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Ambulance Safety Issues: Hazard Analysis and Crashworthiness, Where is the State of the Art?

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Outline

- Overview of the known hazards
- Tools that can be applied to evaluating these safety issues
- Current safety challenges
- Some of the multidisciplinary techniques for optimizing the safety of the system as a whole.

Key Issues

- Mythology
  - That Emergency Medical Service personnel are safe
- Injury Hazards
  - Biohazard
  - 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
    - the workplace is in a vehicle – exposure data are scant
  - Automotive Safety
    - a vehicle is the work place – 'exempt' from automotive research and regulation

Safety oversight of what and by …. whom

- Vehicle Safety
- Vehicle Design
- Safety Equipment Design
- Vehicle and Safety Equipment Testing and Standard development
- Safety policies

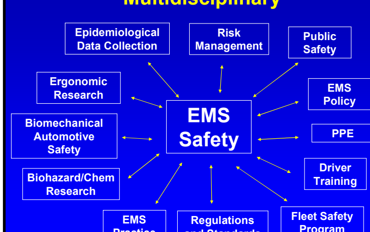
http://www.objectivesafety.net

the EMS 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

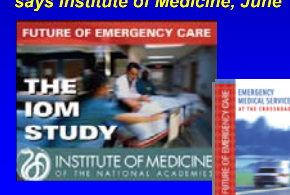
TIME & PLACE

EMS Safety IS Complex AND Multidisciplinary



"Nation's Emergency Care System is fragmented, unable to respond to disasters",

says Institute of Medicine, June 14, 2006



Approach to hazard analysis and optimizing safety

- Unique nature of EMS, it bridges –
  - Public health
  - Public safety
  - Emergency medical care
  - Automotive and transportation safety
  - System safety engineering
  - Occupational health and safety
  - Risk management, liability
- It is paramount that the safety of this system be addressed with a comprehensive multidisciplinary approach.

C45 - A criminal offence to not act in a way that protects the worker

How does an organization become a party to a crime of negligence?

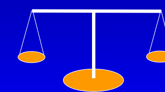
In offences based on negligence, the court must determine whether an individual acted so carelessly or with such reckless disregard for the safety of others as to deserve criminal punishment.

In general, for an organization to be found guilty of committing a crime of negligence, the Crown will have to show that employees of the organization committed the act and that a senior officer should have taken reasonable steps to prevent them from doing so. However, the complicated structure of organizations requires that this relatively straightforward idea be expressed in legal language that covers the many different ways that an organization acts.

With respect to the physical element of the crime, Bill C-45 (proposed s. 22.1 of the Criminal Code) provides that an organization is responsible for the negligent acts or omissions of its representative. The Bill provides that the conduct of two or more representatives can be combined to constitute the offence. It is not therefore necessary that a single representative commit the entire act.

http://canada.justice.gc.ca/en/dept/pub/c45/section03.html

Balance of concerns and risk during transport



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

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

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

This is not acceptable

In the USA*
- ~ 5,000 crashes a year
- ~ One fatality each week
  - ~ 2/3 pedestrians or occupants of other car
  - Approximately 4 child fatalities per year
- ~10 serious injuries each day
- Cost estimates > $500 million annually
- USA crash fatality rate/capita 35x higher than in Australia

*FARS/BTS 2004-5

Firstly!

- An accident ?
- or

a predictable and preventable event

We should use the best safety practices demonstrated

Development of an Effective Ambulance Patient Restraint

Development and Application of a Dynamic Testing Procedure for Ambulance Paediatric Patient Restraint Systems

2001-01-1173

Biomechanics of the patient compartment of ambulance vehicles under crash conditions: testing countermeasures to mitigate injury

Reviewing ambulance design for clinical efficiency and paramedic safety

Ambulance Safety Research: A New Field

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)

** Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency Medical Services: A Hidden Crisis, Annals of Emergency Medicine, Dec 2002*

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

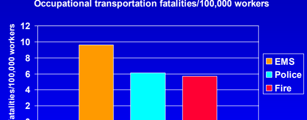
** Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency Medical Services: A Hidden Crisis, Annals of Emergency Medicine, Dec 2002*

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 2.5 vs restrained)*
- 82% of fatally injured EMS rear occupants unrestrained**
- > 74% of EMT occupational fatalities are MVC related***
- Serious head injury in >65% of fatal occupant injuries#
- 70% of fatal crashes EMS crashes during Emergency Use#
- More likely to crash at an intersection with traffic lights (37% vs 18% $p=0.001$) & more people & injuries/crash than similar sized vehicles##

**Kahn CA, Pirrallo RG, Kuhn EM, Prehosp Emerg Care 2001 Jul-Sep;5(3):261-9*
***Becker, Zaloshnja, Levick, Li, Miller, Acc Anal Prev 2003*
****Maguire, Hunting, Smith, Levick, Annals Emerg Med Dec 2002*
#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

A word about occupational transportation fatalities..



- WE HAVE A BIG PROBLEM HERE

** Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency Medical Services: A Hidden Crisis, Annals of Emergency Medicine, Dec 2002*

EMS Injuries*

- Higher than the injury rate for any private industry published by DOL
- 34.6 injuries/100 fulltime workers per year
- 1.5 x that of fire fighters
- 5.8 x that of health services personnel
- 7 x the national average

** Maguire, Hunting, Guidotti & Smith, Occupational Injuries among Emergency Medical Services Personnel, Prehospitial and Emergency Care Oct/Dec 2005*

Haddon/Baker/Runyan Phase-Factor Matrix

FACTOR / PHASE	Paramedic/ patient (host)	Vehicle (agent)	Environment (physical/regulatory)	Sociocultural
pre crash (pre event)	driving history, driver education, speeding, abiding road laws	collision avoidance, anti lock brakes, vehicle weight, speed	tiered dispatch, EVOC implemented, road design, markings & surface	EMS image (scoop & run), public/paramedic awareness, disorientation from L & S
crash (event)	seat belt, restraint use, child safety seat use	air bags restraint design bumper & crumple zone design	collision speed, road side hardware	it can and does happen
post crash (post event)	gender, severity, age, underlying morbidity	ease of extrication, burn resistant fabrics	EMS system,quality trauma care, traffic management system	rehabilitation, documentation and data collection

- Effectiveness
- Cost benefit
- Ethics
- Social acceptability
- Societal need

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

Goals

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

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

Background: USA Problems

- No reporting system or database specifically for identifying ambulance crash related injury
- Rear passenger compartment, > 60cm behind driver - exempt from Federal Motor Vehicle Safety Standards (FMVSS)

USA Ambulances: FMVSS Exempt

DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration

49 CFR Parts 571, 572, and 589
[Docket No. 92-28; Notice 7]
[RIN No. 2127-AB85]

Federal Motor Vehicle Safety Standards;
Head Impact Protection

S6.3 A vehicle need not meet the requirements of S6.1 through S6.2 for:

(a) Any target located on a convertible roof frame or a convertible roof linkage mechanism.

(b) Any target located rearward of a vertical plane 600 mm behind the seating reference point of the rearmost designated seating position.

(c) Any target located rearward of a vertical plane 600 mm behind the seating reference point of the driver's seating position in an ambulance or a motor home.

(d) Any target in a walk-in van-type vehicles.

"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*

Daily American Republic

Ambulance driver in fatal crash is charged

KENNETT, Mo. (AP) -- An ambulance driver from the Missouri Bootheel was charged Friday with two counts of involuntary manslaughter for an accident that killed a patient in the ambulance and the driver of the other vehicle.

The accident happened Sunday on Missouri 164 near Kennett in Dunklin County.

Patrick White, 23, of Poplar Bluff, was driving an ambulance for Poplar Bluff Regional Medical Center. The Missouri State Highway Patrol said White failed to stop at a stop sign and struck a 1992 Buick driven by Dorothy Worrell, 64, of Hornersville.

The ambulance's siren and emergency lights were not on, the patrol report said.

Worrell and a patient in the ambulance, William Braden, 66, of Wappapello, were killed.

White suffered minor injuries. His co-worker in the ambulance, James Simpson, 43, of Pocahontas, Ark., was taken to a hospital in Memphis, Tenn., with serious injuries.

Bond for White was set at $10,000.

Crash Prevention

- EVOC
- Tiered Dispatch
- The "Black Box"
- Intelligent vehicle design
- Appropriate policy

What do we know now??

- Intersection crashes are the most lethal
- There are documented hazards, some which can be avoided
- Occupant and equipment restraint with standard belts is effective. (Over the shoulder harnesses for patients should be used, with the gurney in the upright position where medically feasible)
- Some vehicle design features are beneficial - automotive grade padding in head strike areas, seats that can slide toward the patient
- Electronic Driver monitoring/feedback systems appear to be highly effective
- Head protection??

A number of potential interventions to enhance safety have been identified:

- Safety Policy
- Safety performance standards
- Vehicle crashworthiness
- Vehicle interior ergonomics
- Personal Protective Equipment design
- Driver training and simulation
- Safety and risk awareness modification
- Risk behavior modification
- Intelligent Transportation Systems (ITS)

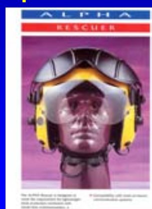
The 'workplace' IS a vehicle

- Providers often in vulnerable positions during transport.
  - Bench seat
  - Captains chair
  - Standing or kneeling

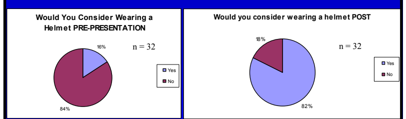
View of Ambulance interior from Rear

It does happen….

But what about head protection?



Preliminary Study:
Attitudes to Head Protection in EMS



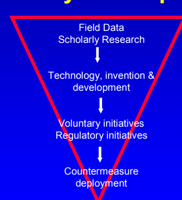
Automotive Safety World

Protective devices/concepts

To prevent a crash
- Driver feedback
- Driver monitoring
- Driver training
- Vehicle ITS technologies
- Tiered dispatch
- Appropriate policies

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

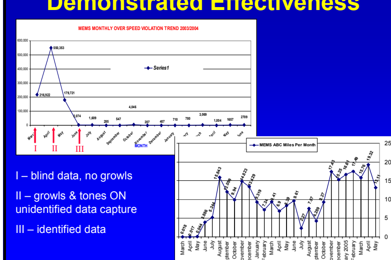
Automotive Injury Triangle and Safety Development



Purpose of 'Black box' Program

- Enhance Safety
- Improve Driver Performance
- Save Maintenance Dollars
- Aid Accident / Incident Investigation

Demonstrated Effectiveness



I – blind data, no growls

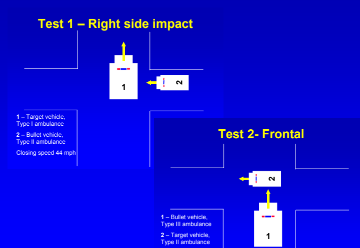
II – growls & tones ON unidentified data capture

III – identified data

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

Full Vehicle Crash Tests - 2000



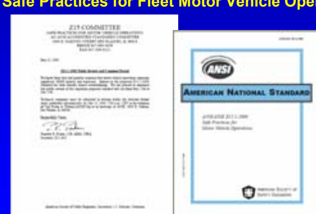
Air EMS is a role model for safety initiatives and focus

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]
  - Z15 – Fleet vehicles safety management
- USA EMS Specification & Guidelines
  - Purchase Specification: KKK & NTEA – AMD
  - Guideline: EMSC Dos and Donts
    CAAS and CAMTS

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

Z15 Incident Rates

- Incident rate based on number of vehicles operated:
  $$\text{Incident rate} = \frac{\text{Number of incidents x 100}}{\text{Number of vehicles}}$$
- Incident rate based on vehicle mileage:
  $$\text{Incident rate} = \frac{\text{Number of incidents x 1,000,000}}{\text{Vehicle mileage}}$$
- Injury incident rate based on vehicle mileage:
  - Injury incident rates, the most frequently used indicator of incident severity, are useful for tracking events that have the potential to affect financial or operational performance of the operating unit.
  $$\text{Injury incident rate} = \frac{\text{Number of incidents with injury x 1,000,000}}{\text{Vehicle mileage}}$$
- Incident rates based on service activity:
  - Motor vehicle operations that pose injury risks other than those associated with driving should also use the service activity as the basis of a safety performance rate. The number of deliveries, stops, or loads should be considered as appropriate indicators of performance.
  $$\text{Incidents per 10,000 transports} = \frac{\text{Number of incidents x 10,000}}{\text{Number of transports}}$$
- Vehicle injury rates based on work hours:
  $$\text{Vehicle incidents per 200,000 hours} = \frac{\text{Number of incidents x 200,000}}{\text{Number of hours worked}}$$

Safety Management

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

EMS Risk/Hazards

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

Safety Enhancements Being Implemented

- EVOC
- Tiered dispatch
- Monitoring & Feedback devices
- Helmets
- Optimized ambulance vehicle design
- New Standards

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

PREDICTABLE
PREVENTABLE
and
NO ACCIDENT

Conclusion

- Major advances in EMS safety research, infrastructure and practice over the past 5 years
- There are clear and very serious safety risks and hazards in ambulance transport now documented
- Technologies for safe vehicle design, occupant PPE and equipment restraint and driver performance are available
- Development of substantive EMS 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 vehicle safety and occupant protection

And….

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

Thank you! Any Questions?

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www.objectivesafety.net