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Ergonomic challenges of USA ground ambulances: An all hazards approach

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Emergency Medical Services (EMS) Definition

- An EMS system is –
  - A coordinated arrangement of resources (including personnel, equipment, and facilities) which are organized to respond to medical emergencies, regardless of cause. (ASTM, 1988)
  - Detection and reporting of medical emergencies, initial care, transportation and care for patients in route to health care facilities, medical treatment for the acutely ill and severely injured within emergency departments, and the provision of linkages to continued care or rehabilitation services (EMS Research Agenda 2001)

EMS is…

- 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 – less than 3%

USA EMS

- EMS Systems - >15,000
- Personnel - ~1 million
  (~30% F/T professional & 70% volunteer)
- 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

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

USA 1960's

1960 to 2007

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

Ergonomics

- Understanding of interactions among humans and other elements of a system, and application of theory, principles, data and methods to design in order to optimize human well-being and overall system performance
  (definition adopted by the International Ergonomics Association in 2000)
- Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people (IEA, 2000)

EMS - very much a human machine/systems interface

- The ergonomics approach — understanding tasks … and the users

Unique workplace

- In vehicles
- At roadside and other emergency scenes

The 'workplace' IS a vehicle

- EMT's often in vulnerable positions during transport.
  - Bench seat
  - Captains chair
  - Standing or kneeling

View of Ambulance interior from Rear

The 'workplace' is also a crash scene

Key issues

- An emergency medical care system conducted in a transportation environment
- EMS, public health and public safety
- Three interrelated dimensions -
  - ergonomics of the work environment
  - acute healthcare delivery and patient transport
  - occupant, automotive and transportation safety
- Safety for three populations –
  - the patient
  - the provider
  - the public

and what is killing EMS ?

EMS personnel fatalities*

- 12.7 fatalities/100,000 EMS workers
- 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*

A tragic emergency health care intervention outcome

It does happen….

National EMS data

In the USA*

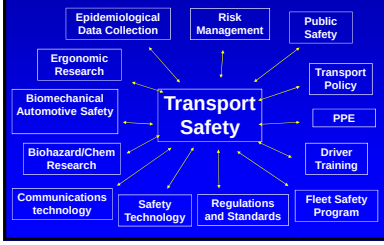
- ~ 50,000 vehicles
- ~ 5,000 crashes a year
- ~ One fatality each week
  - ~ 2/3 pedestrians or occupants of other car
  - Approximately 4 child fatalities per year
- ~10 serious injuries each day
- Cost estimates > $500 million annually
- USA crash fatality rate/capita 35x higher than in Australia

**FARS/BTS 2005-6*

Some USA 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

Ground Ambulance Transport Safety IS Complex AND Multidisciplinary



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

TIME & PLACE

Absence of standards and oversight

- Challenges in identifying best practice
- Myriad of unregulated commercial products
- No safety performance standards
- Absent national safety oversight

Problems

- No safety standards asides from biohazards
- Unique safety and hazard protection needs
- A number of <u>less than appropriate</u> products out there

Important…

- Ergonomics and automotive / transportation safety issues are interrelated in the safe delivery of emergency care and response

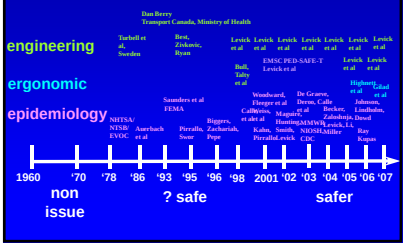
Objective

- To identify an all hazards approach to addressing ambulance transport safety bridging delivery of emergency medical care, transportation and occupant safety and crashworthiness and ergonomics and human factors.

Methodology

- Multidisciplinary team analyzed the diverse challenges to EMS transportation safety
  - EMS field personnel, EMS safety officer, emergency physician and public health researcher, and automotive safety and crashworthiness engineer
- Transport hazards were identified via
  - review of published literature in the fields of epidemiology, ergonomics, ambulance safety engineering
  - case studies to identify potentially hazardous practice.

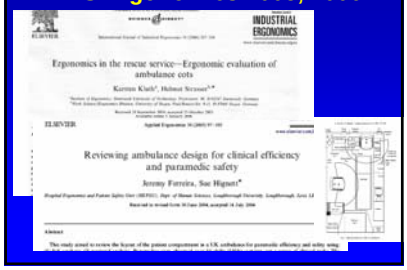
Ambulance Safety Research: A New Field



Priorities…… Research papers in the past 30 years

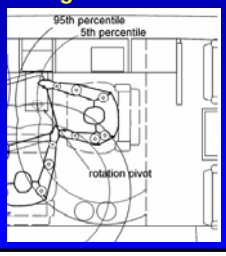
- EMS Safety
  - 40 papers - on ambulance safety
  - 2 papers - on ambulance ergonomics
  - 1 paper – on stretcher ergonomics
- Computer Workstations
  - 30,000 papers – on ergonomics of computer work stations

EMS Ergonomics 2005, 2006



December 2007 Prof Issachar Gilad

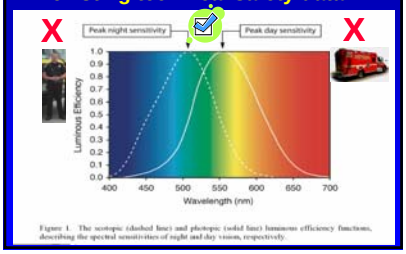
Range of reach



Ergonomics issues Gilad 2007

- *"It seems that the interior design is based primarily on spatial utilization, with little concern for ergonomics. Based on the data and observations of how work is actually performed in the ambulance interior working cell by the variety of personnel who participated in this study, we suggest a few guidelines to enhance the interior design. We believe that these suggestions can reduce the uncomfortable and extreme postures indicated in this study."*

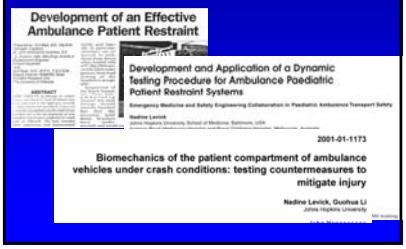
Policy and practice ignorant of existing technical safety data



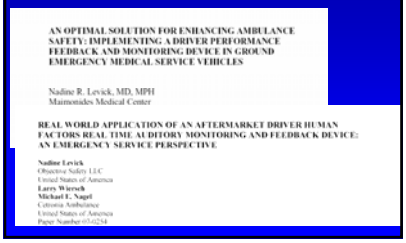
Under Way… Emergency Vehicle Visibility and Conspicuity Study

- Funded by the USFA conducted by IFSTA
- Looking at the effectiveness of reflective markings used on emergency vehicles
- Doing best practice research and working with manufacturers

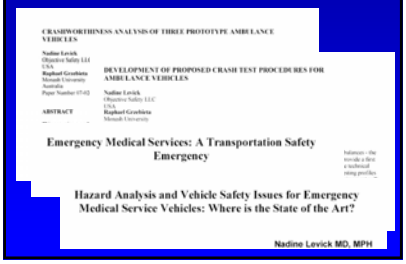
Technical automotive safety and biomechanics information

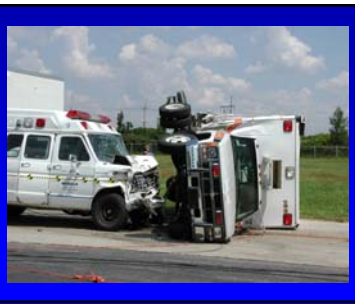


Human factors monitoring and feedback

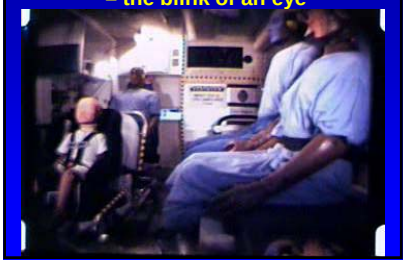


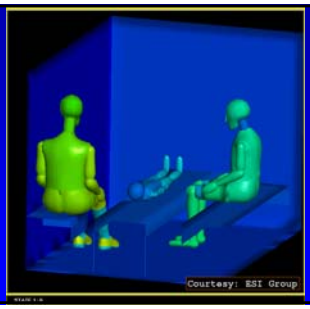
Technical information available





And this all takes place in 60 millisecs – the blink of an eye





NOT new technical data…

Richardson S.A., et al, Int. J. of Crash., 4:3, 239 – 259, 1999

Side facing 4-point harnesses demonstrated to be lethal, even at slow ground vehicle speeds

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METRO

Rollover Crash Kills Medical Technician

Ambulance Runs Off I-66 and Rolls Over, Injuring Two Employees and a Patient

It does happen….

April 14th, 2008

Ambulance worker loses arm in accident - West Nyack, New York

An emergency service worker lost her right arm today after the ambulance in which she was a passenger crashed into a truck parked along Route 59 near the flyover to the Palisades Center mall.

Bonnie Ames, 20, was taken by helicopter to the Westchester Medical Center in Valhalla where she underwent surgery.

"She's out of danger, but she lost her arm," Raymond Florida, director of **Rockland Paramedic Services** said early this evening.

"We used multiple units from the jaws of life to extricate her," West Nyack Fire Chief George Drescher said. "She appeared to be seriously injured."

The paramedic van driver, 19-year-old Scot
there to Westchester Medical Center, said

June 17th 2008
a paramedic and a patient killed

EMS CRASH KILLS PATIENT AND A SUSSEX COUNTY (DE) PARAMEDIC IN THE LINE OF DUTY
Tuesday, June 17, 2008

We regret to advise you that a female Sussex County (DE) Paramedic was killed in the Line of Duty as was a patient killed in a horrific crash involving an ambulance in Sussex County (DE) this morning.
The single vehicle crash happened around 0240 Hours on the John J. Williams Highway near the Lewes-Rehoboth joint fire company substation in Angola.
The Mid-Sussex Rescue Squad ambulance was transporting to Beebe Medical Center with a patient, 2 MSRS Squad members and the Sussex County Paramedic were on board when it struck a tree, which opened the side of the ambulance as seen on our home page. Tragically, the patient was killed as was the Sussex County EMS Paramedic, who was killed in the Line of Duty.
Sussex County EMS also suffered a close call last year when a Paramedic John Schmitt was seriously injured in a crash when a civilian struck the Milford Fire Company ambulance he was riding in, while returning from a run. Additional details on this mornings crash will follow.

In this vehicle…

USA Ambulances: Safety performance standards failure - FMVSS Exempt

DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration

49 CFR Parts 571, 572, and 589
[Docket No. 92-26; Notice 7]
[RIN No. 2127-AB85]

Federal Motor Vehicle Safety Standards;
Head Impact Protection

58.1 Vehicles manufactured on or after September 1, 1998 and before September 1, 2002. Except as provided in S6.3, for vehicles manufactured on or after September 1, 1998 and before September 1, 2002, a percentage of the manufacturer's production, as specified in S6.1.1, S6.1.2, S6.1.3, or S6.1.4, shall, when tested under the conditions of S9, comply with the requirements specified in S7 at the target locations specified in S10 when impacted by the free motion headform specified in S8.5 at any speed up to and including 24 kilometers per hour. The requirements do not apply to any target that cannot be located using the procedures of S10. The phase-in schedule the manufacturer chooses to use during this period shall be reported to the National Highway Traffic Safety Administration pursuant to 49 CFR 584.6.

58.2 Vehicles manufactured on or after September 1, 2002. Except as provided in S6.3, vehicles manufactured on or after September 1, 2002 shall, when tested under the conditions of S9, comply with the requirements specified in S7 at the target locations specified in S10 when impacted by the free motion headform specified in S8.5 at any speed up to and including 24 kilometers per hour. The requirements do not apply to any target that cannot be located using the procedures of S10.

58.3 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.

AMD - Propaganda that kills…

AMBULANCE MANUFACTURERS DIVISION OF
The National Truck Equipment Association

Page 1 of 4

AMD Position Statement on Ambulance Safety and Occupant Protection

The purpose of this paper is to establish the position of the membership of the Ambulance Manufacturers Division (AMD) of the National Truck Equipment Association

Ambulances must comply with some of the strictest safety and performance standards applicable to vehicles in the United States. All motor vehicles operated on public roads and highways must conform to Federal Motor Vehicle Safety Standards (FMVSS) contained in Title 49 of the Code of Federal Regulations Part 571. Ambulances are no exception. FMVSS are the most visible and vigorously enforced safety standards governing the design, engineering and production of such vehicles. Nearly all government purchased ambulances, and the overwhelming majority of those sold to the public, also must be certified to the safety requirements of the Federal Star of Life Specification for Ambulances, KKK-A-1822, promulgated by the federal government. These requirements are in addition to FMVSS.

KKK certified and FMVSS exempt..?

03/04/2007 | Print this Article | Email this Article to a friend |

2 dead in Michigan ambulance crash

The Associated Press

SKANDIA TOWNSHIP, Mich
along an Upper Peninsula r
members, state police sai

The truck was stopped Mo
Township waiting for traff
General Hospital rear-end

Investigators found no evi

Ambulance patient Carrie
Cornell, died at the scene
member, Ryan Peterson, 2

FMVSS exempt……

Occupant protection……??
July 2007

USA ambulance purchase specifications GSA:KKK-A-1822F, Aug 2007

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

KKK/AMD – 'safety testing'

- Ignorant of automotive safety principles – and specifies that a 'successful test' is -
  - No structural damage to any load bearing or supporting members, i.e., torn or broken material, broken welds, popped or sheared body rivets, bolts, and/or fasteners, shall be evident during the application of the force and after the release of the force.

Unacceptable, and ridiculous current USA ambulance '*safety testing*' practices !!??

No 'a'… then NO 'F' !!!!!

- **F = ma**

where F – force
m – mass
a – acceleration

Sir Isaac Newton (1642-1727), Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy) x published in 1687. http://en.wikipedia.org/wiki/Newton's_laws_of_motion

Results Summary

- There are clearly outlined major ergonomic and transportation hazards during ambulance transport for the patient, the provider and the general public which were identified as fundamental by the literature search and case studies, relating to the following areas -

Areas of Hazard

- Three areas -
  - Delivery of emergency medical care
  - Transportation, vehicle operations occupant safety and crashworthiness
  - Ergonomics and human factors
- Three target populations-
  - Patient
  - Provider
  - Public

Delivery of Emergency Care

- Priority dispatch
- Scope of medical practice
- Medical policies and procedures
- Patient outcomes of priorities
- Public safety focus of policies and operations

Transportation, occupant safety and crashworthiness

- Vehicle operations
  - Dispatch policies
  - Driver training, monitoring and distraction
  - Intersection Policies
  - Emergency response mode policies
- Automotive safety and occupant protection
  - Design standards exemptions
  - Payload and vehicle capacity limitations
  - Restraint systems for all occupants
  - Protection from interior hazards
  - Vehicle automotive design and crashworthiness

Ergonomics and human factors

- Communication
  - with patient, coworkers/providers and base and hospital
- In vehicle
  - Access to medical equipment and patient
  - Evaluation of patient
  - Patient and provider safety and comfort
  - Ability to perform medical interventions in a mobile environment
  - Ability to perceive displays and alarms of medical equipment
  - Protection from interior hazards
  - Access to entrance and egress of vehicle
- Patient Handling
  - Loading unloading the patient
  - Transport of patient to and from ambulance
- Biohazards
- Visibility and conspicuity
  - Safety on the road and road side scene

Discussion

- Limited overlap in the published literature in the realms of ergonomics focus, automotive occupant protection priorities and clinical care issues.
- Furthermore it appeared that many recent developments in ambulance design had proceeded with no input from the technical experts in either field in any fashion.

Given the combination of an automotive environment and an operational workplace

- The design of the system is required to provide both -
  - a safe automotive occupant protection and transport environment
  - as well as a functional physical ergonomic environment, and adequate attention to perception and human factors for patient monitoring and communication - to allow essential patient care to occur effectively.

Failure to utilize available technical information

- Integration of technological expertise and practice has not been current practice in EMS design
- Of greater concern is in a setting where the technical principles, knowledge and data to address the safety and optimization of this environment has been in the public domain of both these fields (ergonomics and automotive safety engineering) for in excess of 20 years.

Safety design directions

- Ambulance design compatible with principles of ergonomics, occupant safety, automotive and tansport safety and biohazards:
  - A compact environment with close proximity to access to the upper body of the patient and to access certain items of medical equipment, visually, auditorily and manually, and an integrated communications system that does not require the provider to leave the seat.
- Automotive grade provider seating and restraints –
  - Provider
    - ideally rear facing with protection for frontal and side impact crashes
    - A restraint and seating system that keeps the provider in the seat and that does not cause potential for neck injury on side facing seating and anchored to meet automotive crash forces.
  - Patient restraints –
    - Automotive occupant protective design and orientation
- Monitoring Equipment –
  - Secured in crashworthy mounts located in line of sight of providers (in the absence of head up or other technologies)
- Essential Medical Equipment/supplies –
  - accessible to the provider
- Patient handling transport equipment –
  - Optimization of patient stretcher ergonomics and mobility, including its height mechanism and stability

Conclusion

- Based on existing injury and fatality data, and basic ergonomic and transport safety principles and technology - current USA ambulances have serious deficiencies in the ergonomics of their design and have demonstrated major automotive crashworthiness and occupant protection failures.

Conclusion

- The goal is to design the EMS environment -
  - To minimize predictable hazards, both ergonomic & automotive
  - To facilitate essential patient care activity
  - To enhance safety for the patient, the provider and the public
- Designing solutions for this environment requires an integrated approach between clinical care providers and operational expertise, automotive and transportation safety technical expertise and ergonomists and human factor expertise.
- This current disconnect, between EMS practice and ergonomic and transportation technical input, is unacceptable

Thank you!
Any Questions??

an electronic recording on ambulance safety and a .pdf handout of this presentation awaits you online

www.objectivesafety.net