EDITOR'S CHOICE

Application of information technology within a field hospital deployment following the January 2010 Haiti earthquake disaster

Gad Levy,[1,2] Nehemia Blumberg,[1,2] Yitshak Kreiss,[1] Nachman Ash,[3] Ofer Merin[1,4]

[1]Israel Defense Forces Medical Corps, Tel-Hashomer, Israel
[2]The Tel-Aviv Sourasky Medical Center, Tel-Aviv, Israel
[3]Israel Defense Forces Surgeon General, Tel-Hashomer, Israel
[4]Shaarei - Tzedek Medical Center, Jerusalem, Israel

Correspondence to
Dr Gad Levy, 54 Halivne St, Givaat-Ada 37808, Israel; gad.levy@gmail.com

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ABSTRACT

Following the January 2010 earthquake in Haiti, the Israel Defense Force Medical Corps dispatched a field hospital unit. A specially tailored information technology solution was deployed within the hospital. The solution included a hospital administration system as well as a complete electronic medical record. A light-weight picture archiving and communication system was also deployed. During 10 days of operation, the system registered 1111 patients. The network and system up times were more than 99.9%. Patient movements within the hospital were noted, and an online command dashboard screen was generated. Patient care was delivered using the electronic medical record. Digital radiographs were acquired and transmitted to stations throughout the hospital. The system helped to introduce order in an otherwise chaotic situation and enabled adequate utilization of scarce medical resources by continually gathering information, analyzing it, and presenting it to the decision-making command level. The establishment of electronic medical records promoted the adequacy of medical treatment and facilitated continuity of care. This experience in Haiti supports the feasibility of deploying information technologies within a field hospital operation. Disaster response teams and agencies are encouraged to consider the use of information technology as part of their contingency plans.

INTRODUCTION

The Israel Defense Forces (IDF) Medical Corps maintains a field hospital unit, capable of providing diverse medical services. The hospital comprises seven departments: medicine, surgery (including an operating room and intensive care capabilities), orthopedics, pediatrics (including neonatal intensive care), obstetrics and gynecology, ambulatory care and an auxiliary services department that consists of imaging (x-ray and ultrasound), laboratory, medical engineering and equipment, mental support team, medical informatics team, and a logistics team. As part of an ongoing project to refurbish and revitalize the field hospital, an information technology solution scheme was prepared. The solution consisted of a computer network infrastructure on top of which a dedicated administration and medical record information system had been developed. The response also included a light-weight picture archiving and communication system (PACS).

BACKGROUND

On January 12, 2010, a magnitude 7.0 M_w earthquake struck Haiti. The earthquake caused severe damage to buildings throughout the capital city Port au Prince. The International Red Cross estimated that about three million people were affected by the quake. Hundreds of thousands were killed and injured. In response to the event, the IDF dispatched the above mentioned unit, which set up a field hospital at the soccer field near Port au Prince airport (figure 1). During this deployment of the hospital, the pre-devised information technology plan was activated. Demchak *et al*[1] reported the development of a system named WIISARD (Wireless Internet Information System for Medical Response in Disasters) for collecting and displaying relevant information in a mass casualty disaster scene. However, to the best of our knowledge, the deployment at the Haiti field hospital was the first operational installation of a medical information administration system as well as an electronic medical record within a field hospital operation. In this paper, we describe the system and the lessons learned during its deployment in Haiti.

DESIGN OBJECTIVES

The information system was designed to meet two primary objectives. The first was to serve as an administrative platform for the field hospital and to enable hospital command to make informed operational decisions, based on real-time accurate information. The second was to enable advanced case management at the individual patient level by establishing an electronic medical record. The solution scheme had to include a means of distributing digital radiographs throughout the hospital because of the introduction of a computerized radiography machine as part of the hospital's standard equipment.

SYSTEM DESCRIPTION

Network infrastructure

A dual-network infrastructure approach, both wireless and wired, was chosen. The wireless network was set up using two mobile outdoor wireless routers (3e-525A-3MP by E F Johnson Technologies, Irving, Texas, USA, figure 2). The wired network was based on two interconnected switches (3com, Marlborough, Massachusetts, USA). From the switches, Ethernet wires were run to cover every workstation throughout the hospital (figure 3).

Hardware

Fourteen workstations were distributed throughout the hospital. We elected to use laptop computers as

Figure 1 Satellite image of the Israel Defense Forces field hospital in Haiti. The hospital was set up in tents. 1, triage tent; 2, command center; 3, general emergency department; 4, internal medicine department; 5, laboratory tent; 6, imaging department; 7, orthopedic department; 8, post op recovery tent; 9, intensive care unit tent; 10, operating room; 11, preterm infants department; 12, pediatric department; 13, pediatric emergency department; 14, ambulatory care tent; 15, obstetrics and gynecology department; 16, labor room tent; 17, pharmaceuticals storage tent; 18, medical equipment storage tent; 19, compound gates; 20, helicopter landing zone.

the workstation hardware (IBM ThinkPad, Panasonic Toughbook, figure 4). Workstations were connected to hand-held bar-code readers. Digital cameras were used to photograph patients as they passed through the triage tent. Printers were used primarily to print discharge summaries and bar-code labels.

Software

The main application consisted of an administrative dashboard which provided graphical as well as textual and numerical information updated by the minute. The dashboard summarized admissions (total, daily, hourly), discharges, surgical operations, imaging examinations, births, patient distribution by department, occupancy percentages by department, patient injury severity score on admission and current status, distribution of injuries by body system, patient readiness for discharge, and in-hospital deaths. The system also monitored the flow of patients within the hospital and noted dates and times of entry to the various departments. The cumulative information could be drilled down to the single patient level right from the dashboard screen. A second module within the application was an electronic patient record. The medical record, organized as tabs on the application screen, included the following sections: identification and demographic information, photo album, admission notes and status, survey of injuries by body system, follow-up notes, laboratory studies, imaging studies, surgical reports, evacuation priority level and notes, patient movements within the hospital, diagnoses, and discharge summary. In addition, the application included dedicated modules for ordering and reporting results of laboratory and imaging studies. The application was developed by the IDF Medical Corps Information Technology Branch using Microsoft tools. The hospital had an imaging department equipped with a digital x-ray machine. Therefore a solution for image distribution was needed. Open source PACS workstations were chosen for this task (K-PACS).

Figure 2 Wireless outdoors router used at the deployment.

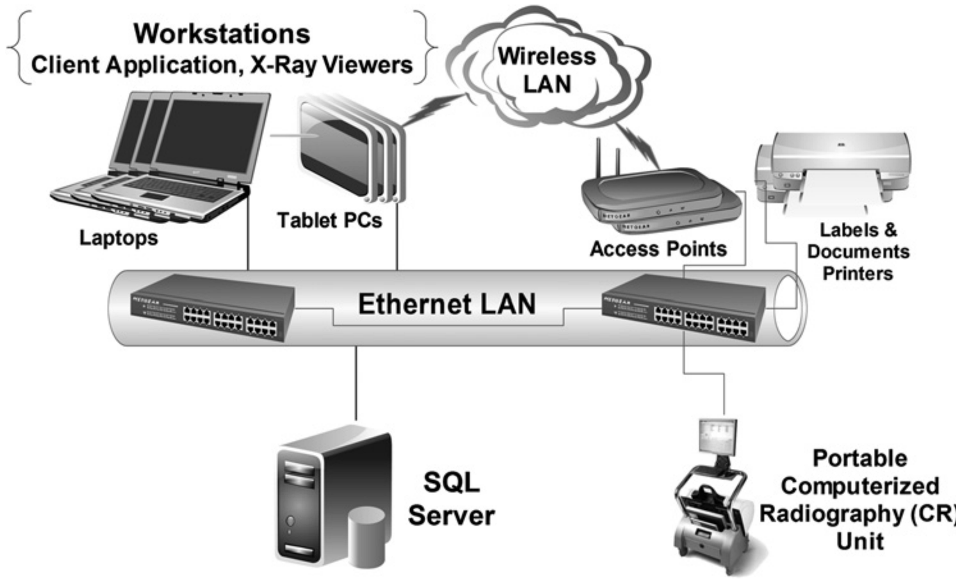
Personnel

The computer system was set up and maintained by the hospital's medical informatics team which consisted of three people: one computer software specialist and two network specialists. The majority of hospital personnel were familiar with the application from a previous drill deployment which had been held just two months prior to the disaster. New personnel were given a short face-to-face training session during the deployment by the informatics team.

STATUS REPORT

During 10 days of operation, 1111 patients were registered by the system and treated in the various hospital departments; 737 of them were admitted as inpatients, 242 operations were performed in the operating room, and 16 babies were born. The computer system was fully operational within six hours of our arrival at the deployment site in Port au Prince, just 89 hours after the earthquake had struck. Initial activity was based on the wireless network infrastructure. The wired network was gradually deployed within the following 48 hours. The network and system were up more than 99.9% of the time. Scheduled maintenance activities accounted for less than 0.1% of the time. Patients, upon passing through the triage tent, were assigned a unique serial identification number produced by the information system and printed as human readable text as well as a bar code on a set of adhesive labels and a bracelet, which was put on the patient's forearm. The patient's face was then photographed from within the application to produce a passport-like image (figure 5). Any obtrusive injuries were also photographed. Images were immediately viewable via the application throughout the hospital. The patient's admission date and time were automatically noted by the system. Preliminary details regarding the patient's injuries and status were then entered by the operator on the admission tab of the electronic medical record with the help of a Creole to English translator who was always available at the triage tent. The patient's bar code was scanned as soon as the patient entered a hospital department (tent). This action triggered an automatic update of the patient's location in the application's database and updated the command dashboard screen. A real-time status of department occupancy percentages throughout the hospital was generated. The patient's medical condition and follow-up information,

Figure 3 Basic system architecture diagram. The network infrastructure consisted of two interconnected switches as well as two wireless routers. Workstation client application communicated with a central database run on a high-end PC machine.



pharmaceutical therapy, imaging studies, laboratory results, and list of diagnoses were updated and maintained by the various care givers, physicians, nurses, paramedics, and medics, using the application. All medical procedures and surgeries were also documented in the electronic record. The documentation of a surgical procedure included at least three photographs: pre-op, during the procedure, and post-op. These photographs were automatically added to the photo-album tab in the patient's electronic record. Radiographs, which were obtained by a portable digital x-ray machine, were transmitted through the network to PACS stations, which were located at the orthopedic tent and at the emergency department tent. Each patient who was discharged to another medical facility had been issued a printed discharge summary signed by their attending physician as well as a CD ROM containing their imaging studies.

DISCUSSION

A mass casualty event following an earthquake is characterized by disorder. One of the major challenges facing a medical aid effort is preventing the extension of the surrounding chaos into the medical facility. Disorder and lack of control in the medical facility means that resources, which are always limited and insufficient in these situations, will be inadequately allocated and not used to the maximum benefit of the population in need. In order to achieve adequate control over the situation, information must constantly be gathered, analyzed, and acted upon to produce clear policies pertaining to key aspects of the field hospital operation. Admission and discharge criteria, resuscitation and intubation guidelines, and directives about usage of scarce resources must be defined and frequently re-evaluated. A computerized hospital administration information system has the ability to gather the required information quickly and accurately, to analyze it, and present it to the decision-making command level promptly, thus enabling an informed decision-making process. Moreover, the use of an electronic medical record in a mega-disaster scenario helps to ensure the adequacy of care in a multi care giver and multi patient environment, enabling rapid patient transits within the various hospital

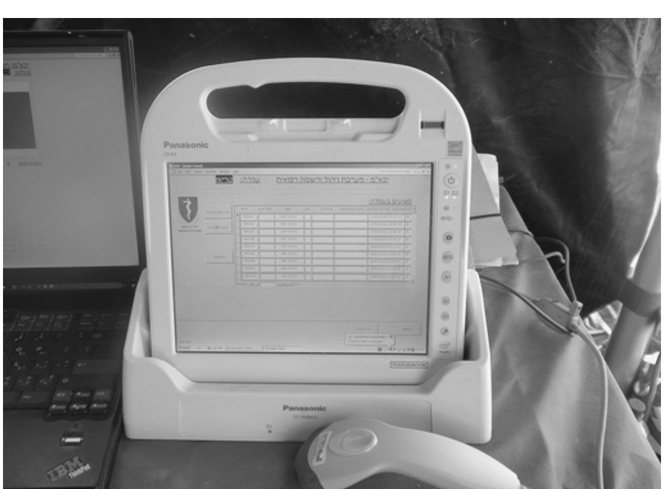


Figure 4 Workstation. Panasonic CF-H1 Toughbook Clinical Mobile Assistant running the application inside the triage tent. A hand-held bar-code reader is also shown.

Figure 5 A paramedic taking a passport-like photograph of an admitted patient at the triage tent. A bar-coded bracelet is worn on the patient's right forearm.

departments while lowering the risk of losing valuable medical information. This had a special significance in Haiti, because of language discrepancies between patients and care givers and the low availability of translators. In addition, an electronic medical record system contributes to effective patient discharge by producing a clear, concise, and easily readable discharge summary. This is crucial in maintaining the continuity of care. Further benefits of using a computerized system in such a situation include the establishment of control over potential bottlenecks in the hospital, efficient management of the surgical waiting list, easy identification and tracking of patient locations within the hospital, facilitation of the treatment of returning patients, and the online production of a well-organized database immediately ready for debriefing and medical research purposes. In addition to these benefits pertaining to the hospital staff and workflows, the system also fulfilled a vital need of the calamity-struck local population. Healthy family members arrived at our gates looking for their injured relatives. Many children arrived at the hospital without a guardian. The database of passport-like photographs produced by the system proved very useful. We encountered several cases of family members who were able to locate their relatives in our database, based on their photographs, and receive information regarding their condition and whereabouts (figure 6).

Technical considerations are crucial to the successful deployment of an information technology solution within a field hospital. The choice of a dual-network infrastructure enabled leverage of the relative benefits of the two types of network: a wireless network has a very short set-up time and enables information systems to be up and running within a short time after installation. Indeed, the information system was up and running in Haiti just six hours after arrival at the deployment site. This was before the completion of hospital assembly. It enabled the system to be relevant from the very first moments of activity. However, wireless networks are vulnerable to radio interference and are currently slower than their wired counterparts. A wired network enables the transfer of larger volumes of information faster, as the hospital's operation scope enlarges. It is also less susceptible to electromagnetic interference. Laptop computers were chosen because of their portability and the existence of an internal battery, which meant resilience to power shortages. Moreover, the application was specifically designed to enable continuous activity of the workstations at times of communication loss with the central server, which was not equipped with a UPS system in this deployment. In addition, the camp was powered by several interconnected generators, which resulted in power shortages being infrequent. Bar-code readers were used to facilitate patient registration upon entry to a specific department within the hospital and to minimize manual data entry errors.

Figure 6 A mother looking for her injured child, browsing the photograph database with the help of the triage tent personnel.

A potential drawback of deploying such a system is the possible formation of a dependency on technology in a harsh, unstable and sometimes unpredictable environment. Such a dependency might become detrimental if technology fails. It is imperative to be aware of this risk and to manage it. Possible means of dealing with it include ensuring a redundancy in network and computer hardware and using toughened hardware, specifically designed for outdoor or military use. It is also vital that computer applications used be specifically engineered to the task and be characterized by high stability and low maintenance requirements. These measures will decrease the risk of failure, but will not eliminate it completely. Therefore it is mandatory to have a fallback plan—the use of plain paper forms. In Haiti, there was a backup paper record for each of the patients. Despite the inherent risks, there is a growing body of evidence in the literature that supports the integration of advanced information and communication technology in the field and in disaster situations.[2–7] The successful deployment of our system in Haiti adds to that body of knowledge. An additional drawback may be that dedicated personnel are required to deploy and maintain a computer system and network. Depending on the scenario, this might come at the expense of medical personnel, which are vital to the mission of a field hospital. However, we were able to deploy and perform all maintenance activities based on three dedicated people only. We feel that the benefits reaped with this system outweigh this potential disadvantage. A light-weight system similar to the one described in this paper may also serve to computerize the activities of other small-to-medium-scale medical efforts in resource-poor settings—for instance, the operation of a rural clinic.

The challenge in Haiti was augmented by pre-earthquake disorder; approximately half the population in the country is unregistered and has no identification documents. Many children arrived at our facility unaccompanied by a parent or guardian. Language discrepancies between patients and care givers added to the difficulty. In the face of these hardships, our system was able to introduce order, provide means of identifying patients and managing their care, and produce timely valuable information that guided the operation.

To conclude, our experience in Haiti shows that deploying a computerized administration and medical record information system within a field hospital during a mass casualty disaster is possible, encompassing many benefits and contributing to the success of the endeavor. It is our recommendation that disaster response teams consider the introduction of information technology solutions as part of their contingency plans. International organizations are encouraged to look into the possibility of developing a generic standardized global information technology solution, perhaps using the internet as the network infrastructure, that may be deployed in disaster scenes worldwide and serve all parties involved in medical and other relief efforts on site.

Competing interests None.

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REFERENCES

1. **Demchak B,** Griswold WG, Lenert LA. Data quality for situational awareness during mass-casualty events. *AMIA Annu Symp Proc* 2007:176–80.

2. **Chan TC,** Killeen J, Griswold W, *et al*. Information technology and emergency medical care during disasters. *Acad Emerg Med* 2004;**11**:1229—36.
3. **Paul SA,** Reddy M, Abraham J, *et al*. The usefulness of information and communication technologies in crisis response. *AMIA Annu Symp Proc* 2008;**6**:561—5.
4. **Troy DA,** Carson A, Vanderbeek J, *et al*. Enhancing community-based disaster preparedness with information technology. *Disasters* 2008;**32**: 149—65.
5. **Chan TC,** Buono CJ, Killeen JP, *et al*. Tablet computing for disaster scene managers. *AMIA Annu Symp Proc* 2006:875.
6. **Killeen JP,** Chan TC, Buono C, *et al*. A wireless first responder handheld device for rapid triage, patient assessment and documentation during mass casualty incidents. *AMIA Annu Symp Proc* 2006:429—33.
7. **Fry EA,** Lenert LA. MASCAL: RFID tracking of patients, staff and equipment to enhance hospital response to mass casualty events. *AMIA Annu Symp Proc* 2005:261—5.