The Usefulness of Information and Communication Technologies in Crisis Response

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Abstract

Information and communication technologies (ICTs) play a vital role in coordinating crisis response between pre-hospital services and emergency departments of hospitals. In spite of the advances in these technologies, there remain a variety of challenges to their usage during a crisis. To identify these challenges, we conducted focus group interviews with emergency department (ED) and emergency medical services (EMS) personnel. We found that ED and EMS personnel have widely varying perceptions about the usefulness and ease-of-use of information tools and communication tools used in crisis management. We discuss the importance of bringing together communication and information tools into integrated networks of ICTs for effective crisis response. We also highlight design features of ICTs which can support seamless and effective communication and coordination between ED and EMS teams.

Introduction

Recently, there has been a push towards deployment of information and communication technologies (ICTs) for emergency crisis response[1]. It is expected that such technologies will improve information sharing, resource allocation, communication, and collaboration among emergency medical services (EMS) and emergency departments (EDs) of hospitals[2]. However, since many of the technologies proposed are new, there is little evidence to support that they will indeed be successful in the field.

Care providers' perceptions of the benefits, ease of use, and usefulness of information systems influence the successful implementation and adoption of these systems in healthcare[3]. Thus, in order to support ED and EMS personnel via emergency response technologies, we first need to understand their attitudes towards these technologies. We must also understand their expectations of the benefits and challenges of ICT usage during crisis response.

We conducted a qualitative study with healthcare providers associated with the pre-hospital services and ED of Hershey Medical Center (HMC), a major teaching hospital in Pennsylvania with high levels of ICT usage. Our study goals were two-fold. First, we were interested in examining EMS and ED personnel's perceptions of the potential role, usefulness, and ease of use of ICTs during a mass casualty incident (MCI). Second, we were interested in examining how current ICTs used by these care providers support management of a potential MCI.

Our study revealed that ED and EMS teams differ on their attitudes towards the role and usefulness of ICTs for crisis response. This results in inconsistencies in information management practices between these teams. Also, there is a difference in how these care providers perceive and use information technology (IT), such as computer-based systems, and communication technologies (CT), such as cell phones and pagers. These findings suggest the need to design well-integrated networks of ICTs and train users about the benefits of these technologies.

Background

ICTs have the potential for supporting information sharing, resource management, and collaboration among pre-hospital services and EDs during an MCI. However, this potential is only realized if the levels of adoption and use of ICTs are equal for all actors involved in crisis response. While both EMS and ED teams use conventional communication tools, there are differences in how computer-based information tools are adopted and used. Many EDs have moved from paper-based systems to electronic medical records (EMRs) whereas EMS agencies still mostly rely on paper, voice, and fax for information recording and exchange[2].

Over the past few years, several computer-based systems have been proposed to help EMS personnel track casualties and resources, communicate with receiving hospitals, and triage casualties effectively. Most of these systems are based on PDAs, GIS, GPS, and local and wireless LAN networking[4-6]. Other systems enable hazardous materials (HAZMAT) units to view hazardous substance databases and patient symptoms on handheld devices at the scene of a HAZMAT incident[7]. Tele-presence systems[8] that stitch together live video feeds in real-time have been developed to help first responders achieve better situational awareness of the incident site.

In healthcare, the implementation of the same technology at different organizations has been found to lead to contradictory results and outcomes[9]. Most contradictory findings are attributed to organizational factors that influence technology adoption and use, as well as limited functionality of commercially available systems[10]. Research in technology adoption and use suggests that users' beliefs and attitudes towards technology use are important predictors of the successful deployment of technologies[3]. Therefore, in order to understand how useful ICTs can be in a crisis situation, we were interested in examining different users' perspectives on the roles, ease of use, and usefulness of ICTs for crisis response.

Methodology
We conducted focus groups at HMC, a 500-bed teaching hospital with nearly 48,000 ED visits per year. HMC is serviced by:

- *LifeLion*: a critical care transport service, with two medically-equipped helicopters and a pediatric mobile intensive care ground ambulance. Supporting LifeLion is a computerized communication center (CC), staffed by specially trained air medical communications and dispatch specialists.
- *University EMS*: A ground service consisting of nine ambulances that respond to 911 calls for the surrounding counties.

ED and EMS personnel utilize information technologies (IT) and communication technologies (CT). IT refers to computer-based systems used for information management. HMC uses an integrated electronic medical record (EMR) with different access portals for admissions, nurses, physicians, and ED staff. The EMR interfaces with lab, radiology, and pharmacy information systems and provides computerized provider order entry (CPOE) and clinical documentation. CT refers to communication devices used for information transfer, such as cell phones, pagers etc.

Procedures
We conducted 7 focus groups with HMC's ED, Life Lion, and UEMS staff. Table 1 shows breakdown of participants by type and focus group number (FG#).

Type of participant	No.	FG#
Attending physicians	5	1
Emergency medicine residents	6	2, 3
Ground and air paramedics	8	4, 5, 6
Communications Center staff	2	7

Table 1. Breakdown of focus group participants.

Participants were presented the scenario of a train derailment involving leakage of hazardous materials. Our scenario was designed to progressively provide participants with time-stamped events to mimic how information would become available to them during an actual MCI. After presenting participants with an event, we asked them several questions regarding how they would respond to the event, such as:

- What information do you need at this point?
- Who provides you with this information and who do you share it with?
- What information and communication tools are you using at this point?

We followed up the focus groups with semi-structured interviews with individual care providers and management staff. We attended review meetings conducted after a disaster drill to discuss positive and negative aspects of the response during the drill. We perused after-action reports, patient triage sheets used during a crisis, and HMC's disaster response plan.

Data Analysis
Using a Grounded Theory approach[11], we analyzed over 100 pages of transcripts of focus group interviews. We coded the transcripts to find common themes. The coding was performed independently by the first and third authors and then all authors met to discuss and reach consensus on the important themes. The study was approved by HMC's Institution Review Board.

Findings
The focus groups highlight the role, ease of use, usefulness, and actual usage of ICTs at HMC.

Uncertainty about the role of IT
Physicians were not sure exactly what role IT would play during an MCI. One physician said "*My prediction, and it's purely conjecture on my part, is that IT will go right out the door the moment this happens*". We found residents, given their lack of experience with crisis management, to be particularly unsure about the role of existing computer-based systems in the event of a crisis. When a resident answered our question as to what role their EMR would play in the given scenario, other residents asked him "*but how do you know that, in a disaster situation, do they still use computers?*" When asked whether they would use electronic records for admission during an MCI, one resident admitted "*We don't know for sure*".

Retrospective use of IT tools
Under normal operation of the ED, every patient's information is entered into the EMR at triage. However, physicians felt that if there were a deluge of patients over a short amount of time, they would go "*low-tech*" and switch to paper-based mode of operation. Only after the crisis was over would they transfer the information collected on paper to the EMR system. Given a large number of patients coming into

the ED rapidly, a resident said, "*Once patients come in they will be assigned a number and that's how you would take care of them until someone from registration will come around, get their name, and then get it into a computer.*" Thus, in an emergency, verbal communication of care-related information would take precedence over entering information into the computer. Thus, the computer system would be relegated to a mere record-keeping tool as opposed to a tool actively used to manage the MCI.

Paper is better than IT

Both ED and EMS staff felt that using current IT systems would constrain them in a disaster situation and they would prefer using paper to computers. One physician said, "*Paper is so much better than the computer. Because in a situation like this is the time when the IT system gets overwhelmed.*" Also, with respect to getting back lab results in an MCI, "*the current IT system would be completely unworkable*". EMS personnel were also skeptical about how useful technology would be given that "*it takes time…things are happening on scene so quickly*". They said, "*…things can escalate rather quickly, so if you take time to start playing with the PDA, you can lose track. Maybe paper would be quicker; you can jot notes, your short notes, short hand…*" In spite of their heavy reliance on communication tools like cell phones and pagers, care providers were not satisfied with the usefulness of these tools. Given their experience with not having cell phone coverage in remote locations, paramedics pointed out that "*technology is good except when you are in the middle of the boondocks*". Instead, paper seemed to be the most easy to use in crisis situations. EMS and ED staff both mentioned that they would exchange information using "*yellow sheets*" which are casualty triage forms used to note patient information in MCIs.

The communications center (CC) is located in the ED and its role is to convey information between EMS units and the ED. Currently, operations of the CC depend mainly on radio, paper and the phone. CC personnel note information given by EMS units on paper and for incoming ambulances they have "*sheets to be filled out*". They use computers to track the helicopters and ground transport units, but rarely for information storage or retrieval. The various information exchanges, such as EMS to CC to charge nurse, are not stored electronically. One of the CC staff said he was most comfortable with paper because he "*…grew up with it at the county level where we did not have the computer aided dispatch system*".

Difference between ED and EMS levels of IT use

We received different responses from EMS and ED personnel regarding their level of computer usage. Computers are extensively used by the ED staff. A physician said, "*All our orders are on computers. There is Internet and all that on computers.*" While the ED uses an EMR and a CPOE, EMS personnel do not carry computers on ambulances or helicopters, and hence do not have on-board access to the EMR or CPOE. The EMS teams expect to install laptops in the near future; however, the laptops will primarily be used for wireless and radio communication. Paramedics said that while they were considering installing laptops on-board, "*the information is usually available on-site or through the communication center. You will call the communication center and say 'this is command such and such, we need to know such and such…'*". EMS teams exchange information primarily through communication technologies and do not perceive IT tools to be particularly important for their information management needs.

Communication tools more important than information tools

Both ED and EMS personnel mentioned the use of pagers, cell phones, walkie-talkies and radios multiple times during our scenario. However, they rarely mentioned using the EMR or the CPOE and did not envision it to play a major role. Interestingly, there was no mention of using information tools to communicate information between different actors; communication tools would be the sole means for exchanging information during a crisis. CC personnel said that they receive patient information from EMS and "*page the trauma responses and put it up on the trauma recorder so all the trauma teams that respond ….call a certain number and listen to what's coming*". Thus important information is disseminated via recorders and phones instead of centralized information systems.

In spite of the heavy reliance on conventional communication devices, participants complained about their severe limitations. Residents admitted that even though the primary means of communicating a disaster alert to them was the paging system, outside the hospital "*at least half or may be a majority of us don't have our pagers on*". The cell phones used by ED and EMS personnel hit dead spots and the 2-way radios fail because of mismatch of frequencies between counties.

Extraction of information depends on individuals

Currently, ICTs do not 'push' relevant and timely information during a crisis to actors who need it. Actors need to actively 'pull' information. Therefore, the quality and timeliness of information extracted depends on an individual's motivation, skills, and training. Given the limited information available in the early stages of our scenario, some residents would go to the CC and ask for more information, but not

others. CC personnel listen to various frequencies of the surrounding counties and reporting frequencies of the Life Lion helicopters and ambulances. From experience they have learnt to extract relevant information when listening to numerous frequencies and pass on required information to ED and EMS teams. When asked whether they get overwhelmed with the amount of information on the various frequencies, they said, "…*with the amount of experience, you learn what to listen to and what just to tune out.*" However, individual motivation and experience determine the quality of information extracted by CC personnel from these communication channels. EMS personnel said about CC staff that "*some listen [to the radio frequencies] more than others...*" and so the amount and quality of information passed on to them "*depends on who's there, depends on their mood*". On occasion, depending on who is working in the CC, EMS units have received inaccurate information and reported to wrong hospitals for patient transfers.

Discussion: Does ICT equal IT + CT?

The term ICT implies the integration of information and communication technologies such that the whole is greater than the sum of the parts. IT and CT need to be seamlessly integrated to leverage processes of care. However, our study revealed that there is a clear distinction in the roles and uses of IT and CT for emergency response. For instance, EMS personnel verbally communicate patient information to the CC which in turn pages or calls the charge nurse in the ED. However, the ED primarily manages patient information electronically using the EMR.

We found that current ICT usage is divided into two distinct domains – the IT domain that contains computer-based systems and the CT domain that contains communication devices. CT enables communication of unstructured information in the form of natural language. IT forces us to convert our verbal communications into structured information to fit into the schema of underlying databases. An ideally integrated ICT environment should enable unstructured communication to flow easily into the structured domain of information systems and vice versa. However, current ICTs do not facilitate seamless information flow between the CT and IT domains; this task is left to the human actor.

In situations where users are unable to extract structured information from unstructured communication, they prefer paper and verbal communications to IT tools. When users are overloaded with verbally communicated information, and where CT are not integrated with IT, users switch to low-tech methods such as paper which provides unstructured information management. Therefore, we need to develop means of real-time integration of CT and IT such that

information can flow seamlessly between them. Integrated networks of ICTs should enable unstructured verbal communication to be automatically converted to structured information for insertion into information systems. In the next section, we highlight some of the design requirements for these types of systems.

Design requirements

Easy conversion of unstructured to structured information: EMS personnel find it difficult to use handheld technology that constrains free-form data entry for the same reasons that ED staff in our study found the EMR unusable in disaster situations. Therefore, we need to design technologies that automatically convert unstructured information into structured information suitable for computer-based systems. For instance, verbal communication devices can be designed to transmit EMS information to speech-to-text systems which extract relevant information and populate EMR databases that can be accessed in the ED.

Interoperability and standardization: Standardization of emergency response information systems is important so that different hospitals and EMS units can exchange information about resource availability, number and types of injuries, presence of decontaminants etc. during a disaster. To complement ED usage, access to the EMR should be made available to EMS personnel on-site[6]. During emergency situations, where existing technologies do not provide support, there is often a mixing and matching of diverse ICTs[12]. Hence, there is a need to ensure interoperability between ICTs used by different agencies and across regional boundaries. Multi-organizational radio interoperability issues have long been cited as an obstacle to communication during response. Potential solutions to such technical problems include designing dual-use technology which allows both normal and emergency modes of operation and built-in architectural and protocol redundancy in tools[13].

Information 'push' model required: For EMS, the "information pull" model of seeking relevant information by listening to various frequencies is grossly inefficient. Technologies need to be developed that can eliminate waste of bandwidth used to seek information by "pushing" relevant incident information to EMS units. This will also ensure that all actors, regardless of their background and experience with IT usage, consistently access accurate information.

Training and awareness about ICT usage

Training and awareness about ICTs will increase readiness of EMS and ED staff to respond when faced with a crisis We found that even as more and more IT tools are being incorporated into EDs and EMS, it is not clear to users what roles these systems

will play in situations that they are not primarily designed to support. Hospital management must train staff about the capabilities and benefits of these technologies for dealing with MCIs. For instance, we found that residents were not formally educated about the usage of IT systems during an MCI. Prior ICT use determines, to some extent, how open and enthusiastic care providers are about using IT. CC personnel with prior experience with using computer-based systems were more comfortable with using the computer-aided dispatch system as compared to others who "*grew up*" using paper. This led to inconsistent methods and media for recording information. Therefore, training is crucial to ensure equal levels of comfort with technology use.

Limitations

Our study is limited by the number and variety of focus groups conducted. Nurses and emergency medicine technicians could not be interviewed due to organizational changes at HMC at the time of our interviews. However, we believe that our focus groups provide a representative cross-section of the multiple perspectives of ICT adoption and use in an emergency response situation

Conclusions

Our study at HMC highlights the various perspectives on usefulness and ease of use of ICTs during a crisis. We found that even among the ED and EMS teams of a hospital with above-average ICT usage, there were more negative than positive views about the role that ICTs would play during a crisis. We must address these negative perceptions of ICT usage during a crisis. There are two important steps that we can take to address these issues.

First, we need to develop integrated systems that support the seamless flow of information between structured and unstructured forms. Second, we need to facilitate 'emergent interoperability' between ICTs[12] through focusing on real-time integration of information and communication technologies.

ICTs are a crucial component of emergency crisis response. However, for these technologies to be successful they must support both pre-hospital and hospital sides of the crises response.

Acknowledgements

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