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Lessons to be learned from three mass casualty events - 2013 Boston Marathon Bombing, 2009 Aurora Movie Theatre Shooting, and 2005 Hurricane Katrina

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Boston University
LESSONS TO BE LEARNED FROM THREE MASS CASUALTY EVENTS - 2013
BOSTON MARATHON BOMBING, 2009 AURORA MOVIE THEATRE
SHOOTING, AND 2005 HURRICANE KATRINA

by

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B.A., Boston University, 2013

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Disaster preparedness is absolutely necessary as the number of both man-made and natural disasters increases worldwide. Not confined to any regions or people, disasters can result in mass casualties. The United States is not spared from these incidents. Ever since the 9/11 terrorist attacks, the United States has tried to establish more effective and efficient emergency management systems at all levels in order to respond to any type of disaster. Due to the effort, much improvement in disaster preparedness was observed when mass casualty events happened within the last 10 years. Although there are many independent studies for each mass casualty event, there are very few studies done to compare multiple mass casualty incidents and find commonly shared lessons. This paper aims to determine whether there are any similarities among three mass casualty events - 2005 Hurricane Katrina, the 2009 Aurora Theatre Shooting, and the 2013 Boston Marathon Bombing. Because the response to the 2013 Boston Marathon Bombing was
the most seamless among the three, the most in-depth investigation was done on this incident. Through the examination, the study will also prove if any of the lessons learned from these events can be implemented in future mass casualty incidents. To do so, many current reports and literature reviews were analyzed. The conclusion gained from this study is that there are indeed commonly occurring challenges in disasters and various aspects of disaster preparedness that require practice and preparation. In addition, learning from others' unfortunate mass casualty incidents and their lessons is an important part of strengthening the existing disaster preparedness systems.
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<td>BAA</td>
<td>The Boston Athletic Association</td>
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<tr>
<td>BIDMC</td>
<td>Beth Israel Deaconess Medical Center</td>
</tr>
<tr>
<td>BMC</td>
<td>Boston Medical Center</td>
</tr>
<tr>
<td>BPHC</td>
<td>The Boston Public Health Commission</td>
</tr>
<tr>
<td>BWH</td>
<td>Brigham and Women's Hospital</td>
</tr>
<tr>
<td>DPH</td>
<td>Department of Public Health</td>
</tr>
<tr>
<td>EMS</td>
<td>Emergency Medical Services</td>
</tr>
<tr>
<td>EOC</td>
<td>Emergency Operations Center</td>
</tr>
<tr>
<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
</tr>
<tr>
<td>HAZMAT</td>
<td>Hazardous Material</td>
</tr>
<tr>
<td>HICS</td>
<td>Hospital Incident Command Structure</td>
</tr>
<tr>
<td>IED</td>
<td>Improvised Explosive Device</td>
</tr>
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<td>MACC</td>
<td>The Multi Agency Coordination Center</td>
</tr>
<tr>
<td>MEMA</td>
<td>Massachusetts Emergency Management Agency</td>
</tr>
<tr>
<td>MGH</td>
<td>Mass General Hospital</td>
</tr>
<tr>
<td>MIC</td>
<td>Medical Intelligence Center</td>
</tr>
<tr>
<td>TASMC</td>
<td>Tel Aviv Sourasky Medical Center</td>
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INTRODUCTION

The definition of disasters encompasses various phenomena. The American College of Emergency Physicians defines disasters as "when the destructive effects of natural or man-made forces overwhelm the ability of a given area or community to meet the demand for health care."(1) Disasters are not confined to certain regions or people, and the United States is not an exception to this indiscrimination.

In the United States, there have been increasing number of disasters that resulted in mass casualty events. One example is Hurricane Katrina in 2005, which shocked the world by striking New Orleans and causing more than 1000 fatalities. Another one is Aurora Movie Theatre shooting in 2009 in which an active shooter attacked a passive audience. Furthermore, the bomb attack at the 2013 Boston Marathon has demonstrated that Boston is not exempt from man-made disasters.

Observing the three incidents mentioned above, one can say that each response became more efficient and effective compared to one happened before that. Though the types of these incidents are different from each other, they share several elements of disaster preparedness in common. Therefore, lessons learned from previous mass casualty incidents can demonstrate possible solutions to commonly occurring challenges during a disaster response. Also, discovering successful aspects of past disaster responses can provide an opportunity to disaster response groups across the globe to strengthen their existing disaster preparedness systems.
OBJECTIVES

As delving into the topic of mass casualty events, it was noticed that there is an abundance of literature reviews on mass casualty events independently. However, there has been a small effort to comprehensively describe and compare multiple mass casualty incidents. Such study would clarify strengths, limitations and possible solutions during a disaster response, and hospitals and cities would learn from those lessons to be better prepared for future mass casualty events.

This study will focus on assessing an interesting case of seamless city-wide response to the 2013 Boston Marathon Bombing. This section describes the achievements of Boston and its hospitals that resulted in 100% survival rate of transported victims. In addition, there will be a thorough assessment on the limitations of Boston and its hospitals' existing disaster preparedness. Next, there will be an in-depth investigation of other mass casualty events due to both natural and man-made causes - Hurricane Katrina in 2005 and Aurora Shooting in 2012. The achievements and the challenges of all three responses will be examined and compared to each other. Knowing the similarities among these incidents might provide possible solutions to commonly occurring challenges in mass casualty events. These analyses will try to prove that hospitals or cities can practice and prepare for any type of disasters as long as they are aware of commonly shared elements in disaster responses.
LESSONS LEARNED FROM THE BOSTON MARATHON BOMBING

On April 15, 2013, two improvised explosive devices made out of pressure cookers exploded at the finish line of the Boston Marathon. Those explosions killed 3 victims at the incident site and injured more than 250 victims. (2) Although there was a high number of the injured, the city of Boston and its hospitals ended up with no death of transported victims. This deadly mass casualty event surprised the world because of the city's seamless response to the event. Many reports and studies explain what made this disaster response possible, yet, they also point out the limitations of current emergency management systems in Boston. Below, both the achievements and limitations of Boston's disaster preparedness will be described and analyzed.

ACHIEVEMENTS

I. Quick Organization of the City's Hospitals

In times of disaster, each second can determine injured patients' lives. During the response to the Boston Marathon Bombing, the quick decision to alert and organize hospitals accelerated the process required for the response.

Among many organizations involved in making a timely first response to the incident, the Stephen M. Lawlor Medical Intelligence Center (MIC) did a prominent job in coordinating medical responders. Since its establishment in 2009, the MIC has maintained its advanced communication and information sharing system to allow Boston EMS, first responder agencies, hospitals, public health departments, community health
centers, long-term care facilities, State and Federal as well as public and private partners to disperse information and work collaboratively in response to large scale incidents. (3) Figure 1 describes how the MIC interacts and shares information with other organizations.

**Figure 1** - The MIC sharing of information with agencies at all levels. Figure taken from the Boston Public Health Commission

On the Marathon Monday, the MIC was fully prepared for any potential mass casualty events that might occur. A team of 12 public health officials were working when an on-scene Boston Emergency Medical Services(EMS) staff member alerted the center soon after the first blast. Figure 2 shows the timeline of the first ten minutes of the Boston Marathon Bombing.
Figure 2 - The first 10 minutes of response of the MIC, Boston EMS, and Boston hospitals' Emergency Departments. Figure taken from Kue et al., 2014

The MIC promptly notified hospitals around the region that there can be a possible surge of injured patients due to explosions at the finish line. Also, they included information that the explosion victims would have red wristbands, which was important to assist healthcare deliverers in efficiently distinguishing explosion victims. The MIC continually supported the coordination of agencies and hospitals by sending reports during the aftermath of the incident. The reports contained information on patients, hospital supply needs, ongoing security updates, and services available to victims. (4)

The State Emergency Operation Center also played an important role throughout the critical hours of the response to the Boston Marathon Bombing. This center constantly updated hospitals in Boston about the incident as time went by. These updates included information on the expected number of patients and types of injuries. (5) With this information, hospitals could prepare equipment for the vascular and orthopedic
procedures which were expected to be necessary for the incoming patients. Furthermore, hospitals shared their information on staff availability and equipment by using statewide WebEOC system. (5) This system is based on real-time updates, and due to its rapidness, hospitals could figure out any problems with their staff availability and lack of equipment early on. (5)

The importance of sharing information across different organizations during mass casualty events is absolutely vital to the success of the response. If the level of coordination and communication was not met during the Boston Marathon Bombing, the city's hospitals might have lost precious timing to get prepared for the unexpected influx of patients and might have led to even more confusion than there already was. In their report about the Boston Marathon Bombing, Federal Emergency Management Agency (FEMA) points out that sharing situational awareness across public agencies, race organizations, and nongovernmental and private organizations was seen in the event, and this particular response is transferrable to other mass casualty events. (6)

II. Preparations within the City Hospitals

For the Marathon Monday, the 10 local Boston hospitals worked proactively with the Boston Athletic Association (BAA). (7) This fact cannot be ignored when discussing the reasons for the successful response to the Boston Marathon Bombing. The hospitals that were assigned to help on the Boston Marathon Monday had combined the marathon
plan with their own emergency preparedness plan. One of the hospitals involved in the event was Newton Wellesley Hospital. This hospital creates its own Marathon Planning Checklist for every Boston Marathon event as listed below (Table 1).

| Emergency Department (ED) | □ Confirm that ED documentation software link is loaded on gastrointestinal (GI) computers  
| □ Med tackle box for GI  
| □ Patient Tracking staff  
| □ Department of Public Health (DPH) in Decon/ambulance bay  
| □ Patient Tracking staff after DPH leaves  
| □ All patients to be directed to ED for triage  
| □ Long-distance calling code for ED and GI  
| □ Taxi vouchers  
| □ Blue bracelets (in triage cart in Decon room)  
| □ Contact command center if any elite runner presents  
| □ 2 ED nurses in GI to enter in ED tracking system  
| □ Process to return elite runner (add to Frequently Asked Questions [FAQs])  
| □ Training for staff in ice immersion  
| □ Email FAQs to all ED staff prior to marathon  
| □ ED will flag lab tests for critically ill patients as Code/Stroke and also call the lab  
| □ Interpreter Phone on a Pole (IPOP) needed for GI and ED (Transport will bring one to GI)  
| □ Provide taxi vouchers to college students if schools will not pick them up on discharge |

| Facilities | □ Verify electrical and water hookups operable in front of Cancer Center  
| □ Ensure brush clear from alternate road entrance  
| □ Make sure signage is removed during grounds cleanup  
| □ Order Port-A-Potties (charge cost to facilities) |

| Nutrition | □ Ensure delivery of Gatorade, bouillon, coffee urns, and pretzels to ED by Friday  
| □ Large cups with straws and lids  
| □ Bottled water and Cans of Gatorade on ice in ambulance bay for Emergency Medical Services (EMS)  
| □ Same in East and West Lobby behind desk (small quantity)  
| □ Contact person with Food and Nutrition on race day to request attendance at preplanning meetings and briefings in command center  
| □ Stage portable freezer and ice in decon room |

| Transport | □ Transporters will be in East and West Lobby.  
| □ Wheelchairs and stretchers available  
<p>| □ All patients who present are to go to ED |</p>
<table>
<thead>
<tr>
<th>Department</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Management</td>
<td>☐ Interpreter available?</td>
</tr>
<tr>
<td></td>
<td>☐ IPOP to GI by 9 am</td>
</tr>
<tr>
<td></td>
<td>☐ Supply carts to ED and GI by 9 am</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>☐ Hypertonic saline to ED nurse manager</td>
</tr>
<tr>
<td></td>
<td>☐ Med tackle box for GI to Minor Treatment Unit leader</td>
</tr>
<tr>
<td>Environmental Services</td>
<td>☐ Process for cleaning tub</td>
</tr>
<tr>
<td>Administration</td>
<td>☐ Email to doctors and Intensive Care Unit (ICU) regarding early</td>
</tr>
<tr>
<td></td>
<td>discharges on Monday</td>
</tr>
<tr>
<td>Nursing</td>
<td>☐ Nursing supervisor coverage list to emergency management coordinator</td>
</tr>
<tr>
<td>Public Affairs</td>
<td>☐ Map and memo to patient floors on Sunday with time of road closing</td>
</tr>
<tr>
<td></td>
<td>☐ Housewide memo regarding road closure</td>
</tr>
<tr>
<td></td>
<td>☐ Communicate with urgent care regarding directions to campus</td>
</tr>
<tr>
<td></td>
<td>☐ Public Information Officer will be notified by command center if any</td>
</tr>
<tr>
<td></td>
<td>elite runner presents in ED</td>
</tr>
<tr>
<td></td>
<td>☐ Signage for outpatient surgical center—front and back doors</td>
</tr>
<tr>
<td>Radiology</td>
<td>☐ Verify that Picture Archiving and Communication software is loaded</td>
</tr>
<tr>
<td></td>
<td>on GI computers</td>
</tr>
<tr>
<td></td>
<td>☐ Patients in GI needing diagnostic imaging will go to the main</td>
</tr>
<tr>
<td></td>
<td>radiology department</td>
</tr>
<tr>
<td></td>
<td>☐ Please enter location of patient when entering exam orders (ED</td>
</tr>
<tr>
<td></td>
<td>versus GI)</td>
</tr>
<tr>
<td>Public Safety</td>
<td>☐ Check Washington Street for parked cars (towing will begin at 7:45)</td>
</tr>
<tr>
<td></td>
<td>☐ Mass Decontamination Unit setup</td>
</tr>
<tr>
<td></td>
<td>☐ Block parking spaces at West Entrance</td>
</tr>
<tr>
<td></td>
<td>☐ Set ambulance entrance door to open access</td>
</tr>
<tr>
<td></td>
<td>☐ Coordinate traffic flow on alternate road (8 am to approximately 4</td>
</tr>
<tr>
<td></td>
<td>pm) 1 hour before and after close/open of Washington Street</td>
</tr>
<tr>
<td></td>
<td>☐ Block Employee Garage roof for ambulance staging</td>
</tr>
<tr>
<td></td>
<td>☐ Security cameras projected in Command Center</td>
</tr>
<tr>
<td></td>
<td>☐ Fire apparatus on site. Stage next to Allen Riddle</td>
</tr>
<tr>
<td>Emergency Prep</td>
<td>☐ Regional mutual aid coordinating entity (MACE) book</td>
</tr>
<tr>
<td></td>
<td>☐ Command Center staffing</td>
</tr>
<tr>
<td></td>
<td>☐ Purchase rectal thermometer</td>
</tr>
<tr>
<td></td>
<td>☐ Shelter information to Newton Police Department</td>
</tr>
<tr>
<td></td>
<td>☐ Megaphones</td>
</tr>
<tr>
<td></td>
<td>☐ Tub setup</td>
</tr>
<tr>
<td></td>
<td>☐ Decon shower cleared as of 6 am</td>
</tr>
<tr>
<td>Lab</td>
<td>☐ ED will flag critically ill patients as Code/Stroke and also call</td>
</tr>
<tr>
<td></td>
<td>the lab</td>
</tr>
<tr>
<td>Communications</td>
<td>☐ Patient-announcement line with directions</td>
</tr>
<tr>
<td></td>
<td>☐ Staff emergency-announcement line</td>
</tr>
<tr>
<td></td>
<td>☐ Provide GI with phones to use in patient room phone jacks</td>
</tr>
<tr>
<td></td>
<td>☐ Switchboard to make announcement at 7:00 am and 7:30 am</td>
</tr>
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Table 1 - A Sample Marathon Planning Checklist of Newton-Wellesley Hospital for the Boston Marathon of 2013

With the thorough preparation and analysis from previous years, the hospital was ready for many types of emergencies. These ensured ED overcrowding by arranging its gastrointestinal suite into a minor-treatment area. Also, they called in extra staff members at the hospital for the possible influx of patients. They even paid attention to minor details such as having multilingual transport workers on duty considering the high percentage of runners who are foreigners. (7)

While other aspects are considered to be the strengths of Boston's disaster preparedness, the main one pointed out is each hospital's continuous effort to maintain and improve its emergency preparedness by regularly conducting drills for all kinds of emergency situations. Many analyses mentioned that it was lucky for Boston to have the mass casualty event on the Marathon Monday since many systems were in place, however, the event was still unexpected. Without the Hospital's routinely performed drills, there could have been a greater number of deaths.

Each hospital has had its own emergency preparedness drills routinely. BWH proved how well-prepared they are as an united team for a wide range of emergencies. According to a public health blog by the Centers for Disease Control and Prevention, BWH had an opportunity to practice 78 emergency scenarios before the Boston Marathon Bombing happened. Among those, there were both real world events and scenario-based
drills such as chemical attacks, oil spills, train crashes, blizzards, and building evacuations. Eight of those events were related to mass casualty events that involved explosions and active shooting. (8) These drills have focused greatly on how to avoid the ED overcrowding in the time of mass casualty events. For the Boston Marathon Bombing, BWH activated its disaster response system by executing a code Amber. This disaster response enabled the emergency department to rapidly transport patients to other departments and discharge others in order to build capacity and capability of the emergency department. (9) Furthermore, the hospital quickly managed to analyze the pending patients for operations and made its operation rooms available for the critically injured patients. MGH's disaster preparedness expert, Dr. Paul Biddinger, noted that hazardous material (HAZMAT) exercises is one of the practices that contributed greatly to MGH's adequate response to the Boston Marathon Bombing. (10) This exercise is performed several times every year and includes a wide range of cases from trauma to HAZMAT contamination. Through this exercise, the hospital could practice quick assessment, security and avoiding ED overcrowding, and perform what they have been practicing at the actual mass casualty event.

The disaster preparedness exercises in Boston's hospitals included setting up command and control systems in a chaotic situation. In a report created by BIDMC emergency department about the Boston Marathon Bombing, it mentioned how important it was for staff members at the hospital to quickly get into their role as they wait to receive their first patient. (11) The emergency department had created a hospital incident
command structure (HICS) chart (Figure 3) to delineate key roles in a mass casualty event such as the Boston Marathon Bombing.

**Figure 3** - Initial incident command structure. Figure taken from Nadworny et al., 2014

According to their emergency response procedure, the clinical manager is the casualty care unit leader for the event. The casualty care unit leader has to make a few key decisions in the initial response to the explosions. The leader should be able to understand the scope of the event, and the impact that the hospital should experience.
their previous experience in disaster preparedness exercises, the staff members utilized HICS throughout the response. As more staffs arrived at the hospital, the labor pool was enlarged, and they improvised and created a chart that fitted the larger labor pool (Figure 4).

**Figure 4**- Final incident command structure. CCUL, Casualty care unit leader; CDU, Clinical decision Unit (observation unit); CMO, chief medical officer; CNS, clinical nurse specialist; GP, green/purple (lower acuity); MRC, medical reserve corps; PCT, patient care technician; RN, registered nurse. Figure taken from Nadworny et al., 2014.
With this orderly command and control system, the department could make a timely and effective response without excessive confusion.

The preparedness was possible because the leaders of Boston hospitals' disaster preparedness team continuously put in effort to learn from others' unfortunate experiences. Dr. Walls, the Chairman of the Department of Emergency Medicine at BWH, had pointed out that the Aurora movie theatre shooting has helped his idea of emergency preparedness. When the Aurora shooting happened, the University of Colorado received 23 patients subsequently, and Dr. Walls' plan only prepared for receiving 12 patients per hour. After his realization, he gathered his disaster preparedness committee at BWH and asked to "tear up" the hospital's disaster preparedness manual and "start all over". (12) With this decision, BWH honed its disaster preparedness and when the marathon bombing event occurred, the hospital was able to respond rapidly and appropriately.

Another point that came up was the appropriate use of residents at involved hospitals. It is important for a hospital to know how to expand its labor pool, and at the same time, how to make use out of the enlarged labor pool. At BWH, there were general surgery residents who professionally helped out in the surge of patients. The Department of Surgery at BWH emphasizes the value of graduate medical education. All of BWH’s surgical residents have to earn Advanced Trauma Life Support certification. Through this
training, the residents learned how to properly assess, triage, and treat patients with traumatic injuries (10). Also, BWH has the Neil and Elise Wallace STRATUS Center for Medical Simulation. This center had educated all surgical residents to practice and improve their clinical and leadership skills where they can refine" technical procedural skills", "clinical decision making in code situations", and "behavioral and nontechnical skills in simulated trauma scenarios with real-time feedback". (12) Boston Marathon Bombing showed how well BWH had trained their residents who hopped into the mass casualty event and performed communication, leadership and management skills.

III. Preparations within the City and the State

When a mass casualty event occurs, the medical response does not only come from hospitals, but also comes from pre-hospital medical providers. Because of that, the importance of EMS' initial response and its communication with the city hospitals was critical in the Boston Marathon Bombing. EMS' effort to distribute patients evenly across
the city hospitals was indeed amazing (Figure 4).

![Patient Distribution: The First 60 Minutes](image)

**Figure 5** - Patient Distribution occurred within the first 60 minutes of the Boston Marathon Bombing incident. Figure taken from a special report from The Journal of Bone and Join Surgery and the Journal of Orthopedic and Sports Physical Therapy, 2014.

The Boston Marathon finish line was cleared of patients within 18 minutes. James Hooley, the Chief of Boston EMS, pointed out that 18 minutes of complete clearing was
possible because EMS staffs and ambulances improvised in the event. Not strictly keeping up with standard protocols, EMS ambulances took 3 to 4 patients out of the incident site. According to Chief Hooley, Boston EMS personnel are trained thoroughly to a plan, but are also given the tools and authorities to deviate from plans if required. (7) Boston EMS' appropriate decision making enabled the hospitals to have more time to treat severely injured patients and therefore lower the number of deaths due to the event.

Boston EMS was also trained well to triage patients quickly and use the tools that they would not use in the civilian world to prevent victims from losing too much blood. Rapid triaging by Boston EMS allowed the most severely injured victims to be transported to hospitals. Furthermore, Boston EMS staff were ready to employ the use of tourniquets. Early tourniquet use has been critical in reducing the number combat deaths in the military operations involving blast injuries with improvised explosive devices (IED). (13) Though it is rare for civilian EMS staffs to use tourniquets, Boston EMS has included tourniquets and related trainings in its hemorrhage-control protocols for years. (14) Boston EMS' effort to be prepared for a wide array of emergency situations played a critical role in the Boston Marathon Bombing. The rapid reaction of Boston EMS as a result of their disaster preparedness contributed to the low number of deaths.

There was also the Massachusetts Emergency Management Agency (MEMA) involvement in coordinating the citywide preparedness for each year's Boston Marathon Monday. This team assembled various multidisciplinary agencies in January 2013 in order to build plans for the upcoming Boston Marathon. For 3 months, this team
developed emergency response plans for a possible mass casualty event by arranging periodical meetings with the stakeholders of the Boston Marathon. (15) On April 15, 2013, the Multi Agency Coordination Center (MACC) in the MEMA Emergency Operations Center was activated for the Boston Marathon. These are the list of agencies that sent their staffs to the MACC - Boston EMS, police, fire, and public safety personnel from Boston and the other seven cities and towns, Massachusetts State Police, National Guard, Commonwealth Fusion Center, FBI, Coast Guard, and BAA. This multiagency communication center managed to continuously share information with the MIC. (15) Preparations made by MEMA also helped the city to be ready for the mass casualty event. Prophetically, MEMA had a pre-Marathon tabletop exercises in 2012 which discussed the possibility of multiple IEDs at the finish line. (7) Even though there was a great possibility that there could have been an unexpected problem to arise within this complex communication system, this team handled the mass casualty event with clear sharing of information through multiple exercises.

Special preparation was certainly done for the Boston Marathon, however, it is important to point out that Massachusetts emergency medical team, in recent years, developed strong communications, coordination, and response capacities and capabilities with police and fire departments, local businesses and volunteer groups. (15) In order to test their emergency response procedures, they not only used scenario-based drills, but also used other large-scale events that happened in Boston. Dr. Biddinger mentioned in an interview that "full-scale federally sponsored Urban Shield exercises that typically
involve 600 people and 50 agencies" particularly helped the city and his hospital's emergency response team to be effective in the Boston Marathon Bombing. (7) He also mentioned that there were other citywide exercises like the Urban Shield exercises. These exercises gathered the entire Massachusetts emergency response teams to work together and do a scenario-based drill. One of the goals of these exercises is to figure out what each agency will be doing in the time of emergency and what their capacities and capabilities are. (7)

One of the exercises performed by the city of Boston was surge exercises and patient distribution. The Massachusetts Department of Public Health (DPH), Boston EMS, the Boston Public Health Commission (BPHC), and the city hospitals had their parts in these exercises. The goal of surge exercises is to distribute patients to the city hospitals according to a set emergency response procedures and to have the city hospitals clear the emergency departments as they still take care of the patients, reschedule elective surgeries, and make operating rooms available for the surge of injured patients. Trauma services at BWH, a team led by Dr. Jonathan Gates, also participated in surge exercises. As his team went through these exercises, they were able to find "holes" to their plans. The first one was that there should be an incident commander in a large-scale, mass casualty event, and there should also be a communicating system between the hospital and the "deep bench" of surgeons who are not always easily reachable through the hospital's page-operator system. These exercises prepared BWH to be fully functioning for the Boston Marathon Bombing, which would have been difficult without the exercises
and drills. The result of these practices was clearly shown through the Boston Marathon Bombing, where the city, which was trained as one team, indeed coordinated appropriately to respond to the surge of patients.

Boston had been willing learn from others' unfortunate experiences in order to refine its emergency response procedures for mass casualty events. Emergency response leaders in Boston studied the literature in order to gain lessons from other cities that went through mass casualty events. The city hosted two symposia in 2008 and 2009, which were sponsored by CDC and the Harvard School of Public Health. (14)These symposia focused on preparing for terrorist bombing incidents in Boston. Many speakers from different countries came to Boston in order to deliver their speeches. The speeches were insightful in that they brought up a few critical limitations that they had to encounter. Limitations included difficulties in triaging patients, figuring out which patients are the most severely injured ones, and challenges that might occur in hospital's operations due to limited time to be ready for the surge of patients. (15) This information greatly contributed to Boston's disaster preparedness, and resulted in successful response towards the Boston Marathon Bombing.

CHALLENGES

I. Crowded ED
The Boston Marathon Bombing showed that the emergency departments should stay as orderly as possible when a mass casualty event occurs. One of the challenges that occurred during the incident was that many of good-willed physicians "self-deployed" to the emergency departments of two hospitals, BWH and BIDMC. (16) Though it was necessary to have a larger labor pool during the response, Meg Femino, director of Emergency Management at BIDMC, figured out that it was important to make sure the ED was not over-crowded with the flood of self-deployed staffs. Femino decided to make a self-deployed clinicians waiting area so that they can be pulled out from the labor pool when it was necessary. (16)

Learning from Femino's improvisation, hospitals responding to a mass casualty event should be expecting the surge of voluntary staffs, and make sure these staffs are directed to the right area, and be informed that they will be pulled into the situation when it is necessary.

II. Unidentified Patients

Though Boston's health care facilities delivered the best possible care to the victims of the Boston Marathon Bombing, there was still a great challenge faced by them - correctly identifying patients.

While BWH had debriefings about its response to the incident, staff members of BWH mentioned several difficulties that came up with patient identification. BWH had
been using a customized electronic health records system which was optimized to be effective and efficient for the specific facility. This system has been used for 30 years, which is unlike other hospitals that are now having transitions to electronic health records system. (17)

Under a normal circumstance, when a trauma patient comes in and staff members are not able to get the patient's personal information, the emergency department would assign the patient a temporary name. The unidentified patient would receive "Unidentified" as the last name and a unique three-letter combination as the first name. The electronic tracking board would reflect the patient's name, sex and location within the department. (18) The patient's actual name would be reflected in the system once registration staffs receive the patient's information. According to Dr. Adam Landman, an emergency physician and BWH's chief medical information officer for health information innovation and integration, the system is effective and efficient under a normal condition when the department only has one or two trauma patients at a time. (17)

Problems arose when the Boston Marathon Bombing occurred. BWH received 19 patients within 30 minutes of the first blast. There was also a time when multiple patients arrived all at once, and all of them required surgical procedures. In this chaotic situation, staff of the emergency department quickly assigned those unidentified patient with names and put their main effort on providing medical care on those patients. As a result, the electronic tracking board showed tiles of numerous unidentified patients with the first initial followed by the last name such as "V. UNIDENTIFIED", or "A. UNIDENTIFIED".
(Figure 6) As shown in the figure, the only unique part of the patients' names was the first initial, which was assigned randomly. Due to this issue, the staff members had to spend extra time to distinguish one patient from another, and also had radiology staff and consultants who came to the ED with an order for a patient and could not depend on the electronic tracking board to identify the patient's physical location. (17)

Figure 6 - Several unidentified patients with names that were hard to be distinguished, checked in to the electronic tracking board. Figure taken from Landman et al., 2014
Dr. Landman confessed in his review that inability to distinguish patients from one another made "patient care challenging and potentially unsafe." (18)

Furthermore, there was delay in the response due to the "difficult-to-distinguish" names, which were entered by the emergency department and were successively "propagated" to all hospital information systems. Downstream information systems included the automated medication dispensing system, radiology, laboratory systems, and the operation rooms and inpatient units used the indistinguishable names since those were what they received from the hospital information systems. Therefore, there was a delay created as the staff members had to perform manual identification of each patient in order to avoid any confusion. (17)

In their review, Landman and his peers concluded that BWH's original naming convention could have resulted in medical errors, confusions, inefficiencies, and patient harm during the event and under a normal condition when there is more than one unidentified patient. (18) A workgroup gathered in order to identify other institutions' naming conventions, and there were multiple ones they found effective and efficient (Figure 7).
Out of all the options, BWH's medical information team chose the best solution to this issue, which would suit their hospital's information system. Since the electronic tracking board shows the first letter of the first name and the full last name, they decided to put "unknown" for every unidentified patient's first name, and "UNK-M/F-YYY" as his or her last name. M/F indicates a patient's sex, and YYY will be a distinctive phrase such as color, state, street name, or lake. (17) An example of the name of an unidentified female patient would be "U. UNK-F-BLUE". When another mass casualty event occurs, BWH's emergency department will be using colors first, and then go on to the next category of unique phrases when colors are all assigned to patients. (18) BWH shifted to the improved naming convention in July 2, 2013, less than three months after the Boston Marathon Bombing. Their effort to quickly find out the problems they have in their
information system helped the hospital to be better prepared for the next event with more than 6 casualties, and the new system was confirmed to be functioning as intended.

In his paper, Dr. Landman suggested that there should be standardized naming convention for unidentified patients at the national level, which could be accessible to all hospitals and electronic health record vendors. This would allow more unified system that can be recognized and understood by every health care providers and hospitals' staff members in the states.

III. Patients' Physical Locations

Another problem that came up alongside of patient identification was difficulties in recognizing patients' physical locations. As seen in Figure 6, the electronic tracking board also shows locations of patients. However, since the patients were indistinguishable, staff members had hard time locating patients and being aware of their status. (18) Especially, it was challenging for the emergency department providers doing initial triage because they were not aware of where the patients were being treated and which rooms were vacant for the next surge of patients. (18) Fortunately, there were BWH staff members from other departments who were voluntarily coming into the emergency department, and they played a role as "runners" in checking each room and letting initial triage staffs know about it.
Dr. Landman's team assessed the challenges that occurred due to the lack of situational awareness among the staff during the mass casualty incident. They identified a major cause to the challenge to be the delay in electronic tracking board update. There were too many critically injured patients coming in all at once, and all the staff members were concentrated on patient care. Knowing this, BWH's emergency department operational leadership group implemented educational and workflow changes in order to make patient check-in and tracking during a mass casualty event to be more efficient and effective. The trainings and changes were created based on much research on the literature reviews, assessments on their response to the Boston Marathon Bombing, and discussions with other trauma centers such as Tel Aviv Sourasky Medical Center (TASMC).

Another solution to raising situational awareness in a mass casualty event is to assign a nurse to be a unit leader. During the Boston Marathon Bombing, nurses who would usually be in charge of each unit participated in patient care, and therefore were not able to take on leadership roles. Learning from this experience, BWH created the unit leader position within the hospital's incident command system, which will reinforce the "nurse-in-charge" role which is critical to maintaining patient status information. A unit leader will be in charge of managing the beds and providers; keeping the electronic tracking board updated real-time; and communicating with triage by phone, radio, or runner in a mass casualty event.
III. Documentation of Assessments, Orders, and Procedures

Patient care delivered by the staff members at BWH was effective and efficient. However, since the focus was mostly on the rapid patient care, the staff did not pay as much attention to computer tasks and procedures. (18) Verbal orders for medication and laboratory orders were delivered instead of electronic orders in real time. (18) There were no serious issues created due to this problem, but there definitely could have problems occurred due to staffs' loss of ability to keep the electronic records simultaneously with treatments and orders.

"Bypassing electronic health record data entry is not uncommon when care is delivered to critically ill patients", says Dr. Landman. (18) Often, when a trauma patient comes in, providers would take care of updating electronic health record once a patient becomes stable. Unfortunately, the situation was completely different in the Boston Marathon Bombing in which there were many patients coming in all at once. These patients could have been left without order or documentations for hours since there was no electronic health record entered. (18) What BWH's medical information team noticed during the Boston Marathon Bombing was that there were many providers coming in voluntarily within a short period of time after the incident occurred. Many could have participated in patient treatment, however, they also could have been assigned to do more of information management tasks as scribes, entering orders and working on medical documentations. It has been proven that scribes played a critical role in improving operational efficiency in an emergency department's operations. (19) As so in daily
operations, it is hoped that scribes in a mass casualty event reduces the time spent on electronic documentation and order entry.
LESSONS FROM AURORA MOVIE THEATRE SHOOTING, 2012

In Aurora, Colorado, there was an active shooting incident during the showing of the movie, “The Dark Knight Rises” at the Century 16 movie theatre. The incident resulted in 12 deaths and 57 injuries. This type of massacre has rarely happened in the past, and the types of injuries occurred were closer to war wounds rather than regular trauma injuries. In spite of the severity of the incident, the city of Aurora was able to respond to the situation in a right way. There have been several reports that have analyzed the disaster preparedness of the city and the main hospital, University of Colorado Hospital, involved in the incident. In the following pages, what enabled the quick and effective emergency response and what challenged the response will be discussed.

ACHIEVEMENTS

I. Flexibility and Creativity

During the response to the shooting incident, injured victims were transported to nearby hospitals via police cars and private cars instead of ambulances. The reasons for this were due to traffic and pedestrian congestion in the parking lots. The parking lots were exceptionally crowded with randomly parked, unattended police cars. On top of the inability of ambulances to access the theatre, there was no coordinated transportation group set up even by the end of the response. Even with this challenge, police officers and firefighters quickly made a decision to transport those who were
injured via their own police cars. Out of the police officers who transported the wounded, there were officers who had never trained in patient care. Furthermore, there were private cars involved in patient transportation, and they carried 13 patients out of 60 patients who were transported to hospitals. (Table 2) Many of the transporters were untrained, yet they were prepared to be flexible and creative in patient transportation.

<table>
<thead>
<tr>
<th>Number of Patients Transported to Hospital</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Ambulance</td>
</tr>
<tr>
<td>27-28</td>
<td>Police Vehicle</td>
</tr>
<tr>
<td>13-14</td>
<td>Private Vehicle or walked (one)</td>
</tr>
<tr>
<td>60</td>
<td>Total</td>
</tr>
</tbody>
</table>

*Table 2 - Mode of Transport for Victims*

Victims of the active shooting incident had severe wounds. Each minute was critical for each patient, and without the decision to transport patients as quickly as possible via non-ambulance vehicles, several more patients likely would have died, according to the hospitals which treated the victims. (21) Although they did not receive an approval from the higher command center, the police officers did not wait, rather they focused on saving lives by performing unconventional transportation. As a result, all of the victims who were transported to the hospitals survived. (20) According to an increasing number reports in the of medical literature, it has been suggested that this type of expedient transport, even without the benefit of pre-hospital care, is associated with improved outcomes for victims of penetrating trauma to the thoracic-abdominal region.
All patients who required immediate interventions were appropriately transported to hospitals within 52 minutes from the first 911 call, in fact, many much sooner than that. This rapid reaction of the police department demonstrates the importance of giving first responders authority to improvise in a mass casualty event.

II. Rapid Transition to a Disaster Response Mode at the Hospitals

The University of Colorado, which received 23 patients within the first 30 minutes of the incident, activated a Code D. A Code D is a code for disaster response at the hospital. As soon as the code was activated, the hospital quickly transitioned itself into the disaster mode. When the hospital received a call about the incident with not much detail, its emergency department was almost full - 49 out of 50 beds were filled. The rapid transition required sending all the extra resources to the emergency department, and also decompressing the department by offloading patients who were in the emergency department to the post anesthesia care unit. Furthermore, the hospitals strengthened their security unit in case they became another target in the chaotic situation. In a shooting incident, it is always important to make sure that the person who shot victims cannot get to a hospital in order to finish his or her job.

Patrick Conroy, a manager of support services for University of Colorado Hospital, has pointed out that all these actions were taken immediately due to the hospital's practices and drills for different types of disasters in the past, much like what
was seen with Boston’s response to the bombings. (20) In fact, the hospital had completed 34 preparedness activities such as a policy review, drills, training and table-top exercises to date. (24) Back in 1999, there was an active shooting incident at Columbine High School. This incident helped hospitals in Colorado be better prepared for massive casualty events. Denver Health Medical Center was a part of the response, and Christopher Colwell, emergency services director, has said that the hospital had "obviously done a lot of training exercises since [the Columbine shooting] to try to prepare for an event like that." (25)

III. Mental Health Support

In many reports related to the Aurora shooting, it was accentuated that the hospitals focused on psychological support of the health care providers, victims and victims' families and friends. When the active shooting incident happened, the hospitals made sure that the loved ones of the victims could contact the hospitals to figure out the victims' status. University of Colorado Hospital established a hotline within the first 12 hours of the emergency. (24) More than 2000 calls of those who were searching for loved ones were received at the hospital. Furthermore, University of Colorado Hospital coordinated with other hospitals and its partner, the Tri-County Health Department, to organize the patient list of each facility in order to have family members be directed to patients' current locations. (24) Indeed, the Tri-County Health Department's main
responsibility during the event was to ensure that each facility had a common operating picture for the incident, one of the aspects on mental health support. (20)

A part of disaster preparedness plans in Aurora Mental Health Center was to have volunteers available during a response to an emergency situation. An 18-member volunteer disaster team was quickly activated after the shooting incident, and their task was to deliver "timely and immediate psychological first aid." (22) There were the disaster response team, fully-staffed hotline, school response team, and other mental health services joining to form a small mental health unit. This unit served more than 3000 people who were seeking mental health support after the mass casualty event. (20)

The mental health care was maintained continuously beyond the day of the incident. According to a report, the month after the shooting, Aurora Mental Health Center had a 58 percent increase in mental health visits. The center not only received patients, but also sent out mental health support teams to the various local school once schools were back into session. In the mean time, the center also cared for their own staff and made sure that they do not become overstressed. For their burned out staff members, the center brought in a masseuse. (20)

CHALLENGES

I. Communication between Police and Fire Departments
The outcome of the city of Aurora's response to the shooting incident could not have been better. All the injured patients transported to hospitals survived. However, many reports had pointed out that there was still room for improvement. One of the difficulties of the night of the disaster was the lack of communication between the police department and fire department of the city, which led to the absence of a unified, joint command during the first hour of the incident.

According to an after action report on the incident, the police department was not able to or did not know how to communicate directly with the fire department, even though there was a fully interoperable radio system. Because there was no communication between these two departments, the fire incident commander could not figure out the severity of the event or the risk level in the movie theatre. Fire commanders did not know when the police had arrested the criminal, which caused delay and confusion in their response. (24)

On top of that, ambulances arrived on site in a timely manner, however, they could not get to the theatre and the wounded. The major reason for that situation was not only due to a crowded parking lot, but also due to the lack of communication. Although police incident command was aware of how ambulances could access the incident site, the police did not provide directions or instructions for the fire department and EMS, assuming they could navigate their own way through the parked cars as had police vehicles. (21) On the other hand, the fire department did not seek for directions or
assistance from the police to ease ambulance access to victims. As a result, the police vehicles had to transport critically injured patients who needed immediate care.

II. Patient Identification

On the incident site, triage was done quickly, however, there was a problem with patient identification because there was little use made of any patient identification system during the triage or treatment phases of the response. (21) There was an effort made by Century Triage Group to use tags for the wounded, but the system was soon left behind, because the healthcare providers were not familiar with the system. The huge challenge arose when the lack of patient identification created confusion downstream because all the patient records were incomplete. This confusion created difficulty for providers to sort the large influx of trauma patients in a timely and effective manner. (25)

There were no known, documented mistakes made in patient treatment due to the lack of patient identification. However, there could have been mistreatment due to the confusion. The greater problem was a confusion created among family members and friends of the victims. The police and victim advocates were not able to get information on patient status to answer family questions on the status of loved ones. Since there were close to 80 victims, the police and victim advocates had trouble collecting and distributing information on patient's names, status and locations. (26)
LESSONS FROM HURRICANE KATRINA, 2005

When Hurricane Katrina struck New Orleans in 2005, the city saw themselves in a rather vulnerable state. The deadliest natural disaster in U.S. history at that time left the city with $220 billion in damages and more than 1800 deaths. (27, 28) Though disaster preparedness had been strengthened ever since 9/11 incident happened, the U.S. was still not thoroughly prepared for different types of disasters, which could be either natural or man-made. (29) Many reviews pointed out that the city of New Orleans was basically unprepared in all aspects of disaster preparedness. The city had big storms that passed by previously by luck, and they kept hoping for the same to happen when they first heard about Hurricane Katrina. (30) There were lessons learned from Katrina, and these surprisingly had much similarity with the two other mass casualty events of a completely different disaster type.

ACHIEVEMENTS

I. Commitment of Medical Responders

Unlike many other disasters happened in the U.S., Hurricane Katrina was exceptional in that the damaged areas included multiple states. Medical providers could not avoid the disaster since there was no specific target population. During the response to the incident, medical providers, many of whom had themselves lost their houses and family members, stayed professional and committed and did all they could in the devastating situation.
On top of the local medical responders, there were volunteer health providers coming from all over the places. Their presence reduced the burden of those local responders, and took the initiative to work against inefficiencies in the medical support system and meet patients' needs. (31) Though there was a lack of resources, harsh environments and conditions working against their response, healthcare providers at all levels did not stop putting their best effort in caring for the sick.

CHALLENGES

I. Lack of Advanced Planning

After Katrina hit Louisiana and other states, many reviews studied the case to identify problems within the state's existing disaster preparedness plans. Many reviews constantly emphasized that Louisiana indeed had disaster plans. In fact, it was the matter whether those plans were effective or not. The state's response to Katrina proved the impracticality of those disaster plans.

First of all, the state of Louisiana has such a small number of trauma centers - there are only 2. (32) Most types of disasters require immediate medical response. However, as the number of trauma centers in Louisiana clearly depicts that the state cannot be effective and efficient in their response to critical natural disasters such as Katrina, Colorado with similar population size compared to Louisiana has 62 trauma centers, and Iowa with smaller population size to Louisiana has 116. (32)
Furthermore, hospitals and nursing homes in Louisiana were required to set up their own disaster response plans. This policy put a great deal of responsibility on these medical facilities that led to a lack of inter-operability. The state had set up an example plan such as Louisiana Model Nursing Home or Home Health Emergency Plan.

(30) When Katrina hit Louisiana, nursing homes were all alone in seeking out the appropriate care from hospitals or other facilities to establish the safety of their patients. The nursing homes were also required to pre-arrange patient evacuation and sheltering via contracts with commercial carriers. (32) These many requirements and policies proved to be ineffective in response to the disaster.

II. Lack of Incident Command

As a major aspect of emergency preparedness, practical control and command system during emergencies is required to be planned. The federal government has noticed the lack of structured command system during and after hurricane Katrina, and since then, it has been emphasizing the unity of command during emergencies. (33)

Due to the impact of Katrina, state command and control facilities were not able to share information, even though their system were intact. Furthermore, federal command and control agencies were not able to communicate with each other. This lack of communication led to the incomplete unity among command and control agencies at all levels from local to federal. This situation is similar to what we saw in the Aurora
The state emergency operations centers (EOCs) had challenges in coordinating and sharing information among themselves and other agencies. Several factors came up as reasons for these difficulties. First of all, there was overwhelming number of requests for aid of the centers. Second, the EOC building and main room were very crowded by the large number of state and federal officials. (34) The main room had 200 people in it, while its capacity was up to 50 people. Furthermore, the EOC building was crowded with 750-1000 people in it. (34) Lack of physical space led to much confusion and difficulty in communication among the EOC personnel. The EOCs were also visited by politicians and celebrities which created greater overcrowding and distracting the EOC personnel from their tasks that required immediate attention. Another major problem occurred with the EOCs' Information Technology systems. The Information Technology was overloaded due to the excessive number of additional computers using the system and the amount of information being processed. (34) The system was too unstable to operate at its optimal level.

The lack of communication was the reason why agencies involved in the response to Katrina could not reach the maximal level of coordination. A published report has described that maximal coordination can be reached when there is unity of command, unity of effort, and an accepted chain of command. (34) Though all response groups were
working toward caring for the people both displaced and trapped and reconstructing the impacted area, their destroyed command infrastructure worked against their effort. Without unity of command, there could not be an accepted chain of command during and after Katrina.
DISCUSSION

In the comparison of three key disasters that occurred in the U.S. within a 10 year-period, many aspects of disaster preparedness keep appearing to be significant. While there are commonly shared lessons learned from the three events, there are also some aspects of emergency responses that were not shown in common. Therefore, those aspects will be compared and analyzed. In this section, it is hoped that sharing these comprehensive lessons learned from the three mass casualty events would strengthen disaster preparedness systems of any hospitals or cities around the world.

ADVANCED PLANNING

Boston was ready for the mass casualty incident at the Boston Marathon because the city had put much effort in advanced planning. The city's emergency management agencies, hospitals, police and fire departments, and EMS all participated in mass emergency drills, which had happened consistently for many years. These drills allowed for the groups to go over which parts of their emergency preparedness were practical or not and which parts needed improvements. It also appeared in the Aurora shooting that constant practice of emergency drills help better prepare for disasters. University of Colorado Medical Center was able to respond quickly to the shooting incident by rapidly transitioning into emergency mode. Before patients arrived, the hospital was ready to assess and treat them. The staff member of the hospital stated that the hospitals had done
drills and exercises for different types of disasters, and these helped them have stronger emergency management system. What lacked in Louisiana was practical emergency management plans. As a result of insufficient funding for the state's emergency preparedness, the emergency management plans often remained paper-based, without practicality. This inefficient plan ended up costing the state multiple times more than it would have cost them to have a practical emergency plans. (32) A great lesson learned from all three mass casualty events is that emergency management plans should focus not only on the mobilization of great numbers of resources, but also on the installation of mechanisms to organize these resources.

Several recommendations for advanced planning came up while comparing the three mass casualty events. In one of the reviews, it was mentioned that a former army nurse made a decision based on her experience at Honduras during the Boston Marathon Bombing response. (8) This shows how important it is to incorporate the experienced ones' knowledge into hospitals' disaster preparedness. Civilian hospitals and public health agencies should gather with their military counterparts and learn from their experience and knowledge to improve existing emergency preparedness before an actual mass casualty event occurs. Furthermore, Boston had consistently put in efforts to enhance their plans by learning from other mass casualty events. The city of Boston hosted conferences on emergency preparedness in recent years. Lessons learned by cities, which suffered terrorist bombing incidents were delivered by many speakers from different places around the world. Learning from others’ experience greatly refines one's existing
disaster preparedness system. Last, there should be actual drills and exercises happening in a city, which should incorporate all emergency response groups from local hospitals to federal agencies. Through these practices, these groups shall thoroughly review their emergency management plans and figure out what would need improvements and what was practical or not.

INFORMATION TECHNOLOGY

As current technology improves, information technology for emergency preparedness should also improve. Common challenges that occurred during the three mass casualty events included maintenance of communication networks and medical records.

Communication during the response to the Boston Marathon Bombing stayed efficient and effective. Particularly, the State Emergency Operation Center played a central communication arena throughout the critical hours of the response. This center had the WebEOC system that could update hospitals in Boston about the incident real-time. Due to the well established system, the information about the expected number of patients and types of injuries was delivered timely to Boston's hospitals which could prepare properly for incoming patients. The Aurora Shooting incident showed how much confusion can occur due to a lack of communication between the response groups, police and fire departments. Although their interoperable communication network was intact,
they were not able to use it. It is likely that they had never practiced using it. This implies the importance of acquiring a communication system, but also knowing how to use it. In the aftermath of Katrina, federal government pointed out that the response to Katrina was less effective due to a critical challenge on communications. It was recommended that current laws, policies, plans, and strategies related to communications should be reviewed by the Department of Homeland Security. Furthermore, the Department of Homeland Security should cooperate with the Office of Science and Technology Policy to develop a National Emergency Communications Strategy that allows communications operability and interoperability. (34) This recommendation clearly depicts the importance of communications among response groups of all levels - federal, state, and local.

As a preparation for emergency situations, agencies should test their communication networks in drills and exercises and make sure they are aware of the manual for the network systems. Furthermore, they should think about a situation where communication infrastructure gets destroyed either by men or nature. Alternative communication system should be planned for an incident like that. High-tech information technology is needed, but low-tech and no-tech solutions should not be underestimated. In a case of tornado in Greensburg, Kansas, the state used printed newsletters as a means to distribute information about potential health issues during the aftermath of the tornado. Their method suggested a possible use of paper forms in the absence of electronic systems in a disaster. (35)
Medical record system is important for patient identification. Many Boston's hospitals studied challenges during their response to the Boston Marathon Bombing, and several of them mentioned difficulties in patient identification due to difficulty reading electronic record board. During Katrina incident, caring for the sick became a huge issue since a large number of the displaced patients got marked by different agencies in their own distinctive ways. A unified easily-read electronic medical record system across a city, state, or even country will allow unification of records, and it will reduce confusion among healthcare providers when a patient gets displaced to another region or transported to another healthcare facility. If the system gets implemented everywhere in the U.S., there would be no worries about losing the patient's medical records.

**STRENGTHENED SECURITY SYSTEM**

In both man-made and natural disasters, increased security issues is observed. For a man-made disaster such as terrorist attacks, hospitals should ensure that security system is strengthened in order to protect victims and themselves from being the second target of the attack. In an active shooting incident, the shooter is often injured or killed and may be transported to the hospital for medical care. Since there will be a patient surge, it might be hard for responders to distinguish the shooter from victims. Therefore, it is important to search patients for guns. In a natural disaster, there is an increased chance of public disorder. In order to prevent public disorder, there should be enhanced public safety and
security. It is recommended for future disasters that disaster response groups at all levels should build security systems which have practical operational mechanisms suitable for different types of emergencies. These security systems will prevent greater casualty from happening.

EMOTIONAL SUPPORT FOR ALL THE INVOLVED PERSONNEL

It was particular of Aurora Shooting incident that Aurora Mental Health Center instantly activated its volunteers for emotional support. The support was provided to not only patients and their family members, but also healthcare providers. They even brought in masseuse for tired staff members. What is not demonstrated in the literature reviews for Boston Marathon Bombing is emotional support for responders. Often, the mental health of the responders is overlooked. However, they are the ones who work in a devastated situation, constantly encountering situations, which seem to be hopeless. It is an important responsibility of response groups to take care of their workers' mental health so that they would not be exhausted.
Conclusion

Mass casualty events have been occurring throughout the history of the U.S., and it will be impossible for the country to avoid another one. Boston, which only had three terrorist attacks since 1990, had a devastating and unexpected event due to two bomb attacks at the Boston Marathon on April 15, 2013. If Boston were not prepared, the attack could have resulted in a great number of deaths. However, no one among the injured who were transported to hospitals ended up passing away. This event teaches everyone around the world an important lesson. The city's enormous effort to refine emergency preparedness learning from their practices and others' unfortunate mass casualty events and each responder's commitment for recovery resulted in no death of transported victims. This study has shown that hospitals and cities can prepare for emergency situations with much practice and education. Just as other cities' unfortunate mass casualty events were studied by Boston in order to strengthen its emergency preparedness, the Boston Marathon Bombing shall serve as a case to raise an awareness around the world about the importance of emergency preparedness.
REFERENCES


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