Translational Safety Impact through Immersive Learning

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AUTHORS:
Gregory H. Botz, MD, FCCM
Professor Anesthesiology and Critical Care
UT MD Anderson Cancer Center, Houston Texas

William Adcox, MBA
Chief Security Officer, UT MD Anderson Cancer Center and UTHealth
Chief of Police, UT Police Department – Houston, Texas

Charles R. Denham, MD
Chairman, Texas Medical Institute of Technology
Austin, Texas

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ABSTRACT

Patient safety has been a significant focus in the American healthcare system since the Institute of Medicine report estimated that as many as 98,000 patients died of preventable medical errors each year in US hospitals. Progress has clearly been made, however, as recent estimates more than double the original projections and new categories of harm are being identified every year. One successful strategy to reduce preventable harm and error is the use of immersive learning techniques, including medical simulation. There are a number of different medical simulation categories that have historically been used including the standardized patient. A novel use of immersive learning techniques involves the use of a standardized clinician to educate, train, and engage patients and families as members of the healthcare team. We provide two examples of the use of deliberate practice through immersive simulation using real life scenarios to reduce preventable harm. This includes a pilot project using a standardized clinician and multimedia resources to better prepare patients and families for the transition from inpatient to outpatient care during the initial treatment phase of leukemia, and a medical tactical certificate training program that uses simulation for education and training of school-age through college students, and adults in the workplace, to address high impact care hazards. These include sudden cardiac arrest, life-threatening anaphylaxis, choking, opioid overdoses, and school and workplace violence.

INTRODUCTION

Much attention has been focused on patient safety in the American healthcare system since the *Institute of Medicine* first published “To Err is Human” in 1999.[1] In that report, it was estimated that somewhere between 44,000 and 98,000 patients die of preventable medical errors each year in US hospitals. In 2013, James proposed that between 210,000 and 440,000 patients annually suffer preventable harm contributing to their deaths in hospitals.[2] Most recently in the *British Medical Journal* in 2016, Makary and Daniel proposed that inpatient medical care is the third leading cause of death in the US; this estimate did not include outpatient medical errors.[3] Academics may debate the exact number of preventable errors in healthcare. Frontline caregivers know, however, that they can do better and that although practice may not make them perfect, deliberate practice through simulation can have an enormous impact not unlike its impact on aviation safety. After the impact of medical error on preventable hospital mortality was described, the authors of the I*nstitute of Medicine* follow-up report, “Crossing the Quality Chasm” in 2001 emphasized that “between the health care we have and the care we could have lies not just a gap, but a chasm.”[4] The daunting task of understanding and redesigning the American healthcare system to reduce errors has often been a slow and frustrating process. The years-long delay from identification of best practices to the reliable and consistent implementation of those best practices in the care of our patients, the “bench to bedside delay”, reflects the tremendous inertia that impedes patient safety work in our healthcare system. It has been estimated that this bench to bedside delay is as much as 17 years.[5]

Given that little systematic information existed about the extent to which standard processes involved in health care--a key element of quality--are delivered in the United States, McGlynn et al undertook a national study to evaluate whether patients truly receive recommended evidence-based care. Their findings at that time showed that we were at best doing so approximately 55% of the time for preventative, acute, and chronic care; results that shocked the healthcare system.[6] There is little evidence to support the claim that we are doing any better since then. In fact the *National Academy of Medicine* (formerly known as the IOM) *Diagnostic Error in Health Care* report released in fall of 2015 revealed an enormous problem in diagnostic failure that is typically not well counted in the medical error deaths described above. [7, 8]

FINDINGS

TRANSLATIONAL SAFETY

Just as the field of translational research has tried to reduce the bench to bedside timeline for integration of empirical research into clinical care, the field of translational safety strives to improve the development and deployment of patient safety practices in our healthcare delivery system. One strategy that is integral to translational safety is the use of immersive learning techniques in our healthcare systems to bring about more rapid change in the behaviors of individuals and teams providing care.

IMMERSIVE LEARNING

Immersive learning relies heavily on the use of medical simulation techniques to enhance the education, training, and assessment of healthcare providers.[9] Immersive learning serves as a bridge between classroom learning and real-life clinical experience. Using simulation technologies in true-to-life medical settings, learners are free to build on their current knowledge base and develop important clinical skills before they work with real patients. "Immersive" conveys the sense that participants have of being immersed in a task or setting as they would if it were the real world. These techniques address many gaps in the current system of training and assessment, providing focused learning experiences that cannot be readily obtained using traditional techniques or in real patient care situations.[10]

HISTORY OF MEDICAL SIMULATION

Although the field of medical simulation is a recent development in medical education and training, simulation has a much longer history in other high-stakes industries like aviation, nuclear power, and aerospace. Rosen previously published an excellent review of the history of simulation in medicine.[11] From simple verbal role-playing, to trained actors portraying standardized patients, to high fidelity human patient simulators, we have seen tremendous advances in the technology of medical simulation. However, it should be clear that medical simulation is a technique, not a technology. It is used "… to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner".[12] Adult learners benefit most from interactive, meaningful, and contextual approaches to both education and training.[13]

As our healthcare delivery system has evolved to a patient-centered focus, medical education and training has evolved to include the patient and family in the interdisciplinary approach to care. New opportunities to include the patient and family as team members have called for new innovations in patient education, and caregiver training in patient-centered care. One example is the development of the standardized clinician in education and training. That is, simulation-based education and training for patients and families. Just as medical education has used standardized patients for many years to teach medical and nursing students how to communicate and evaluate their patients, standardized clinicians can be used to teach patients and families how to participate and communicate with the healthcare team.[14]

TYPES OF MEDICAL SIMULATION

In order to best understand the use of immersive learning as a technique for education and training, one must understand the types of medical simulation available and the domains in which they fit. Gaba described the five categories of medical simulation as: verbal, standardized patients, part-task trainers, computer patient, and electronic patient.[15]

- **Verbal simulation:** is simply role playing.
- **Standardized Patients:** are actors trained to portray aspects of particular diagnoses to educate and evaluate history taking and physical examination skills, communication, and professionalism.
- **Part-task Trainers:** may be simple or complex anatomical models of body parts in a normal or pathological state.
- **Computer Patients:** are screen-based patient representations that can be static or interactive, and targeted at one or more physiologic principle`s.
- **Electronic Patients:** can be either mannequin or

virtual reality-based models that reside within a clinical environment

Early attempts at creating medical simulation tools were mostly limited by the available technology. In the 1960s, Gordon at the University of Miami developed the Harvey cardiology mannequin. This truly revolutionary tool for demonstrating normal and abnormal cardiac physiology was dependent on the available computing power. Most modern cell phones have many thousand times more sophisticated computing power. The Sim 1 anesthesia simulator developed at the University of Southern California in the late 1960s similarly provided exceptional physiologic modeling, but was limited by the available technology.[16] In the late 1980s, more sophisticated human patient simulators were developed at Stanford University[17] and the University of Florida Gainesville.[18] Many of the physiologic models used in these electronic simulators were based on screen-based computer patient simulation models developed in the 1980s at the University of California San Diego.[19] Each of these techniques or devices was targeted at one or more of the domains of medical simulation. These domains include education, training, and assessment.

DOMAINS OF MEDICAL SIMULATION

The education domain focuses on enhancing knowledge acquisition. This is often accomplished by transitioning from passive to active learning. By expanding the students' experience to include multi-sensory, problem- or scenario-based topics, the educational material is presented in a more meaningful context. This is been shown to lead to better integration into knowledge base, and more long-term knowledge retention.[20]

An example of simulation in the educational domain includes the use of multimedia materials like video clips and 3-D animation to present a topic. Much of the cadaver dissection activities in gross anatomy curricula can be accomplished now with a virtual dissection table, augmented by integration of radiology images, anatomical drawings, and supporting educational materials.[21]

The training domain focuses on mastery learning through deliberate practice. The opportunity to learn cognitive and psychomotor skills using simulated task trainers or multimedia content allows the student to gain experience without placing patients at harm. It is the repetitive and deliberate practice of these skills that leads to expert performance.[22] Ericsson et al infer that expert performance is not necessarily innate, it is the result of expert-level practice.[23] Deliberate practice involves the repetitive performance of cognitive or psychomotor skills in a focused domain, coupled with rigorous skills assessment, and specific, informative feedback, which results in increasingly better skills performance.[24] Much like professional athletes or musicians dedicate significant time to master specific elements of their work product, like putting for a golfer or playing a challenging musical passage for a violinist, medical caregivers can deliberately practice aspects of medical procedures to gain mastery using simulation rather than real patients. This not only avoids patient harm, but allows for scheduled, repetitive, and reproducible practice in clinical situations that might only occur very infrequently in real patients during their training.[25] In the popular literature some authors recognize a threshold of at least 10,000 hours of practice to attain expert performance such as Malcolm Gladwell in his best seller *Outliers*.[26]

An example of simulation in the training domain is the use of a part task trainer to practice insertion of a central venous catheter. The participant can deliberately practice the entire procedure, or concentrate on particular intermediate steps in order to gain mastery learning.[27]

The assessment domain is focused on critical evaluation of performance demonstrated using medical simulation techniques. This allows for individuals or teams to demonstrate their performance of simple or complex tasks or teamwork without placing the patient at risk.[28] It also allows for measurement of behavioral or psychomotor changes following remediation.

Simulation can be used in the actual healthcare setting, referred to as in situ simulation, to measure real-time performance of individuals and teams in their actual work environment.[29] This application of systems probing allows for a snapshot, or a more longitudinal evaluation of clinical performance. This is exceptionally helpful in detecting and measuring performance gaps in healthcare delivery.[30]

An example of simulation in the assessment domain is the use of an evaluation tool to measure individual and collective performance in team training. An evaluator can use a standardized tool to assess the technical and nonverbal skills of team members during a team-based exercise.[31]

SIMULATION IN PATIENT-CENTERED CARE

As the American healthcare system has begun a transition from volume-based to value-based care, an increasingly important element in healthcare delivery is the patient experience, and the focus on patient-centered care as a priority. This is evident in the quality measures being implemented to assess quality of care, and is directly tied to reimbursement.[32] There are

opportunities for improvements in the transition from one care environment to another. There are sparse data reflecting the potential patient harms in transitions from inpatient to outpatient care. It is estimated that the magnitude of patient harm in the outpatient environment is several fold higher than the estimated harm to hospital inpatients.[33] Using simulation to understand potential patient harm, and implement best practices, in the transition to the outpatient environment is an emerging focus in patient centered care team.[34] The use of innovative, immersive strategies for patient hospital discharge may result in reduced patient harm in the outpatient environment where the patient and family are responsible for all aspects of their care.

SAMPLE PROGRAMS: DISCHARGE TRANSITION AND MED TAC PROGRAM

High-Impact Care Hazards, Lifeline Behaviors, Competency, and Currency

- **CareUniversity Performance Model:** Founded in 2013 in association with TMIT, a virtual education and training program was developed to address High Impact Care Hazards described below with education and skill building measured by competency testing to equip home family caregivers, patients, and families with what they need to work well with their caregivers.[35] Spawned by studies undertaken by AARP and Pew that verified that more than 90 million Americans are caring for someone with serious active medical problems, the program sought to help develop a bridge between the home family caregivers, the public, and their care providers.[36] It began working with Google, Sesame Street, and others to address needs of families and expanded the work to address leading causes of death with training described below.

- **High-Impact Care Hazards:** The conditions that are the most frequent, severe, and preventable were targeted as high-impact care hazards. Measure dimensions are clinical, operational, and financial that with outcomes, process, structure, and experience measures. Such metrics are addressed at both the caregiver's side of the relationship and at the care recipient side including patients and their families.[37]

- **Lifeline Behaviors:** The behaviors of caregivers and patients that can impact improvement in the metrics described above are defined as "Lifeline Behaviors" which can range from following return instructions after chemotherapy as described below in a discharge study of leukemia patients, or learning CPR and how to use an Automatic External Defibrillator at a sporting event when someone experiences Sudden Cardiac Arrest. None of these behaviors contradict caregiver's instructions and may range from the patient's role in medication reconciliation to making sure they follow instructions for anticoagulation management.

- **Competency Testing:** Aviation innovation has been one of America's greatest exports. According to the National Oceanic and Atmosphere Administration:

  > On any given day, more than 87,000 flights are in the skies in the United States. One third are commercial, one third are private general aviation flights, and the rest are air-taxis and cargo flights. All in all 5,000 planes are in the sky at any given moment. The safety of our system is fully dependent on the competency of the pilots who fly those planes.[38]

  Not only are such pilots tested for what they need to know, but what they need to do in a range of scenarios – simulation using deliberate practice techniques is a cornerstone of such competency testing. Clearly, as Captain Sully Sullenberger describes, he could not have accomplished the heroic feat of landing on the Hudson river in 208 seconds with total power failure as he and 155 souls fell from the sky over one of the most populated areas of the planet if his competency had not been tested and verified through simulation and repetitive deliberate practice.[39] The aviation model has much to teach us. It incorporates knowledge transfer and skill-building, however its goal is verified learner competency through simulation of real life scenarios. True competency testing verifies that the learners have the ability to reliably behave in the right way, at the right place, and at the right time…every time.

- **Currency of Competency:** Finally, not only will a learner have to be competent in lifeline behaviors, but they will have to regularly update their knowledge and have their skills or lifeline behaviors re-verified on a regular basis to be sure they are competent. Learners will be awarded certificates of completion and competency; however they will have to be re-tested to keep the certificate current. Just like Sully Sullenberger or any general aviation pilot who earns a Instrument Flight Rating (IFR), they may hold the rating for life, but not be "current" unless competency has been verified. In the aviation environment, you may not operate an aircraft in IFR conditions (weather that will

not allow you to fly according to visual flight rules) unless you are “current”. If you are not current, you are “not legal”.[40] The currency of competency is the lynchpin of aviation safety as it relate to pilot error.

We believe deliberate practice through immersive simulation of real life scenarios will enhance our ability to enhance and maintain the competencies of both caregivers and patients including their families.

LEUKEMIA PATIENT DISCHARGE STUDY

An example of a study of immersive simulation techniques to evaluate specific modes of education is provided below. The envisioned pilot study will be undertaken using standardized caregivers to teach lifeline behaviors which can prevent life threatening conditions in leukemia patients after their first course of chemotherapy. Leukemia Patients with a new diagnosis undergoing first inpatient chemotherapy discharged to the outpatient setting will be studied for 90-120-180 days post discharge.

- **High-Impact Care Hazards and Readmissions of Leukemia Patients**. Most of the leading causes of preventable adverse events post discharge in leukemia patients after their first course of inpatient chemotherapy can be reduced when patients and families act quickly when patients first show signs of deterioration. A review of all-cause readmission identified that cancer patients had higher-than-average readmission rates. Early recognition of fever that can lead to sepsis, bleeding, GI problems, dehydration and malnutrition, and pressure ulcers can reduce such admissions.[41] A review the chief reasons for Emergency Department visits and hospital use by patients newly diagnosed with acute leukemia patients after induction chemotherapy and up to one year after discharge is revealing. A longitudinal study of all visits to the ED or unplanned hospital admissions at a single institution for patients with acute leukemia found 81% of patients had an unplanned visit to the ED or hospital within the first year and top reasons for visits were neutropenic fever/ infection, bleeding and gastrointestinal problems.[42]
- **Lifeline Behaviors–Action Triggers:** The knowledge, skills, and verifiable competencies of patients and families that can reduce ED admissions, hospital re-admissions, and deterioration leading to expensive care, and even death revolves around early recognition of problems or triggers that prompt actions to seek caregiver advice or care. Early recognition of signs and symptoms is not enough. Action is required.

Having the confidence to act on information when patients and home family caregivers are in the “fog of war” and in stressful situations is critical. The term “fog of war”, attributed to Carl von Clausewitz, is described as the uncertainty in situational awareness experienced by participants in military operations. The term seeks to capture the uncertainty regarding one’s own capability, adversary capability, and adversary intent during an engagement, operation, or campaign.[43] The most experienced caregivers are often surprised by the degradation of their performance when their own family is threatened by the conditions they treat competently every day. The aviation industry and military experts have proven that the best intervention to cut through the fog of war and fatigue is prior training using immersive simulation and deliberate practice of behaviors for likely scenarios. Archilochus, the Greek lyric poet has often been quoted by champions of training with variations of the following quote: “We don’t rise to the level of our expectations, we fall to the level of our training.” If patients and families have clear indications or “action triggers” they can recognize to help them act quickly to return to hospital or contact their caregivers, enormous suffering and cost can be avoided. Rapid Response teams have proven their value in the in-patient environment. We now need to consider the concept of a Family Rapid Response Team, teams of family members who trained to act when they recognize certain triggers.[44]

A Three Arms Study: Control vs High Tech Only vs High Tech-High Touch

Patients will be randomized to three groups and followed post discharge to measure the impact of certain interventions compared to the typical discharge process.

- **Care Transition Control Group:** The control group receives the typical standard of care discharge process across the transition from inpatient to outpatient settings. The typical discharge process with clinical nursing staff, case management staff, and social workers will collaborate in concert to facilitate the transition to the outpatient setting. The nursing staff addresses medical issues, indwelling central venous access management, side effect management, and co-morbid conditions that need to be addressed. Return Precautions will be provided to patients and families in the typical discharge process for first time leukemia patients. They will be made aware of the personal web- portal that gives them access

to their medical records.

- **High Tech Only Group:** In addition to the identical standard discharge process above, a clinician will provide a standardized briefing and demonstration of how to access to their personal healthcare records. They will be briefed and provided access to CareUniversity Training Modules and tools they can use to address typical complications for leukemia patients–the high-impact care hazards described above. They, and in the case of pediatric patients, their parents will be provided a standardized access briefing, but NOT deliberate practice the use of the technologies. The CareUniversity media training modules are videos and tools that will be easily accessible by smartphone or computer delivered over the internet. One such tool is a modified version of the SBAR tool commonly used by caregivers for structured communication whereby caregivers communicate using a framework of "Situation, Background, Assessment, and Recommendation". A modified version for patients has been created for patients and families to communicate with their caregivers whereby the "Recommendation" element has been replaced with "Request" so that they may make a request of action on their condition.[45] An addition of another "R" will be added this second version of SBAR standing for "Reconciliation" that will guide patients to provide a reconciled list of their medications and their latest laboratory and test results.

- **High Tech – High Touch Group:** This third patient group will receive the identical briefings and information as the Control Group and High Tech Only Group. The added "High Touch" component will use a scripted "standardized clinician model" to lead the patient and family through a set of deliberate immersive practice exercises for each of the high impact care hazards whereby the learners will recognize Action Triggers that should prompt them to act early on potential adverse events. Learners will practice using the tools and information provided to re-engage with care providers, seek help in Emergency Departments, and prevent delays when patients are deteriorating.

It is anticipated that the pilot program will be undertaken as a multi-site Texas Medical Center study with adults aged 18 to 50 years of age at one site and a collaborative program with pediatric oncologists caring for children and adolescents younger than 18 years of age. The content for the three arms of the study will be uniquely suited to the age groups with both control groups receiving the same discharge support as they do today. The precautions and education for the families of pediatric leukemia patients are very similar to those for adults and standardized content is typically provided to families such as the *Children's Oncology Group Family Handbook*.[46]

MED TAC COURSE USING SIMULATION

Meeting a Critical Unmet Need: A recent review of the harm caused by active shooter events in hospitals and schools that included interviews of investigators who have analyzed both the celebrated events and many that have not been extensively covered revealed a surprising list of preventable health hazards and conditions that may lead to loss of life. Further, most were not being addressed by an integrated program tackling them together. Despite their frequency, severity, preventability and measurability, most of them are not being tracked by federal or state agencies.[47] A proposed program using the above model of knowledge transfer, skill building, competency testing, and competency currency called the Med Tac Certificate Program is being developed to impact this critical unmet need. Targeting 10 year olds and above, and complimenting existing first aid programs, it will use immersive simulation and deliberate practice to train non-clinical and clinical individuals to help save lives.

High Impact Health Hazards - K through College and Adult Workforce: The following conditions represent an enormous opportunity for impact on students from Kindergarten through college, and surprisingly very important conditions for which the US workforce is at risk.[48]

- **Sudden Cardiac Arrest (SCA):** It is well known and publicized by the CDC that cardiac disease is a leading cause of death in our aging public.[49] Vital organizations such as the American Heart Association have developed excellent programs to address the 350,000 out-of-hospital cardiac arrests that occur in the United States. According to the AHA, almost 90 percent of people who suffer out-of-hospital cardiac arrests die and CPR, especially if performed in the first few minutes of cardiac arrest, can double or triple a person's chance of survival.[50] What is not well-known, is that sudden cardiac arrest is a leading cause of death of children and young adults in the United States. One quarter of SCA cases in children occur while at a sporting event. In fact one child dies of SCA every three days in America in organized sports.[51] Among young athletes, only one in 10 who suffer SCA survives.[52] The American Heart Association CPR training course is excellent and will be a component of the Med Tac program[53]. So successful is such a program that the State

of Texas now requires that CPR training be completed by every high school graduate.[54] Given, the average response time for first responders is reported to be 8-12 minutes and the survival of SCA patients drops 10% for every minute without adequate perfusion, action by the public is absolutely critical. According to the American Red Cross, the use of the Automatic External Defibrillator can save up to 50,000 lives per year in our country.[55] The opportunity for non-clinical staff at healthcare institutions, schools K through Graduate School, and major employers to address SCA with practical training and interventions is enormous.

- **Choking:** The fourth leading cause of unintentional death in America of all ages is choking according to the National Safety Council.[56] Many victims are of older age; however one child per day dies of choking.[57] It is estimated that the Heimlich Maneuver has saved at least 50,000 lives.[58] Children, youth, adults, and even the elderly can be taught what to do when someone is choking, including calling for help and initiating the Heimlich Maneuver. Even Dr. Heimlich, the originator of the Heimlich maneuver now in his 90's, had the first opportunity to save a choking victim with his namesake maneuver at an assisted living facility where he lives in 2016.[59]
- **Opioid Overdose:** According to the American Society of Addiction Medicine, drug overdose is the leading cause of accidental death in the US, with 47,055 lethal drug overdoses in 2014.[60] Opioid addiction is driving this epidemic with the dramatic growth of prescription opioids since 1999.[60,61] The problem is exploding in adolescents (12-17) with an estimate of 467,000 adolescents current nonmedical users of pain relievers, with 168,000 having an addiction to prescription pain relievers. So threatening is the problem in universities, that students such as those at the University of Texas at Austin are demanding availability of Narcan (Nalaxone), a medical opiate antidote, on college campuses.[62] In June of 2015, the National Association of School Nurses Board of Directors adopted a position statement supporting the emergency use of naloxone in a school setting.[63] Programs are being established to teach children in grade school regarding the recognition and treatment of opioid overdose with EpiPen®-like auto-injector devices and nasal delivery systems.[64] The students, teachers, parents, and frontline workers in our nation will very likely be the first responders to someone experiencing an opioid overdose. Knowledge and practice regarding quick response will be lifesaving.
- **Anaphylaxis:** Life threatening allergic reactions to foods, medications, and insect bites represent serious risk to our population. Overall, 2% of our population are at risk and 4-5% of children are at risk for anaphylaxis. At least one in 25 students in our schools are at risk for such life threatening allergic reactions.[65] As for adults, one in twenty adults will experience anaphylaxis in their lifetime.[66] Anaphylaxis is a medical emergency with multi-systemic manifestations due to the rapid release of inflammatory mediators that requires immediate recognition and intervention. Quick action and the early use of epinephrine is the most important step in managing anaphylaxis. Everyone can be trained to ask the right questions, call emergency responders, and administer epinephrine using an EpiPen® device.[67]
- **Active Shooter Events:** Every week there is a school or college active shooter event. The growth in number, sophistication, and casualty pattern evolution are dramatic and demand our attention.[68] Further, the number of Healthcare Active Shooter events in hospitals, and ambulatory and outpatient settings are growing and continuously evolving in character as well.[69] Hospital staff face the unique challenge of practicing Run-Hide-Fight principles for active shooter events promoted by the US Department of Homeland Security because they are dedicated to their patients and will not likely abandon them.[70]

Most hospitals employ a defend-in place strategy since many patients are not mobile or such movement could lead to possible death. With modern building codes and advances in fire protection this strategy works well for fires. The best expectation in a hospital setting is horizontal movement to a more secure or protected place, if practical.

There is an increased severity of injuries with all active shooter events compared to conventional casualty incidents.[71] The wounding pattern is different from those seen in military conflicts with very few cases of life-threatening extremity hemorrhage; therefore, extrication and transfer to definitive care needs to be a priority in addition to any in-place care provided.[72] Penetrating wounds and blast injuries can kill rapidly, therefore quick assessment and hemorrhage control with rapid evacuation are critical. Skills in the use of tourniquets and compression bandages, like the

Israeli Emergency Bandage can be easily taught to adolescents and non-clinically trained adults. According to the 2016 *National Academy of Science* report: "recent consensus statements encourage law enforcement to secure "corridors" of rapid access to victims, with minimal hemorrhage and airway interventions provided—consistent with military combat casualty care techniques—prior to rapid evacuation to ambulances in a more secure area for transport." [73, 74, 75]

There are almost always signs and indicators in place prior to an active shooter event, often referred to as "leakage".[76] Active shooter events are often over in 10-15 minutes[77] and according to the FBI 2014 report in 2014, *A Study of Active Shooter Incidents* in the United States Between 2000 and 2013, for those incidents where the duration of could be ascertained 69% ended in 5 minutes or less.[78] It is well known by law enforcement leaders that a full SWAT team response would take much longer, perhaps an hour or more. Training of the public, leaders at schools and universities, and healthcare leaders regarding rapid response mass casualty scenarios and timely safest evacuation will be valuable. The annual turnover of students at schools and universities demands continuous training.

By integrating instruction and skill building from law enforcement experts, tactical medical experts, government leaders of homeland security and integrating input from educators and caregivers at frontline institutions, the Med Tac Program in various forms will train non-clinical and clinical personnel, from age 10 to adulthood, in the development of lifeline behaviors. Younger learners will be less exposed to content that may cause fear. The Run-Hide-Fight program disseminated by the Department of Homeland Security and recommendations for active shooter – violent intruder events cited above will likely continue to evolve and deliberate practice will help learners act properly in the fog of war.

- **Onsite Transportation Events:** Non-traffic related transportation [79]accidents claim an enormous number of lives and cause significant suffering. More than 50 children are victims of back over events weekly, and an average of 36 kids are killed annually in front over accidents at schools and close to home.[80 , 81] As many as 44% of the back-over deaths are children under 5 years old.[82] 70% of these accidents have a parent or relative behind the wheel. An estimated 525 people were killed while riding in school transportation or as pedestrians struck by school transportation, or by other vehicles on school property between 1998 and 2012.[83] Another safety area commanding much press attention are deaths of children left unattended in hot cars each year due to heat stroke which are entirely preventable with awareness building and education.[84] It is clear that there are significant opportunities for the 4 A's of Innovation: awareness building, accountability for new behaviors, the development of new abilities or competencies, and new actions that can be taken and taught. Deliberate practice through immersive simulation will save lives.

- **Non-transportation Related Events:** Accidents and events unrelated to motor vehicle accidents and onsite transportation accidents are more common than previously thought and are preventable. Every hour a child is seen in the ED for a TV Tip-over Accident.[85] Cusimano et al in the article Toppled television sets and head injuries in the pediatric population: a framework for prevention revealed the vast majority (84%) of toppled television injuries occurred in homes and more than three-fourths were unwitnessed by adult caregivers. In an earlier study he found "Kids are left unsupervised around a big television that is not properly secured". The numbers of accidents paralleled TV sales.[86] Other gravity-related accidents include those related to ropes and cords being unintentionally used by children at play. More than 24,000 children are injured annually from shopping cart-related incidents requiring treatment in the Emergency Department.[87]

- **Bullying:** The impact of bullying is now starting to demand fierce attention in schools and even healthcare. The 2016 *National Academy of Sciences* report entitled "Preventing Bullying Through Science, Policy, and Practice" sheds new light on the subject. The correlation of bullying with suicide, active shooter events, and other harmful outcomes are being studied, however it is clear bullying harms everyone involved and that the public can be trained to recognize it and help reduce it. Perceived or real abuse of power ignites human response.[88] A *US Government Accounting Office* report in March of 2016 entitled "Workplace Safety And Health: Additional Efforts Needed to Help Protect Health Care Workers from Workplace Violence" addressed the enormous frequency and severity of workplace violence within healthcare organizations and abuse of healthcare staff by patients and the public.[89] The *Joint Commission*'s 2016 report

entitled “Bullying Has No Place in Healthcare” has now put more positive energy in the arena and has recognized the enormous problem developing in healthcare organizations.[90] Workplace bullying is frequently trivialized; however recognition by the Joint Commission has brought it into the mainstream. Learners of all ages benefit from learning how bullying can be an “on-ramp” for violence. Typical scenarios are easily portrayed by video vignettes.

- **Safety Huddle at Athletic Event Example:** Recognizing the high risk of delayed response to SCA, choking, opioid overdose, and even active shooter events; it becomes clear that a pre-event safety huddle with key stakeholders could have enormous impact. A “safety huddle” with assignments of who calls 911 with exact address coordinates, meets Emergency Medical Services responders, meets law enforcement, locates and brings AEDs to the event, and who performs CPR can save the precious minutes that could directly influence survival. For those who have active shooter training, knowing the evacuation corridors can be of enormous value.[91] The safety huddles should be added to the normal event emergency planning process to insure they take place before an event with assignment of accountability to the level of specificity described above.

- **Schools, Employers, Healthcare Simulation Training:** By integrating the above high impact health hazards into one program, learners are able to develop situational awareness, common skills and the mental muscle memory so critical to acting quickly in an emergency when the fog of war and stress are so very high. Non-clinical staff in healthcare can play a great role at rapid response when they are serving the public. The Med Tac program is designed to be adopted by healthcare organizations, schools, employers, scouting organizations, faith-based membership organizations, and community groups so that the content is free and certificate management is nominal. It will be initially piloted at Texas Medical Center, sites in California, and virtually over the internet.

CONCLUSION

Although tremendous attention has been paid to medical error and harm, and new areas are being identified every year. It will take truly innovative approaches to impact preventable harm and to succeed we will have to make patients and families part of the healthcare team by developing in them verifiable competencies to address high impact care hazards. We believe deliberate practice through immersive simulation of real life scenarios will enhance our ability to develop and maintain the competencies of both caregivers and patients including their families. We must evaluate and optimize such techniques using continuous improvement methods. We believe scenarios where patients transition from inpatient to outpatient care for complex illnesses and high impact health hazard scenarios in our schools, universities and workplaces are two excellent test environments. By standing on the shoulders of great work of those in the field of simulation in healthcare and other industries such as aviation and nuclear power, we can translate safer care through immersive learning. To those who have been given much, much is expected.

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