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Emergency Medical Services: A Transportation Safety Emergency

Nadine Levick, MD, MPH
Objective Safety LLC
New York, NY, USA

Abstract

There are a spectrum of safety issues for the (Emergency Medical Service) EMS transport environment and an increasing number of potential solutions – addressing provider safety, patient safety and the safety of the public in a systems approach. This paper outlines risks and hazards involved in EMS transport, highlighting the automotive safety, workplace safety including ergonomic and engineering perspectives, as well as existing and developing standards and guidelines. Despite the large strides that the automotive industry, occupational health and safety as well as public safety have made in the last 30 years, this expertise has not yet been translated to the safety of ambulance transport. This is a unique transportation and health care delivery environment for a number of reasons. In the USA there are no specific EMS transportation safety databases, so that ascertaining the overall safety of the system is very challenging, also there are few applicable system safety standards, no comprehensive personal protective equipment standards and no vehicle crash safety testing standards that pertain to ambulance vehicles.

Unfortunately, because no reporting system or database exists specifically for identifying ambulance crash related outcomes, injuries and their nature, specific details as to which injuries occurred and to whom and what specifically caused them are extremely scarce. There have been extensive studies that have identified that the rear patient compartment is the most dangerous part of the ambulance for its occupants, yet this part of the vehicle is currently not regulated by the Federal Motor Vehicle Standards. Furthermore it has also been demonstrated that for each ambulance occupant fatality in an adverse event involving an ambulance vehicle, that there are 3 non-ambulance occupants fatalities, largely related to intersection crashes, and secondarily pedestrians struck.

This paper demonstrates that utilizing a systems safety based multidisciplinary approach - addressing patient, provider and public safety with comprehensive data capture, strategic highway safety planning integration, ergonomic and automotive safety perspectives in conjunction with vehicle and fleet safety standards development - is necessary to ensure improved outcomes in EMS transport safety.

Introduction

Emergency Medical Service (EMS) is a unique transportation and health care delivery environment for a number of reasons. Even though there is comprehensive medical and clinical oversight, training and standards in EMS - this is not the case with the transportation safety aspect of this system. In the USA there are few applicable transportation system safety standards for EMS, essentially no vehicle crash safety testing standards that pertain to ambulance vehicles patient compartments and no comprehensive personal protective equipment standards. There is only very limited national data captured on the safety of this EMS transportation system, primarily by the Fatality Analysis Reporting System (FARS), which captures fatalities only and has no denominator data. Thus ascertaining the safety of EMS transport system, its vehicles and products remains limited to expert and peer evaluation in a piecemeal fashion.

EMS is fundamentally a transportation based emergency service, responding to approximately 30 million emergency medical/injury calls annually and estimated at least as many routine transports. There has been much recent focus nationally[1,2,3,4,5,6], federally[7] and academically[8,9] on the issues pertaining to air EMS safety, and extensive focus in many dimensions on truck and bus safety[10,11], and comprehensive attention on Fire Service transport safety[12]. However, safety issues pertaining to ground ambulance transport has not shared this either this focus or oversight.[9,13,14,15] The broader transportation safety issues in EMS, and system risks and hazards and how they are measured – as well as what can be done to optimize the safety of this system for the patient, the provider and the public, are fundamental systems safety engineering issues. These issues warrant a systems safety engineering approach similar to that which has been applied to these related fields.

In addition to the impressive truck and bus safety programs[11], initiatives and research[10], there are also excellent models in system safety analysis within the emergency services – particularly the Fire Service, which has recently held the "Safety Summit"[12], and has developed an extensive multimodal safety approach – from the perspectives of comprehensive occupational health and safety, vehicle handling safety, and public safety.

The published research addressing these transport safety questions within EMS is very recent, the vast majority being published over the past 5 years[16]. The relevant literature is in a combination of multidisciplinary fields bridging epidemiology and public health literature, engineering and ergonomic literature as well as in the liability and risk management field[16], however it is very limited in contrast to other fields of transportation safety.

EMS is a relatively new field when compared to other emergency services, fire and police. It has only been a formal infrastructure since the late 60's. The history of the development of EMS transport has the unusual beginnings of being from the mortician industry. Though there is currently no federal oversight of EMS systems safety, there are however, two new initiatives underway to in some way advance this – one is the National EMS Information System (NEMSIS)[17] data base development and the other is the recently under establishment National EMS Advisory Committee (NEMSAC)[18]. Additionally at State levels there are now initiatives to advance EMS transport safety both within Department of Health infrastructure, for example in New York and Pennsylvania[19,20], where EMS usually 'resides' and now also in strategic highway safety planning, such as in New York State, where the 2006-2007 New York State Strategic Highway Plan specifically addresses issues pertaining to the safety of EMS transport[21].

Additionally there are recent publications from the Transportation Research Board (TRB) addressing Rural EMS, and the Federal Highway Administration addressing Emergency Transportation Operations: Preparedness and Response[22].

Despite the large strides that the automotive and transportation safety, occupational health and safety as well as public safety have made in the last 30 years, this expertise has not yet been translated to the safety of emergency medical service transport, unlike the related fields of air medical safety, fire transport safety or the truck and bus industry. Ambulance transport practice and policy has developed largely outside of the purview of both the automotive and transportation safety and occupational safety and health arenas (asides from biohazards)[9, 13,14, 15]. Compounding this further is the fact that ground ambulance vehicles are a very diverse fleet: vans, light and heavy trucks and freightliners. Of serious concern, it is a fleet exempt from the Federal Motor Vehicle Safety Standards (FMVSS) for all occupants seated 60cm behind the drivers seating position[23].

Ambulance vehicle crashes have been shown to be the most likely cause of a work related fatality in EMS[24] and estimated to have fatality rates per mile above that of trucks and passenger vehicles[11, 25]. Unfortunately, no reporting system or database exists specifically for identifying ambulance crash-related injuries and their nature. Therefore, specific details as to which injuries occurred and what mechanisms specifically caused them are currently scarce. Even this information for fatal ground ambulance injuries is lacking or very difficult to access.

There have been a number of publications in the epidemiology literature addressing ground ambulance transport morbidity and mortality crash related statistics.[13, 16,24, 26-29] These publications reach very similar general conclusions and identify serious risk and hazard from intersection collisions and the use of high speed and lights and sirens. Such findings are not surprising when there is a systems designed with a primary outcomes benchmark of 'response time' and no integrated factor of safety performance. Also identified was the risk of serious injuries and fatalities from failure to use seat belts in the rear patient compartment, with very high fatality risk for unbelted providers in the rear compartment (83%) [13, 26]. There are also hazards to ground EMS providers at an emergency rescue scene, where they are at risk of being struck by a passing vehicle due to poor visibility or vehicle placement issues. Recent data suggests that one in five EMS provider transportation-related fatalities occur in this type of setting[30]. The peer reviewed automotive safety engineering testing conducted for the EMS environment [13, 31-35] has clearly identified some predictable and largely preventable hazards, which pertain to the rear compartment design, layout and vehicle crashworthiness. Additionally new technologies for tiered dispatch and real time driver feedback and monitoring have been demonstrated to have major positive impact on EMS transport safety.

Safety standards from the USA and internationally that pertain to the EMS transport environment are very limited. There are EMS vehicle design, crashworthiness safety testing and performance standards in Australia, Europe and the UK [36, 37]. USA has no such crashworthiness performance or dynamic testing standards for ambulance vehicles but rather a purchase specification, the GSA Star of Life KKK Ambulance Specification[38], which at present has no dynamic or crash testing safety performance component. The new USA ANSI/ASSE Z15.1 fleet management standard, approved in March 2006[39] is the first USA national fleet management standard to have oversight which includes over EMS fleets. Currently there are plans for a specific ASSE standard pertaining specifically to EMS transport safety underdevelopment.

Clearly what has been demonstrated to date is that EMS is a complex transport and health delivery system with a multidisciplinary need in the safety management environment. Management of the safety of this transportation system bridges: data capture, automotive safety, transportation safety (including driver performance and interaction with the environment), occupational health and safety, ergonomics and human factors, practice policy and acute health care delivery as well as public safety and essentially involves a multi disciplinary systems safety engineering approach Utilizing a systems based multidisciplinary approach, in conjunction with safety standards development is necessary to ensure improved outcomes in EMS transport safety. This innovative framework bridging key EMS safety research and current ergonomic and automotive technology with a safety systems approach is necessary in the future to facilitate enhanced cross disciplinary collaboration in development of safety initiatives and optimizing safety outcomes in EMS transport.

Optimizing Safety and Systems Engineering

Initiatives to optimize safety for EMS transport should be focused on a multidisciplinary systems approach to safety and risk management. Optimizing the safety of EMS transport bridges the expertise of a number of disciplines: Data capture, Intelligent Transportation Systems, Vehicle Biomechanics and Crashworthiness, Occupant Safety and Personal Protective Equipment design, Ergonomics/Human Factors and Biohazards, EMS Practice, Structured safety programs including Scene safety, Public safety and Fleet management policies. These technical fields must all be interwoven with the needs and demands of acute and emergency health care delivery and patient transport. A comprehensive systems engineering approach to bridge these diverse disciplines to enhance the safety of the system as a whole is essential. Some of the key aspects of this approach are discussed in the following sections and outlined in Table 1 below.

Data Capture

In order to determine safety performance and effectively evaluate any safety interventions or initiatives, be they related to the safety of the patient, the provider or the public, it is essential to have reliable and meaningful denominator data describing the system as a whole in addition to numerator data of adverse events.

Identifying the ideal denominator parameters has its challenges – as to which parameters best profile a baseline description of a system. The choice of the optimal denominators is further challenged by what data is available – EMS unit hours utilization, miles traveled, number of runs, number of vehicles, or more loosely per capita population. Unit hours utilization is a most valuable and comprehensive measure – however not readily utilized by all services yet, and does not comprehensively allow for cross service true comparison where there are diverse demographic and transportation congestion issues. As systems such as NEMSIS become implemented broadly – the difficult challenges of denominator data capture will likely become more manageable. An creative method to facilitate capturing reliable denominator data is via systems such as the onboard driver monitoring and feedback systems[40-42], such systems have the additional benefit of not only providing major enhancements in safety performance, but they also provide for enhanced denominator data capture. There remain many open questions with regards data capture – both denominator and numerator data.

Data Capture

- **Vehicles**
  - Total number and type
  - Total number of runs
  - Total number of miles traveled
- **Providers**
  - Total number and type
  - Hours worked
- **Transportation adverse events, including mechanism – both injuries and fatalities**
  - The vehicle, patient, provider, public

Vehicle Biomechanics and Crashworthiness

- **Vehicle**
  - Compact vehicles (i.e., vans)
  - Non-hostile interiors
  - Lock down positions for equipment
  - Seat belts for all occupants
  - Over-shoulder harnesses for all patients on the stretcher

Ergonomics and Biohazards

- **PPE**
  - Head protection
  - Protective Clothing
  - Visibility
  - Biohazard protection
- **Equipment and Vehicle Layout and Design**
  - Equipment interface ergonomics
  - Vehicle interface ergonomics and human factors
  - Vehicle visibility and appropriate warning signals

Transportation Environment

- **Integration with Highway Safety strategies**
  - Partnerships/collaboration andInformation sharing
- **Intelligent Transportation System (ITS) Technologies**
  - Driver/vehicle performance monitoring and feedback devices
  - Collision avoidance vehicle technologies
  - Signal systems
- **Roadside safety design and planning technologies**
  - Vehicle positioning and scene safety issues
  - Hospital ambulance bay access and egress
- **Fleet mix**
  - Rapid response vehicles
  - Vans, Trucks, Motorcycles, other

Safety Management

- **Culture of Safety**
- **EMS Practice and Policy**
  - Tiered dispatch
  - Safe driving policy and practice
  - Driver selection and training
  - Seat belt use policy - for providers, patients and passengers
  - Safety monitoring and feedback
  - Stop at red lights and stop signs
  - Emergency Vehicle Operators Course (EVOC)
  - Secure all equipment
  - Use portable communications
  - Notify driver if rear occupants are in vulnerable positions
- **Fleet Management**
  - Fleet Safety program
  - ANSI/ASSE Z.15

TABLE 1: System safety approach for optimizing EMS transport safety

Figure 1. NEMSIS Data Capture Technical Assistance Center web site (www.nemsis.org)

Regarding vehicle and fleet data, valuable data to capture includes: the number of vehicles used within an EMS system, the unit hours of utilization, miles traveled by each vehicle, number of runs done for each vehicle, vehicle mile life and purchase and maintenance costs. Also a profile of the number of different vehicles of each vehicle type in the system is valuable data in evaluating the merit of different vehicle types for performance and safety. For patient data currently there is limited information accessible regarding the nature and types of patients transported, such as age, size and illness or injury severity distribution, and very limited information on any clinical outcomes for patients. Information on the number of providers who are in the system is essential, their level of training and qualification, age distribution, whether or not they are volunteer or paid staff, how many hours they work or how long have they been working in EMS - are all important fields of information when attempting to ascertain system performance and system safety. Data on members of the public who maybe occupants in the ambulance vehicle, or involved with the EMS transport at the scene of an emergency event, are also important to consider in the overall safety equation.

<u>Transportation adverse events, including mechanism</u>

It is most important to have comprehensive data captured on adverse transportation events, for both injuries as well as any fatalities. There are many challenges relating to how the severity of an adverse transportation event is measured or gauged. What evaluation of vehicle adverse event data is undertaken, what are the fields for which data is captured? What information regarding a patient's condition before and after an adverse event is captured? What safety equipment was being used to protect the occupants? Were the gurneys over the shoulder harnesses on the patient?

Basic information such as was the run an emergency run or not, and was it to or from the scene are difficult to ascertain even for fatalities nationally. Where there injuries to the providers, how did these injuries occur, by what mechanism? What protective or safety equipment was being used at the time? Were any members of the public involved, and were there any injuries, if so what were the mechanisms?

Much of this type of data is already being captured for non-EMS carriers, via the Federal Motor Carrier Safety Administration[11] (see Fig.2), however clearly is not being uniformly collected for EMS vehicles, if it is being collected at all in many states. The recently developed American National Standards Institute/American Society of Safety Engineers Z15.1 Fleet Safety Standard[39] is possibly the only nationally approved safety standard in the USA that is now applicable to the safety management of ground EMS vehicle fleets. It is likely that the implementation of this standard will hopefully provide more emphasis on EMS vehicle safety generally, enhance the data collected regarding EMS vehicle safety, and assist in bringing EMS vehicle safety more inline with state of the art automotive safety practices.

Figure 2. Federal Motor Carrier Safety Administration (FMCSA) website

Vehicle Biomechanics, Crashworthiness and Design and Occupant Safety Devices

There has been a limited amount of peer reviewed automotive safety and crashworthiness engineering testing conducted for the EMS environment[13, 31-35]. The published research has clearly identified some predictable and largely preventable hazards, which pertain to the rear compartment design, layout and vehicle crashworthiness[13, 31-35]. Recent publications have identified the importance of substantive involvement of automotive safety engineering expertise in the crashworthiness and design of ambulance vehicles [1, 31-35, 43, 44] – particularly in the setting currently in the USA where there are essentially no crashworthiness testing requirements.

The rear patient compartment has been demonstrated in both biomechanical and epidemiological studies to be the most dangerous part of the ground ambulance vehicle with regards to vehicle occupants.[24-28, 13, 31-35, 45] While lack of use of seatbelts by EMS personnel is cited frequently in the literature as a predominant cause for the high injury and fatality rates in ground EMS crashes, there are also reports describing serious hazards resulting from the failure to secure equipment in the patient compartment. Examples of such events include unsecured defibrillator/monitors causing a severe traumatic brain injury, and unsecured oxygen cylinders causing serious and fatal head injuries in the event of a collision[46, 47]. These findings are supported by the engineering data from ambulance safety research involving crash tests, [31-35] as well as insurance and litigation records[16].

These studies demonstrate the benefit of use of existing restraints and securing equipment, identifying hazardous surfaces, as well as a need for personal protective equipment such as head protection, protective and high visibility clothing. Lack of use of seatbelts by EMS personnel is cited most frequently in the literature as one of the predominant causes for the high injury and fatality rates for EMS providers, this is supported by the engineering data from ambulance safety research involving crash tests. Similarly, failure to secure equipment in the patient compartment has been found to cause serious injury in the event of a rash or a near collision, however there has been no evaluation of the human factors and ergonomics aspects of this transportation system in the USA. There has been very limited appraisal of EMS safety as part of a transportation system – with no systematic or comprehensive evaluation of the transportation circumstances that were factors in these adverse events.

Unlike other passenger vehicles or even the air medical environment, restraint systems for the rear compartment of ambulance vehicles have essentially no specific design or safety standards to ensure that they perform safely in this unique environment. Access to the patient while seated is a constant challenge, particularly so in the larger EMS trucks. The compact vehicles appear inherently safer by minimizing this problem in their design. For the larger ground transport trucks, the design of a seat which slides toward the patient can offer enhanced access to the patient, while still allowing the medical personnel to remain securely belted in the seat. There are a number of well designed studies identifying the serious hazards of side facing occupants in the setting of high speed frontal crashes [48, 49] and there has been peer reviewed published literature demonstrating the serious hazards of 4 or 5 point harnesses for side facing occupants in these situations[48, 49]. In this current setting of absent biomechanical and crashworthiness safety standards there are features and devices being designed and marketed for the ambulance environment that may well be harmful, based on existing published data. There are some serious concerns regarding the ‘trapeze’ or ‘standing up’ harnesses that are marketed currently. These harnesses are not only potentially dangerous as they encourage the crewmember to leave the safety of being securely belted in the seat, they may even cause more injury in the event of an accident. As there are no safety testing standards for such ‘trapeze’ harnesses, (nor even crash dummies that are designed to be appropriate so as to test them) any claims regarding the ‘safety’ of these devices may be flawed – and in fact such devices may not protect providers from injury in the real world and may even cause harm.

Importantly, consultation with true experts in the field of automotive safety and crashworthiness in the EMS environment, and with a sound understanding of vehicle impact biomechanics and qualified to evaluate the merits of such occupant environments and devices [33-35, 43, 44] is key. There are numerous examples of devices that to the non-engineering expert, appear to be good solutions, when in fact, they maybe worse than current practice. This is in some fashion a new field and attention should be focused on recent peer reviewed scientific papers [33-35, 43, 44 48, 49] and reliance should be on independent and objective evaluations rather than manufacturers claims in this setting of absent safety standards. Safety and design standards are now beginning to be developed [36, 37, 43, 44], and should eventually make this current and somewhat challenging situation less problematic.

Ergonomics and Biohazards

Personal Protective Equipment (PPE) in the EMS environment is usually solely associated with biologic/chemical/radiation hazards. However the data on EMS injuries strongly points to vehicle transport and patient movement (lifting and interaction with stretchers) as a major cause of injury[50]. There exists only one peer reviewed publication on the ergonomics of the EMS work environment [51] and one on the interaction with stretchers [52] and both were only published within the past year.

The issue of head protection devices is an area addressed in the recent literature,[53, 54] and the design and safety standards for head protection is currently being reviewed. Based on research conducted to date[54], a head protection device for ground transport ideally needs to be protective for a range of situations and circumstances, such as providing for head protection, visibility and identification, as well as biohazards protection and also a means of communication.

High visibility clothing, such as is required out side of the USA in EMS, would also optimize the safety of providers at an emergency scene – and should be a routine practice for all providers, and standards for the optimal safety of this apparel should be developed for the environment I the USA. This is particularly important in a setting where one in 5 ground EMS provider transport fatalities resulted from a medic being struck and killed whilst at the scene[30].

The engineering studies have demonstrated the benefit of using existing restraints (lap belts) for all seated occupants, and thus layout of the equipment should be designed to consider this. There are examples of some creative designs to address this with respect to equipment storage in some ambulance fleets in Australia. The issue of the dangers of 4 or 5 point harnesses in side facing seats and additionally the danger of any restraint device that allows the occupant to be out of a seated position, or in any way out of their seat is addressed in the previous section on vehicle crashworthiness. The importance of always using the over the shoulder harnesses for the recumbent patient on the stretcher (with the stretcher back in an upright or 45 degree angle where medically acceptable) is key not only for the safety of the patient, but also for preventing the patient from becoming a projectile and also causing injury to others. At all times all equipment should be firmly secured and in a position where it will not be a hazard to occupants[17-19,26] These studies specifically identify hostile interior surfaces and hazardous head strike zones, poor design and interior layout of the rear compartment, and a non crashworthy rear compartment as well as a need for head protection.[17,18,19] Ensuring non hostile surfaces in predictable 'head strike' zones would likely assist in minimizing inevitable minor or major head injury.

The paper on vehicle interior ergonomics highlights both the importance of ergonomic analysis of this environment[51] and also that it can and should be done. Ironically in many ways the old Cadillac had better ergonomics than a modern large USA EMS vehicle with the box and chassis design, with forward and rear facing seating only, and easy access to equipment and the patient from the seated position.

Transportation Environment

Integration with Highway Safety Strategies

There are a number of areas of potential overlap of the needs of EMS transport safety and the activities of highway and transport safety organizations and infrastructure. The Transportation Research Board (TRB), part of the National Academies, has great breadth and depth of expertise on transportation safety issues – and there are important opportunities for translation of research across to EMS. Much of the research in the truck and bus infrastructure that pertains to safety may have key relevance to EMS transport safety. The 2006 TRB Annual Symposium hosted an EMS Transport Safety session[25], and there is increasing interest from both EMS and the TRB and Highway Safety fields to share ideas and practice approaches. The author is strongly supportive of such initiatives.

Intelligent Transportation Systems (ITS)

While some crashes may not have been preventable, data suggests many fatal and injurious ground ambulance crashes are related to risky driving practice by EMS personnel or risky policies. One paper cites that 80% of the crashes are caused by 20% of the drivers[28, 45]. Failure to stop at intersections has been identified as an extremely high risk practice.[13, 27, 28, 29]. Some of the larger EMS services have clear policies in place requiring ground ambulances to come to a complete stop at a red light or stop sign.

To optimize driver performance and safety and to enhance collision avoidance there are a number of new technologies, pertaining to intelligent vehicle design and other safety technologies. Also, driver feedback "black box" monitoring and feedback technology has been implemented in some regions, and has shown very promising safety enhancements of driving behavior[41, 42]. These devices provide real time immediate feedback and data recording that has shown impressive positive change in driver behavior and performance, specifically in reducing risky driving practice, decreasing the number of collisions, decreased severity of collisions, as well as improving seatbelt use by EMS personnel. In one EMS site in the USA, in Richmond Virginia, has there been any piloting of integrating these devices with other aspects of the transportation system and GIS technologies.

There have been extensive studies that have identified that intersections are responsible for many ambulance crash fatalities and injuries. Collision avoidance vehicle technologies are no longer technologies of some distant future age. As outlined by the author[13] there are increasingly readily available technologies for enhancing vehicle operations safety. These include technologies for keeping the vehicle stable (Enhanced Vehicle Stability technologies), electronic sensing and warning devices[55, 56] for intersections, lane changes, blind spots, rear end collisions and pedestrians to mention a few. Regarding signal pre-emption, as discussed previously by the author[13], although there has been some positive data on signal preemption[56], such studies have not been controlled for other variables – and it is not yet clear if these findings a generalizable or are applicable to congested traffic environments.

Roadside safety design and planning technologies

Effective vehicle positioning and scene safety issues are key in preventing the EMS vehicle or the EMS providers being struck at a rescue or other scene. Additionally it is important that road and highway design allows EMS vehicles to access an emergency scene. Given the need for increased congestion of EMS vehicles around hospital, focused attention to hospital ambulance bay access and egress, so there is minimal congestion of pedestrians or other traffic is also an aspect of optimizing EMS transport safety.

Fleet mix

There is great environmental, geographic and demographic diversity in the USA, and a clear understanding of the optimal vehicle type for each specific environment is important. Much of the safety data globally suggests that for most EMS purposes, a van style of vehicle is optimal. However in some parts of the USA and in congested urban cities around the world, rapid response vehicles such as motorcycles or small sedan vehicles are being used to bring advanced EMS responders and their equipment to the scene promptly, as the patient transport vehicle navigates the congested urban roads to follow. Rough terrain, extreme heat and cold, longer transports in rural areas are some of the aspects that warrant consideration in fleet mix determinations.

Safety Management

It is key that EMS safety practice and oversight should address patient and provider safety, as well as public safety. Developing a culture of safety is an approach being adopted by a number of EMS Services and regions around the USA.

Somewhat hampered by the reality that EMS services are essentially overseen by medical directors and not transport directors, identifying the optimal transportation safety practice and policy does have some real challenges. However, what does make addressing safety more easily manageable for EMS than in many other fleet workforces – is that practice and policy are well structured in EMS essentially from clinical care perspectives. There are also excellent models to learn from in related aspects of EMS and emergency services. Personnel and patient and public safety awareness and practice is a model that is well understood and applied in air medical environment – an environment of very structured safety practice and safety policy. It is somewhat of an irony that the stringent safety precautions, monitoring and oversight that are so accepted to be an essential part of air EMS, are not currently so readily translated to the ground EMS transport environment even by the very same program its medical directors and even the same personnel. EMS providers are a unique workforce and a fundamentally highly responsible cohort of individuals who are committed to protecting, supporting and assisting society and its well being and also who are accustomed to being routinely closely monitored for clinical performance. They are also accustomed to following highly structured policy and procedure, particularly in reference to delivery of medical care. They expect close supervision and scrutiny. It would appear that this should also extend seamlessly into the realm of vehicle operations and safety.

Identifying best safety practice with respect to vehicle safety has been a challenge for the EMS industry[13]. There have been longstanding exemptions for ambulance vehicles from the Federal Motor Vehicle Safety Standards[57]. This is true, even in the face of the National Transportation Safety Board (NTSB) making recommendations to the contrary[57], as far back as in 1979. However there is now enough data available in the peer-reviewed literature to address the important elements of a data driven safety culture and practice policies[13, 59].

Tiered Dispatch, effectively can minimize unnecessary use of potentially dangerous lights and sirens transport mode, and is being used routinely in many sites across the USA and globally. Policies for safe driving practice are being implemented – with a focus on intersection safety, safety performance measured with the use of driver monitoring and feedback technologies. Seat belt policies are being developed in an increasing number of services in addition to the initiative by the National Association of EMTs (NAEMT) in 2006 to advise seat belt use for all occupants, providers, patients and passengers. Implementing policies that support the securing of all equipment and the use of portable communication devices are important – so that there are no lethal projectiles of unsecured equipment and that an EMS provider does not have to stand up in a moving vehicle to reach a communication device. And a policy, similar to that used in aviation EMS, to notify driver if rear occupants are in vulnerable positions, so that overall risk can be minimized by safer driving practice.

Driver selection, specifically, has also been identified as an area for enhancing safety. Noted to be at higher risk for adverse vehicle operations events are younger driver and drivers with previous driving offences.

To optimize driver performance and fleet safety there are also a number of driver training courses available. The Emergency Vehicle Operators Course (EVOC), is an example of a nationally recognized program, a result of the 1979 NTSB[58] recommendations, that is an expert panel derived risk and safety awareness driver training program. EVOC is not mandated across the USA. There is a spectrum of EMS driver training approaches internationally – with fulltime driver training courses over many weeks and special licensure in some Scandinavian countries, to no requirement in many regions in the USA. There are some EMS driver training programs additionally using simulators to enhance driver training, and evaluations of the effectiveness and cost effectiveness of these technologies are underway.

Until the American Society of Safety Engineers and American National Standards Institute fleet vehicle standard ANSI/ASSE Z.15 standard[39] there has been limited guidance nationally for general EMS fleet vehicle and driver performance safety management and there was no national standard in the USA specifically for fleet management that encompassed EMS fleets. The ANSI/ASSE Z 15.1 fleet management standard is a major advance and provides a comprehensive template for the safety oversight and safety management of a fleet of vehicles. This is a most valuable adjunct in addition to EMS specific safe practices such as safe driving practice, coming to a full stop at red lights, stop signs, and requiring EVOC training.

The national EMS associations and accreditation organizations, the Committee on the Accreditation of Ambulance Services (CAAS) and the Committee on the Accreditation of Medical Transport Systems (CAMTS) provide guidance and certification for the management of an ambulance service. The guidelines for these organizations cover the broad scope of what is involved in managing an ambulance service and they strongly advance awareness for ambulance vehicle safety issues. Initiatives such as the AAMS 'Vision Zero' initiative, for enhancing transport safety, are major contributions to progress in EMS transport safety.

In Australasia and Europe there exist specific ambulance vehicle safety standards: The AS/NZS 4535:1999 in Australasia[36], and the EN 1789:2002[37] in Europe. Both are true safety performance standards and specifically address the design, restraint system integrity, safety performance testing, dynamic crash testing and safety features of ambulance vehicles. The only guidelines in the US specifically addressing ambulance vehicles are the KKK specifications, which are Federal purchase specifications for a General Services Administration (GSA) Star of Life ambulance[38]. These are purchase specifications, not safety performance standards. These purchase specifications do not address crashworthiness issues or any dynamic crash or impact performance testing – nor do they address equipment or occupant restraint safety or performance, in contrast to the international standards. There is also the Do's and Dont's guideline for the transport of children in ambulances[60], but these do not address vehicle design or safety performance Rather, they are practical guidelines to optimize the safety of transporting pediatric patients in ambulances. Improving specific policies (dispatch policies, shift length, safety oversight) and interaction with other road users ('wake effect' and high density EMS traffic and hospital access road design) – are more likely to benefit EMS system wide.

Accessing EMS Safety Information

In addition to the challenges of capturing reliable numerator and denominator data on ambulance transport safety, one of the true obstacles to optimizing ground ambulance transport safety is accessing technical safety information that is reliable and objective. This is a complex and very multidisciplinary field, where much of the relevant technical information and peer reviewed literature is in the engineering, safety and other non-EMS literature[16]. This makes it very difficult for EMS decision makers medical directors to keep abreast of current developments addressing ground ambulance vehicle safety.

To address this in part, publications and presentations relating to ground transport safety at scientific meetings are helpful. It is important that the sources represented are of information that is objective and data based in the appropriate safety disciplines. Specific Safety Summits, such as those established within the air medical discipline [61] and Fire Service [12] are major steps forward. Modeling initiatives such as this for ground transport, with representation from the different disciplines and infrastructure relating to ground transport safety (such as epidemiology, engineering and automotive safety and crashworthiness) would be an important and valuable approach. A regular biennial or twice decade summit to bring together ambulance transport safety expertise could provide for those involved in fleet management an opportunity to hear the latest in safety practice and management developments. This will also provide an environment which facilitates the translation of the safety practices in transport safety to EMS transport. Also, use of objective web based resources, such as the information portal recently established by the author, can assist in facilitating access to current practical and technical information.

Summary

In contrast to the safety culture and the comprehensive federal safety oversight of the bus and truck industry, the comprehensive multidisciplinary focus on enhancing Fire service safety and also air ambulance transport safety, ground ambulance transport safety focus and oversight is lacking in both safety standards and safety data and oversight. There is a need for a systems engineering approach to bridge the diverse disciplines that are part of the EMS transport environment and to address the risks and hazards involved in ground transport, and have the knowledge and resources to minimize these hazards and optimize safety both with design and practice aspects and also policy.

A prime deficiency is the lack of meaningful national data on transportation systems safety in EMS. Hopefully as the NEMSIS data base becomes implemented there will be some valuable data captured to address safety. In the absence of reliable either denominator or numerator data it is very challenging to effectively evaluate safety interventions. There are some relatively simple solutions that are available now to address technology, practice and policy as well as optimized design.

Use of technologies such as the onboard computerized monitoring and feedback devices to optimize safe driving and vehicle handling has been demonstrated to be highly effective. Implementation of a comprehensive safety program and basic policies such as those that ensure optimal use of seat belts, safe driving practice, strict intersection safety policies and policies that ensure that all equipment is secured – are key and cost effective enhancements to safety performance. In addition to these safety initiatives, use of personal protective equipment such as and high visibility clothing and also head protective devices should be implemented. The new ANSI/ASSE Z.15 standard is a valuable tool in designing and maintaining a safety program, culture and safety oversight for the ground vehicle component for a patient transport system. Additionally, recently published papers by the author address the pressing need for crashworthiness analyses and standards [13, 43, 44].

The findings of limited research conducted to date suggest EMS transportation safety is in need of urgent focus and has been left behind commercial truck and bus safety and other areas of emergency service transport safety. EMS transport safety is a unique gap in the standards, oversight and coordination of the transport system. A synthesis of the research conducted to date that applies to or could be applied to this field has potential for substantively enhancing EMS transport safety – as does following the model of the Fire Service with a "Safety Summit" for enhancing the safety of EMS for the patient, the provider and the public.

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