THE CONCEPT OF SCALABLE, INTEROPERABLE,

AND FULLY INTEGRATED HEALTHCARE INFORMATION

TRACKING SYSTEMS FOR DISASTERS

Nikiah G. Nudell, MS, NRP

http://paramedicfoundation.org

nnudell@paramedicfoundation.org

(760) 405-6869

PREFACE

This paper represents the original work and intellectual property of the author. It was first described in 1998 as a framework for supporting agricultural production in what at the time was just beginning to be known as "Precision Agriculture". Several years later in December 2004 this framework was applied to the humanitarian needs in disaster response. This work is copyrighted under US and International law. You are free to copy, distribute, and perform the work under the following conditions:

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Introduction

On a global scale healthcare information technology has been slow to integrate over the past 30 years but has recently gained momentum.[12] Dr. Brailer of the federal Office of the National Coordinator for Health Information Technology advised information technology companies: "A recent study showed that clinical information is frequently unavailable in primary care, and that this missing information can be harmful to patients. That study also showed that clinical information was less likely to be missing in practices that had electronic health records. This adds to the substantial evidence that health IT – such as computer-physician order entry, ePrescribing, preventative reminders, and bar code scanning to name a few – improves care, reduces wasteful and redundant treatments, and prevents medical errors."[3]

Many factors have resulted in disparate information systems with proprietary software that performs only specific functions. "One challenge that has not yet been adequately addressed is the development of scalable, interoperable EHR systems. It is debatable whether the lack of emphasis on interoperable systems is more a result of vendors fragmenting the market, buyers' lack of interest, resistance from payers, perceived market advantage by provider groups or health systems by those making the investment, or fear of sharing information." [4]

In 1999 a National Electronic Health Records Taskforce was established in Australia under the auspice of the National Health Information Advisory Council, to bring a coordinated approach to electronic health record systems and to avoid the potential for incompatible systems and duplication.[5] The Canadian Health Infoway project[6] began a few years ago and continues to be a work in progress, establishing a nationwide Electronic Health Record System. In the health informatics industry an "open source" movement with International Standards Organization (ISO) standards is also gaining momentum.[7]

Emergency Management and Preparedness for Healthcare

Disaster and emergency health first responders and first receivers must make critical patient care decisions rapidly with minimal information. These decisions will result in the survival or demise of the victims of accidents, attacks and natural disasters. These may result in exposure to fast acting deadly chemicals, slow and diseases causing massive suffering, radioactive materials exposure or traumatic events such as bombings, shootings or the crashing of large vehicles, as experienced on September 11, 2001. In most cases the primary logistical challenge of such events is the management of large numbers of patients that overwhelm the relatively few medical care providers and their meager resources.

Training programs are available to specifically prepare first responders and first receivers for the rapid triage of large numbers of patients, which sorts patients into various categories based on the extent of the injuries and resources that will be required to treat them. Prehospital policies have been developed to automate the

process by which victim transport decisions are made. Emergency Department personnel have been trained in Incident Command, a structured paramilitary like personnel management system used only during disasters. In many cases, specific caches of medications, wound care and surgical supplies have been purchased to supplement mass casualty incidents. Disaster response plans have been written, trained, exercised and revised by many public and private organizations. The infrequent disasters do not allow for frequent real-world practice of the many important tasks so events must be simulated to provide opportunities to exercise these vital preparedness initiatives. Many preparations are funded through federally agencies and grant programs.

The Issue for Healthcare Emergency Management and Preparedness

Mass casualty incidents, in the form of motor vehicle accidents, are common and well-practiced events for EMS and Emergency Department providers. Commonly when reviewing these incidents a better method of identifying and tracking the victims is identified as a high priority need. Paper based tracking systems are highly inefficient, are difficult to update and provide multiple opportunities for failure. Sadly, September 11, 2001 made the importance of having digital records more than simply a good thing.[8] The threat of bioterrorism also raised the awareness level of Public Health officials for the need to make computer-based community healthcare records an essential part of their homeland security efforts. [9]

The National Academy of Sciences Institute of Medicine undertook a study to improve patient care records. This committee concluded that "computerization can help to improve patient records and that improved patient records and information management of heath care data are essential elements of the infrastructure of the nation's health care system." The committee also identified five objectives for future patient record systems.

1) Future patient records should support patient care and improve its quality; and

2) They should enhance the productivity of health care professionals and reduce the administrative costs associated with health care delivery and financing; and

3) They should support clinical and health services research; and

4) They should be able to accommodate future developments in health care technology, policy, management, and finance; and

5) They must have mechanisms in place to ensure patient data confidentiality at all times[10]

Actively employed disaster and emergency responders practice their skills on a daily basis one patient at a time. Patient assessments, medical history interviews, treatments and medication administration will nearly always follow the same pattern. One key task that traditionally does not follow this familiar pattern is the

documentation of the assessment and interview, perhaps even the treatments and medication aspects also, will be documented on forms designed for the shortened and aggregate notations required during chaotic mass casualty events.

During the patient encounter a medical record also known as a Patient Care Record (PCR), electronic PCR (ePCR), or Electronic Health Record (EHR) is created. In the prehospital setting, the complete record is generated by the sole care provider. In the hospital setting, the medical record is comprised of entries from the numerous staff members caring for the patient. Common aspects of nearly all medical records include, past medical history, current prescriptions, medication allergies, patient demographics, insurance policy information, and treatment and response records. Some information is requested of the patient at multiple points during their encounter.

Information such as past medical and surgical histories, prescriptions, and medication allergies, if inaccurate or unavailable prior to treatment, compromise patient safety standards and will lead to poor outcomes. Contraindications or prior allergic reactions to medications are a concern for medication administration. Easy access to such information during any incident would greatly improve patient safety.

During disaster operations, all healthcare providers have to change their normal mode of operations. Resources are shared and victims must be prioritized when cared for by specialized teams in appropriate facilities. Prehospital providers must consider the patients' mechanism of injury, presenting symptoms, transportation limitations, local policy, and hospital availability in determining destinations. Dr Ortiz shared this sentiment when discussing the Madrid train bombings. Activating the hospitals disaster plan for the first time, they immediately began preparing for the 180 victims that presented in the first two hours following the incident. Communications with the Incident Commanders and field personnel were inadequate resulting in chaos at the hospital dealt with by Dr Ortiz and his colleagues. The first two 'walking wounded' or 'worried well' categorized patients arrived within minutes of the blasts, prior to official notification and nearly 30 minutes prior to the first ambulance arrivals.

Hospitals who will receive these patients must be ready to respond on a moment's notice to maximize their immediate surge capabilities. Dr Ortiz and his colleagues effectively discharged 83 patients from the Emergency Department, prepared 22 Operating Rooms and 30 ICU beds within the first hour and discharged 347 hospital patients within the first two hours, an amazing feat accomplished with reports of strong teamwork and staff collaboration.

Integrated resource management at all levels could be better managed with access to real-time incident information for managers, if patient care providers had access to patient specific records and individual businesses and agencies had access to financial data.

This paper will describe the Concept of Operations of a Scalable, Interoperable and Fully Integrated Information Tracking System for Disasters. These concepts will address all five of the Institute of Medicine's research committees' suggested objectives. The concepts will use best practices while improving care, reducing wasteful and redundant treatments, and preventing medical errors. Once fully implemented these concepts will contribute to an estimated $77.8 billion in healthcare savings![11]

Lessons Learned

As the result of Lessons Learned during San Francisco Bay area's Loma Prieta Earthquake of 1989, the Pentagon and World Trade Center Attacks of 9-11 and the continuing Mass Casualty Incidents that occur on a frequent basis, the hospitals and EMS providers of San Francisco have asked the EMS Section to implement a Patient Tracking System. The After Action Reports of most large scale disasters repeatedly indicate a need exists to improve status reporting during an incident, on a real time basis.

The identification of victims during the first minutes to hours of any large incident becomes problematic and difficult. Dr Ortiz the Emergency Services Chief of Madrid's largest hospital system provides this perspective following the March 11, 2004 terrorist bombings experienced by their country, "The stress put upon the families of the potential victims by not knowing the location of or whether the family members where alive or dead, had the most significance of the entire disaster"[12]. The hospital set up patient identification teams and an electronic patient tracking database was developed within three hours of the attacks so that families arriving at the hospital could be informed as soon as possible in the designated Family Assistance Center. This helped the "severe problems for family members looking for loved ones" although it had not been practiced nor planned in advance.

Pediatric victims of large incidents are particularly difficult to identify as was illustrated following the South Asian Tsunami of December 26, 2004 where one infant was not identified until February 14, 2005 after DNA testing. One Indian newspaper article reporting on a fire in a local religious temple and the resulting aftermath found "Some who could not find their dear ones started getting frustrated. Some of them started to ransack and burn shops and houses. Scared, the doctors and policemen fled the place."[13]

Reporting on the aftermath of the Asian Tsunami another website says, "(The death toll) numbers are expected to rise and experts fear some of the badly decomposed bodies, many wearing only what they had on when the tsunami stuck, may never be identified." Most victims' bodies were unrecognizable… For some, there were no photographs, only hints -- a watch, a ring, a cell phone.[14] Forensic investigators frequently use photographs for positive identification by family members. Only after the most recent disasters, publicly accessible websites have been setup for this purpose.[15]

Disasters are categorized by their cause as either “natural” or “man made”. Man made disasters include both terrorist attacks and collisions resulting from human error. They are further classified by conditions affecting the response or treatment of victims, such as chemical or biological attacks, or radioactive and may also involve explosions. In the US the National Transportation Safety Board (NTSB) is responsible for responding to, investigating and coordinating the responses to aircraft, railway and pipeline incidents. In addition, the Airline Accident Victims Act of 1996 gives the involved airline the operational and financial responsibility to provide assistance to families through a Family Assistance Center, mortuary reimbursement and other forms of assistance.

Integrated Health Incident Tracking

Many US urban EMS providers, Public Health Departments, and other healthcare providers have expressed a desire to track patients in an efficient and accurate manner during mass casualty incidents. For a number of years the basic technology and equipment has been available to perform this task but only recently has been incorporated into mass casualty planning. Additional planning, response, and recovery tasks may also be accomplished utilizing the same equipment and software either ‘off the shelf’ or with minor modification and customization, are discussed below.

Personnel, supplies, equipment, and other resources may be individually tracked. The tracking of these components would create a log indicating the item/person being tracked, the location or movement of the item/person, its status (contaminated, decontaminated, task completed, etc), the time of the entry (or start and end times) and any other detail that should be tracked.

Tracking personnel serves multiple purposes. For accountability this allows a safety officer or scene commander to rotate crews through strenuous or hazardous duties and rehab or breaks. They will also be able to identify responders who may have been exposed to a substance to provide follow-up treatment or to limit potential liability. Incident commanders will be able to identify how many and which responders are on the scene and in the case of a crime scene, who may be actual witnesses of evidence. The personnel tracking offers finance officers accurate real time accounting of personnel costs, allowing for a rapid submission for reimbursement. This would also simplify and expedite the mutual aid reimbursement from neighboring jurisdictions.

Tracking supplies and equipment allows operations and logistical personnel to maximize the usage and minimize the downtime of equipment that requires servicing between uses. It also allows for immediate cost capture and documentation of use, such as medication administration, wound care or surgical supplies. Inventories can be better managed and the system wide impact of an incident is reduced.

Communicable Disease Prevention officers would utilize the capabilities of the tracking software and equipment for managing a mass prophylaxis response, investigating epidemiological events, and other similar

functions. This would allow for rapid processing of high volumes of patients through treatment areas providing documentation and tracking suitable for medical records, event logging and seeking reimbursement.

Performing algorithmic monitoring of symptoms and complaints, surveillance of public health for known syndromes, provides a primary protective health service for regions utilizing such services. A SOFIT4D would enable surveillance of every patient encounter, including 911 callers, private ambulance requests, primary care physicians, clinics, urgent care centers and emergency departments.[16]

Electronic Patient Tracking

Tracking of patients begins with the patients' first encounter with medical providers, whether on the scene or at a facility. The patients will be rapidly assessed and triaged for the severity of injury or illness and the resources that they will require. This is done in many locations by using the START triage algorithm which places each victim into one of four categories. A paper-based triage tag is physically attached to the patient, with a color referencing the category. The triage tag will also contain a bar code and human readable unique identification number. Some applications include the use of a Radio Frequency Identifying Device (RFID) with features allowing the device to be programmed with specific data points.

The triage officer will use a PDA with specifically developed software to scan the bar code. Through a simple interface the officer will add the triage category. The PDA, which is enabled for wireless networking, will immediately transmit the identification number and triage category through a mobile ad hoc LAN/WAN to a laptop computer. The scene commander, viewing the display on the laptop, will immediately have access to the number of patients and the triage category for each patient under his 'span of control' in real time as they are collected by each triage officer. In this manner, Electronic Patient Tracking supplements the Incident Command hierarchy and becomes a component of a SOFIT4D.

The next phase depends on the specifics and the pre-planning for the nature of the incident. Victims will either be immediately transported to a treatment facility,[17] such as a specialty trauma, burn or infectious disease hospital, to a local Emergency Department or they will be treated on the scene prior to transport. For those patients being transported, the EMT or Paramedic providing patient care will scan the bar code and choose a destination from a preset list. This list can be modified during an incident to provide adequate load balancing of an integrated healthcare system. Destination facilities suffering physical damage or contamination would not be an available destination on the list. Once a destination entry has been made, the tracking system will then update the hospital notification screens, with the ability to provide visual, audio, and text message alerting for receiving staff.

Patients not immediately transported may require basic or advanced life support care in a designated Treatment Area. These treatments may include prophylactic medication administration, IV fluids, pain medication,

oxygen administration, definitive airway control, bandaging and splinting. Irrespective of the location of patient care initiation, whether in a Treatment Area, in a transporting ambulance, at a mobile field hospital or a fixed hospital site, the system will now begin recording a unique Patient Care Record (PCR) for each patient.

The creation of an electronic PCR allows for proactive gains in efficiencies covering nearly every spectrum of patient care during disasters. For continuity of patient care, it is imperative to have an accurate record of all treatments and responses. Logistical supply officers benefit with an accurate record of supply usage simplifying reordering and restocking. Financial officers benefit from an accurate and real time record of patient care, supplies, and personnel costs allows for immediate cost capture to seek rapid reimbursement from payers. Safety officers and quality control officers benefit from having an accurate picture of clinical performance to prevent patient care errors, due to fatigue and other factors.

Early in patient care, if the patient is unable to self identify, an effort will be made to identify them from available information. Identification may be made with documents such as drivers' licenses, passports or other official photographic identification or with biometrics such as fingerprints and retinal scanning.[18] Driver's licenses may be swiped through a magnetic strip reader or bar code scanner to pre-populate certain demographic fields of the PCR. Proper identification will provide the public liaison officers or volunteers to inform relatives of the location of their family members.

Fatality Tracking

Victims that suffer fatal injuries are the jurisdiction of the Medical Examiner.[19] Accurate identification of the victim, their location and processing of related evidence are important investigative duties. To reconstruct the event, each piece of evidence must be accurately catalogued, a task particularly crucial for accident and crime scenes.[20] Tracking of personnel and volunteers with access to a crime scene or have been exposed to potentially infectious diseases can now be accurately completed.

In mass fatality incidents, identification of victims is a burdensome and difficult process.[2122] The bodies must be preserved to allow for autopsy and identification. Dental records are obtained and compared with victims for identification.[23] In explosive or traumatic incidents, victims may become dismembered requiring a systematic process of searching the rubble for body parts, jewelry, wallets, purses and other personal affects. After the Asian Tsunami disaster and the 9-11 attacks on the World Trade Centers and the Pentagon, this was the primary source of evidence for victim identification.[24]

Concerned family members who have not successfully located their loved ones by other means will demand to know the location and condition of their unidentified family members. If not located alive, their distress and demands will be focused on the Medical Examiner who has the tremendous task of rapidly identifying large

numbers of dead victims. During many prior disasters, photographs have been displayed in public places, on the Internet and in the media with these families crying out for information publicly. The political pressure on community leaders will extend to those involved in the investigative and identification process seeking rapid completion of this gruesome task.

Photographic identification will become a primary method for identifying the dead, unless an appropriate database is developed before the event. This process is arguably a traumatic event for those viewing photographs of dead victims in the attempt to locate their loved one. Grief counselors standing by will ease the process but the stress of the entire incident is likely to have long-lasting effects. Families may require follow-up contact and counseling to ease their grief and assist the healing process. Tracking these affected ones, who may not be located in the immediate area, will require coordination and accurate record keeping.

Epidemiological Tracking

Investigating a biological incident is the responsibility of Epidemiologists. These professionals will try to determine timelines of illness, symptoms, and victim to victim contacts. During the aftermath of an attack or event, these are key pieces for protecting the health of responders, receivers and the general public. Knowing who was where, when, how they were or were not protected and the purpose of the interaction will allow health threat modeling to be efficient and improves accuracy.

Epidemiologists are also responsible for mass prophylaxis of their communities. Once a public health threat treatable by vaccination or antibiotic has been identified, Mass Prophylaxis Centers are established, commonly referred to as Points of Distribution (PODS). Plans may call for the use of school gyms or rapidly deployable tents or other large controlled environment with the capability for high volume foot traffic. Current Centers for Disease Control (CDC) recommendations suggest having the capability to vaccinate or prophylax the entire population within 24 hours. That is an extreme logistical challenge, for the City of San Francisco that equates to 555 people per minute who must be treated. This will require intense pre-planning and practice gaining efficiencies in every possible manner.

Each person being assessed or treated must have a brief health survey to identify existing symptoms, pre-existing conditions, medication allergies, medical history and to gain consent. A brief distributed education video or computer based lesson will be given. They will then enter a treatment area to receive the appropriate medication dosage either through injection or pill. Finally they will complete processing before being released. Depending on the medications being administered, some persons or medications will require a follow-up to test for vaccination acceptance or additional dosing.

To gain the high level of efficiency required for such an incident, electronic tracking is necessary.[25] Upon arrival at the POD, a person will be able to enter their demographic information into a kiosk or on a paper form. The health survey may be performed automatically at this step or manually by a volunteer. If paper based, a bar code will be printed on the form and/or a wrist bracelet for rapid identification. Each station will log the patients encounter. If contraindications for medication exist, the medical provider will be cued to follow a pre-determined protocol depending on the situation. This may include the administration of an alternate medication or if no alternate exists, the appropriate procedures to follow will be displayed.

The POD supervisor will have a screen displaying data relating to the entire scene, allowing for adjustments and improvements in real-time to gain maximum efficiency in the process. Inventory managers will have real-time access to the levels of supplies and medications, enabling 'just in time' deliveries replenishing inventory levels from the secure centralized Regional Strategic Stockpile (RSS). These deliveries may require emergent and secure escorts throughout the city for safe and timely deliveries, further emphasizing the need for accurate information.

Personnel Accountability and Volunteer Tracking

The extreme nature of large scale disasters and terrorist attacks require large numbers of properly trained and equipped personnel and volunteers to successfully mitigate the incident. Specialized training to work under these conditions and to fill the necessary roles to complete the tasks is needed. To ensure that personnel and volunteers have received adequate training prior to an event and at the time of the event, they must be tracked and then credentialed. Some positions require highly specialized training, the verification of which would become burdensome if done during the management of an incident.

Prior to any incident, a web based volunteer recruiting campaign would be initiated. The initial registration would occur on specific web based forms detailing pertinent experience, licensing, training and other background information. The appropriate reference, background and criminal history checks would be automated to the extent possible. Once processed, each person would be issued a unique credential, an ID 'smart card' containing a photograph, basic demographics and a bar code or RFID chip that would be readable by any section of the integrated disaster response commanders.

During an incident, the employees and volunteers would be able to access a secure website where they could remotely 'check-in' or report their availability, allowing incident commanders to schedule and coordinate deployments. If additional volunteers are needed public announcements could be made providing appropriate details for the general public to become available as needed, eliminating confusion and providing for rapid processing of new volunteers on an as needed basis.

Future Advancements

There are a number of future advancements being developed by a number research groups for large scale disasters and terrorist attacks. The University of California San Diego's California Institute for Telecommunications and Information Technology (CalIT2) in collaboration with the VA San Diego Medical Research Foundation has been developing advanced technologies for these incidents. [2627] Remote monitoring of patients has been commonplace for years through traditional telemetry techniques in hospitals, requiring a tremendous investment in expensive hardware and networking components. Now remote monitoring of heart rate, blood pressure, oxygen saturation, and even 12-lead EKG can all be performed with a minimal investment, based on off the shelf components in concert with common PDA's.

Personnel Accountability Systems (PAS) have been disparate, simple, and mechanical giving an audible alarm for whoever is able to hear it. Firefighters wearing Self Contained Breathing Apparatus (SCBA's) are aware of the '5-minute' bell that rings as their oxygen supply is nearing its end. More recently, simple alarms have been developed which detect when the wearer stops moving for 30 seconds, calling the attention of nearby rescuers to the immobile wearer of the device. These alarming devices have no further capability and rely on others being close and hearing the alarm. Technology allowing rescuers to locate an alerting PAS with directional guidance or even map based guidance are currently in development. Recognizing that firefighters are at great risk for cardiac arrest during stressful and strenuous responses, a combination of PAS and remote vital sign monitoring will soon become commonplace greatly improving the survival of affected responders. Safety officers will monitor rescuer vital signs and can have two-way communications with anyone, bringing at risk personnel out of the incident and into the rehab sector where they can rest, avoiding overexertion, exhaustion or worse.

Depending on the type of incident, identifying the exact location or routes of responders and victims or key evidence may be crucial for processing an accident or a crime scene. If outside this is accomplished through surveying and GPS positioning. Those processes may be more difficult if not impossible when inside a building, in a tunnel or under water. Recent advancements in networking technologies allow responders or investigators to set up ad-hoc mesh networks capable of triangulation and positioning. This technology has the potential for streamlining all phases of LAN or WAN network usage greatly extending the battery life and range for small portable devices.[28]

Disaster Registry Database

Many of the time consuming tasks in managing a large scale incident can be completed in preparation for an event. These tasks are typically simple data entry processes that may or may not require human guidance. Nearly all of the information is already available, unfortunately in disparate databases. Government records such as the Department of Motor Vehicles, various departments or agencies providing professional licensing, income

tax, social security and welfare agencies, local and national law enforcement databases exist with the bulk of the data that would be required. Hospital, Physician and Dental offices have the important medical history based information. Records identifying civil domestic partnerships and marriages are maintained identifying relationships. Various databases are also available from commercial enterprises such as Medic Alert and Vial of Life, companies whose subscription services may be able to provide vital information regarding victims after a disaster.

To develop an integrated and effective information system for tracking during disasters, these databases should be developed prior to an incident. Immediate access to critical information should be as simple as the click of a mouse and be available to anyone who requires it. Memorandums of agreement should be developed prior to an incident with software programmers writing the essential elements for the database to access appropriate records. On a frequent and regular basis this database would be updated, in either a push or pull method. Appropriate security measures would be required, ensuring the encryption of any data streams, limiting access to the database depending on the role and the database should be replicated for redundancy. Extreme measures would be taken to ensure the access and availability of the database during any conceivable event. These procedures will require a number of years to achieve and may require appropriate legislation to be developed.

A method of collecting data prior to an incident may be more appropriate for the interim. Community based organizations such as the American Red Cross, The Citizen Corps, and The Corporation for National and Community Service and others would encourage the public to submit their information in advance. The venues may include public and private schools, churches and places of worship, fairs and events, mass mailings, senior centers, healthcare facilities and others. These forms would be simple yet comprehensive, available in multiple languages with Optical Character Recognition (OCR) forms for scanning directly into the database simplifying data entry.

The necessary fields for the database would be compiled by comparing typical forms used for EMS and hospital records, birth and marriage certificates, driver's license, health, and life insurance applications, and the Victim Identification Packet[29] used by the Disaster Mortuary Teams of the National Disaster Medical Service. The Disaster Registry Database would be fully interoperable with future Electronic Health Records and the emerging standards for their implementation.

Syndromic Surveillance

Biological symptom surveillance or "Syndromic Surveillance" of 911 calls, Emergency Department, Urgent Care, Clinic, and Primary Care Physician Office visits by Public Health Epidemiologists occurs in many metropolitan areas. Healthcare providers have anecdotally noted trends in the past, such as seasonal influenza outbreaks, this occurs only after the fact. Syndromic surveillance provides an opportunity to track medical complaints and

symptoms, in real time, and compare this data with historic controls. [30]Extensive mathematical modeling is being developed to provide predictive reporting and alerting of detected trends. The key strength of the surveillance is to access the patient's chief complaint and/or symptomology as early as possible, for accurate modeling.

Real-time patient tracking provides an opportunity for key data points to be entered into the surveillance system, at the moment the provider has access to the information. Some virulent strains of biological weapons and naturally occurring diseases may not become apparent until after a number of healthcare workers have become exposed and potentially infected, perhaps cross-infecting further providers, patients, or the public. Immediate decision tools can be incorporated into tracking software to immediately warn providers of potentially infectious encounters, and provide Personal Protective Equipment and decontamination recommendations while simultaneously alerting the receiving facility and Public Health Officers.

Confirmatory testing may be performed while personnel previously exposed continue with their job duties. Tracking all primary and secondary exposures allows for appropriate treatment decisions to be made for all potentially infected persons. If supported by multiple alerts, advisory alerting may occur, to prevent further cross-infection or exposures, averting widespread disease or illness that otherwise would not be possible.[31]

Diversion Aversion

Hospital diversion is a serious problem in the United States and in other developed countries. Hospitals make a formal request of the local EMS system, "requesting" that ambulances do not bring patients to their facility unless the patient is suffering an extremely urgent condition, such as cardiac arrest. Hospital Emergency Rooms may be too busy or short staffed, leading to the diversion request which may last for only a short time or a full day. [32] [33] Many healthcare experts have been trying to reduce the impacts of the EMS system on hospital diversions but the trend has not been reported to be improving.[34] Policies are developed to provide guidance to hospitals and EMS administrators during times of diversion[35] [36] but these policies do not eliminate the practice of diversion.[37]

Integrated tracking systems provide a unique capability for hospital and EMS system administrators to provide improve load balancing of patients.[38] Nearly all EMS systems in the US who have multiple hospital destination choices benefit from some form of hospital status tracking. A screen is displayed which indicates the status of each hospital in a given area. EMS dispatchers and field providers can visually determine which hospitals are available at any given moment using this method. Some hospitals have internal patient tracking software packages[39] while some still utilize whiteboards requiring manual tracking of patients and dispositions.

When on 'divert', hospitals may not turn away walk-in patients, while ambulances are diverted. Many healthcare providers and patients have learned to work around this policy.[40] In once instance, paramedics declined transport of an 8-month old status post seizure patient, following the family car to the front door of the

Emergency Room, where the patient was seen as a walk-in, avoiding the diversion policy. [41] Reportedly only 25% of all Emergency Department patients arrive by ambulance. The 75% that arrive on their own arguably have the greatest impact on hospital diversions.

Integrated tracking systems have multiple opportunities for reducing or even eliminating frequent hospital diversions through load balancing of the system. The public who will arrive without EMS intervention have a desire to reduce the time waiting to be seen. The hospital status displays, available online or at kiosks placed in waiting rooms would be categorized for emergent versus urgent care patient conditions. Hospitals with specialty facilities, such as chest pain centers or cardiac catheterization labs, would likely have a streamlined process for assessing, treating and admitting these patients, while another hospital without this specialty care may have longer waiting and treatment times, followed by lengthy transfer procedures to the specialty care center. Many of those patients may benefit from transportation directly to the specialty care center, even with the addition of five or ten minutes of transportation.

Providing the public with access to the hospital tracking screens, as securely provided to EMS providers and hospitals now, would give these patients system status information. The information provided could be as simple as the current hospital diversion status or detailed to average wait times for patients, further categorized by chief complaints. This feature would give hospitals a competitive incentive to improve patient flow-through, while greatly increasing patient satisfaction for wait times.

EMS providers would further provide load balancing on a daily basis using the same information, providing patients with the choices available and their anticipated wait times. Informed patients would choose destinations based on their priorities with current and accurate information. Patients with life threatening conditions may benefit from this process, with reduced initial treatment times, delays in transfer processes, and potentially greatly reducing the cost of critical care transfers.

Scalable for individual patients or victims of large events, EMS system and Emergency Department load balancing may have the greatest daily impact for the healthcare industry. Prehospital personnel using hospital availability information calculated by surge capabilities within the system can transport victims to the most appropriate destination. For some patients, the time to definitive care is the greatest factor in their outcome, while some victims may not require any specialized treatment. Efficiently utilizing scarce and expensive resources during times of tremendous demand will provide the greatest good to the greatest number.[42] [43] [44]

Victims of multiple casualty incidents, terrorist attacks, critical illness and trauma may receive the greatest benefit from such integrated information tracking systems. The potential benefits would be measurable, definable, and reviewable with accurate data collection. Diversion Aversion should be further explored and will require the collaboration of EMS and hospital regulators, administrators and legislators.

Pet Tracking

During times of disaster, some victims include pets and animals that may be left behind or become lost.[45] Many animal shelters and community based organizations offer tips and advice for animal owners to prepare for disasters.[46] [47] [48] It is highly recommended that pets have an Identification Tag placed and that owners carry a photograph of the animal. Many locations now also provide for implanted identification chips, or RFID tags, for animals. These implanted tags contain basic information about the pet and its owner but special equipment must be used to 'read' them. Bar coded tags could be developed to be placed on animal collars and added to a database correlating the animal with the owner.[49]

If an area is evacuated or destroyed, animals will be located, the bar code scanned and the database searched. If the owner is identified, the animal services personnel can reunite the animal with its owner or identify relatives of the owner, relieving the public burden. Veterinary care for the 'lost' animal would be tracked, allowing animal hospitals providing the care to seek reimbursement.

During non-disaster times, the bar coded collars or tags would allow animal officers to quickly and confidentially identify an animal's owner and track encounters over time. This would increase the accountability of animal owners for animals that have repeat negative encounters. Animals that have been exposed to areas of known chemical or biological attack may then be tracked and provided appropriate treatment for the exposures[50], improving human and animal safety post incident.[51] Data collection of animal movements may be vital for epidemiological investigations of infectious illnesses, particular those with animal to human traits.

Medication and Supply Tracking

Tracking the inventory, distribution, and usage of supplies, including medications, is greatly improved with integrated tracking systems. On a daily basis, the supply and restocking of EMS and hospital supplies when automated improves the economic factors of the 'cost of goods' required. Industry has benefited from 'Just in Time' ordering for many years while many EMS systems still rely on inadequate inventory control tools. With inventory levels and usage patterns tracked materials managers can develop models reducing the in house inventory levels and leverage their purchasing power. Cooperative supply agreements among various agencies have a greater economy of scale.

Narcotic tracking is a tedious task many have worked around with theft of narcotics in healthcare on the rise. Bar code tracking of individual medication vials down to the patient who received it, improves record keeping for medication error tracking, product recall notification and overall accountability. Improved accuracy in narcotic record keeping makes theft and forgery more difficult to accomplish while avoiding pitfalls leading to Insurance and Medicare Fraud charges.

Patient safety is improved with accurate communications. The US Pharmacopoeia recently reported the three medication errors most involved with causing harm were performance deficit, procedure or protocol not being followed, and communication errors (usually between different health-care professionals).[52] Three tools were developed by the American Hospital Association, the Health Research and Educational Trust (HRET) and the Institute for Safe Medication Practices (ISMP), Pathways to Medication Safety, to assist healthcare professionals to incorporate medication safety into strategic planning, identify specific error prone processes and to institute a bedside bar coding system in 2002.[53] The bar coding tool references the JCAHO medication safety standards of 2001. Eight of the nine standards may be addressed by bar coded medication tracking, such as:

- Establish ongoing program to reduce medication errors
- Leaders provide information systems to improve patient safety
- Orders verified & patient identified before medication administered
- Aggregate patient safety data to identify improvement areas
- Provide mechanism to measure & analyze processes that affect patient safety
- A patient medication dose system is implemented
- Educate patient on safe use of medications
- Systematic medication use processes

"JCAHO has also adopted as one of several patient safety goals for 203, "improvement in the accuracy f patient identification." One of JCAHO's recommendations for achieving this goals is for providers to "use at least two patient identifiers (neither to be the patient's room number) whenever taking blood samples or administering medications or blood products. Acceptable identifiers may be the patient's name, an assigned identification number, telephone number, or other patient specific identifier." JCAHO has subsequently determined that bar coding including two or more patient specific identifiers will comply with this recommendation and thus provides organizations with on option for meeting this requirement."

Advanced systems would allow the provider to scan their employee identification, the patient's identification and medications to be administered. The system would ensure the provider was authorized to administer the medications and the dosage was consistent with the demographic based protocols for the patient. If the dosage was not within the protocols or contraindications existed, the system would alert the provider requiring their immediate attention possibly allowing exceptions for austere care scenarios. The system would also

provide drug reference information such as interactions, contraindications, look-alike names, and side affects. Quality assurance programs would then have access to aggregate data to monitor trends for improved patient safety and outcome.

The National Patient Safety Foundation now offers Train-The-Trainer programs in the Pathways program for healthcare managers.[54] A Bridge Medical literature review published October 2002 calculated a 51% reduction in medication errors with the use of bar code technologies over traditional methods, some case studies report error reductions in excess of 70%![55]

Reducing the time between inventory usage and reimbursement provides a financial incentive for business managers. Unreadable handwriting, misspelling, and insufficient documentation hampers reimbursement, forcing billing officers to reduce supply charges for otherwise chargeable supply and medication usage. Improved charge capture provides an opportunity for near real-time billing.[56]

211/311

Many cities have instituted 211 and 311 non-emergency telephone numbers to provide public access to city services.[57] [58] This service has been shown to reduce the impact on emergency 911 call centers by redirecting non-emergent calls elsewhere. During times of disaster, callers to these numbers can speak with an operator who has access to the various tracking databases. These operators would provide a primary vital public service, under the coordination of the Public Information Office. During non-disaster times, these operators would provide outreach services and database entry.

Inpatient Tracking

Hospital departments with higher traffic flows benefit from tracking patients and managing their care.[59] [60]The Emergency Department provides the greatest volume of patient traffic and logistical needs within the hospital. ED patients require registration, triage, admission, laboratory/radiological/EKG diagnostic services, physician consults, pharmacy, dieticians, transfer to other departments such as CT, Ultrasound, cardiac catheterization, and eventually discharge. Every interaction requires an order, a task and follow-up. Each of these processes lead to improved patient safety when automated.[61] These tracking mechanisms when integrated with prehospital and disaster tracking systems, give each patient seamless care with the greatest level of safety and security. Researchers will have unprecedented access to data for quality assurance programs, research and clinical trials, and education.

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