Chapter

Patient Safety in Emergency Medical Services

Bryan R. Wilson and Ashley Woodrow

Abstract

Patients deserve high-quality, evidence-based care delivered from the moment they call for help to the moment they are safely delivered to the hospital. Often patient safety is not viewed as a fun or exciting topic by prehospital clinicians, but it need not be a burden. A culture of safety in emergency medical services can enhance patient outcomes and improve the overall safety in a community. The design and structure of the ambulance are the first layer of protection for patients. Couple that with ambulance operations topics, such as speed and light and siren use and that covers a large swath of the patient safety engineered into the system. There are patient-focused topics such as medication safety protocols, structured handoffs, and competency assessments of high-risk procedures that all serve to increase patient safety. Lastly, an emergency medical services clinician-oriented topic that also heavily impacts our patients is fatigue mitigation. Actively addressing fatigue and employing fatigue mitigation strategies can be used to enhance the safety of patients and will likely enhance the experience of prehospital clinicians in the organization.

Keywords: emergency medical services, EMS, patient safety, medication safety, lights and sirens, EMS vehicle operations, paramedics, fatigue, transfer of care, SBAR, DMIST

1. Introduction

In the landmark document, "EMS Agenda 2050" leaders are challenged to create a people-centered emergency medical services (EMS) system that "serves as the front line of a region's healthcare system and plays a core role in supporting the well-being of community residents and visitors through data-driven, evidence-based, and safe approaches to prevention, response, and clinical care" [1]. While not a new topic in healthcare, the inclusion of safety in this statement represents the first time that the topic is introduced into a federal government publication on emergency medical services, marking the progress and importance of patient safety initiatives. The challenge is many of the interventions that increase safety can be difficult to implement for a number of reasons: cost, resistance to culture change, and a lack of knowledge of the risks involved, just to name a few. So how do we create a system that focuses on the patient first, but also is not wasteful? Can we create a system that takes into consideration the clinician and the patient together? Thankfully, there have been years of research into this question and many national stakeholders have provided resources to help inform our decision-making in this area. Patient safety endeavors not only keep

the patient safe but avoiding harm and errors can serve to enhance the well-being of the EMS system workforce, it is a topic that is widely discussed given developing shortages in staffing [2]. The burden that medical errors place on the healthcare system and the economy at large has come into clearer focus since the Institute of Medicine's landmark white paper "To Err is Human." Estimated to cost between $17 and $29 billion in 2000, "preventable adverse events" are a huge burden on the healthcare system, but errors are not the only aspect of the EMS system that focuses on patient safety [3]. As a system of care, there are many aspects of emergency medical services to explore that have an impact on patient safety.

2. Methods

Research pertinent to this manuscript was performed using a comprehensive literature search strategy. Internet-based search platforms used during the preparation of this manuscript included Google™ Scholar, PubMed, and Bioline International. Specific search terms included, but were not limited to, "patient safety," "emergency medical services," "EMS," "medication safety," "medication cross-check," "ambulance safety," "transfer of care," "SBAR," and "stretch operations," out of a total of 5,938,485 initial search results, we narrowed down our reference list to approximately 340 results highly specific to our intended area of focus. Further screened and excluded were sources that did not specifically address the concepts of patient safety in the prehospital environment. After the above screening was completed, our literature sources were narrowed down to the list of 48 citations included herein.

3. Ambulance configuration

One of the first aspects of safety to consider is the design of the ambulance. These vehicles serve their communities by responding to emergency calls and transporting patients to the hospital, so ensuring they operate appropriately and safely is vital to the nation's EMS systems. Whether it is how they are visible to other drivers, how their lights and sirens are configured for emergency responses, how necessary equipment is stored, or how the patient is secured inside the vehicle, there are standards that exist to describe how to safely design an ambulance. These standards are described in detail in this chapter.

While ambulance design and configuration can be viewed as an occupational safety initiative intending to keep our EMS clinicians safe, it also serves as a patient safety consideration as well since these vehicles deliver life-saving care and transport our patients [4, 5]. The absence of an ambulance at a scene or an unnecessary delay can result in worse outcomes for some time-sensitive conditions that the patient is experiencing. Likewise, the patient can be seriously injured inside the ambulance in the event of a crash or stretcher loading mishap. For this reason, aspects of ambulance configuration will be discussed to emphasize their importance for patient safety.

There are 3 main recognized ambulance configuration standards: (1) Federal Specification for Star-of-Life Ambulances (KKK-A-1822(F)) published by the United States General Services Administration; (2) National Fire Protection Agency (NFPA) 1917: Standard for Automotive Ambulances; and (3) Commission on Accreditation of Ambulances Services (CAAS) Ground Vehicle Standards (GVS). These are generally referred to as K-Specs, NFPA 1917, and GVS, respectfully, and this nomenclature

will be used in this document. It is important to note the K-specs undergo annual updates posted as separate notices and not attached to the published standard document, whereas the other documents are updated occasionally, and the full published document is updated. This fact makes interpretation and understanding K-spec more difficult than other standards due to the need to review and cross-reference different documents.

While these three organizations publish separate but similar standards, it is rarely up to the individual agency to decide which standard to follow. Since EMS is regulated at the state level, each state decides which standards ambulances must follow. The National Association of State EMS Officials (NASEMSO) developed a project called SafeAmbulances.org through a grant from the National Institute of Standards and Technology (NIST) in 2015 that outlined how different states handle these regulations and provided a background of how each of the backgrounds developed. **Table 1** below shows a breakdown of how many states require each standard in the regulations [6]. It should be noted that CAAS and NFPA have fees associated with their organization and as such, no states require only one of these organization's standards, typically allowing a choice to utilize them if an organization wishes to. GSA K-specs are by far the most popular with over half of the states requiring at least this standard. Lastly, for those states that utilize their own state-specific standards, many employ at least some of the K-spec standards as the foundation [6].

Perhaps the largest change in ambulance safety configuration occurred in 2015 when the GSA adopted a new standard published by the Society of Automobile Engineers (SAE). This new standard, SAE J3027, changed the allowed amount of movement for a stretcher in the event of a frontal impact. Through years of analyzing crash data involving EMS units and creating their own simulated crashes, this organization took steps to make sure that all patients are protected in the event of an ambulance crash [7]. As a result of this change, the old stretcher mounting system was no longer compliant with K-spec standards since the SAE specification is noted in the K-spec standard. At the same time, SAE's new standard also recommended changes to the restraint system on the stretcher itself, which is a huge advancement for the safety of patients as these standards actually considered the varying sizes of the US patient population to ensure ergonomically efficient standards [8]. The pairing of these two changes together ensures that patients, when properly restrained, minimize their risk of injury from dislodgement of the stretcher or breaking free from the restraints.

Nosocomial infections represent a significant burden to the healthcare system, as they are associated with increased mortality, length of stay, and costs [9]. One systematic review identified a high prevalence of organisms, commonly associated with these nosocomial infections [10]. Because of this impact, an important aspect of the design of ambulances is infection prevention. Specifically, all 3 standard-setting organizations have requirements for materials that can and cannot be used inside the vehicle. To prevent cross-contamination between patients, the inside of the ambulances may not contain "absorbent material such as carpeting, fabric, or indoor/outdoor plastic-type

No standard	State specific	GSA K-spec	CAAS GVS	NFPA 1917	Multiple*
4	17	14	0	0	16

**Any combination of GSA, CAAS, and/or NFPA standards totals to 51 as the District of Columbia is included.*

Table 1.
Ambulance safety standards breakdown.

carpeting, that resists cleaning and decontamination" [11]. From the design of the structure to the materials used inside the ambulance, all these complex standards contribute to keeping Americans safe while receiving care inside ambulances.

4. Ambulance operations

The creation of a safe ambulance only goes so far in ensuring the safety of patients. A large onus belongs to the prehospital clinicians caring for the patient. The manner in which a vehicle is operated is paramount to ensure safety features function as designed. Speed, the use of lights and siren warning devices, and positioning of the vehicle at scenes are all things to consider.

4.1 Traffic laws

Many people falsely believe that just because an ambulance has lights and sirens they can ignore traffic laws related to speed, intersection control devices, and passing. That is not the case, however, and emergency vehicle operators should be familiar with their jurisdiction's laws. In New Jersey, for example, there is a statutory requirement that an emergency vehicle must be operated in a manner showing "due regard for the safety of all persons," but ambulances are missing from the "exemption from speed regulations" provision of NJ Code Title 39 [12]. In Pennsylvania, however, ambulances are specifically noted in their motor vehicle code. Per their state law, ambulances are prevented from exceeding speed limits or proceeding through traffic control devices or stop signs until they have come to a full stop and ascertained that they have been given the right of way [13]. All EMS clinicians should review their local rules and regulations to make sure they understand how they are allowed to operate in their jurisdiction. It should be noted, though, that just because an ambulance can operate in a certain manner does not mean that it should. There has been much discussion about improved patient outcomes when prehospital clinicians drive calmly, deliberately, and without speeding as this allows treatments to continue and for minimizing hemodynamic changes that can occur with excessive endogenous epinephrine release [14].

4.2 Emergency warning devices

One of the most serious risks in providing prehospital care is surprisingly not related to medical treatment, but rather how the patient is transported from the scene to the hospital. Though the use of lights and sirens (L&S) decreases response and transport times for just a couple of minutes on average, it increases the risk of ambulance crashes during response by 50% and threefold during patient transport [15]. Despite these statistics, a vast majority of responses and nearly a quarter of patient transports occur using L&S [14]. Not only does this pose a direct threat to the EMS clinicians and patients on board but also can cause delays in patient care, injure the public, ruin expensive essential equipment, and tie up resources that could otherwise be used elsewhere. In a joint position statement released by NAEMSP and various other organizations in 2022, it is advised that "L&S should only be used for situations where the time saved by L&S operations is anticipated to be clinically important to a patient's outcome" [9]. However, there are different factors that must be taken into consideration when discussing which circumstances require L&S in response to a call versus transport to a hospital.

Determination of response priority should be determined by standardized emergency medical dispatch protocols [16]. When writing and implementing these protocols, L&S should be reserved for medical conditions in which a few-minute delay in medical care would be detrimental to the patient's health. Such conditions include significant airway compromise, respiratory and cardiac arrest, loss of consciousness, advanced stages of shock, obstetrical emergencies, and severe trauma. Recent studies have shown these situations to be exceedingly rare [17]. Special exceptions to this standard may be made in situations where significantly delayed response is anticipated due to distance or traffic and the patient has a real potential to decompensate into one of the above categories due to the extended response. In addition to EMD protocols that reflect cautious use of L&S, it is also imperative that dispatchers are properly certified and receive continuing education, which enforces the necessity of keeping priority responses at a safe minimum [14].

Though L&S responses to scenes can be standardized, the utilization of L&S when transporting to the hospital is much less scriptable and statistically more dangerous [14]. When deciding whether or not to utilize L&S, an EMS clinician must quickly evaluate whether or not shortening the transport time by an average of three or four minutes would actually be beneficial [14]. In some cases, such as STEMIs, strokes, and trauma, early notification of the hospital of the impending arrival of the alert allows for advanced preparation leading to improvement in patient outcomes [18]. This time saving may allow for a non-L&S transport, during which the prehospital clinician maximizes medical treatment and stabilization of the condition without the increased risk of being involved in a motor vehicle accident. However, in situations where the patient is rapidly deteriorating or has significant airway compromise, the use of L&S during transport may be warranted. If the use of L&S is unavoidable, there are ways to optimize safety throughout transport.

1. Identifying potential hazards prior to the event: Risk analyses should be performed by EMS agencies to identify potentially hazardous intersections and roadways that increase the risk during an L&S response. EMS clinicians should be made aware of said dangers and avoid them during the L&S transport when possible.

2. Ensure a sterile cockpit: Though not proven, it is thought that the majority of increased risk in an L&S transport is due to driver distraction. Without a second person up front to answer radio communications, manage the control board, and potentially identify road hazards, these duties become additional duties and potential distractions for the emergency vehicle operator. The driver of the emergency vehicle should minimize these distractions and should be familiar with the locations and proper use of all signals, controls, and radios prior to utilizing a vehicle.

3. Emergency vehicle operator training: All emergency vehicle operators should receive rigorous training and continuing education on proper use of an emergency vehicle and should be well versed on the laws and policies pertaining to emergency vehicle operation specific to their state.

4. Agency-wide QA review of L&S use: Agencies should routinely review all transports that require the utilization of L&S and give constructive feedback to their employees on the appropriateness of such.

While this list is not exhaustive, these are some steps that can improve the safety of using lights and sirens. No one step can totally remove the risk involved in L&S use,

so agencies are encouraged to take a comprehensive quality improvement approach when it comes to decreasing the use of L&S during transport and response. Each agency needs to weigh the risks and benefits of L&S use and nonuse with other aspects of their system's operation and performance and decide how to proceed. The data are clear though, agencies provide safer care when there is a focus on decreasing the use of L&S, as such every agency should cut their use in some part of their operation [16].

5. Stretcher operations

Though rare, patient injuries from stretcher-related incidents do occur and can pose a significant risk to both the patient and the EMS clinician. In a retrospective study reviewing the 671 reported stretcher-related incidents occurring from 1996–2005, 52 patients were injured, resulting in injuries from lacerations and fractures to traumatic brain injury and death [19]. Not surprisingly, injuries to personnel occurred at a higher rate than to patients, with most of those injuries occurring as sprains/strains. This may seem like an insignificant number of injuries given the 10-year span of data; however, this data is only from incidents reported to the FDA and is likely an underrepresentation of risk. Injuries occurred due to numerous reasons and can be classified into four broad categories: equipment malfunction, operator error, surface conditions, and patient-related [20].

5.1 Equipment malfunction

With the repetitive use of stretchers on patients of varying sizes and over a variety of terrains, it is natural for these to have significant wear and tear over time. Though the breakdown is inevitable, prehospital clinicians should routinely check stretchers to ensure all parts are present and working properly. Any equipment not passing inspection should be immediately taken from the ambulance so that it can be repaired by a qualified professional. It may be inconvenient to take a vehicle out of service over a small missing part or break, but this could potentially lead to a devastating injury from a stretcher failure.

5.2 Operator error

As with all aspects of the job, knowing how to fully operate a piece of equipment safely is imperative, and a stretcher is no exception. Before a patient is ever placed on the stretcher, an operator should be comfortable demonstrating all the functions required for safe use. Partners should also practice lifting, loading, and unloading a stretcher together to ensure development of a systematic approach to ensure proper timing of releases, therefore optimizing safety. In the study by Wang, the largest portion of injuries occurred while unloading the patient from the ambulance [19]. A two-person unloading technique should be utilized to ensure the undercarriage deploys correctly and the stretcher does not collapse. Other potential human errors leading to injury include not latching the stretcher properly into the ambulance safety latch upon loading and not utilizing the recommended safety restraints prior to movement.

5.3 Surface conditions

EMS clinicians work in a variety of environments, regardless of weather conditions. Rain, ice, and snow pose a threat to safety with moving, loading, and unloading stretchers

by creating slippery conditions beyond the control of the clinician. These conditions have been shown to precipitate tipping events during movement, as a patient shifting on the mattress in response to slipping or sliding can throw the entire stretcher off balance. In these cases, it may be helpful to have an extra set of hands available to stabilize the side of the stretcher throughout the movement. Additionally, it can be very difficult to safely load and unload a patient when both the stretcher and the floor of the ambulance are covered in precipitation. In these cases, having towels on hand to dry off the floor and the locking mechanism could prove useful in ensuring both patient and crew safety. Though hazards such as cracks in the concrete and uneven gravel surfaces are beyond the control of EMS personnel, keeping a watchful eye for such barriers to safe stretcher use and having a plan for navigating them safely is highly recommended to prevent injury.

5.4 Patient related

The two patient-related stretcher issues most likely to cause harm to the patient and EMS clinician are combative and morbidly obese patients. Combative patients can easily tip a stretcher during movement, therefore, it is important to ensure that the patient is either calmed or appropriately restrained prior to movement. If possible, have extra personnel to secure the sides during movement to prevent tipping. If feasible, it may also be beneficial to walk the patient to the ambulance, securing the patient to the stretcher just prior to loading. Obese patients lend another challenge, not only due to weight and safety harness size limitations of a stretcher but also for crew safety while lifting. Never place more weight on a stretcher than recommended by the manufacturer, as this could lead to catastrophic injuries from collapse, and use safety belt extensions as needed to properly secure the patient to the stretcher. For stretcher lifts and loading of obese patients, maximizing the number of personnel available to help is important for both patient safety and career longevity. Despite typical EMS job descriptions displaying a lifting requirement in the range of 100–200 pounds, the NIOSH recommended load limit set per healthcare clinician is 51 pounds [3]. Surprisingly, the use of hydraulic stretchers does not completely mitigate the risk of injury when lifting an obese patient, as hydraulic stretchers are significantly heavier than manual stretchers [21]. When faced with lifting any type of stretcher with an obese patient, increasing the starting height of the stretcher and ensuring use of proper body mechanics can be advantageous in preventing injury.

6. Medication safety

The five "rights" of medication safety, "right medication, right dose, right patient, right route, and right time" are ingrained in the foundation of every pharmacological safety discussion, yet most medication errors stem from one of these five "rights" being wrong. Medication errors are made even by the most careful and experienced clinicians; therefore, a system of safety checks should be established. Medication errors are rarely simple and typically are complex system failures. Creating a culture of safety around medications can be challenging due to many reasons, such as preconceived notions or workplace rumors. Recently, a medication error made national headlines that resulted in a nurse being charged with and found guilty of criminally negligent homicide [22]. Critics of this decision have all called this action a step back regarding patient safety [23]. Agencies should maintain a comprehensive medication safety policy that encourages reports of events and near-hit events and allows for a root cause analysis to make

changes to the system to prevent a recurrence. Outlined below are some ideas and concepts that can be utilized to enhance patient safety when it comes to medication errors.

6.1 Medication cross-checks

Medication cross-checks, or having a second qualified professional verbally verify that the appropriate medication and dose have been selected for the patient's size and condition, have been proven to be effective in preventing most medication errors [24]. During a 54-month period, these authors showed that implementing the system shown in reduced monthly errors from a rate of 0.19 to 0.09%. As opposed to other steps to ensure patient safety, this one is unique as it requires no up-front costs.

Despite the known benefit of cross-checks, they are not always utilized due to high-stress situations, varying levels of partner certifications, the delay when cross-checks are needed for multiple medications, and in administration of medications to pediatric patients. Creating this kind of culture of safety can also be difficult because of stigmas associated with patient safety, which serves as another barrier for implementation of these kinds of systems.

6.2 Pediatric medication safety considerations

In addition to cross-checks, easy-to-read medication aids or checklists, which include indications, contraindications, dosage and administration amount, and route of delivery, could serve as a protective layer against medication errors. These medication aids are especially important in the case of pediatric patients, as weight-based dosing in kilograms is the standard of care and errors in dose calculations are common. According to a position paper released by the NAEMSP in 2020, all pediatric medication aids should list the volumetric amount of a weight-based dose to be given instead of a mass-based amount [25]. For example, a chart referencing pediatric acetaminophen dosing based on the standard concentration of 160mg/5 mL would list that a child weighing 11 kg would receive 5mL of acetaminophen rather than 160 mg. Any changes in formulary concentration should be immediately communicated and medication aids revised to reflect such changes as soon as possible. Another step to take is requiring all weights entered in the ePCR to be in kilograms and not pounds [25]. This is a simple standard to adopt but seeks to eliminate any confusion between pounds and kilograms in the management of patients.

6.3 Medication storage

Safe medication storage is vital to patient safety, and careful consideration must be taken when selecting medications for EMS use and in what arrangement they are kept. When selecting medications, there are many factors that influence what medications should be included in an algorithm. As it pertains to storage, temperature, naming, packaging, varying concentrations, and compatibility requirements should be thoroughly planned out prior to medication selection and storage.

6.4 Temperature

When choosing medications to be included in local EMS protocols, the ability to store a medication at an appropriate temperature is important for both patient safety and cost reduction. For instance, an advanced life support (ALS) crew would typically align protocol medications with what is preferred at the receiving facilities. In the case

of benzodiazepines, lorazepam is often preferred for sedation within emergency departments because of the longer half-life and smaller individual dosages. However, this may be impractical for EMS use, as it experiences statistically significant degradation in warmer temperatures and must be replaced every 60 days [26]. For agencies operating in warmer climates, the degradation occurs even faster. Therefore, ambulances in hotter climates must be either stocked with midazolam, which does not degrade in higher temperatures, or have the ability to refrigerate lorazepam appropriately. Unfortunately, temperature degradation can occur with medications across all classes, necessitating cautious choices and strict medication rotation regimens to ensure efficacy. Using a medication with decreased potency or efficacy is certainly not in the best interest of a patient.

6.5 Naming

Medication names can be equally important to patient safety in the selection and storage process. Look-alike and sound-alike medication names are a common source of medication errors, whether due to EMS clinician confusion or grabbing the wrong medication because they were stored in proximity. For example, a paramedic might intend for a patient with stable rapid atrial fibrillation to receive diltiazem, but what if it were stored next to diazepam and was administered instead? Not only would the patient not receive the appropriate medication but it would also become difficult to assess stability of the patient, as they would likely become lethargic and possibly hypotensive due to the adverse effects of the benzodiazepine. In cases where look-alike and sound-alike medications are both part of the EMS protocols, these should be clearly labeled and stored in separate locations [27, 28].

6.6 Packaging

As with look-alike and sound-alike medication names, medications can also be packaged in similar vial sizes or box colors. Ideally, these issues would be engineered out of the system by manufacturers, and in some cases they are. However, there are numerous times when different medications from different manufacturers look similar. When storing medications with similar packaging, try to keep maximum distance between look-alike packages within the medication box. Additionally, agencies should point out these high-risk situations before they become a problem (i.e. when the new packaging is noted, staff should be notified of the similarities before using it with a patient). In the event of a mix-up, medication cross-checks could prevent a medication error due to packaging issues [27, 28].

6.7 Medications with varying concentrations

If possible, avoid procuring varying concentrations of the same medications unless medically necessary. For example, if ketamine was initially purchased at a concentration of 10mg/mL but became unavailable due to supply chain issues, necessitating a switch to a more concentrated 50mg/mL concentration, this could pose a significant threat to patient safety if both concentrations ended up in the same drug box. In order to avoid overdose, it would be appropriate to not only make clinicians aware of the change but also to remove all vials of the more dilute medication from all agency medication boxes. In cases where varying concentrations are necessary, such as in the case of epinephrine, clear labeling, separate storage sites, and medication cross-checks should be employed to prevent medication errors [28].

6.8 Compatibility

Medications that must be diluted prior to administration should be stored together in order to avoid confusion and to ensure the proper diluent or solvent is chosen. For example, amiodarone for infusion should be stored with D5W so that it is not accidentally mixed with an incompatible diluent such as normal saline. Storing medications that must be coadministered in the same location also allows for expedient administration, decreasing the amount of time spent searching for the appropriate concentration or volume of medication or diluent.

7. Transfer of care

Communication skills are crucial for patient safety yet transfer of vital information from EMS clinician to receiving facility personnel is often noted as a source of medical error. It is not only what is communicated between clinicians, but how the information is delivered that affects patient safety. Transfer of care is such a critical juncture for patient safety that in 2013 the National Association of EMS Physicians (NAEMSP) and the American College of Emergency Physicians (ACEP) published a joint physician statement (along with three other key organizations) outlining the importance of this time and highlighting key elements to ensure patient safety when this occurs [29].

7.1 Structured Handoff

In addition to patient demographics, essential information, such as history of present illness, vital signs, interventions, responses to the interventions, and results of any diagnostic testing such as ECG's and point of care laboratory results, should be clearly conveyed to the receiving clinician. In order to prevent information loss in high-acuity situations, a standardized approach to handoff should be developed and routinely used, whether by the EMS clinician or the employing agency itself. There are many different forms of structured handoffs, but two of the more common are SBAR and DMIST (**Table 2**).

7.1.1 SBAR

One such method commonly used by hospitals is the SBAR approach, which is conveying information regarding the situation, background, assessment, and recommendations, in that order, for every handoff and request for evaluation or

SBAR	DMIST
Situation	Demographics
Background	Mechanism
Assessment	Injuries/illness
Recommendations	Signs [Vital Signs]
	Treatments

Table 2.
Structure handoff formats.

intervention. In hospitals, this has been shown to improve safety of patients during handoff [30]. Though this has not been tested in an EMS environment, this can be applied to a patient handoff to maximize patient safety.

1. *Situation:* Who are you providing treatment to and for what? How high is the acuity of this patient's condition? What were you called to the scene for?

   Example: Ms. Smith is a 56-year-old female in significant respiratory distress. Her husband reports that she has asthma and has tried her albuterol inhaler several times today without relief from her symptoms.

2. *Background*: What relevant medical information or prescribed medications are pertinent to the current condition?

   Example: She takes both inhaled corticosteroids and a leukotriene modifier daily and has not missed any doses. She has not required oral steroids for her asthma recently but was intubated 2 years ago for a severe asthma exacerbation.

3. *Assessment*: What were the critical diagnostic or physical exam findings? What interventions were attempted? How effective were they?

   Example: She was found in a tripod position, respiratory rate of 36, SpO2 82% on room air, with both nasal flaring and intercostal retractions, and minimal air movement on lung auscultation. She was given two duonebs and 125mg solumedrol and also placed on supplemental oxygen via nasal cannula, resulting in a slight improvement in SpO2 but no change in respiratory rate, work of breathing, or lung sounds.

4. *Recommendations*: What do you feel are the necessary next steps? EMS providers are encouraged to make recommendations within their respective scope of practice, as an EMS clinician's continued assessments and resulting concerns are helpful in directing immediate care.

   Example: Because of her continued respiratory distress despite nebulizer treatments, steroids, and oxygen administration, I am concerned that she may need further interventions, such as noninvasive positive pressure ventilation or intubation.

7.1.2 DMIST

Another common structured patient handoff technique is the MIST or DMIST tool. Unlike SBAR, where there has not been extensive study of prehospital use, MIST has been studied in multiple centers, including the Southwest Texas Regional Advisory Council, which published one of the largest studies of its use involving over 100 prehospital clinicians pre and post implementation. The overwhelming results of the implementation show that all involved felt that communication between the hospital and prehospital team improved [31]. In 2019, the Commonwealth of Pennsylvania implemented the use of DMIST statewide with a small modification, adding the D for demographics at the beginning [32]. To this point, there has not been comprehensive patient outcome data on this tool.

1. *Demographics*: Age, gender, and weight (as appropriate). This is intended to be simple and for the whole team's knowledge. Information, such as an address, date of birth, and phone number, can be exchanged after transfer of care with hospital registration staff.

2. *Mechanism*: In the trauma setting, this includes time of injury, type of injury, and additional info, such as speed, type of collision, height of fall, type of weapon, and safety devices used. In the medical setting, this includes a review of the *OPQRST* [onset, pain, quality, radiation, severity, and timing].

3. *Injuries/illness*: In the trauma setting, the clinician should list injuries from head to toe. In the medical setting, this includes a review of the SAMPLE history, EKG, Stroke Scale, and other screenings as needed.

4. *Signs (vital signs):* Including GCS, heart rate, blood pressure, respirations, oxygen saturation, and blood sugar.

5. *Treatment*: This is the time when the clinician can review the care provided, such as airway interventions, oxygen delivery, IVs, medications, chest decompression, defibrillators, wound care, splinting, and other interventions. The clinician should also provide relevant patient responses to key interventions.

   Example: This is a 24yo M unrestrained driver frontal impact MVC, car vs tree. He was unconscious at the scene, with an obvious head injury, bruising of the chest wall with crepitus, and bruising of the abdomen. He has obvious lower extremity deformity. His GCS was 3, HR 120, BP 100/50, RR 6, and SATs 80%. He was emergently intubated with no medications for airway protection and his SATs improved to the 90s. He became hypotensive in the 70s following intubation and underwent bilateral chest decompression with an improvement of SpO2 to 100% and BP to 108/62. He has two bilateral 16g IVs in the AC. Received 1000mg TXA at 1002 hours. He received no other medications from us, including any sedative post intubation. We splinted his lower extremity and maintained a cervical collar with c-spine precautions for the duration of the extrication and transport. Any questions?

One part to note about many systems that have implemented the DMIST structured handoff is the "EMS timeout," where the trauma team takes 30 seconds of no action to listen to the EMS clinicians uninterrupted. This time-out can occur upon arrival in the trauma bay while still on the EMS stretcher for the stable patient or after critical interventions have occurred in the unstable trauma patient.

These two examples represent potential methods of content delivery, and it would be perfectly acceptable to formulate alternative handoff communication algorithms, which meet the needs of the individual or EMS agency. Whatever style is adopted, ensure that the skill is practiced and utilized with every patient, and its implementation occurs in partnership with the receiving hospitals. This ensures that in high-stress situations, the report becomes automatic and easy to deliver, without loss of information leading to adverse patient outcomes. Studies continue to show that this is a high-risk area that needs continuous improvement [33].

7.2 Delivery

How information is delivered is just as important as the message content, which is being communicated. Handoff communication should be clear, concise, and without the use of slang or other terminology, which might not be understood by the receiving clinician. Avoid giving handoff during patient transfer from the stretcher to the bed, as the listener may be distracted by the patient's movement and not be actively listening. Ideally, handoff should be given directly to the nurse or physician

who will be assuming care, with a verbal demonstration of understanding being given by the receiving clinician (closed-loop communication). A radio report is not considered an adequate handoff, as the receiver will likely not convey all aspects of the report to those who assume care, and important information will likely be lost [29]. Additionally, all critical elements of a verbal handoff should also be documented and available at bedside in case there are questions regarding treatment prior to arrival or if care is transferred to another clinician not present for the initial handoff. Additionally, results of point-of-care testing and copies of the ECG must be made available to the receiving institution so that they may become part of the patient's permanent medical record. A 2009 study found that even in controlled settings, "information gaps" occurred leading to the suggestion that further scrutiny is needed to assess and improve delivery and handoff of information [34].

8. Fatigue

A simple internet search for motor vehicle accidents involving drivers who fell asleep at the wheel yields multiple results of devastating incidents, also populating numerous articles related to first responders being found sleeping on the job. When identifying risks to patient safety, the first things to come to mind are medication errors, high-risk procedures, and equipment malfunctions-issues, which can be mitigated with medication cross-checks, education, safety checklists, and preventive maintenance checks and services. However, according to the World Health Organization, healthcare worker fatigue is the largest contributing factor to both patient injury and medical errors [35]. Fatigue, whether physical or mental, can lead to many threats to patient safety, including delayed judgment making, medication administration errors, slow response to threats or obstacles, and failure to adhere to written protocol. Though inherent to the nature of the job, creation of evidence-based fatigue mitigation programs should be prioritized for both patient and prehospital clinician safety. A strong program should consider the needs of the community, available resources, and clinician feedback, while also incorporating formal education on effects of fatigue and strategies to reduce risk.

8.1 Needs of the community and available resources

When thinking about factors contributing to fatigue, shift length and call volume immediately come to mind. Though it would make sense that the longer an employee works, the more likely they are to be fatigued, available literature suggests that there is no statistically significant difference in the number of unfavorable events, which occur in shifts of varying lengths as long as they are 24 hours or less in duration [35]. This may not make sense at first glance, but it is thought that this could be attributed to the ability to rest between calls and longer periods of time between shifts for those who work 24-hour shifts, which reduces the risk of adverse events. In other healthcare fields, higher individual workload has also been shown to contribute to increased adverse patient events due to effects of fatigue, however, no prehospital studies have been conducted [35, 36]. Regardless, factors such as call volume, transport times, and call acuity should be taken into account prior to determining appropriate shift length to remedy fatigue. However, adjustments to shift structure may not be possible in all response areas given increased costs of additional equipment and lack of available EMS professionals, therefore, other mitigation techniques may be more feasible.

8.2 Clinician feedback

Risks for potential harm due to fatigue cannot be adequately assessed without ongoing structured feedback from those in the field. Knowing how fatigued EMS clinicians feel, what resources would be valued for combatting fatigue, and how the fatigue is affecting both their personal and professional lives is crucial in tailoring both educational programs and risk-reduction tools to the needs of the individual agency. No validated assessment survey is currently available; however, this should not prevent an agency from seeking such information [37].

8.3 Education

How can EMS personnel know the seriousness of fatigue and how to prevent those poor personal and patient outcomes if the topic is never formally addressed? Routine education covering topics such as sleep disorders, successful sleep habits, health maintenance, and circadian rhythm awareness could be beneficial [37]. Additionally, clinicians should be educated on the mitigation techniques employed by an agency and available resources that may be utilized. Continuing education on the topic also opens the door for further dialogue, enhancing the quality and quantity of the feedback necessary to develop risk reduction strategies in the first place.

8.4 Formal guidelines about fatigue in EMS

In response to numerous research projects demonstrating the negative impacts of fatigue on patient safety, the National Association of State EMS Officials, in conjunction with the National Highway Traffic Safety Administration (NHTSA), published a set of five evidence-based guidelines in 2017 [37]. Though each guideline may not be universally applicable given the individual needs of a community or EMS organization, it does set the framework for agencies to establish their own system of fatigue hazard mitigation (**Table 3**).

These recommendations serve as a tool but not a comprehensive list of innovative strategies to decrease risks to patient safety due to EMS clinician fatigue. It remains the responsibility of an agency to conduct its own internal assessment of practitioner

Recommendation	Strength of recommendation	Quality of evidence
Use fatigue/sleepiness survey instruments to measure and monitor fatigue in EMS personnel	Strong	Low
Recommend that EMS personnel work shifts shorter than 24 hours in duration	Weak	Very low
Recommend that EMS personnel have access to caffeine as a fatigue countermeasure	Weak	Low
Recommend that EMS personnel have the opportunity to nap while on duty to mitigate fatigue	Weak	Very low
Recommend that EMS personnel receive education and training to mitigate fatigue and fatigue-related risks	Weak	Low

Table 3.
Evidence-based fatigue management recommendations.

fatigue, develop mitigation techniques unique to its service, and reassess the practicality and effectiveness of these policies [38]. Ultimately, regardless of shift length or agency guidelines, an EMS professional should develop their own personal health and sleep regimen to prevent fatigue to avoid making critical mistakes or the news headlines for an adverse event.

9. High-risk procedures

When reading through NHTSA's "National Scope of EMS Model," some of the more notable complex procedures within the paramedic's minimum psychomotor skill set include intubation, decompression of the pleural space, and percutaneous cricothyrotomy [39]. It is important to clarify that these are minimums, and the potential for even riskier procedures, such as rapid sequence intubation using paralytics, finger thoracostomy, and surgical cricothyrotomy, could be included in an ALS clinician's scope at the discretion of the individual state and agency medical director. These procedures, along with other procedures within the ALS scope of practice, are inherent of higher risk because they require a higher level of understanding of anatomy and physiology, are performed infrequently, require both more initial and continuing education, and come with significant risk to the patient if improperly performed [39]. To improve patient outcomes and decrease risk, adjuncts such as checklists, procedural competency assessments, and clinical simulations should be taken into consideration for inclusion into agency performance improvement algorithms.

9.1 Checklists

Use of procedural checklists to enhance safety has been proven to be effective in various industries, and healthcare is no exception [40]. These point-of-care cognitive aids are a useful way to augment procedural memory and could be especially useful in high-risk prehospital procedures in distracting and austere environments. For example, checklists for intubation have been extensively studied for in-hospital use, and though not proven to have a mortality benefit, checklist use was associated with statistically significant decreases in peri-intubation hypoxic events [41]. One longitudinal before and after a study conducted using data from an air ambulance company concluded that not only did use of checklists decrease hypoxic and hypotensive events during RSI but also improved the first-pass intubation success rates [42]. A similar study on a ground ALS service showed a checklist as part of a bundle of care showed lower rates of peri-intubation hypoxia, further demonstrating that checklists are a helpful resource for patient safety [43].

Though not studied, checklists could be of benefit for improving outcomes in a variety of high-risk prehospital procedures. A high-quality checklist should be easy to read, written in plain language, and could include various data such as patient considerations, necessary equipment and medications, procedural steps, and countermeasures should complications be encountered.

9.2 Competency assessments

Ensuring provider competency prior to performing high-risk procedures is vital to patient safety. Competency assessments should not only be aimed at procedural steps but also include evaluation of appropriateness of use of the high-risk procedure based

on patient condition. Just as in medication safety, knowing the indications, alternatives, and ideal patient demographic for a procedure is just as important as being able to physically perform the procedure itself. Initial provider certification is issued based on a basic level of competency to appropriately implement and perform a procedure; however, it is up to an agency to credential a provider based on an assessment of those procedural competencies. In addition to initial credentialing, the NAEMSP recommends that "reverification of a provider's cognitive, affective, psychomotor, and critical thinking skills, pertinent to relevant clinical situations, occurs no less frequently than every two (2) years" [44].

9.3 Simulation

Simulation has been proven effective for evaluating and teaching psychomotor skills, communication, teamwork, and patient management in a variety of medical environments. Though not well studied for use in the prehospital setting, the ability to repeat uncommon, high-risk procedures in a controlled environment affords the provider opportunity to gain experience, education, and muscle memory in tandem [45]. Moreover, prehospital simulations and assessments can be used to strengthen non-procedural skills, such as communication, leadership skills, stress management, and decision-making, all of which are fundamental to patient safety. Simulation is not only useful for initial and ongoing education but also as a remediation tool for both self-identified and agency-specific performance improvement initiatives [46].

10. Conclusion

Patient safety is a complex topic that has to overcome significant resistance to change. Over twenty years since the publication of "To Err is Human," medical adverse events still represent a significant burden to our healthcare system [47]. As discussed above, there are many intricate parts of the system to consider. In some areas, progress has been made, such as engineering safe ambulances and storage compartments. In other areas, such as handoffs, much work is still to be done. In some areas, such as L&S use, there are national partnerships that are seeking to improve systems across the country [48]. The journey to a safer system for our patients will take time, which is why the EMS Agenda 2050 lays out a foundation for improvements to be made over the next 30 years. Partnerships with public safety, public health, healthcare systems, insurers, and the government are necessary to continue growing EMS to fill the need that exists and allow it to develop with these safety mechanisms engrained in the culture. Continued work is needed, but the foundation is strong to create a safer system for patients.

Acknowledgements

The authors wish to acknowledge the contributions of Dr. Dawn Brown who provided valuable ideas and feedback during the development of this text. Inspiration for this text came from the NAEMSP Quality and Safety Course and the NEMSQA National Lights and Siren Collaborative. Funding for open-source publishing was provided by St. Luke's University Health Network's Graduate Medical Education Fund.

Conflict of interest

The authors declare no conflict of interest.

Note and thanks/other

The authors wish to thank the men and women serving in EMS systems across the globe. Without their hard work and dedication, many few lives would be saved——be safe out there.

Author details

Bryan R. Wilson[1*] and Ashley Woodrow[2]

1 St. Luke's University Health Network, Bethlehem, PA, USA

2 St. Luke's Anderson Emergency Medicine Residency, Easton, PA, USA

*Address all correspondence to: bryan.wilson@sluhn.org

References

[1] EMS Agenda 2050 Technical Expert Panel. EMS Agenda 2050: A People-Centered Vision for the Future of Emergency Medical Services (Report No. DOT HS 812 664). Washington, DC: National Highway Traffic Safety Administration; 2019

[2] George K, Sweeny S. State Actions to Address EMS Workforce Shortages. National Conference of State Legislatures [Internet]. 2022. Available from: https://www.ncsl.org/research/health/state-actions-to-address-ems-workforce-shortages.aspx [Accessed: October 10, 2022]

[3] Institute of Medicine (US) Committee on Quality of Health Care in America. In: Kohn LT, Corrigan JM, Donaldson MS, editors. To Err is Human: Building a Safer Health System. Washington (DC): National Academies Press (US); 2000

[4] Centers for Disease Control and Prevention. Emergency Medical Services—NIOSH—CDC [Internet]. 2022. Available from: https://www.cdc.gov/niosh/topics/ems/default.html [Accessed: August 1, 2022]

[5] Ambulance Patient Compartment Human Factors Design Guidebook. US Department of Homeland Security. 2015. Available from: https://www.dhs.gov/sites/default/files/publications/Ambulance%20Patient%20Compartment%20Human%20Factors%20Design%20Guidebook.pdf

[6] National Association of State EMS Officials. SafeAmbulances. [Internet]. 2019. Available from: http:safeambulances.org [Accessed: August 1, 2022]

[7] Castillo D, Bobick T, Pratt S. New Research and Findings from the NIOSH Division of Safety Research. Washington (DC): American Society of Safety Engineers; 2013

[8] Centers for Disease Control and Prevention. Emergency Medical Services—NIOSH—CDC [Internet]. 2022. Available from: https://www.cdc.gov/niosh/topics/ems/data.html [Accessed: September 10, 2022]

[9] Stone PW. Economic burden of healthcare-associated infections: An American perspective. Expert Review of Pharmacoeconomics & Outcomes Research. 2009;**9**(5):417-422

[10] Obenza A, Cruz P, Buttner M, Woodard D. Microbial contamination on ambulance surfaces: a systematic literature review. The Journal of Hospital Infection. 2022;**122**:44-59

[11] US General Services Administration. KKK-A-1822F: Federal Specification for the Star-of-Life Ambulance. 2007. Available from: https://www.ok.gov/health2/documents/KKK-A-1822F%20%2007.01.2007.pdf

[12] New Jersey Revised Statutes. Title 39 - MOTOR VEHICLES AND TRAFFIC REGULATION. Section 39:4-103 [Internet]. Trenton (NJ): State of New Jersey Department of State; 2013. Available from: https://law.justia.com/codes/new-jersey/2013/title-39/section-39-4-103 [cited 2022 Sept 1]

[13] Title 75 PA Motor Vehicle Code. Part III. Section 31A:3501. Harrisburg (PA): Department of Transportation. Available from: https://www.legis.state.pa.us/WU01/LI/LI/CT/HTM/75/00.031..HTM [cited 2022 Sept 1]

[14] Kupas DF. Lights and siren use by emergency medical services: Above all,

do no harm. National Highway Traffic Safety Administration. 2017. Available from: https://www.ems.gov/pdf/Lights_and_Sirens_Use_by_EMS_May_2017.pdf

[15] Watanabe BL, Patterson GS, Kempema JM, Magailanes O, Brown LH. Is use of warning lights and sirens associated with increased risk of ambulance crashes? A contemporary analysis using national EMS information system (NEMSIS) data. Annals of Emergency Medicine. 2019;**74**(1):101-109

[16] Kupas DF, Zavadsky M, Burton B, Baird S, Clawson JJ, et al. Joint statement on lights & siren vehicle operations on emergency medical services responses. Prehospital Emergency Care. 2022;**26**(3):459-461

[17] Jarvis JL, Hamilton V, Taigman M, Brown LH. Using red lights and sirens for emergency ambulance response: How often are potentially life-saving interventions performed? Prehospital Emergency Care. 2021;**25**(4):549-555

[18] Lim CB, Peterson ED, Smith EE, Saver JF, Liang L, Xian Y, et al. Emergency medical service hospital prenotification is associated with improved evaluation and treatment of acute ischemic stroke. Circulation. 2012;**5**:514-522

[19] Wang HE, Weaver MD, Abo BN, Kaliappan R, Fairbanks RJ. Ambulance stretcher adverse events. Quality & Safety in Health Care. 2009;**18**:213-216

[20] Goodloe JM, Crowder CJ, Arthur AO, Thomas SH. EMS stretcher "Misadventures" in a large, urban EMS system: A descriptive analysis of contributing factors and resultant injuries. Emerging Medical International. 2012;**2012**:45706

[21] Prairie J, Plamondon A. Hegg0Deloye S, Larouche D, Corbeil P. Biomechanical risk assessment during field loading of hydraulic stretchers into ambulances. International Journal of Industrial Ergonomics. 2016;**54**:1-9

[22] Timms M. Ex-Nurse RaDonda Vaught Found Guilty on Two Charges in Death of Patient [Internet]. Nashville, TN: The Tennessean; 2022. Available from: https://www.tennessean.com/story/news/crime/2022/03/25/radonda-vaught-trial-vanderbilt-nurse-jury-verdict/7154135001/ [Accessed: August 10, 2022]

[23] Bean M. A backward step for patient safety': Medical groups respond to RaDonda Vaught sentencing. Becker's Hospital Review [Internet]. 2022. Available from: https://www.beckershospitalreview.com/patient-safety-outcomes/a-backward-step-for-patient-safety-medical-groups-respond-to-radonda-vaught-sentencing.html

[24] Misasi P, Keeble JR. Medication safety in emergency medical services: approaching an evidence-based method of verification to reduce errors. Therapeutic Advanced Drug Safety. 2019;**10**:1-14

[25] Cicero MX, Adelgais K, Hoyle JD, Lyng JW, Harris M, Moore B, et al. Medication dosing safety for pediatric patients: recognizing gaps, safety threats, and best practices in the emergency medical services setting. A Position Statement and Resource Document from NAEMSP. Prehospital Emergency Care. 2021;**25**(2):294-306

[26] McMullan JF, Pinnawin A, Jones E, Denninghoff K, Siewart N, et al. The 60-day temperature-dependent degradation of Midazolam and Lorazepam in the prehospital environment. Prehospital Emergency Care. 2013;**17**:1-7

[27] Kupas DF, Shayhorn MA, Green P, Payton TF. Structured inspection of medications carried and stored by

emergency medical services agencies identifies practices that may lead to medication errors. Prehospital Emergency Care. 2012;**16**:67-75

[28] Walker D, Moloney C, SueSee B, Sharples R, Blackman R, Long D, et al. Factors influencing medication errors in the prehospital paramedic environment: A mixed method systematic review. Prehospital Emergency Care. 2022. DOI: 10.1080/10903127.2022.2068089

[29] Transfer of patient care between EMS providers and receiving facilities. Prehospital Emergency Care. 2014;**18**:305-305

[30] De Meester K, Verspuy M, Monsieurs KG, Bogaert PV. SBAR improves nurse-physician communication and reduces unexpected death: A pre and post intervention study. Resuscitation. 2013;**84**:1192-1196

[31] Maddry JK, Simon EM, Reeves LK, Mora AG, Clemons MA, et al. Impact of a standardized patient hand-off tool on communication between emergency medical services personnel and emergency department staff. Prehospital Emergency Care. 2021;**25**:530-538

[32] DMIST. Standardizing the EMS to Trauma Team Patient Handoff in Pennsylvania. 2014. Available from: https://pehsc.org/wp-content/uploads/2014/05/PA-DMIST-PPT.pdf

[33] Goldberg SA, Porat A, Strother CG, Lim NQ, Wijeratne HRS, Sanchez G, et al. Quantitative analysis of the content of EMS handoff of critically ill and injured patients to the emergency department. Prehospital Emergency Care. 2007;**21**:14-17

[34] Carter AJE, Davis KA, Evans LV, Cone DC. Information loss in emergency medical services handover of trauma patients. Prehospital Emergency Care. 2009;**13**:280-285

[35] Patterson PD, Weaver MD, Frank RC, Warner CW, Martin-Gill C, et al. Association between poor sleep, fatigue, and safety outcomes in emergency medical services providers. Prehospital Emergency Care. 2012;**16**:86-97

[36] Patterson PD, Weaver MD, Hostler D, Guyette FX, Callaway CW, Yealy DM. The shift length, fatigue, and safety conundrum in EMS. Prehospital Emergency Care. 2012;**16**:572-576

[37] Patterson PD, Higgins JS, Van Dongen HPA, Buysse DJ, Thackery RW, et al. Evidence-based guidelines for fatigue risk management in emergency medical services. Prehospital Emergency Care. 2018;**22**:89-101

[38] Martin-Gill C, Higgins JS, Van Dongen HPA, Buysse DJ, Thackery RW, et al. Proposed performance measures and strategies for implementation of the fatigue risk management guidelines for emergency medical services. Prehospital Emergency Care. 2018;**22**:102-109

[39] National Association of State EMS Officials. National EMS Scope of Practice Model (Report No. DOT HS 812-666). Washington, DC: National Highway Traffic Safety Administration; 2019

[40] Chen C, Kan T, Li S, Qiu C, Gui L. Use and implementation of standard operating procedures and checklists in Prehospital Emergency Medicine: A literature review. The American Journal of Emergency Medicine. 2016;**34**(12):2432-2439

[41] Turner JS, Bucca AW, Propst SL, Ellender TJ, Sarmiento EJ, et al. Association of checklist use in endotracheal intubation with clinically important outcomes: A Systematic

Review and Met-analysis. JAMA Network Open. 2020;**3**(7):e209278

[42] Weir WB, Olvera D, Lauria M, Noce J. Implementation of a rapid sequence intubation checklist improves first pass success and reduces peri-intubation hypoxia in Critical Care Transport. Air Medical Journal. 2022;**41**(1):24

[43] Jarvis JL, Gonzales J, Johns D, Sager L. Implementation of a clinical bundle to reduce out-of-hospital peri-intubation hypoxia. Annals of Emergency Medicine. 2018;**72**(3):272-279

[44] Clinical credentialing of EMS providers. Prehospital Emerging Care. 2017;**21**(3):397-398

[45] Abelsson A, Rystedt I, Suserud B-O, Lindwall L. Mapping the use of simulation in Prehospital Care—A literature review. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2014;**22**(1):1-12

[46] Langdalen H, Abrahamsen EB, Sollid SJ, Sørskår LI, Abrahamsen HB. A comparative study on the frequency of simulation-based training and assessment of non-technical skills in the Norwegian Ground Ambulance Services and helicopter emergency medical services. BMC Health Services Research. 2018;**18**(1):509

[47] Bates DW, Singh H. Two decades since to err is human: an assessment of progress and emerging priorities in patient safety. Health Affairs (Millwood). 2018;**37**(11):1736-1743

[48] Lights and Sirens Collaborative. National EMS Quality Alliance [Internet]. 2021. Available from: https://www.nemsqa.org/lights-and-siren