.Ed.; Lee, Yoonmi; Feldman, Sue R.N.; and Hilton, Brian Ph.D., "Improving IT Enabled Continuity of Care Across Pre-Hospital and Hospital Settings" (2010). AMCIS 2010 Proceedings. 584.
http://aisel.aisnet.org/amcis2010/584

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ABSTRACT

Pre-hospital Emergency Medical Services (EMS) are often the patients’ first contact with the health care system. These services are a collaborative effort between several organizations providing different levels of care. These services are also multi-organizational, process oriented, and information dependent. As a result, a significant challenge exists in these fast-paced environments in terms of collecting and handing-off accurate and timely patient information from one care provider to the next. Consequently, there is a significant need for technology-enabled process improvement initiatives and guiding frameworks for streamlining information hand-offs across pre-hospital and hospital settings. This multi-method study explores the current state and potential improvements of technology-enabled pre-hospital to hospital information hand-offs in the State of California (CA). A questionnaire was administered to EMS leaders across the State. Qualitative interviews and focus group discussions were then conducted on two CA county EMS systems to explore potential improvements and to construct a set of principles to guide system development to support emergency care processes. A set of design principles, guidelines, themes, and end-user needs are presented and future research directions discussed.

Keywords

Emergency Medical Services (EMS), Time Critical Information Systems (TCIS), Continuity of Care

INTRODUCTION

Emergency Medical Services (EMS) are designed to care for and transport sick or injured patients to the hospital (IOM, 2006). In the United States, there are over 16 million patients transported by EMS to Emergency Departments (EDs) every year (Burt et al., 2006). These services lie at the intersection of health care, public health, and public safety, interacting with and carrying out the roles and responsibilities of each (IOM, 2006). For each emergency incident, multiple organizations including 9-1-1 call centers, first responders (e.g., Fire Departments), ambulance transport providers, and hospitals engage in a time-sensitive, process-oriented service that is highly information dependent. However, the collection, aggregation, and reporting of patient and incident information for EMS has long been a challenge largely due to the dynamic, fast paced, high stress, emergency care delivery context (Institute of Medicine, 2006).

Prior research has indicated that health care providers in the ED could benefit from timely and complete information from pre-hospital organizations to support them in making clinical and system-wide operational and policy decisions, and to provide higher quality health care to patients. However, pre-hospital organizations commonly describe a range of challenges to collecting, aggregating, and reporting information prior to patient hand-off to the ED (Schooley and Horan, 2007a).

There have been many recent technological developments and improvements to enhance emergency care delivery processes. Better electronic user interfaces, extensive training programs, wireless telecommunications technologies, and more effective collaborative relationships between organizations have all contributed to faster and better emergency medical services (Woodhall, 2006; NENA, 2001; NHTSA, 2001; Sawyer et al., 2004; Turoff et al., 2004). Yet there continues to exist a need for improving the timeliness and accuracy of pre-hospital to hospital information hand-off, which has been identified as an
important element for improving the timeliness and quality of care provided in emergency medicine (Benner et al., 2007; Schooley and Horan, 2007a; Institute of Medicine, 2006; Adams et al., 2004).

This paper reports on a multi-method study to explore the role of information technology in EMS health care delivery processes to facilitate timely delivery of pre-hospital information to emergency departments. Methods included a questionnaire administered to EMS Agency leaders across the state of California, a comparative case study across two California Counties in what is known as “Silicon Valley” (Santa Clara and San Mateo Counties), and a focus group with National EMS Policy leaders. The objective was to understand issues and challenges with information exchange in this health care delivery setting, and explore potential process, policy, and technological improvements in the design of information systems to improve delivery processes.

BACKGROUND: DISCONTINUOUS CARE AND INFORMATION HAND-OFFS

Discontinuous patient care, which occurs when one clinician relinquishes care to another, is a significant challenge that is further magnified in fast-paced and short-stay environments such as the ambulance or ED (Wiler et al., 2010; Benner et al., 2007; Schooley and Horan, 2007a; Carver and Turoff, 2007). In emergency medical settings, written and verbal information is often forgotten, misplaced, omitted, or unreadable (Adams et al., 2004; Erich, 2007; Orthner, 2005). For example, in one study, necessary information such as patient’s name (only reported 67.6% of the time) was not included in the verbal report (Ye et al., 2007). In another study, verbal handoffs occurred for only 44% of patient handoffs (Benner et al., 2007).

Many emergency care providers are unable to identify a standard operating procedure for the information handoff period (Bomba and Prakash, 2005). It has been suggested that the lack of conformity and structure during critical information traffic is a significant cause for redundant or omitted information, most of which is either verbal or handwritten (Agency for Healthcare Research and Quality, 2007); this can lead to medical errors (Chisholm et al., 2000).

When information is transferred across care settings, there are additional challenges. The emergency medical setting requires committing an increased amount of medical information to memory (Arora et al., 2005). As the amount and complexity of information increases, so does the risk of forgetting important details, which can lead to serious medical complications (Bates and Gawande, 2003).

For EMS specifically, information processes frequently occur as verbal and written information exchanges. In a typical scenario, a first responder (e.g., fire department or ambulance) crewmember will collect patient and incident information from the patient, family members, or bystanders. Multiple fire department, law enforcement, and ambulance crews may arrive at an incident and collect information. These personnel may then write the collected information in various places such as a paper form, any available piece of scratch paper, a latex glove, or other convenient location (Orthner, 2005; Schooley and Horan, 2007a; Institute of Medicine, 2006; Schooley and Horan, 2007b). These information collection points act as a ‘staging location’ until electronic records can be completed – one by each responding organization. Frequently the patient will arrive at the ED in advance of a comprehensive electronic record. It is not unusual that the paramedic has not had time to transfer all of the information from the various pieces of paper and memory into the record. Hence, a verbal information handoff to providers at the receiving ED is provided, many times in an environment that is not conducive to hearing and understanding important details (Trzeciak and Rivers, 2003).

The Use of Electronic Patient Care Record (PCR) Systems

In general, health information technology (HIT) has been found to help improve the quality of patient handoffs, lead to decreased errors of omission, and reduce risk of patient injury during the transition of care (Erich, 2007; Van et al., 2005). This has been found in emergency settings for better meeting patient needs (Taylor, 2004; Watcharasiroj and Tang, 2004; Van De et al., 2007). One tool that has been used in EMS to help facilitate accurate and timely information handoff is the electronic Patient Care Record (ePCR) (Spaite, 1990; Meislin et al., 1999). E-PCR systems have been designed to: aggregate data across 9-1-1 call centers, First Responders, and Transport organizations; capture over 400+ standardized data elements (Dawson, 2006); record health care procedures, patient assessments, medications, protocols, patient history, demographics, and situational context information. E-PCR’s have been very important for record keeping, research, and clinical quality improvement initiatives. A more effective utilization of an ePCR could play a key role in increasing the likelihood of complete and timely communication during information hand-offs (Marich et al., 2007; Orthner, 2005).

While there is increasing use of ePCR systems across the US (Williams, 2008), challenges to collecting and sharing pre-hospital information remain. For example, an analysis of over 22,000 EMS transports across one California County showed completion of an ePCR took an average of 39 minutes 42 seconds (median 33 minutes 59 seconds) after EMS arrival and
patient hand-off to an ED (Schooley, 2007). A larger study showed that only 49% of EMS Agencies report collecting some electronic data at the patient’s side prior to arriving to an ED (Williams, 2008). It remains unclear to what extent governance, policies, and information system design features have been established to guide technology enabled care processes in EMS. This paper explores current practices and opportunities for improvement.

**Time Critical Information Services (TCIS) Framework**

From a conceptual standpoint, this study draws from the Time-Critical Information Services (TCIS) framework (Horan and Schooley, 2007). The framework was developed to aid in the study of emergency services that are multi-organizational, highly time and information dependent. Researchers developed TCIS to guide a multi-dimensional view and analysis of an emergency incident across the continuum of patient care, or from one end of service provision to the other (end-to-end). Figure 1, extracted from TCIS, provides a way to frame the analysis through the end-to-end EMS process, from medical onset through definitive care (Horan and Schooley, 2007). It specifies that information handoffs occur across a process that initiates with the onset of a medical condition, reporting of the incident, dispatch and coordination across emergency responder organizations, on-scene care provision, transport to a medical facility, and provision of definitive medical care. The framework suggests a holistic approach to evaluating information technology enabled process needs and opportunities. This research focuses on the process of collecting pre-hospital information for handoff to a medical facility for the provision of definitive care to a patient.

![Time-critical Service Process](image)

**Figure 1. Time-critical service process**

**RESEARCH METHODS**

This research involved multiple methods including a questionnaire sent to 31 EMS agencies in California followed by qualitative interviews and focus groups across two California County EMS systems. Additional details on research methodology are discussed below.

**RESULTS FROM SURVEY**

A single-stage, 20 question, web-based questionnaire was developed. Invitations were sent to all EMS administrators and medical directors at all 31 California EMS agencies - the total target population was 62. A total of 17 administrators and 13 medical directors brought the response rate to 30, or 48%. In addition, 11 more individuals completed the questionnaire on behalf of their superiors, adding relevance to the responses. There were a total of 41 responses representing 28 of the 31 CA EMS systems with the majority (73%) of responses coming from EMS administrators/directors and medical directors. Internet Protocol (IP) addresses of survey respondents were collected and checked against participant name, title, and EMS system to ensure that each response was unique. Data collection took place over a 14-day period.

The purpose of the questionnaire was to explore technologies, organizational structures, and policies relating to the use of information technology to handoff patient information from pre-hospital to hospital organizations. An important goal of the questionnaire was to assemble a profile for each of the CA EMS systems from the perspective of individuals responsible for EMS system oversight. Questionnaires were sent to individuals in leadership roles responsible for developing operational and clinical policies, procedures, and governance mechanisms for their respective EMS systems. As such, an important element of the survey analysis was to aggregate the participant responses so as to ensure consistency across respondents from the same EMS system. This enabled researchers to arrive at system level answers for each survey question.
Results from the survey are discussed below in terms of: 1) the current adoption of electronic PCRs in California and the types of organizations using them, 2) the current governance structures for PCR ownership and management, 3) how PCRs are completed in terms of processes and policies that direct their use, and 4) the variety of potential solutions to increase efficiency and effectiveness of the hand-off process.

Electronic Patient Care Record (PCR) Use

The first objective of the questionnaire was to understand the extent to which EMS systems in CA are using either electronic or paper PCRs (or a combination). Findings indicated that 13% of EMS systems in CA use paper PCRs, all of which are currently transitioning to electronic systems. 23% of the EMS systems reported using primarily electronic PCRs, and 55% reported using a combination of both electronic and paper within their systems. Of these 55%, fill-in responses indicated that many of these systems are in a multi-year transitioning process from paper to electronic systems. Findings also indicated that 23 respondents (74% of EMS systems) require that both first responders (fire departments), and transport organizations (ambulance companies), complete ePCRs while the remaining 16% require only the EMS transport organization to complete an ePCR.

Electronic PCR Governance

Respondents were asked which organization owns and manages the ePCR system (i.e., EMS Agency, ambulance provider, first responder (fire department), third-party technology company, or some combination of each). Survey results indicated that a number of different ePCR governance structures exist across EMS systems. EMS providers own and manage ePCR systems for 26% of CA EMS systems, third-party technology vendors in 6% of the CA EMS systems, the EMS Agency in 16%, and “other” governance arrangements in 29%. The remaining four EMS systems still use paper based PCR forms as explained in the previous section. The “other” governance arrangements included: 1) differing PCR ownership structures in different city jurisdictions within the county, 2) joint ownership between a combination of EMS agencies, EMS providers, and technology vendors, and 3) other unique arrangements including federal government level involvement. These results indicate a wide variety of software ownership and technology provision structures including purchased “commercial off-the-shelf” software (COTS), software paid for as a service, software developed in-house, and software provided through federal grant programs. It is unclear if and how these various ownership structures translate into more effective and timely PCR completion.

PCR Completion Processes and Policies

The survey asked respondents about PCR completion policies and processes. Almost two-thirds of the respondents indicated that the medical attendant (paramedic) is primarily responsible for the completion and submission of a PCR, as opposed to assistants, emergency medical technicians (EMTs), and/or EMS vehicle drivers. The majority of respondents (68%) reported formal EMS system policies specifying that the PCR must accompany a patient to the ED and remain there upon departure of the ambulance. However, results indicated that few EMS agencies have mechanisms in place to enforce these policies. EMS agencies (43%) have clear policies on how long an ambulance can remain at the hospital before responding to the next 9-1-1 call. These policies ranged from 0-30 minutes with 9 of those systems allowing for time extensions. Relative to this, almost 70% of the respondents did not know how long it usually takes to complete the PCR and there exists no standard reports, metrics, or methods for evaluating the timeliness of PCR completion. Of those who quantified time to completion, answers varied dramatically from 5 minutes to 10 hours. In contrast to the 62.5% that reported some level of satisfaction with their current PCR software, only 42% of ED physicians reported they were satisfied with the PCR completion policies and procedures. These results highlight that completion policies and processes vary significantly across CA EMS systems.

Potential Methods for PCR Process Improvement

The questionnaire asked participants to describe potential process, policy, or technology methods for improving the timeliness and accuracy of information handoff processes as well as the challenges to implementing suggested improvements. Open-ended responses included the following:
<table>
<thead>
<tr>
<th>Potential Improvement</th>
<th>Description</th>
<th>Implementation Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice activation and recognition software</td>
<td>Used by Military Medics. Allows paramedics and EMTs to keep their hands free to care for patient.</td>
<td>Cost prohibitive technology. Cost to train employees to incorporate technology into processes may be even more expensive. Technology available on the commercial market is immature.</td>
</tr>
<tr>
<td>Use a scribe – let a professional observer do the record keeping.</td>
<td>Scribes are used in many healthcare settings to record procedures, medications, and other healthcare related activities.</td>
<td>Cost prohibitive. Small EMS providers can’t afford paying an additional employee/resource. This model works well in situations where the scribe is paid far less than care providers, which is not generally the case with EMTs and paramedics.</td>
</tr>
<tr>
<td>Abbreviated ePCR – a shorter version of the full ePCR</td>
<td>A short version of an ePCR would enable capture of the most pertinent information while saving the details for later. This solution is used in some locales for Mass Casualty Incident (MCI) data capture.</td>
<td>Care providers disagree on what the abbreviated data set should include. Providers worry about liability of there being differences between the short and long versions.</td>
</tr>
<tr>
<td>Incremental Data Pushes– send data as it’s entered</td>
<td>Incremental data pushes could send at least some data forward as it is entered prior to the full report being completed.</td>
<td>To date, PCR vendors have not implemented this technology. There are many concerns about data validation. Many users believe that such technology will not enhance handoff processes.</td>
</tr>
<tr>
<td>Streamline the ePCR Interface</td>
<td>Many vendors are selling tablet touch screen versions of their software, implement business rules for streamlined data entry, and provide interfaces to devices (e.g., EKG) for automated data capture.</td>
<td>Streamlining the ePCR interface is an ongoing quality improvement process. It is difficult to assess the impact of each incremental improvement on care processes.</td>
</tr>
<tr>
<td>Implement policies for mandatory ePCR completion at patient hand-off</td>
<td>New policies could push emergency providers to enter data quicker.</td>
<td>Policies are difficult to enforce. It is difficult to define all scenarios where exceptions should be made. Care processes should be the most important focus, not data entry.</td>
</tr>
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The questionnaire provided an overview of the diffusion of ePCR systems across CA, the governance structures for those systems, and the general policies guiding ePCR completion. It also provided an initial overview of potential technology enabled process improvement solutions and their associated challenges. A next step in the research was to drill down in more detail to understand the information processing needs of EMS systems in CA. The goal was to investigate a core set of needs and requirements for designing technology enabled solutions to enhance pre-hospital to hospital information exchange.
Case Study Qualitative Data Analysis and Findings

This research involved multiple methods including a questionnaire sent to 31 EMS agencies in California, qualitative interviews and focus groups with EMS practitioners across two California County EMS systems, development of a prototype application, and qualitative evaluation of its potential benefits. Interviews and focus groups discussions were held across two CA County EMS systems – San Mateo County, and Santa Clara County. In San Mateo County, there were a total of 33 participants across 18 organizations. For Santa Clara County, there were a total of 68 participants across 21 organizations. Organizations included Fire Departments, air and ground ambulance transport organizations, hospitals trauma centers, the EMS Agency, and 9-1-1 call centers. A single-stage, 20 question, web-based questionnaire was developed and sent to 62 EMS administrators and medical directors at 31 California EMS agencies. There were a total of 41 responses representing 28 of the 31 CA EMS systems with the majority (73%) of responses coming from EMS administrators/directors and medical directors. Internet Protocol (IP) addresses of survey respondents were collected and checked against participant name, title, and EMS system to ensure that each response was unique. Data collection took place over a 14-day period. A detailed discussion of qualitative findings has been presented in Schooley et al. (Schooley, 2009).

While the questionnaire sought responses from Agency decision makers, the qualitative interviews and focus group discussions sought responses from on-the-ground practitioners. Interview questions focused on the challenges and opportunities for improving care processes using information technology and the information needs and requirements of users, with particular emphasis on the use of technology to facilitate improvements to patient care and safety. Four overarching and guiding principles emerged for the design of technology-enabled processes. These included:

- Technology must facilitate information hand-off at or before the patient hand-off to the ED. Responses included:
  “I usually give a quick [verbal] snapshot to whoever meets me there [at the ED]. The PCR just isn’t done in time” (EMT)
  “We need to get past the process of giving a paper PCR to the receiving ED, and then filling out the ePCR afterwards.” (Paramedic)
  “When the EMT isn’t there [at patient side] when I arrive, depending on the issue, I have to call him up or get him on the radio. We need to get away from that.” (ED Physician)
  “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)

- Technology must interfere in least possible way with care processes and practices. Responses included:
  “I don’t have time to enter all that [PCR] information. If I have a choice between stopping profuse bleeding and messing around with a laptop, the choice is pretty obvious.” (Paramedic)
  “I really need the information at patient’s side. I can’t go searching all over for it.” (Physician)
  “I use my own phone to take pictures and show someone at the ED. Its faster that way.” (EMT)

- Technology must provide value added context to decision makers at the ED/Trauma Center. Responses included:
  “I want information. But not all of it. I just want what I need.” (Trauma Physician)
  “A picture is worth a thousand words.” (ED Physician)
  “We need something we can read, hear, look at. Calling the EMT after they’ve left seems to be too common a practice.” (EMS System Medical Director)
  “I think the basic information, the context of what happened on scene helps out the most.” (Director, Trauma)

- Technology must provide value to policy and oversight professionals for post-incident evaluation. Responses included:
“The real value of PCR data is to put together studies on how we’re performing. We need to keep doing that.” (EMS Administrator)

“Its great to finally be able to take 5 years of data and compare it. The data still needs to be higher quality.” (Clinical Coordinator)

“Adding GIS and pictures would really help with education, case reviews, medical reviews, QI. It would be nice.” (EMS Medical Director)

Findings from focus group discussions also helped elicit the meanings, needs, issues, and benefits of an open, standardized, integrated, yet secure and private information-sharing environment. Key architecture design features were identified including:

1. End-to-end operational process considerations to provide emergency medical care as seen through the eyes and experience of a patient.
2. A multi-organizational view of the system architecture.
3. Dynamic information sharing considerations by a range of user types including dispatch, EMS, trauma, and public health oversight organizations.
4. Visualization of a range of data, images, video, and audio from a range of devices (e.g., mobile phones, computer aided dispatch software).
5. End-to-end performance reporting capabilities across organizations and information systems.
6. Additional enterprise architecture characteristics are illustrated including:
   a. Security/Privacy
   b. Patient tracking system
   c. Directory and Access Services

Focus group sessions also elicited the following themes as key to communicating EMS and Trauma issues related to emergency response:

- Visual Display – It is critical to portray EMS response in a manner that is both comprehensible to a wide range of users and at the same time brings together a range of related disparate data.
- Human – It is important to humanize the EMS response. Past research indicated that EMS personnel want to know what happened to a patient they treated. A solution must enable personnel a holistic view of an emergency response for a particular patient.
- Integrated Analysis – A wide range of users need a performance profile of EMS responses at individual and aggregate levels. This would allow for developing local and regional system-wide improvements with policy leaders and health and safety professionals.

From these themes, the following functional requirements were defined:

- Handheld device – utilize handheld, mobile technologies to capture digital voice, video, images, GPS for display and easy access in the ED.
- Map – visually display spatial data about an incident for situational awareness and decision support, along with key clinical indicators (age, response time) as derived from statistical analysis.
- EMS Incident Profile – visually display pre-defined queries of EMS events, including EMS responder and patient information.
- EMS Response Statistics – enable drill-down (query/filter) through various data sets to extract specific information needed by end-users about a specific EMS incident.
- Real-time incident and patient status – provide indicators and dashboard gauges that allow visualization of EMS performance and patient status across a range of defined EMS incidents.
- Graphical display of patient status – allow the capture of pictures and video by paramedics on-scene through a mobile device and display such in a real-time incident status window.

Information needs included: (1) assimilation of data from heterogeneous sources, sites, and devices, (2) “mashing up” these data to produce a composite geographic based display, (3) visualizing incidents, patient records, and voice, video, and images collected on-scene in a composite page, and (5) visualizing aggregate clinical and performance information.
DISCUSSION: IMPLICATIONS, EXPECTED BENEFITS, AND NEXT STEPS

It is expected that these findings will lead to new protocols and applications for enhancing emergency medical response, by aligning emergency health services with potential technology solutions. From a theoretical perspective, this work addresses a significant gap in the literature on methods and processes for improving the handoff of information across pre-hospital and hospital organizations to improve continuity of care. In short, this work has aimed to address a societal and end-user needs to provide a set of design principles to potentially impact the design and visualization of a complex array of activities, users, organizations, and information sources. The Time-Critical Information Services (TCIS) framework has emerged to support emergency services providing continuum of patient care. Methodologically, this work illustrates multi-method research to address utility and application of information from both a top-down and bottom-up approach. From a practical perspective, the design principles and guidelines discussed continue to be presented to a wide range of EMS practitioners to aid in the next steps of our research – to design a prototype application through iterative design and development. Expected uses for the prototype include:

- Patient information handoff. Exchanging patient information (including images, video, and audio) across pre-hospital and hospital domains for more real-time use is believed to have significant impact on continuity of care.
- EMS training and education. The visual display of an incident, the location, and targeted data could provide a platform for training EMS professionals.
- Clinical Quality Improvement. Oversight EMS and Trauma organizations use case examples at regularly scheduled medical advisory and committee review meetings. The system would provide a visual basis for discussing the “good” and “bad” cases and scenarios to improve care protocols and processes.
- Feedback Mechanism to Practitioners. A common need described by paramedics, 911 operators, and firefighters is the desire to see what happened to a patient he/she served. The tool would allow for a quick query of an incident and related patient outcome information.
- Visualization for select user types. The potential exists for decision-makers within trauma centers and across trauma regions to have a common operating picture (COP) for larger scale decision making, such as trauma center diversion and re-routing in the case of mass casualty incident (MCI) situations.

These system design principles were presented to participants in follow-up meetings and presentations validated as important to the design of IT systems that could improve health care delivery for practitioners and patients. Stakeholders discussed that an important next step would be to instantiate these principles into the design of EMS data systems and test its ability to impact care delivery.

CONCLUSION

This multi-method research provided an exploration into the state of PCR system processes and procedures in use, governing policies therein, as implemented in CA. The survey and focus group discussions, taken together, have provided a foundation to begin to explore the design features of a solution to address challenges with emergency medical care processes and to begin conceptualizing the development of a prototype application. It would be valuable to conduct a more in-depth study into the few EMS systems in California and elsewhere that have implemented effective information sharing policies and can demonstrate the benefits and challenges of measuring compliance with those policies.

In sum, while an ePCR deployment in and of itself will not ensure optimal collection, reporting, and transfer of patient information in a timely manner, there is an important parallel activity that should take place. That is, refinement (and possible reengineering) of the work flows, processes, procedures, and policies that facilitate information hand-offs across pre-hospital and hospital settings.

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