Emergency Medical Service (EMS) Transport Safety: Where is the state of the art, and where SHOULD it be?

Nadine Levick, MD MPH
CEO, Research Director
EMS Safety Foundation
Objective Safety LLC

Introduction
Emergency Medical Services – (EMS)
- Important interface between public health, public safety and emergency and acute care and the community
- Unique challenges - patient, provider and public safety and transportation safety
- Unique needs of this important part of our health care and transportation system

Some odd facts
- Ambulances are generally not built by the automotive industry
- Intelligent Transportation Systems (ITS), transportation safety engineering and transport systems engineering are not generally integrated into EMS systems
- Although all EMS systems have medical direction and oversight, it is rare for there to be transportation expertise oversight

What happened??
- Why is it that Emergency Medical Services have developed outside the umbrella of transportation safety infrastructure??

A very serious gap in data, performance and oversight
- FMCSA Truck safety goals – to decrease the fatality rate of 2.8 per 100 million truck-miles in 1996 to 1.65 by 2008
- EMS crash fatality estimates are - 7.66 - 41.93 fatalities per 100 million ambulance-miles

Scope
- Safety data on EMS transport and its oversight
- EMS vehicle crash rates are in excess of similar sized vehicles
- EMS worker transport fatality rates are above other emergency services
- Is a part of the transportation system that is largely exempt from most of the Federal Motor Vehicle Safety Standards (FMVSS), and not covered by other national transportation system safety oversight (ie. FMCSA)
- 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.

What are the solutions?
- Training?
- Practice Policy?
- Transportation Systems Engineering?
- Automotive Engineering?
- Education of other road users???

EMS
- Emergency Medical Services (EMS) - an important and unique aspect of the transportation system, it encompasses public safety, public health and an emergency service.
- What are the system wide transportation safety issues and challenges faced by the Emergency Medical Services?
Transport related aspects of EMS
- dispatch of EMS vehicles
- transport policies and protocols
- vehicle fleets and vehicle design
- vehicle purchase standards
- Intelligent Transportation Systems technology
- driver training
- training simulation
- roadside and road design
- integrated traffic safety technologies
- scene safety and visibility
- safety data capture
- safety oversight

USA EMS
- EMS Systems - ~15,000
  (~30% F/T professional & 70% volunteer)
- Personnel - ~1 million
- Vehicles - ~50,000
  (Type I, Type II, Type III, Freightliners, motorcycles)
- Transports - ~50 million
  (to Emergency Depts - 50%, < 1/3 emergent)
- Cost - ~$8 Billion annually
- Safety Oversight - ? Disparate

Transport oversight?
- In contrast to the bus and truck industries, which have comprehensive safety oversight, and transportation safety interventions, as well as transportation safety data capture via the Federal Motor Carrier Safety Administration (FMCSA), EMS has been focused more as an acute health care delivery and emergency service and largely outside of much of the other transportation oversight infrastructure that exists.
- This is an opportunity for transportation planners, engineers, and system operators to see a comprehensive overview some of the multidisciplinary transportation challenges faced by Emergency Medical Services.

EMS Definition
- An Emergency Medical Services system is —
  - A coordinated arrangement of resources (including people, equipment, and facilities) which are organized to respond to medical emergencies, regardless of cause. (ASTM, 1988).
- EMS —
  - The services provided to accident victims and patients suffering from severe acute illness and psychiatric emergencies.
  - Detection and reporting of medical emergencies, medical transportation and care for patients en route to health care facilities, medical treatment for the acutely ill and severely injured within emergency departments, and the provision of linkages to supplemental care or administrative services. (EMS Research Agenda 2001)

What is the scope of EMS?
- Emergency care, public health, public safety and patient transport
- Bridge between the community and the hospital
- Volunteer – professional
- Urban – rural
- Disaster response
- Majority of transports NOT critical or life threatening

The ‘workplace’ is also a crash scene

Today’s news
Caught On Video: EMT Struck By Car

USA EMS System Finance
- Annual Cost: $27 per capita
- > $8 billion per year
- Need to provide the biggest bang for the buck

Emergency Medical Service (EMS) vehicles - Ambulances
- What are the transport safety issues that pertain to this important public service and public safety industry?
- What do we know of the risks and hazards and how can we measure these?
- How can the safety of this transport system be optimized?
What’s missing

1. What data is collected nationally?
   - We have no denominator data
   - We have incomplete numerator data
2. Absent population-based national injury data or injury mechanics data
3. Absent structured transportation safety engineering input
4. What oversight is there?
5. Which organizations would determine policy?

**History of EMS**

- EMS is a relatively new industry
- An unusual history of beginnings within the mortician industry.
  - Early ambulances were hearses, once motorized usually a Cadillac, a vehicle in which an occupant could be transported in the recumbent position.
- Over the past 100 years, the sophistication of EMS medical care has advanced dramatically
- EMS communications and transportation technology have not kept up with that pace

**A devastating tragedy…**

- An ETT down the wrong hole may kill your patient and be a terrible burden for the pts family and for the medic involved
- BUT an EMS crash can kill all involved AND wipe out an EMS systems response capacity…

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**General Concerns**

- Consequences can be predictable & likely preventable
- Costs of these adverse events are high in loss of life, financial burden and negative impact on delivery of EMS care
- Other high speed vehicles (eg. racing cars) have a different safety paradigm
- Design of interventions to mitigate injury is predicated on a valid testing model
- Complex both engineering and public health issues

**Goals**

- Standards for safety
- Policy based on Science
- Databases to demonstrate outcome

**Balance of concerns and risk during transport**

- Response and transport time
- Clinical care provision
- Occupant safety/protection
- Public Safety

**Firstly!**

- An accident?
- or a predictable and preventable event

**This IS a transportation safety issue**

- Systems engineering
  - Where do ambulance crashes occur?
  - What transportation safety engineering interventions
  - ITS –
  - Does opticom work effectively in this environment given the traffic density and emergency vehicle density?
  - Mans of emergency vehicles being fitted with early warning technologies
  - Proper design of emergency vehicle traffic flow
  - Fleet mix to match anticipated transport environmental challenges (ie police model – bicycle, motorcycle, horse, three-wheeled, cruiser, van, truck)?

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the EMS transport process
- communications/dispatch
- the patient
- restraining device/seat
- transporting device/gurney
- paramedics/transport nurses, doctors & family
- patient monitoring equipment
- clinical care & interventions
- protective equipment
- the vehicle
- the driver/driving skill
- other road users
- the road

Challenges to Optimizing EMS Transport Safety
- Disparate and fragmented safety infrastructure
- Lack of a centralized EMS Safety oversight or data
- A large number of small groups of end users, with a mix of volunteers and professionals
- Ambulances are hybrid non-standard vehicles, a truck chassis and an after market box or a modified van
- EMS vehicle safety is not integrated as a part of the transport safety industry

Challenges to Optimizing EMS Transport Safety
- Rear compartment exempt from FMVSS
- Complex automotive safety area bridging acute clinical care, public health, public safety and automotive safety
- Very recent history as a research issue
- Limited fiscal support for cross disciplinary EMS transport safety research

Benefit of Safety
- Any cost of addressing these issues is dwarfed in contrast to the huge burden of not doing so - in financial costs let alone the personal, societal, ethical and litigation costs

EMS Transport Safety IS Complex AND Multidisciplinary
- Epidemiological Data Collection
- Clinical Research
- Ergonomic Research
- Biomechanical Research
- Automotive Safety
- EMS Practice
- Regulations & Standards
- Fleet Safety Program
- Risk Management
- Public Safety
- EMS Policy

Is it your services tragic year?
- ~ 50 fatalities a year
- 15,000 EMS services
- Each year one in 300 services experiences a fatality

This is not acceptable
In the USA*
- ~ 5,000 crashes a year
- ~ One fatality each week
- ~ 2/3 pedestrians or occupants of other car
- ~ 10 serious injuries each day
- Cost estimates > $500 million annually
- USA crash fatality rate/capita 35x higher than in Australia

Is there an acceptable rate of morbidity and mortality for pre-hospital transport systems??

Paramedic charged in crash that killed 2

*FARS/BTS 2004-5

Morsel Society: 2/3 of pedestrians, 2/3 of vehicle occupants

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*FARS/BTS 2004-5
Key Issues

- Mythology
  - That Emergency Medical Service personnel are safe
- Injury Hazards
  - Radiation
  - Chemical/Radiation
  - Physical/Mechanical trauma - THE BIG PROBLEM
- Motor Vehicle Crashes are the highest cause of death at work - EMS has > 2X the mean national rate
- An R & D and Regulatory Gap
  - Occupational Health and Safety
  - Automotive Safety
    - "exempt" from automotive research and regulation

911 Call to Hospital/ED Definitive Care Time Intervals*

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Occurs</td>
<td></td>
</tr>
<tr>
<td>911 Contacted</td>
<td></td>
</tr>
<tr>
<td>EMS Vehicle Dispatched</td>
<td></td>
</tr>
<tr>
<td>EMS Arrives on Scene</td>
<td></td>
</tr>
<tr>
<td>EMS Leaves Scene</td>
<td></td>
</tr>
<tr>
<td>EMS Arrives at ED</td>
<td></td>
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<tr>
<td>Hospital/ED Definitive Care</td>
<td></td>
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*Not drawn to scale

A Simple Question....

Active Projects

- Commercial Motor Vehicle Driver Training Curricula and Delivery Methods and Their Effectiveness
- Commercial Motor Vehicle Carrier Safety Management Certification
- The Role of Safety Culture in Preventing Commercial Vehicle Crashes
- The Impact of Behavior-Based Safety Techniques on Commercial Motor Vehicle Drivers
- Health and Wellness Programs for Commercial Motor Vehicle Drivers

What about FMCSA’s Mission

- Office of Research and Analysis is committed to reducing the large truck-related fatality rate from 2.8 per 100 million truck-miles in 1996 to 1.53 by 2008.

Mission

- The mission of FMCSA’s Office of Research and Analysis is to reduce the number and severity of commercial motor vehicle (CMV) crashes and enhance the efficiency of CMV operations by:
  - Conducting systematic studies directed toward fuller scientific discovery, knowledge, or understanding
  - Adapting, testing, and deploying innovative driver, carrier, vehicle, and roadside best practices and technologies
  - By expanding the knowledge and portfolio of deployable technology, the research and technology program will help FMCSA reduce crashes, injuries, and fatalities and deliver a program that contributes to a safe and secure commercial transportation system.

FMCSA’s Objectives

- Produce Safer Drivers:
- Produce Safer Carriers:
- Advance Safety Through Information-Based Initiatives:
- Improve Security Through Safety Initiatives:
- Enable and Motivate Internal Excellence:
What type of passenger carrier do you need?

Credit: USA Ambulances: FMVSS Exempt

Very Predictable...

Intersections are lethal environments

"Are our policies killing people?"

1991-2000, 302,969 Emergency vehicles were involved in MVCs - 1,565 involving fatalities*

In PA 1997-2001, ambulances were more likely than similar sized vehicles to be involved in:

- 4 way intersection crashes (43% vs 23%, p<0.001)
- Collisions at traffic signals (37% vs 18%, p<0.001)
- MVCs with more people injured (76% vs 61%, p<0.001)

*Comparison of Crashes Involving Ambulances with those of similar sized vehicles – Adam Ray, Douglas Kupas, PEC Dec 2005; 9:412-415

The real world for an EMS vehicle approaching a red light

- You think they heard you...
- You know they must have seen you...
- And maybe they did
- ..... But...
- There is NO way humanly possible that they could stop.....

The real world

Intersection passenger car stopping distance* at 40 mph dry and wet

A peer reviewed tragedy

Persistent disconnect between automotive safety science and EMS transport safety approach

Pre-hospital and Emergency Care 2004

"EMS vehicle drivers are advised to approach the intersection, slowing to ensure that traffic has stopped and making eye contact with other drivers before entering the intersection.

In the modern era of road safety to suggest that a strategy of "eye contact" to be made at an intersection with a driver traveling at ~40mph in the hope that this would result in a safety intervention, is at best frightening"
Increasing awareness ...

Some challenges

- No accepted national safety standards for -
  - EMS fleet management or safety practice
  - Ambulance vehicle rear compartment design and performance
  - Provider occupational injury protective equipment
  - Yet convincing data for injury risk and hazard
  - Need for patient, provider and public safety focus

An important and unique system

- Public safety, public health and emergency service
- Is there to save lives
- A more recent service compared to Fire and Police
Best Practice…..? The technology described in your junk mail is far more advanced than that used in EMS.

Data
- What national statistics are there for EMS transport safety
- What is known about 'wake effect'

Ambulance Safety Research: A New Field
- Engineering
- Ergonomics
- Epidemiology
- Non Issue
- Safe
- Safer

We should use the best safety practices demonstrated in engineering.

So for EMS personnel...
- What's going to kill you?
- What's going to injure you?

EMS Research /Data Vacuum
- ? total no. of ambulances
- ? total no. of medics
- ? total no. of runs (per age & severity)
- ? total pt. miles (per age & severity)
- ? true crash fatality rate per mile
- ? crash injury rate
- ? adverse events

Predictable risks
- More often at intersections, & with another vehicle (p < 0.001)
- Most serious & fatal injuries occurred in rear (OR 2.7 vs front) & to improperly restrained occupants (OR 2.2 vs restrained)
- 82% of fatally injured EMS rear occupants unrestrained
- > 74% of EMT occupational fatalities are MVC related
- Serious head injury in 60% of fatal occupant injury
- 70% of fatal crashes EMS crashes during Emergency Use
- More likely to crash at an intersection with traffic lights (37% vs 19% p<0.001) & more people & injuries/crash than similar sized vehicles

- Becker, Zaloshnja, Levick, Li, Miller, Acc Anal Prev 2003
- NIOSH, 2003
- Ray AM, Kupas DF, Prehosp Emerg Care 2005 Dec; 9:412-415
- NHTSA, 49 CFR Parts 571, 572 & 589 Docket no. 92-28; notice 7
EMS Provider Fatalities

- 12.7 fatalities/100,000 EMS workers
- Greater than 2 x the national average (5.0 fatalities/100,000)
- Similar to Police (14.2/100,000) and Fire Fighters (16.5/100,000)

and what is killing EMS?

EMS personnel fatalities*

- 74% transportation related
  - 1/5 of ground transport fatalities were struck by moving vehicles
  - 11% were cardiovascular
  - 9% were homicide
  - 4% needle sticks, electrocution, drowning and other

So does it make sense?

- Gloves and universal precautions?...
  - ... good biohazard protection but aren’t going to give much protection in an ambulance crash

A word about occupational transportation fatalities..

Fleet Mix?

Full Vehicle Crash Tests

- Test 1 – Right side impact
- Test 2 – Frontal

Air EMS is a role model for safety initiatives and focus
Safety Management

- A Safety Culture
- Protective Policies
- Protective Devices
  - In the event of a crash
  - To prevent a crash
- Continuous Education and Evaluation

Protective devices/concepts

To prevent a crash
- Driver feedback
- Driver monitoring
- Driver training
- Vehicle Intelligent Transportation System (ITS) technologies
- Tiered dispatch
- Appropriate policies

In the event of a crash
- Vehicle crashworthiness
- Seat/seat belt systems
- Equipment lock-downs
- Pedaling
- Head protection

Tiered Dispatch

Back up Camera... Shouldn't all vehicles have one of these?

The "Black Box"

- Driver behavior monitoring and feedback device
- Purpose of 'Black Box' Program
  - Enhance Safety
  - Improve Driver Performance
  - Save Maintenance Dollars
  - Aid Accident / Incident Investigation

Other monitoring devices

- Primarily to record events during and immediately preceding a crash
- Give no driver crash prevention feedback
- Administratively burdensome
- Intrusive
- Not demonstrated to be as effective in improving vehicle maintenance costs or as effective in modifying driver behavior long term

Data, but is it generalizable
EMS is emerging in the transport safety arena

- First and only presentation of ambulance safety research at ESV Congress was 2001
- SAE Toptec on Military and Emergency Vehicles, USA, September 2001
- Emergency Vehicle Symposium, Australia, Melbourne, May 2003
- Sporadic Ambulance safety research presented at peer reviewed AAAM, ITMA, SAEM, Safe America, World Injury, Asia Pacific Injury Conferences 1999-2005
- Next week at inaugural meeting at 2007 TRB Congress in DC

Global EMS Vehicle Safety Standards v Specifications and Guidelines

- EMS Safety and Performance Standards
  - Australia & New Zealand 4535
  - Common European Community (CEN) EN1789
  - Non EMS Specific USA Standards
  - (Aviation - FAA/CAA/JAA)
- 215 - Fleet vehicles safety management
- USA EMS Specification & Guidelines
  - Purchase Specification: KKK & NTEA – AMD
  - Guideline: EMSC Dos and Donts
  - ASTM, CAAS and CAMFS

USA ambulance purchase specifications

- Static Pull test
- 2200 Lbs. (8G's) in Longitudinal and Lateral
- No dynamic test
- No definition to manikin mass
- No restraint for equipment
- Voluntary

American National Standard
ANSI/ASSE Z15.1-2006
Safe Practices for Fleet Motor Vehicle Operations

- What Z15 encompasses
  - Safety Program
  - Safety Policy
  - Responsibilities and Accountabilities
  - Driver Recruitment, Selection and Assessment
  - Organizational Safety Rules
  - Orientation and Training
  - Reporting Rates and Major Incidents to Executives
  - Oversight

Healthcare Safety

- Importance of safety as an organizational value
- Proactive approaches to safety management and leadership
- Prevention of accidents, injuries
- Presents authoritative data from OSHA, EPA, NFPA, NRC, and JCAHO
- 7 EMS Transport Safety? – Not a mention

EMS Risk/Hazards

- Predictable risks
- Predictable fatal injuries
- Serious occupational hazard
- Public safety hazards

What’s new

- New automotive safety technologies
  - ZF
  - TRB
  - Monitoring and feedback enhancements
- New expertise
  - TRB
  - ASSE
  - UTRC
  - Ergonomics
  - Industrial Design

Regional University Transportation Research Centers
FDNY a leader in safety

Future
- Meaningful Goals
- New policies
- New practices
- New standards
- New vehicles
- New technologies

Very Important Principle
Ambulance transport safety is part of a SYSTEM, the overall balance of risk involves the safety of all occupants and the public

Conclusion
- Major advances in EMS safety research, infrastructure and practice over the past 5 years
- New technologies for vehicle design, occupant PPE and equipment restraint and driver performance are now available
- Development of substantive EMS transport safety standards is a necessity and a reality
- Enhanced cross disciplinary collaboration in development of safety initiatives now exist
- EMS is still way behind the state of the art in transport and vehicle safety and occupant protection

And....
- It is no longer acceptable for EMS to be functioning outside of transportation, automotive and PPE safety standards for prevention of and protection of EMS providers and the public from injury and death

Any Questions??
Electronic handout available online
http://www.objectivesafety.net