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Common areas for improvement from After Action Reports (AARs) generated after exercises or actual disasters, as reported by a national sample of U.S. hospitals

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List of Abbreviations

AAR	After Action Report
BWH	Brigham and Women's Hospital
CT	Computerized Tomography
DHS	Department of Homeland Security
EMS	Emergency Medical Services
ESF	Emergency Support Function
IOM	Institute of Medicine
IP	Improvement Plan
FEMA	Federal Emergency Management Agency
PHEP	Public Health Emergency Preparedness
HPP	Hospital Preparedness Program
HIS	Hospital Safety Index
NDMS	National Disaster Medical System
NHSS	National Health Security Strategy
NEP	National Exercise Program
HHS	Health and Human Services
MMRP	Metropolitan Medical Response Program
MCE	Mass Casualty Emergency
NBHPP	National Bioterrorism Hospital Preparedness Program
PAHPA	Pandemic and All-Hazards Preparedness Act
ASPR	Assistant Secretary for Preparedness and Response
HCC	Health Care Coalitions
CDC	Center for Disease Control and Prevention
JCAH	Joint Commission for Accreditation Hospitals
EM	Emergency Management
HSEEP	Homeland Security Exercise and Evaluation Program
RCA	Root Cause Analysis
SWAT	Special Weapons and Tactics
WHO	World Health Organization

Background

Recent acts of international terrorism, the increased frequency of extreme weather events and newly emerging health threats highlight the need to develop effective emergency response plans and capabilities for responding to all types of disasters. Many countries recognize the importance to consider emergency preparedness as the key health planning activity. Since the September 11th, 2001 terrorist attacks, and the devastation of Hurricanes Rita and Katrina, the United States have extensively reinforced hospital disaster preparedness and response.

Although since the major disasters, hospitals have implemented and continuously tested their emergency operation plans, recent studies reported existing confusion over roles and responsibilities, poor communication, lack of planning, suboptimal training, and a lack of hospital integration into community disaster planning. Therefore, it is important that further studies are conducted in order to capitalize on lessons learned from previous real-incidents and emergency response exercises.

Many hospitals conduct exercises every year, and they conclude the process with an After-Action Report and Improvement Plan. Therefore, there are thousands of AAR/IP's across the country with limited opportunity to compare them or to learn from them collectively. Our project has gathered Improvement Plans (IP's) and conducted a qualitative analysis which determined whether the "lessons learned" can be categorized into common themes.

Introduction

Since the terrorist attacks of September 2001, anthrax attacks, Hurricane Katrina of August 2005, and the flu vaccine shortage of 2004-2005, the United States (US) has considerably strengthened its public health emergency preparedness (PHEP) (Seid et al., 2007). To effectively respond to the dramatic increase in the frequency and intensity of natural disasters (Yu, Zhong, Pei, Bian, & Heilman, 2016), infectious disease, technological, and human-caused disasters, multiple resources were allocated and directed to enhance U.S. public health system and address gaps in emergency preparedness operations (Der-Martirosian et al., 2017). However, the experience of the 2017 Hurricane Harvey showed that disasters continue to cause loss of human life, environmental damage, disruption of infrastructure, and economic loss. At the same time, terrorists are using new technologies and militarized tactics to cause maximum terror among unprotected civilians (Bobko et al., 2018). Therefore, concerns remain about the ability of the public health system to promptly and effectively respond to disasters (Seid et al., 2007). Studies of previous disasters have documented that hospitals located in disaster areas are not well prepared and most of the time experience poor emergency response performance due to functional collapse (Nekoie-Moghadam et al., 2016). Preparing hospitals for disasters has become a national security priority (Toner, 2017). Therefore, hospitals should implement actions, programs, and systems that improve their capabilities and capacities to provide essential healthcare while minimizing the negative effects of the disaster (Djalali et al., 2014).

As an important component of the public health preparedness system, hospitals require a continuous process of planning and exercising while measuring performance through indicators and metrics, and implementing and testing improvements (Jenkins, Kelen, Sauer, Fredericksen, & McCarthy, 2009; Shine, Hill, Pope, & Altevogt, 2008). Hospital surge capacity is based on the hospital's ability to meet a sudden and unusual spike in demand for resources (Waxman et al., 2017). Maintaining high-level emergency preparedness for hospitals is challenging as the process requires resources that many hospitals may lack (Adini, Laor, Hornik-Lurie, Schwartz, & Aharonson-Daniel, 2012). A multitude of intractable disasters tests the ability of hospitals to effectively manage emergencies situations. Confusion over roles and responsibilities, poor communication, lack of planning, suboptimal training, and lack of hospital integration into community disaster planning can lead to poor readiness (Nekoie-Moghadam et al., 2016). There is a significant urgent need for reliable and valid methods to measure hospital preparedness capabilities in order to ensure their resiliency, continuity, and rapid recovery (Der-Martirosian et al., 2017). Valid and standardized assessment tools are required to evaluate the correlation between the level of preparedness and the efficacy of response performance (Djalali et al., 2014).

Effective management of disaster operations will improve readiness, decrease response time, and facilitate recovery (Altay & Green III, 2006). Planning and training for disasters will reduce both human and property loss, and improve the rapid recovery from the disaster (Singleton, DeBastiani, Rose, & Kahn, 2014). However, planning and training might not be sufficient if valuable lessons learned from

disasters and exercises are not used to anticipate response challenges (der Heide, 2006). The World Association of Disaster Medicine has highlighted the need for a more scientific approach to all aspects of disaster medicine and has noted the lack of standardized methods to assess mass casualty incident responses (Ingrassia et al., 2010). In the United States, the Hospital Preparedness Program (HPP) has evolved in developing core capabilities to support hospital emergency readiness (Morris, 2016; Toner, 2017; Waxman et al., 2017).

The National Disaster Medical System (NDMS), which has existed since the Cold War, is designated as the primary federal response mechanism for mass casualty situations (Toner, 2017). Originally designed to respond to large numbers of military casualties from foreign battlefields, the NDMS's mission has evolved toward civilian medical support (Franco, Toner, Waldhorn, Inglesby, & O'Toole, 2007). Due to increasingly frequent terrorist activities, the Metropolitan Medical Response Program (MMRP) was created at the Health and Human Services (HHS) (Toner, 2017). The MMRP was eventually transferred to the Department of Homeland Security (DHS) until the program became defunded in 2011 (Toner, 2017; Waxman et al., 2017). At the Hospital level, much stricter Joint Commission standards for emergency preparedness were released in early 2001(Morris, 2016). But the September 2001 terrorist attacks led to major transformation regarding the Joint Commission standards due to the creation of the Office of Public Health Preparedness (Toner, 2017).

The new office created the National Bioterrorism Hospital Preparedness Program (NBHPP) whose mission was to prepare the country's 5,000 hospitals for

expected bio-attacks (Franco et al., 2007). In 2006, the Pandemic and All-Hazards Preparedness Act (PAHPA) was signed, replacing the Office of Public Health Preparedness with the new Office of the Assistant Secretary for Preparedness and Response (ASPR) (Morris, 2016; Toner, 2017). After the creation of ASPR, the NBHPP was changed to the Hospital Preparedness Program (HPP), whose mission involves all-hazard healthcare preparedness (Toner, 2017). The HPP has continued to evolve and has increasingly focused on the development of healthcare coalitions (HCC) designed to increase emergency preparedness collaboration among hospitals and between hospitals and public health agencies, emergency management agencies, and emergency medical services (Toner, 2017). In parallel with the HPP, in 2002, the Center for Disease Control and Prevention (CDC) launched the Public Health Emergency Preparedness (PHEP) cooperative agreement to effectively prepare territorial, tribal, local, and state public health departments (Toner, 2017). On the other hand, the Joint Commission has continued to evolve by ensuring that health professions are committed to a high quality of patient care.

The frequency and magnitude of medical errors and deadly disaster in the US have increased awareness about the need for effective medical processes and emergency preparedness responses (Devkaran & O'Farrell, 2015). Therefore, the Joint Commission has developed Emergency Management (EM) processes to allow hospitals to plan to respond to the effects of potential emergency events that could disrupt normal healthcare capabilities (Joint Commission, 2014). To effectively respond to an emergency, the JCAH has developed six critical areas that hospitals can consider to address a range of incidents (Joint Commission, 2014).

Although numerous planners and responders have documented lessons learned during emergency responses (Djalali et al., 2014), the review of the literature highlighted that many challenges experienced during planning and real-events seem to repeat themselves disaster after disaster (der Heide, 2006). There is a lack of standards for defining and measuring preparedness, and for effectively incorporating lessons learned from past experience and implementing systematic changes (Nekoie-Moghadam et al., 2016; Seid et al., 2007). Whether from real events or simulations, public health and healthcare organizations recognized the need to use a lessons-learned approach to identify and disseminate the experience gained over time (Savoia, Agboola, & Biddinger, 2012). It is important that lessons learned are transferred from individuals directly involved in emergency operations to systematic changes within the entire organization (Seid et al., 2007). An objective method for assessment should determine strengths and weaknesses in the disaster response and provide information that could ultimately lead to improvements in the response system (Ingrassia et al., 2010). Systematically collected data from disasters or fictional exercises might help emergency planners to avoid common disaster response pitfalls (der Heide, 2006). Therefore, it is useful for emergency preparedness planners to implement formal tools for identifying, documenting and disseminating corrective actions before a response to disasters and simulations.

After-Action Reports (ARRs)/Improvement Plan (IP) guidelines are designed to document the exercise planning, execution, and analysis that have become the implementation requirements for the Department of Homeland Security' State Homeland Security Grant Program, the Department of Health and Human Services,

the Center for Disease Control and Prevention's Public Health Emergency Preparedness Grant Program, and the Urban Area Security Initiative (Singleton et al., 2014). The use of AAR templates became strongly recommended in several federal funding agencies' capability and exercise guidance. Therefore, the Homeland Security Exercise and Evaluation Program (HSEEP) AAR/IP template is considered the primary tool of the National Exercise Program materials and improvement process (Norige, Yenson, Elkin, Mapar, & Legary, 2012; Singleton et al., 2014).

The HSEEP provides a set of guidelines and principles for exercise programs to effectively manage preparedness simulations, design and develops exercises, evaluate outcomes, and improve planning (Norige et al., 2012). The Joint Commission requires healthcare institutions to conduct and maintain emergency operations plan, and to conduct exercises and drills at least twice a year (Ferrer, Ramirez, Sauser, Iverson, & Upperman, 2009). Exercises and drills are key components of national preparedness as they provide the opportunity to shape planning, assess and validate capabilities, and address areas for improvement (Norige et al., 2012). Preparedness exercises play a vital role in national preparedness by allowing whole community stakeholders to test and validate plans and capabilities. Exercises enable the identification of both capability gaps and areas for improvement in order to strengthen whole community efforts to prevent, protect against, mitigate, respond to, and recover from all disasters (Norige et al., 2012). The National Exercise Program (NEP) is consistent with the HSEEP methodology because in that it provides tools and guidelines that are flexible, scalable, and adaptable to all mission areas (such as prevention, protection, mitigation, response, and recovery) (Norige et al., 2012). The

HSEEP methodology is based on an exercise cycle which involves design and development, conduct, evaluation, and improvement planning (Norige et al., 2012). Immediately after the conduct of the exercises, a "hot wash" session provides an opportunity to discuss strengths and areas for improvement (Norige et al., 2012). Information collected during Hot Wash, the debriefing, and completed participant feedback forms can be used to generate the AAR/IP to ensure future exercise improvements (Norige et al., 2012).

The HSEEP developed the After-Action Report/Improvement Plan (AAR/IP) to provide a template and guidance to evaluate exercise objectives and capabilities (Norige et al., 2012). Preparedness exercises test the knowledge, skills, and abilities that are likely to be needed during emergency situations (Ingrassia et al., 2010). AAR/IP is used to document strengths, areas for improvement, core capability performance, and corrective actions (Norige et al., 2012). They summarize key information related to the evaluation of the exercises and their length, format, and development timeframe depend on the exercise type and scope. AARs are emergency preparedness tools for collecting and documenting evaluations of key processes during the response to both simulations and real emergency situations (Savoia et al., 2012). The HSEEP AAR/IP templates are the standards for reporting preparedness exercises, real incidents, and continuous quality improvement across various federal agencies on disaster management (Singleton et al., 2014). AARs are routinely generated after drills or exercises to assess improvements (Seid et al., 2007). In fact, formal AARs are now required by public health and healthcare agencies and organizations such as the Centers for Disease Control and Prevention (CDC), the

Assistant Secretary for Preparedness and Response (ASPR), and the Joint Commission (Morris, 2016; Savoia et al., 2012; Waxman et al., 2017). The AAR templates are intended to assist in identifying lessons learned from disaster preparedness exercises in order to facilitate the quality improvement of the response process (Norige et al., 2012; Singleton et al., 2014). They contain basic information, such as the exercise name, the type of exercise, dates, location, participating organizations, mission areas, specific threat or hazard, a brief scenario description, and the name of the exercise sponsor (Mast et al., 2016; Norige et al., 2012).

The main focus of the AARs is the analysis of core capabilities which involves the collection of sufficient relevant data to support effective evaluation and improvement planning (Mast et al., 2016; Norige et al., 2012). Hospital emergency preparedness planning is done based on core capabilities that are listed in the HPP (Toner, 2017). The AARs should provide an overview of performance related to each exercise objective and associated core capability while highlighting strengths, as well as areas for improvement (Norige et al., 2012). Areas for improvement requiring corrective actions are those that will continue to seriously impede capability performance if left unresolved. It is important to provide useful information as to how quality improvement aspects are built into AARs to better implement corrective actions. After the identification of strengths and areas for improvement that directly addresses core capability gaps, improvement planning should be done to implement concrete corrective actions (Norige et al., 2012).

Improvement planning is the final phase of the preparedness exercise as it involves the qualitative assessment of actionable recommendations that are intended

to resolve capability gaps and issues identified during the exercises or real-world disasters (Norige et al., 2012). Corrective actions documented in the AAR/IP should be monitored and continually reported until fully completed (Norige et al., 2012). However, most of the time lessons learned embodied in AARs are not acted on and sit on shelves due to unclear expectations and measures (Seid et al., 2007).

Hospitals play a major role in emergency response because a disaster can create medical needs that are beyond their normal capabilities. They are an important link in the chain of disaster response (Nekoie-Moghadam et al., 2016). There is a need to improve hospital preparedness that addresses a full range of potential disasters (Jenkins et al., 2009). Achieving and maintaining a high level of emergency preparedness is very challenging for hospitals because of the complex role they play during disaster response (Der-Martirosian et al., 2017). It is equally challenging to evaluate hospital emergency readiness to effectively respond during disasters (Der-Martirosian et al., 2017). Evaluation and reporting tools should be included in hospital disaster plans in order to recognize potential gaps and weaknesses (Nekoie-Moghadam et al., 2016). AARs in hospitals are a fundamental part of emergency preparedness and quality improvement (Brunner et al., 2014). For instance, during the April 2013 Boston Marathon attack, the Brigham and Women's Hospital (BWH) called for a substantial volume of radiological imaging, taxing their capacity to perform such studies (Tobert, von Keudell, & Rodriguez, 2015). Due to the severity of physical injuries, the BWH AAR revealed that greater use of computerized tomography (CT) scans should have been anticipated in the disaster planning (Brunner et al., 2014). Another example included a tabletop exercise that

acknowledged that adult patient hospitals are lacking pediatric supply caches (Ferrer et al., 2009). Other important ethical issues were raised regarding whether or not adult general surgeons were allowed to operate on pediatric patients during emergency situations (Ferrer et al., 2009).

Statement of the Problem

In recent years, communities throughout the United States and other countries have experienced large-scale disasters that challenged the capacity of response (Ferrer et al., 2009). Despite multiple attempts to document and learn from previous emergency responses and scenario-based exercises, the challenges experienced in planning and responding to disasters seem to be persistent (der Heide, 2006; Savoia et al., 2012). Improvement areas keep repeating themselves in AARs because corrective actions are not implemented due to unclear expectations and measures. Lessons learned embodied in the improvement matrix are not acted on and sit on shelves due to unclear expectations and measures (Seid et al., 2007). For instance, although many hospital's improvement areas keep mentioning the need for effective communication, poor communication systems remain a common concern in disaster preparedness efforts (Ferrer et al., 2009). Systems-level learning remains challenging to accomplish, therefore, review of incidents and the identification of lessons should be more readily performed (Savoia et al., 2012). Nationally aggregated pools of AARs should be used to collect the most common response challenges that hospitals are experiencing routinely and proven problematic (Savoia, Agboola, & Biddinger, 2012). Accordingly, emergency preparedness and response planners can use data collected

when drafting their training programs, so that the challenges could be included, and hopefully not occur again.

This project will endeavor to perform a qualitative review of hospital AARs in order to catalog the most common corrective actions identified during real-incidents or simulations. The project also strives to identify the link between the improvement efforts and the core capabilities to maximize knowledge management and quality improvement practices. With our results, we will attempt to identify most common improvement efforts which can be translated into concrete actions to be incorporated into the design of future emergency preparedness planning and training.

Significance of study

Preparing hospitals for disasters has become a national security priority because the US has experienced large-scale emergencies that caused the death of large numbers of people (Toner, 2017). Despite a large amount of approximately $300 million spent yearly in hospital emergency preparedness program (Lindsay, 2017), hospital's preparedness improvement areas continue to repeatedly document common pitfalls in their AARs (Waxman et al., 2017). It is important that educational and training programs focus on common concerns in disaster preparedness efforts as well as challenges that were experienced during actual disaster responses. Thus, funding could be directed to assist in solving the common problems which may save lives and money or at least generate a better return on investment in the long term.

i. Purpose of the study

1. Research question

What are the most common areas for improvements identified during preparedness exercises or real disaster responses, as reported by a national sample of U.S. hospitals?

2. Specific Aims

To identify common themes in a sample of Improvement Matrices from US hospitals in order to categorize the correctives actions.

3. Definitions of terms

We believed that it is important to define certain terms used in our study to ensure common understanding. Therefore, we have attempted to define the following terms:

- The term “code” is often considered to be a system of words, letters, figures, or other symbols substituted for other word, letters, etc., especially for the purpose of secrecy. In our study the term “code” refers to an analytical process in which data are categorized to facilitate analysis;
- The term "segment" is often associated with parts into which something is or may be divided. Our study has associated "segment" to a portion of statement that has been coded;
- The terms “elements of performance” generally mean work assignments or responsibilities that are used to plan, monitor, and appraise performance. Our study has used the terms “elements of performance” to

categorize the components of the critical areas by which hospital emergency response capabilities can be planned, monitored, and rated;

- The verb “extrapolate” refers to the extension of an application to an unknown situation by assuming that existing trends will continue, or similar methods will be applicable. Our study has used the verb "extrapolate" to link coded segment to its assumed corresponding elements of a performance.

4. Assumptions

The major assumption of the study considered that hospital emergency response readiness does not depend on the size of the hospital. Therefore, the size of hospitals was not controlled during the analysis. Another assumption was made that the sample was a representative of the full scope of threats as data were randomly collected.

2. Literature Review

The increasing human and economic impact of disasters, the globalization of the terrorist activities, and the declaration of the 1990s as the International Decade of Natural Disaster Reduction are among the reasons for the rise in interest in emergency management (Altay & Green III, 2006). Healthcare systems should prepare effective emergency response models to cope with mass-casualty incidents (Adini et al., 2006). Disaster management involves two stages; pre-event and post-event. Pre-event efforts include predicting and analyzing potential risks and developing strategies for mitigation, while post-event tasks begin during the emergency (Altay & Green III, 2006. Since 2002, the need for pre-event preparedness

has been reinforced by the HSEEP and underlying issues or root causes should be uncovered to develop corrective and actionable solutions to improvement areas (Singleton et al., 2014). Effective emergency management efforts should involve both pre-event and post-event data to locate, allocate, coordinate, and manage available resources (Altay & Green III, 2006). For years, hospital emergency management services have used various modes to collect and disseminate lessons-learned from exercise or real emergency responses (Djalali et al., 2014; Savoia et al., 2012). Specifically, over the past decade, numerous initiatives and preparedness tools have been developed to help hospitals improve their ability to become better prepared for major disasters (Der-Martirosian et al., 2017).

To date, there is limited agreement about indicators that constitute effective hospital emergency preparedness (Adini et al., 2006; Ingrassia et al., 2010; Nekoie-Moghadam et al., 2016) and no largely-accepted, validated instruments to measure readiness exist (Adini et al., 2006; Adini et al., 2012; Der-Martirosian et al., 2017; McCarthy, Brewster, Hsu, Macintyre, & Kelen, 2009). Furthermore, there are a number of differences in the protocols and tools that exist for evaluating hospital's emergency management capabilities (Jenkins et al., 2009; McCarthy et al., 2009; Nekoie-Moghadam et al., 2016). The Hospital Safety Index (HSI) developed by the World Health Organization (WHO) is one of the internationally-accepted and standardized evaluation methods (Djalali et al., 2014). While a number of instruments are hazard-specific, some tools are more comprehensive with the ability to be used to measure hospital all-hazards preparedness (Der-Martirosian et al., 2017). Hospital preparedness evaluations also may include drills and functional exercises to assess

performance during a simulated mass-casualty emergency (MCE) (Ingrassia et al., 2010). In the process of building resilient medical systems under the leadership of the HHS Emergency Support Function 8 (ESF8), healthcare coalitions have been established (Lowe, Hansen, Sanger, & Obaid, 2016). For instance, due to key leadership gaps identified in a hospital decision-making capacity, community-wide healthcare coalition-based exercises are being more and more commonly recommended (Lowe et al., 2016). The aim of hospitals is to be prepared to effectively respond to disasters and other potential disruptions to health care service delivery. Based on the National Health Security Strategy (NHSS), the HPP core capabilities were strengthened to improve hospital readiness (Rose, Murthy, Brooks, & Bryant, 2017). In 2012, the National guidance established 10 HPP core capabilities aligned with the 15 PHEP capabilities (Lowe et al., 2016). Based on the 2012 national guidance, the ASPR developed the 2017-2022 Health Care Preparedness and Response Capabilities guidance which outlined four core capabilities (Veenema, 2018). One of the conditions for hospitals to access federal grants is to fully engage themselves in emergency preparedness operations (Barnes, 2017). In 1965, financial incentive approach created by US government is the establishment of the 'deemed status' by which any hospital accredited by the Joint Commission would be deemed to be eligible for the Medicare program (Schyve, 2000). Medicare program represents a large portion of the hospital income and that can contribute in financing emergency preparedness programs.

The story of the Joint Commission started in 1910 and its development has increased with technological progress in the practice of medicine to offer

considerably safer care for patients (Roberts, Coale, & Redman, 1987). The Joint Commission accredits over 20,000 ambulatory care, behavioral health care, home care, long-term care organizations, hospitals, laboratories, and health care networks (Roaten, Johnson, Genzel, Khan, & North, 2018). Over 96% of hospital beds in the US are in accredited hospitals (Schyve, 2000). The Joint Commission created an Office of Quality Monitoring to effectively handle quality-related issues (Schyve, 2000). To specifically manage an emergency in hospitals, the Joint Commission introduced the six critical areas: communication, resources and assets, safety and security, staff responsibilities, patient clinical and support activities, and utilities (Joint Commission, 2014). Hospitals are encouraged to consider their capabilities in these critical areas in order to improve their emergency response efforts. Therefore, hospitals have started using AARs to summarize lessons learned or recommendations made to improve outcomes (Ross et al., 2008).

Although several disparate forms of debriefing methodologies were used, the AARs were originally developed by the U.S. Army before becoming widely adopted by non-military private institutions, and healthcare organizations (Savoia et al., 2012). The Military AARs were used to provide feedback on the accomplishment of exercises, deployments, or other military operations (Ross et al., 2008). Although the original purpose of HSEEP AAR template was used to better identify and derive critical lessons from preparedness exercises, it is also used to facilitate continuous quality improvement for real disaster reporting (Singleton et al., 2014).

The use of the HSEEP AAR template by all public health services allowed comparisons across jurisdictions for a better understanding of the range of

jurisdictional capabilities (Singleton et al., 2014). The HSEEP AAR guidelines provide reporting equivalent measures by recommending the use of consistent standards that can be applied to public health services. The HSEEP AAR format created a common approach to exercise preparedness plans while evaluating improvement needs within the emergency preparedness and response communities (Norige et al., 2012; Singleton et al., 2014). Improvement planning involves tracking the implementation of corrective actions to ensure tangible preparedness improvements (Norige et al., 2012). The HSEEP AAR was developed to ensure that a sufficient level of detail needed to improve preparedness capabilities are well reported (Singleton et al., 2014). AARs provide a reservoir of vital information to prepare public health services to effectively perform in a contingency environment (Ross et al., 2008). Yet, despite the large dissemination of the ARRs, variability and variety of healthcare, and public health systems may increase the risk of failure to fully implement the corrective actions (Savoia et al., 2012).

One major challenge was the fact that most operational data collection on disaster medical planning was done on sudden, single impact events such as explosions, tornadoes, or flash floods, and in such conditions, the location of the research could not be selected (der Heide, 2006). The unexpected nature of disasters obliged the data to be collected retrospectively, which leads to challenges in the comparison of pre-disasters and post-disasters (der Heide, 2006). Previous literature reported various challenges in the after-action reporting process regarding the involvement of healthcare professionals as not everyone has the opportunity to be involved in the after-action review (Ross et al., 2008). Traditionally, the written AAR did not provide

an adequate feedback loop, therefore the alternative process involved the use of hot wash meetings, online submissions, e-mail contributions, and verbal debriefings (Ross et al., 2008).

As early as 1988, the Institute of Medicine (IOM) recognized that the public health system is a complex network of individuals and institutions (Curry, 2005; Savoia et al., 2012). The multiplicity of stakeholders involved in the emergency preparedness management effort can be challenging to coordinate and that significantly impact the type and quality of response efforts (Seid et al., 2007). In addition to the complexity of the public health system, disaster preparedness is challenging due to the uniqueness of events, the frequent changes of the environment, and the lack of standardized processes (Seid et al., 2007). Therefore, it can be challenging for public health services to work together to achieve the goal of keeping people secure and healthy (Savoia et al., 2012). To avoid recurring challenges during emergency response, it was important for health institutions to produce generalized recommendations that can be useful in all types of disasters (Altay & Green III, 2006; Savoia et al., 2012). The improvement effort involved the effective connection between the observations of difficulties and the implementation of corrective actions (Savoia et al., 2012; Seid et al., 2007).

The medical emergency planners should address the response problems identified in descriptive disaster studies in order to assess the impact of preparedness and response measures on morbidity and mortality (der Heide, 2006). Therefore, the Federal Emergency Management Agency's (FEMA) Homeland Security Exercise Evaluation Program (HSEEP) requires organizations to link lessons learned

to the planned implementation of improvement efforts (Savoia et al., 2012). AARs were designed to accommodate both discussion-based and operations-based exercises as reflected in the Homeland Security Presidential Directive 8 (Norige et al., 2012; Singleton et al., 2014). For instance, during the 2009 Influenza (HINI) pandemic response, all recipients of federal funds were required to use the HSEEP AAR template and guidelines to document their emergency response (Singleton et al., 2014).

The HSEEP guidelines recommended that exercises and drills are performed to test the improvements that are identified in AAR in response to the challenges (Savoia et al., 2012). The AARs which are the final written documents of the after action reviews will be used as quality improvement instruments (Singleton et al., 2014). In addition, AARs data is updated to contain the most representative, recent, and most common response difficulties (Savoia et al., 2012). It is important to implement structures and rigorous information reviews of post-event in order to appropriately make system-wide changes (Szoenyi, Venkateswaran, Keating, & MacClune, 2017). For instance, lessons learned from December 2015, terrorist attack in Southern California has considerably shown that there is a distinct difference between a qualified Police Special Weapons and Tactics (SWAT) paramedic and a paramedic responding as part of the rescue task force (RTF)(Bobko et al., 2018). SWAT paramedics are trained to operate in unsafe zones whereas the EMS personnel are not most of the time trained to provide care under a direct threat (Bobko et al., 2018). Confusion of operational objectives during an emergency response can impact the performance of both Emergency Medical Services (EMS) and their law enforcement partners (Bobko et al., 2018). During an emergency response, hospital staff may

encounter challenges regarding altered standards of care (Ferrer et al., 2009). Another example is that, after the 2014-2016 West Africa Ebola response, hospitals in many countries used their AARs to identify gaps in operational interventions in the US(Hurtado, Meyer, Snyder, & Nuzzo, 2018). Some studies suggested the use of Quality Improvement (QI) methods to improve the performance and outcomes of public health systems during emergency preparedness and response (Seid et al., 2007).

QI involves an ongoing multidisciplinary, systems-focused, data-driven method of understanding and improving the efficiency, effectiveness, and reliability of public health practices and processes related to emergency preparedness (Seid et al., 2007; Szoenyi et al., 2017). QI is a pervasive philosophy to ensure that information about past performance should be used to improve the quality of response (Ross et al., 2008). The preparedness process should involve building response capabilities which involve informing, educating, and empowering people while setting goals and measurements to evaluate performance (Seid et al., 2007). Public health organizations should be accountable for implementing the QI methods to identify corrective actions of the AARs (Seid et al., 2007). Since 2005, Root Cause Analysis (RCA) has been an integral component of AARs for more effective analysis of emergency preparedness issues (Singleton et al., 2014).

RCA is a qualitative, retrospective, quality improvement tool used to understand the source of the problem down to the lowest level of the process (Percarpio, Watts, & Weeks, 2008; Singleton et al., 2014; Woodward, 2004). During the after action review, RCA is used to analyze identified issues in order to document successful or

promising practices (Singleton et al., 2014). It can provide an appropriate level of needed insight into disaster response successes and challenges (Norige et al., 2012; Singleton et al., 2014). Identifying deficit-based factors will identify changes to be made to prevent the recurrence of problems that were already highlighted (Singleton et al., 2014). Changes will involve corrective actions that contain sufficient detail to be implemented and must be intended to correct the root cause of the issue (Rooney & Heuvel, 2004; Singleton et al., 2014). The HSEEP guidelines involve continuous improvement system through the effective implementation of corrective actions (Norige et al., 2012; Singleton et al., 2014). The corrective actions should be specific in containing enough useful information to clearly state what steps should be taken to effectively address the issue (Singleton et al., 2014; Szoenyi et al., 2017). By including the reason, purpose, or benefit of implementing the corrective actions, improvement recommendations must clearly indicate measurable key performance indicators to gauge progress toward full implementation (Norige et al., 2012; Percarpio et al., 2008; Rooney & Heuvel, 2004; Singleton et al., 2014; Woodward, 2004). AARs that include RCA, as well as corrective actions associated with quality improvement of capabilities will increase the effectiveness in the emergency preparedness efforts.

The aim of this project is to contribute to the maximization of knowledge management and quality improvement practices in hospitals emergency response efforts. Therefore, we have endeavored to analyze improvement plans in order to identify common challenges from real events disasters and emergency preparedness and response exercises. Our study has attempted to describe how hospitals can

mitigate these issues, by suggesting that recurring response challenges are integrated into the design of future emergency operations planning.

3. Methodology

i. Sample population:

Improvement plans will be collected from a convenience sample of approximately 30-50 hospitals, which are actives members of the Association of Healthcare Emergency Preparedness Professionals (AHEPP). The AHEPP was formed in 2014 to provide healthcare preparedness professionals with the best range of strategic, educational, operational, networking, and planning resources. The requests to participate in the study were sent to hospitals with no regards to their size and specialties. The assumption was made that the sample was a representative of the full scope of threats as requests were randomly sent to hospitals that participated to the AHEPP Annual Conference in 2017. We preferred to address hospitals that were members of the AHEPP as we could experience some reticence from hospitals in sharing their confidential documents.

ii. Data collection methods

We sent a web link to 114 AHEPP's members to request their participation in our study and five hospitals responded favorably. We had a rate of participation of 4.38% of hospitals of size ranging from large to small. AARs were received and de-identified by the AHEPP before sending them to the research team.

Although secondary data were used, our design was based on case study research design by which data will be systematically collected and coded in order to facilitate connection to underlying principles. Based on the request from AHEPP

leadership, hospitals will have a period of two weeks to share their improvement matrix by e-mail. Data received from hospitals will be redacted and will not contain any identifiers. IRB will not be required given this study is preliminary needs assessment as being part of a quality improvement project for AHEPP.

iii. Study data

The study will involve both real-incidents and emergency response exercises reports. The AARs are written in narrative form; thus, the qualitative approach will be used to analyze the content of the improvement plan. Twenty-three reports have been received and all of them will be included in the study.

iv. Data analysis

1. Statistical analysis

An integration of both top down and bottom-up qualitative analysis method were used in our study. Improvement matrix received from hospitals were entered into MAXQDA for analysis. MAXQDA version 12 and produced by VERBI GmbH is a software program designed for computer-assisted qualitative and mixed methods data, text and multimedia analysis in academic, scientific, and business institutions. We aimed to perform a content analysis of IPs included in twenty-three AARs. AARs were categorized based on types of incidents and the six Joint Commission critical areas were used to identify the hospital capabilities that are being tested. IPs' content analysis was performed according to thirty-four critical areas 'elements of performance which were retrieved from the Joint Commission hospital accreditation standards.

Each Improvement Plan is reviewed and coded, and notes were taken in order to categorize the reports into types of incidents. Coded segments were assigned to relevant elements of performance which were sub-coded to the critical areas. MAXQDA will be used to abstract data based on types of event, capability being evaluated, and improvement areas. Descriptive statistics were performed to identify the recurrence of the themes and their frequencies were tabulated from each elements of performance. The first step of our analysis involved the description of differences across types of incidents. Then, we have described variations in capabilities and their corresponding elements of performance.

4. Results

Table 1. The Occurrence of Improvement Areas Per Critical Areas and Types of Incident.

Improvement Areas Occurrences Per Threat Category								
Threat Category	**Resources and Assets**	**Patient clinical and support activities**	**Utilities management**	**Staff**	**Safety and security**	**Communication**	**Total**	**Percentage (%)**
Communication System failure	0	0	0	10	0	8	**18**	**3.8**
Natural disasters	14	12	2	25	18	24	**95**	**19.9**
Child abduction	0	0	0	3	3	6	**12**	**2.5**
Real Event- Road Accident	4	9	0	13	4	4	**34**	**7.1**
Utility Failure	4	2	4	2	5	4	**21**	**4.4**
Facility Evacuation	7	12	2	31	14	24	**90**	**18.8**
Active Shooter	2	0	0	12	14	12	**40**	**8.4**
Hazardous Materials	12	5	2	23	10	13	**65**	**13.6**
Code Bleu: Cardiac or Respiratory arrest	10	2	0	11	1	6	**30**	**6.3**
Code Red: Fire or Smoke	2	3	3	16	20	29	**73**	**15.3**
Total	**55**	**45**	**13**	**146**	**89**	**130**	**478**	
Percentage (%)	**11.5**	**9.4**	**2.7**	**30.5**	**18.6**	**27.2**		

Twenty-three AARs were received from hospitals and all of them were included in our study. AARs included in the study had variable volume of information (at least one statement) that were sufficient for the content analysis of hospital emergency preparedness critical areas. Ten types of incidents were identified based on the exercise overview and the real events mentioned in AARs. Of the twenty-three ARRs, two focused on the response to communication failure, four focused on response to natural disasters, one focused on the response to child abduction, two focused on response to utility failure, three focuses on response to facility evacuation, two focused on response to active shooters, five focused on response to hazardous materials, one focused on response to code blue emergency, two focused on response to code red emergency, and one real event road accident. All ARRs involved improvement plans that focused on at least one of the six Joint Commission accreditation critical areas.

All six critical areas and their element of performance were coded according to the improvement plan of each AAR/IP. The number of occurrences of critical areas is shown in table 1. A total number of 478 occurrences of element of performances were coded from the twenty-three AARs, with staff (30.5%) and communication (27.2%) having the highest element of performance. Utility management (2.7%) had the lowest area of improvement as a result of the exercises or real event reports. The element of performances per threat categories has shown higher occurrences during natural disasters (19.8%) and facility evacuations (18.8%). Lower occurrences were observed during code red (15.2%), hazardous materials (13.5%), active shooter

(8.3%), road accident (7.1%), code blue (6.2%), utility failure (4.3%), communication system failure (3.7%), and child abduction (2.5%) (see details in table 1).

i. Staff

Of the twenty-three AARs describing challenges associated with the capability of staff responsibilities, we were able to extrapolate one-hundred-forty-six different statements. Top three types of incident with improvement areas related to staff involved: facility evacuation (21.2%); natural disasters (17.1%); and hazardous materials (15.7%). The content analysis was done based on elements of performance that were derived from staff capability as shown in table 2.

Table 2: Staff Elements of Performance with some of their corresponding improvement areas

Staff primary and cross-trained roles and responsibilities	How staff are assigned to all essential functions	How the emergency operation plan describes how to identify licensed independent practitioners, staff, and authorized volunteers	How hospital identifies individual (s) to whom staff report in the incident command structure
▪ The Business Continuity Plan (BCP) was not timely received, even though command implemented a deadline; ▪ Staff were unfamiliar with hospital incident command system practices, incident response guides, and job action sheets; ▪ Some staff were not well trained on the utilization of specialized medical equipment.	▪ Confusion on appointing roles and what exactly that role entailed; ▪ There wasn't trained public information officer available is the response team; ▪ There was not enough staff to effectively search for the missing child.	▪ The hospital needed more staff at the entrance throughout the time we were diverting patients; ▪ Needed someone designated as the family care unit leader; ▪ Needed a liaison between the nursing and imaging department.	▪ Staff were not clear on whether to report to the Incident Command Commander or not; ▪ Communications unit leader wasn't sure who to call; ▪ some patient care sections operated independently of the chief of operations.

ii. Communication

Challenges associated with communication have been extrapolated hundred-thirty times and it was across the ten types of incident. Most communication issues were observed during code red emergencies (22.3%), facility evacuations (18.4%), and natural disasters (18.4%). Elements of performance from the communication capabilities were used to extrapolate areas of improvement from AARs as shown in table 3.

Table 3: Communication Elements of Performance with some of their corresponding improvement areas

How an employee will be notified that the emergency response procedures have been initiated.	**How the hospital will communicate with the patient and their families.**	**Demonstrate successful use of internal and external radios sending and receiving transmissions.**	**Backup systems for communications and downtime documentation procedures**
▪ Not all leaders were notified of the event; ▪ Staff were unable to access the hospital emergency preparedness portal for corporate notification of exercise; ▪ Administrators On Call (AOC) were not included in the code pink emergency paging group.	▪ There was no communication when a patient was dropped off in the front lobby; ▪ there was lack of verbal call outs and closed-loop communication, and families and friends were not notified of the new location that the patient was relocated to within the hospital; ▪ The communication plan did not consider external services	▪ Radios were requested for the command center but were not utilized; ▪ Not all information went through the chain of command; ▪ Security and plant operations were not able to communicate with each other because security went on digital radios while plant operations still using analog ones.	▪ Limited landline phones available; ▪ Public Switched Telephone Network (PSTN) devices were kept in cabinets; ▪ Hospital electronic incident command system was having intermittent problems.

iii. Safety and Security

Safety and security capabilities were coded with eighty-nine statements that involved all AARs. Most safety and security issues were extrapolated from code red emergencies (23.4%), natural disasters (20.2%), facility evacuation (15.7%), and active shooter (15.7%). The remaining types of incident mentioned few improvement areas regarding safety and security. For example, communication system failure reported zero improvement area and one segment was extrapolated from code blue emergencies. We extrapolated the statements from the AARs and coded them with different elements of performance as shown in table 4.

Table 4: Safety and Security Elements of Performance with some of their corresponding improvement areas

How hospital will coordinate security activities internally and with community security agencies.	**How to restrict facility access and control movement of an unauthorized person.**	**How the hospital will manage hazardous materials.**	**Demonstrate a chain of custody for personal belonging.**
▪ Security staff were present in the command center, but not utilized sufficiently; ▪ There was not enough security staff to effectively search for the missing child; ▪ Some video surveillance cameras were not working during the power outages.	▪ Security staff did not have proxy badges to access certain areas of the hospital; ▪ Unnecessary personnel and visitors in close proximity to scenes; ▪ Not all employees were wearing their identification badges.	▪ Some hazardous materials spill procedures were found not up to date; ▪ No safety and security staff were present for the drill; ▪ Handling hazardous materials was not performed appropriately	▪ Patient evacuation was delayed due to poor handling of their personal belongings; ▪ Patient care devise batteries were overcharged and heated up during power outage; ▪ Upon initial patient movement, it was unclear as to what entrance was being used by the vans to transport patients.

iv. Resources and Assets

Resources and Assets were coded, and fifty-five statements were extrapolated from AARs. Natural disasters (25.4%), hazardous materials (21.8%), and code blue (18.1%) had the highest coded segments. Improvement areas were extrapolated based on their relation to the elements of performance of the capabilities.

Table 5: Resources and Assets Elements of Performance with some of their corresponding improvement areas

How the hospital will monitor quantities of its resources and assets during an emergency.	How hospitals will obtain and replenish medications.	How the hospital arranges transportation of patient.	How to conserve and share resources with other health care organization
▪ All evacuations regardless of the department generating evacuees had to go through the ICS system as they all compete for the same resources; ▪ Some of the inventory forms came back incomplete; ▪ Patients rooms were not ready to accommodate pediatric treatments.	▪ Some hospital's departments did not have medications and supplies when requested; ▪ Having patients all the way down the hall was a struggle bringing medications and supplies down to the point of operations; ▪ Some department did not have pediatric chest tubes.	▪ There was no plan for full evacuation of hospital; ▪ There were not enough vehicles to evacuate staff as not all them drive to work; ▪ There was no separate location designated to set up Emergency Management Services transport, and patients who were discharged.	▪ Equipment such the suction unit was non-functional; ▪ There was not a specific EOP for dialysis.

v. Patient clinical and support activities

Patient clinical and support activities are one major capability that has been extensively evaluated by hospitals and it we have extrapolated statements from AARs forty-five times. Segments from AARs involved various types of incidents and the highest are as follow: Natural disasters (26.6%), facility evacuations (26.6), and road accident (20%). Exercises for active shooter did not mention improvement areas related to patient clinical and support activities. Elements of performance related to patient clinical and support activities were coded by relevant improvement areas segments as shown in table 6.

Table 6: Patient clinical and support activities Elements of Performance with some of their corresponding improvement areas

How the hospital will manage patient scheduling, triage, assessment, and treatment.	**How patient documentation and tracking capabilities during emergency.**	**How hospital demonstrated horizontal and vertical patient evacuation using equipment, routes, and location of staging areas.**
▪ No plan was made for alternate triage or treatment sites; ▪ there was no plan for alternative blood courier service to provide blood to the point of treatment; ▪ There was a delay in providing food to the patients.	▪ No use of the disaster kits and patient charts; ▪ The tracking forms that were available for the exercise were not used during the event; ▪ There wasn't appropriate internal and external patient tracking system, and there was delay accessing patient chart.	▪ Improvement areas involved the fact that not all evacuation tags were filled out; ▪ The specialty clinic did not appropriately use the wheelchair stair machine to vertically move patients; ▪ Staff who were assisting in the relocation of patients were not made aware of any medical precautions.

vi. Utilities management

The capability for utility management resulted in thirteen coded segments and utility failure (30.7%) had the biggest number of improvement areas. As mentioned in table 7, various elements of performance were coded based on improvement areas from AARs.

Table 7: Utilities management Elements of Performance with some of their corresponding improvement areas

Availability of water, electricity, and HVAC.		
▪ Gas line rupture was not timely addressed; ▪ Fire in kitchen caused by electricity was not timely addressed; ▪ Loss of power and non-functional back-up generator were not properly addressed;	▪ Multiple medication administration machines were usable during the power outage; ▪ The Complete blood count (CBC) machine in the laboratory shut down due to heat; ▪ Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) were unable to be used during power outage due to heat sensitivity;	▪ staff were not sure what to do with the blood and regents during power outage; ▪ Dryer that was on fire did not have high-temperature sensors; ▪ Double doors well closed and that limited the ventilation efforts.

5. Discussion

AARs are knowledge management tools that can be used to identify, describe, and disseminate the insight and experiences gained by individuals and groups during a challenging event (Savoia et al., 2012) The analysis of AARs comprises an opportunity to identify common and/or recurring systems-level challenges. Recurring themes across different types of incidents and across multiple types of systems may present a direct mandate for hospitals to address the areas of improvement. The goal is to

create a requirement to test the areas of improvement in exercises to ensure that the corrective actions were successful. Therefore, improvement areas should be directly addressed by emergency operations planners, and tested through the interactive cycle of planning, testing, measuring and improving, as recommended in the FEMA guidance for the development of AARs/IPs (Savoia et al., 2012). Our study analyzed twenty-three AARs and improvement areas grouped according to the six Joint Commission critical areas of emergency response. Most common improvement areas were related to staff roles and responsibilities, and communication. We were unexpectedly surprised by the fact that staff roles and responsibility was the highest capability that needed improvement. Most literatures have mentioned communication to be challenging during emergency response as multiple responders coordinate their efforts. Therefore, we expected communication capability to involve more improvement areas.

The analysis of results related to staff revealed that most AARs have highlighted difficulties related to confusion in roles and responsibilities among various response personnel, and staff demonstrating a poor depth of knowledge of individual response roles. Ambiguity regarding role and responsibilities, and lack of use of the ICS were due to lack of training among responders. At various points of operation, additional staff was needed. Additional staff could have been mobilized from the labor pool.

In terms of how the hospital communicates with staff, patients, and external systems, the most frequent issues were related to the ability to process and release new information, which was often reported as not timely and not reaching all stakeholders. Therefore, we suggested the need to develop pre-approved messages

to increase the timely release of information. Communication tracking was a challenge during code red, facility evacuations, and natural disasters with cases ranging from the redundancy of information to absolute lack of information. During the response to natural disasters, code red, and power outage, the damages to communication infrastructures such as radio and wireless communications systems may be the cause of major communication difficulties. Communication across different teams within the same hospital was a major issue due to a lack of clarity between routine activities and emergency operations. A recommendation would be to train more people to send out messages during emergency events using appropriate communication methods.

Our study has identified a number of common themes of "lessons learned" that we were able to retrieve from the AARs collected from hospitals. We believe that the common themes identified in our study provide data in support of current emergency preparedness and response initiatives. Our goal of the study is to provide substantial information on potential issues related to emergency response in hospitals. Instead of relying on complex training programs such as the multi-year training and exercise program (MYTEP) recommended by the HSEEP, local and state exercise planners can take advantage of simple summaries of the most common response challenges that have routinely proved to be problematic. Therefore, such data could be used by planners when drafting their MYTEP in order to proactively mitigate challenges during real events or exercises.

As recommended by the HSEEP guidelines, some AARs were designed to include improvement areas to address the problems they encountered. However, many of the

recommendations for improvement were often rather generic and could not be converted into concrete corrective actions. For example, one hospital reported the need to *"create a communication plan"* but was unable to describe the requirements that the plan would entail. Many other hospitals argued that "*the planning section needed to fill additional positions to assist with the amount of information that needed to be evaluated and processed"* leaving ambiguity about which specific additional positions were needed. Many improvement areas were lacking specific examples to clearly illustrate what went wrong. Further, the lack of a consistent structure in AARs creates more challenge in the identification of root causes of problems. Therefore, it would be difficult to identify specific problems in order to aggregate the lessons learned.

We suggest that recommendations for improvement provide more detailed response challenges, and extensively use root cause analysis methodology to better understand the sources of the problems. A hospital should use a consistent and simple structure to identify emergency response challenges to its ability to apply lessons learned. The HSEEP and the Joint Commission should work together to reinforce the use of consistent AARs/IPs template across all hospitals in the US. Further, hospitals should be encouraged to test the emergency response capabilities described by the Joint Commission accreditation standards to facilitate consistent reporting mechanism for all types of incidents. That will avoid confusion regarding the competing, conflicting, and evolving federal capabilities lists. AAR data should be used by regulatory services for accountability purposes and to provide feedback to hospitals. Government may consider providing financial incentives that encourage

meeting certain quality criteria in conducting exercises and producing IPs. Quality criteria could involve the use of standard capabilities frameworks, root cause analysis, concrete examples to illustrate response challenges, and result testing mechanisms to ensure effective implementation.

We believe that the use of consistent structure and including the definition of acronyms in AARs will facilitate the identification of problems that may be common to several hospitals. Therefore, urgent needs can be immediately addressed, and corrective actions can be proactively included in regional training and exercise programs. Emergency preparedness and response planners would have the opportunity to access best practice central repositories to facilitate the identification of common response challenges. Therefore, hospitals will have greater potential for learning from each other, and other healthcare organizations can benefit from IPs that were well produced and submitted to the central repositories.

i. Limitations/Delimitations of the study

Major limitation of the study is the reluctance of hospital to share information due to their fierce competition. A limitation of our study involved the fact that we had incomplete information as only the improvement matrices were requested from hospitals. Understanding the improvement matrices were challenging as they did not contain information regarding the overview of the exercise and the analysis of core capabilities. It was noted during the AARs analysis that there was no consistency on what was included in each critical area section, on how the critical areas were named or defined, or on the improvement areas. Furthermore, it was difficult to understand acronyms that were extensively used in the improvement matrices. Due to staff

turnover and the use of independent practitioners or volunteers, AARs should be written in the most clear way. We delimitated our study not to compare emergency response efforts between hospitals as our focus was more directed towards identifying common improvement areas. Also, we did not focus on the format of AARs as we did not receive full documents from some hospitals.

6. Conclusions

Knowledge management is an important discipline which involves the use of various strategies and practices to identify, define and disseminate insights and experiences gained over time (Savoia et al., 2012). A platform such as the Lessons Learned Information Sharing program and the AHEPP are available resources that could be used by hospitals to improve their emergency preparedness and response operations. Our systematic analysis of AARs enabled us to identify common challenges that have consistently emerged during emergency events or exercises related to different types of disasters from a small sample of U.S. hospitals. These improvement areas involve issues that should be avoided in future emergency responses. Training and educations could focus on common improvement areas in order to achieve best value for the use of their resources. We believe that the outcome of our study could be a basis for a future widespread data-driven support system for identifying key areas of concerns to be mitigated during the emergency response planning process. Further, we believe that future exercises could include these challenges in their objectives as a mechanism for ensuring that emergency response efforts are successful. Future studies could involve larger comparisons of hospitals or the evaluation of the implementation of corrective actions within the same

organization in order to create a collective learning platform from which the entire country can learn from.

Annexes 1

Improvement Areas Occurrences Per Threat Category								
Threat Category	Resources and Assets	Patient clinical and support activities	Utilities management	Staff	Safety and security	Communication	Total	Percentage (%)
Communication System failure	0	0	0	10	0	8	18	3.8
Natural disasters	14	12	2	25	18	24	95	19.9
Child abduction	0	0	0	3	3	6	12	2.5
Real Event- Road Accident	4	9	0	13	4	4	34	7.1
Utility Failure	4	2	4	2	5	4	21	4.4
Facility Evacuation	7	12	2	31	14	24	90	18.8
Active Shooter	2	0	0	12	14	12	40	8.4
Hazardous Materials	12	5	2	23	10	13	65	13.6
Code Bleu: Cardiac or Respiratory arrest	10	2	0	11	1	6	30	6.3
Code Red: Fire or Smoke	2	3	3	16	20	29	73	15.3
Total	55	45	13	146	89	130	478	
Percentage (%)	11.5	9.4	2.7	30.5	18.6	27.2		

Annexes 2

Number of Coded Segment Per Document					
Document group	Document name	Creation date	Number of coded segments	Number of memos	Author
Code Red: Fire or Smoke	Submission 1 Code red: fire or smoke in the hospital	3/25/2019 10:30:47	48	0	AdilyAbdoulaye
Code Bleu: Cardiac or Respiratory arrest	Submission 10 Code blue: cardiac or respiratory arrest	3/25/2019 10:30:48	30	0	AdilyAbdoulaye
Communication System faillure	Submission 13 Fiber Optic Line Cut	3/25/2019 10:30:49	4	0	AdilyAbdoulaye
Hazardous Materials	Submission 15 Hazmat Incident Full Scale Exercise	3/25/2019 10:30:49	17	0	AdilyAbdoulaye
Active Shooter	Submission 16 Active Shooter Full Scale Exercise	3/25/2019 10:30:49	24	0	AdilyAbdoulaye
Real Event- Road Accident	Submission 18 Real Event Bus accident	3/25/2019 10:30:49	34	0	AdilyAbdoulaye
Natural disasters	Submission 19 Tornado/Hazardous Materials Table Top Exercise	3/25/2019 10:30:49	12	0	AdilyAbdoulaye
Child abduction	Submission 20 child abduction	3/25/2019 10:30:49	12	0	AdilyAbdoulaye
Utility Faillure	Submission 22 power outage	3/25/2019 10:31:29	16	0	AdilyAbdoulaye
Facility Evacuation	Submission 23 Evacuation	3/25/2019 10:31:29	4	0	AdilyAbdoulaye
Communication System faillure	Submission 3 IT system Faillure	3/15/2019 13:03:41	14	1	AdilyAbdoulaye
Utility Faillure	Submission 5 Utility Failure resulting in RO treatment system s	3/15/2019 13:03:41	5	0	AdilyAbdoulaye
Active Shooter	Submission 8 Active Shooter	3/25/2019 10:30:47	16	0	AdilyAbdoulaye
Code Red: Fire or Smoke	Submission 11 Code red: fire or smoke in the hospital	3/25/2019 10:30:48	25	0	AdilyAbdoulaye
Hazardous Materials	Submission 12 Medical gas Leak	3/25/2019 10:30:48	4	0	AdilyAbdoulaye
Natural disasters	Submission 14 Simulation Drill	3/25/2019 10:30:49	52	0	AdilyAbdoulaye
Facility Evacuation	Submission 17 Evacuation Full-Scale Exercise	3/25/2019 10:30:49	45	0	AdilyAbdoulaye
Facility Evacuation	Submission 2 Facility Evacuation and Closure Functional Exercis	3/15/2019 13:03:41	41	0	AdilyAbdoulaye
Hazardous Materials	Submission 9 Hazardous Materials exposure	3/25/2019 10:30:48	19	0	AdilyAbdoulaye
Natural disasters	Submission 21 earthquakes	3/25/2019 10:30:49	29	0	AdilyAbdoulaye
Natural disasters	Submission 6 F5 Tornado	3/15/2019 13:03:41	2	0	AdilyAbdoulaye
Hazardous Materials	Submission 7 Air Quality Incident - Hazardous Materials exposur	3/15/2019 13:03:41	6	0	AdilyAbdoulaye
Hazardous Materials	Submission 4 Airborne threat to the healthcare facility	3/15/2019 13:03:41	19	0	AdilyAbdoulaye

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