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iRevive, A Pre-Hospital Mobile Database

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ABSTRACT
A majority of emergency medical services (EMS) events are documented by hand, requiring an extensive amount of processing, sorting and review. The data required to obtain quality results researching EMS systems exists in disparate locations with limited access due to current patient privacy laws, poor penetration of data mining and incompatibility of technical systems. iRevive, a handheld mobile database for the pre-hospital setting addresses these problems. It allows point-of-care data capture in an electronic form and uses wireless technology to interface with a back-end server. This server, with web services, provides billing and research applications. Initial field trials of iRevive were performed with Professional Emergency Services on 16 emergency responses. Key issues in workflow and content of the resuscitation software were identified and barriers to its successful integration discussed.

KEYWORDS
iRevive, Emergency Medical Services, Computerized Patient Care Report, Healthcare Data Integration

INTRODUCTION

People's lives often depend on the quick reaction and competent care of emergency medical technicians (EMTs). Incidents as varied as automobile accidents, heart attacks, drowning, childbirth and gunshot wounds all require immediate medical attention. Emergency Medical Service personnel provide this vital attention as they care for and transport the sick or injured to appropriate medical facilities. Dispatched to the scene by a 911 operator, EMTs arrive, determine the nature and severity of the patient's condition while trying to ascertain whether the patient has preexisting medical problems. Following strict rules and guidelines, they give appropriate emergency care and transport the patient to an appropriate medical facility. EMTs may use special equipment such as backboards, defibrillators, airway adjuncts and various medications before placing patients on stretchers and securing them in the ambulance for transport. At the medical facility, EMTs transfer the care of their patients to emergency department personnel by reporting their observations and actions to staff.

EMS personnel must document the care they provide. They do so in the form of a pre-hospital record, which must be completed for each patient that is treated or transported by them. The pre-hospital record is "a medical and legal document used by Emergency Medical Technicians to record a variety of data concerning a patient's current illness or injury, treatment rendered by EMS, subsequent improvement or worsening of the patient's condition and past medical history" (Mann, 2002). This type of pre-hospital documentation is completed to support the transfer of care and it is used to gain reimbursement from various insurance companies. The vast majority of EMS events are documented in a hand-written format, which requires an extensive amount of manual processing, sorting and review. In addition, the patient care report does not contain data regarding patient outcomes, making effective EMS research difficult. Currently, there are limited methods to adequately measure the effectiveness of an emergency medical system (Dunford, 2002). The data required to obtain quality results exists in multiple disparate locations with limited access due to current patient privacy laws, poor penetration of data mining and incompatibility of technical systems.

This report will provide an overview of the current state of EMS workflow, pre-hospital documentation and EMS research. It will emphasize the National Highway Traffic Safety Association's goals for EMS in the future, including the need for a national EMS database and improved information systems. The report will use, as an example, iRevive, a new tool for EMS professionals that can streamline data capture, communication, reimbursement processing, quality assurance and research in the field. Finally, actual deployment of iRevive for live field-testing by Professional Emergency Services personnel will be examined and critiqued.

BACKGROUND

Ambulances of the early 1900s were regarded as a means of transportation for the sick and injured from homes, work sites and public places to hospitals, where real treatment could begin. It was not until the advent of cardio-pulmonary

resuscitation (CPR) and the 1966 publication of a National Academy of Sciences paper entitled *Accidental Death and Disability: The Neglected Disease of Modern Society* that Modern EMS systems came into being (Callahan, 1997). Later, with the introduction of cardiac defibrillation by trained crewmembers and more extensive airway training, the back of ambulances became the sites of true life-saving treatments. While emergency medical services have grown rapidly over the past 30 years, EMS research has not. Most EMS research focuses on a single intervention or health problem, and it rarely addresses the inherent complexities of EMS systems (Delbridge, 1998).

Ambulance services use continuous quality improvement (CQI) to assess the quality and effectiveness of an EMS system and its personnel. Most CQI efforts are short-term measures to evaluate effectiveness. For Example, outcomes from cardiac arrest are often cited as a means to evaluate a system. A recent USA Today article measured the effectiveness of 50 cities' EMS systems based on cardiac arrest data because, "sudden cardiac arrest is the purest measure…and victims can be saved only by fast, heroic action" (Davis, 2003). There is little documentation evaluating the effect of pre-hospital care on trauma outcomes and other medical emergencies. In particular, there is limited data evaluating treatment options in the field, response times, disability, and the overall cost-effectiveness of Emergency Medical Services.

This limited amount of data is seen because healthcare is one of the last industries to transition to the use of computers during daily operation (Foxlee, 1993; Mikkelsen, 2001; Cheung, 2001; Tello, 1995). Although several aspects of the system are now automated, many facilities still manually record clinical information and other data. These methods lead to many problems in the hospital setting including inefficiency, illegible handwriting, misplaced pages and charts, inaccessible information, delayed reimbursement and sub-optimal patient care (Foxlee, 1993; Tello, 1995). Today's EMS systems are no different. The data required to completely describe and document an entire EMS event exists in multiple, disparate locations. (Delbridge, 1998). A lack of integrated information systems further perpetuates the problems found throughout EMS.

Current Methods

Today, EMS personnel usually work in teams of two and divide the workload at a particular event. They are required to obtain information ranging from the incident location to the patient's social security number and their Glasgow coma score. It is when the patient's condition is more critical that EMS team members must give their full attention to patient care, foregoing any attempts at data capture or documentation. Yet, it is usually data from these types of events that is of greatest interest. The dilemma is that as EMS evolves to offer more and more advanced care, more time is needed for hands-on patient care and in turn; more information should be documented (Mears, 2002). To overcome this obstacle, EMS systems must adopt information systems that streamline the recording, storage, retrieval and application of quality information.

Need For a National Database

As EMS systems mature, providers are being held accountable for response times, quality of service, medical care provided and the overall value to the their patient and community. Today, the nation's EMS systems are treating victims of illness and injury with little or no evidence that the care they provide is optimal. It is estimated that EMS systems treat and transport up to 30 million patients per year (NHTSA, 2001). It is assumed that EMS intervention positively affects patient outcomes, but this is difficult to quantify. Studies have shown that early defibrillation and administration of particular drugs saves lives, but other interventions including intubation in the field, the use of pneumatic anti-shock garments and other tools may in fact cause more harm than good (Adnet, 2001; Vahedi, 1995). The fact that so few therapies have been examined in outcome studies illustrates the lack of evidence for most pre-hospital interventions and EMS itself.

New methods are being developed to quantify and organize the plethora of data being collected. In 1996 the NHTSA published the *EMS Agenda for the Future: Implementation Guide* in which it stressed the need for a standardized EMS information system to develop uniform data elements and uniform definitions (NHTSA, 2001). In order to accurately draw conclusions there must be some information regarding care in the field, transportation, emergency department care, hospital care, and final patient disposition. Better information is difficult to obtain because of poor linkage of pre-hospital and hospital databases, new patient privacy laws and inadequate funding.

EMS information systems must develop a means of storing and retrieving patient data so that patient information is always available. Data must be pooled from a communications center, ambulance personnel, emergency department staff and finally, other agencies including fire departments, police departments and medical examiners. Only then can there be a complete database containing all of the information necessary to describe an entire EMS event and facilitate continuous EMS system evaluation and research across multiple systems and to support patient care and EMS-related research (Delbridge, 1998).

iRevive

In order to fulfill this vision of a national EMS database and healthcare data integration, changes must be made with regard to how data is originally collected. iRevive is an application designed to address this need. iRevive is a mobile database for pre-hospital personnel. Originally conceived from the frustrations of obtaining quality patient information from the original source (EMS crew) in an effort to run a surgical practice, iRevive allows point-of-care data capture in an electronic form. This information can be sent wirelessly from the field to a server that stores and relays the information to the receiving hospital. The stored data can be accessed for billing and research purposes using web services (fig 1).

One of the objectives of this system is to improve the response by EMS and the management of patients by the emergency department. Conveying patient medical information from point-of-care to a receiving hospital should facilitate preparations prior to the arrival of the ambulance. Currently, EMS personnel must call a receiving hospital using a cellular telephone or radio connection, taking time away from essential patient care and requiring that written records be made on the receiving end.

iRevive is designed to improve documentation of patient management during EMS events, consequently improving the care delivered and service to clients by streamlining data capture and providing essential pre-hospital information for integration with the remainder of their medical record. It is the vision of the makers of iRevive that the PCR started in the field become a part of the patient's hospital chart. Using a central server, emergency department personnel could incorporate field data with data that is collected during the hospital stay. Linking the data would provide a means to study the data in an effort to improve the care of patients during ambulance runs. This, in turn, is expected to improve quality control, and allow for a greater scope of planning and development of emergency medical services (Ananthataman, 2001).

In addition to improved patient management and communication, iRevive relieves billing departments from the tedious task of manually entering illegible data into billing software. Once completed, iRevive produces a complete, electronic, legible record of an EMS event that can easily be obtained using web services and used for billing purposes.

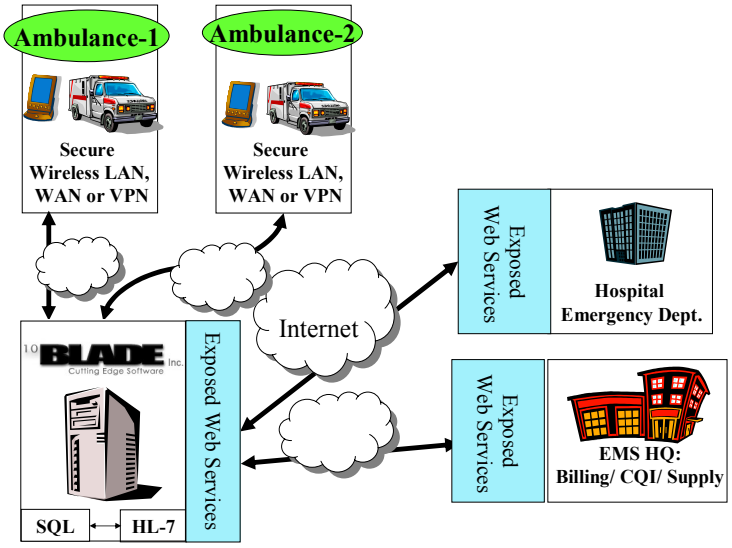

Figure 1: iRevive interface between field, 10-blade server

iRevive is written in C# and built to run on any type of hardware including PDAs, laptops or wearable computers running Microsoft Windows CE. This allows flexibility when choosing a platform. iRevive is a menu driven database. There are drop-down menus that can be customized to increase efficiency. These allow for quick navigation and data collection. iRevive is divided into two main sections, the first contains patient demographics, past medical history (PMH), current medications, emergency care provided and the history of the present illness (HPI) (fig. 2). Here, standardized narratives for the most common chief complaints are found. These range from an allergic reaction to dead on scene. The use of standardized narratives allow EMTs to quickly describe each incident using a series of drop down option boxes to yield a complete standardized narrative of each incident. The addition of pertinent negatives and additional information regarding special circumstances is also allowed. Furthermore, these narratives enrich the database and in the future will aid in the development of new knowledge-based treatment algorithms.

The second section is devoted to an extensive physical exam including head, neck, chest, extremities and central nervous system. From this main menu, users may select a part of the anatomy that has been found to be abnormal. Selecting an "abnormal" body area immediately brings the user to additional pages where they may document the physical findings in a more detailed manner through a series of pull down menus. Currently, users connect to a back end server running Microsoft SQL Server 2000. This offers an optimal database for management and the ability to query for research applications. This centralized database can be accessed via the Internet. Once data has been synchronized with the database, EMS and hospital personnel can instantaneously track current patients and a complete patient care report can be generated and printed. Specific providers will have complete access to their entire record base for billing, supply tracking and continuous quality improvement (CQI) applications. Other users will have the ability to access de-identified data that is non-proprietary

or confidential for use in overall emergency service research and systems management. All data transfer is Health Information Patient Privacy Act (HIPPA) compliant and encrypted using industry standard HL-7.

MATERIALS AND METHODS

One ambulance from Professional Emergency Services (Pro) was selected to field trial iRevive. Professional provides emergency medical care for the City of Cambridge Massachusetts, responding to over 16,000 emergency medical calls per year.

iRevive was used in parallel with the service's existing handwritten documentation methods during emergency responses. Data was collected using a Hewlett Packard iPAQ Pocket PC and was synchronized with a laptop satellite station before being uploaded to the server at the end of each shift. In an attempt to steer further product development, the effectiveness of iRevive in integrating and streamlining data capture was studied. Its ability to merge with the current workflow of EMS professionals was also evaluated. Factors examined included ease of use, documentation completion and content. The use of iRevive in the field was examined by a proficient user and ambulance crew chief as well as via interviews with other ambulance crewmembers. Printouts of iRevive PCRs were compared to handwritten reports from the same EMS events.

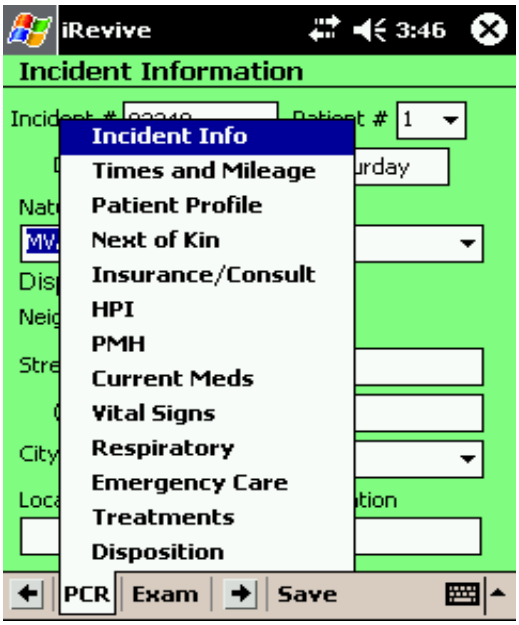

Figure 2: iRevive patient care report sections

RESULTS

iRevive was used in conjunction with the standard method of EMS documentation at Professional Ambulance for 16 emergency medical responses. Of these responses, 12 were for calls for medical help, 3 for trauma and 1 for an assist. iRevive was demonstrated and used between calls by 12 of the 50 field providers at Pro.

While there was no difference seen in the type of data collected by both forms of documentation, throughout the course of the study difficulties were encountered with iRevive's flow of data capture. 7 of the 16 PCRs attempted with iRevive could not be completed due to the inability to save a PCR in progress or view and edit a PCR once saved. Other difficulties were encountered with the workflow of the program including need for the "history of present illness" and "times" pages to be changed to the end of the report.

DISCUSSION

Throughout the study, several problems were noted regarding the use of iRevive with the current workflow at Professional Ambulance. As the PCRs were filled out, it was noted that the "history of present illness (HPI)," needed to be navigated before enough data was collected to accurately complete this section. Also, Using iRevive to record event times was not as successful as it was intended to be either. The "times and mileage" page was found at the beginning of the PCR, this required jumping back and forth to record a time. Since these times are already recorded by the dispatch center, it was found that using dispatch data was more accurate and much easier. Major difficulties were also encountered when trying to save PCRs. The program does not allow a PCR to be saved unless mandatory fields are completed. This feature is in place to prevent incomplete documentation, but in practice it is not appropriate. An ambulance turning over a patient at a hospital would be assigned another emergency requiring a "quick turnaround." In these instances, iRevive reports could not be saved and completed at a later time. In addition, there is no way to return to a specific saved PCR for editing before synching with the server. The user should be able to save the PCR at anytime during its use and be able to return to it at a later time for completion, preventing a costly loss of patient demographics, EMS event descriptions and revenue.

These issues highlight the problems of integrating pre-hospital data with the rest of the healthcare enterprise. Obtaining the information necessary to accurately describe such high paced, high stress situations combined with the need to effectively treat the patient, follow protocols, and inform the receiving hospital while upholding the "business" of EMS is problematic. Integration cannot be made with applications like iRevive until the data can be initially obtained in a way that satisfies the needs of the end user. How can a patient's name be integrated with hospital data if it cannot be initially recorded accurately? There is no question of the need for this type of technology to allow EMS to expand and improve, but if we are to successfully integrate such valuable data with the rest of the healthcare system we must first design systems that can effectively support the complex and heterogeneous work of the rescue professional. The methods used by EMS crews have

been perfected to be as efficient as possible. Having an application like iRevive that does not offer an immediate benefit to the patient will be quickly ignored if it cannot be integrated into EMS' current workflow.

In the next version of iRevive, several data points will be added to more accurately document an EMS event and improve research. Points will be added to capture: the type of response, location type, patient's race, patient's weight, signs and symptoms, provider impression, reason for transport, pain rating, skin condition, transport type, difficulties encountered and reason for destination determination. Furthermore, changes will be made to allow the user to return to and save PCRs in progress. In addition, the use of voice activated and "wearable" computers with heads-up display is being investigated to further streamline data capture and data integration in a method that is least intrusive to the end user. Ideally, dispatch data like times, mileage and location will be automatically entered into the program by dispatchers as they process a call limiting the amount of data needed to be entered by the crew. Using wearable computers, EMS crews will be able to better document events as they happen while still giving them use of both hands to perform life-saving skills. With a simple internet connection, hospital emergency departments will not only be notified of an incoming ambulance, but also be provided with updates on a patient's condition, allowing them to better anticipate the patient's arrival.

Once these goals are met, further challenges will be seen as we attempt to further integrate pre-hospital data. Using a central server to store and aggregate this data improves the existing process, removing disparate locations of pre-hospital data, but does not address the problem of integration with systems outside EMS. In addition, new barriers will be encountered when attempting to share this data with other entities for research due to new patient privacy laws and business competition among software vendors and private ambulance services.

CONCULSION

The need for advanced technology in today's healthcare system is unquestionable. Healthcare is one of the last industries to transition to the use of computers during daily operation. This leads to many problems including time consumption, illegible handwriting, misplaced pages, inaccessible information, decreased quality of care and sub-optimal reimbursement. The data required to completely describe an entire EMS event exists in multiple, disparate locations including hospitals, dispatch centers and ambulance providers. In most cases, links between these locations do not exist. A lack of integrated information systems further perpetuates the problems found throughout EMS and healthcare. Using software programs like iRevive at the point-of-care will facilitate data capture, improve medical response by EMS and improve the management of patients. These same programs are meant to assist billing departments. The ability to recall and generate this information will provide emergency medical systems the ability to effectively critique their service and effectiveness and allow investigators to examine outcomes using large sample sizes.

Successful preliminary field trails of iRevive have demonstrated its ability to streamline data capture in an electronic form while highlighting several points of the application that do not fit with the current workflow of EMS professionals. Additionally, changes to the current data points have been proposed to strengthen the program. As barriers to successful integration are overcome, further studies are planned providing EMS crews with a new version of iRevive to use as their primary form of documentation to revolutionize the way patients are treated and data is collected in the pre-hospital setting and used throughout the remainder of the healthcare enterprise.

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