Ambulance Re-design to Reduce EMS Injuries: Influencing Design through Standards Development

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NIOSH Ambulance Safety Research

- Initiated 2001
- Focus on preventing crash-related injury to EMS workers
- Provide patient compartment occupants with the same level of crash protection as passenger car occupants.
Forward Barrier Crash, 30 mph, 1999 Type III, Unrestrained and Lap Belts
** Lap belts should always be used in conjunction with net **
PCP Contacts with Assist Handle and Edge of Front Wall

Injuries:

- Left Occipital intraparenchymal hemorrhage
- Left occipital contusion
- Positive loss of consciousness
- 20 cm laceration into muscle on the right parietal/occipital scalp
- Right occipital scalp contusion
Some procedures require more mobility than provided when using seat belts properly.

What Safety Issues Do Emergency Medical Services Personnel Face?

- Patient compartment designed with patient treatment as first priority.
- Interior configuration significantly affects worker safety
- Interior design poses numerous crash-injury sources
- Patient compartment is largely exempt from meeting traditional vehicle safety standards.
Conclusions from earlier research

- Most patient compartment designs force a worker to leave his/her seat to complete job tasks

- Our testing indicates both lap belts and multi point mobility restraints or fixed harnesses can sustain loads and reduce injury risk

- Patient shoulder restraints reduce travel and thus likelihood for contact with worker or surfaces

- Lock down equipment whenever possible, loose equipment becomes injury producing projectiles
Current Project Objectives

- Provide patient compartment occupants with the same level of crash protection as passenger car occupants.
- Work with end users to ensure designs meet needs
- Move NIOSH research results to practice to influence future ambulance design
- Near Term: Develop revisions to GSA purchase specifications and AMD industry based standards –
- Long Term: Incorporate changes into second revision of new NFPA 1917 Automotive Ambulance Standards
- Ensure all proposed standards are based on actual test data not conjecture
Partnerships to Influence Change

Current Research Team

Government Agencies

- Dept. of Homeland Security
- General Services Admin.
- Nat’l Institute for Stds. and Tech

Private Sector Manufacturers

- Ambulance Manufacturers Div. of NTEA & its members
- Cot\Litter Manufacturers
- Equipment Manufacturers
- Seating & Restraint Manufacturers

Independent Test Facilities

- IMMI/CAPE, Indiana
- MGA Research, Detroit
- MGA Research, Wisconsin
- Transportation Res. Ctr., Ohio
Specs and Standards Today

- Federal Specification for the Star of Life Ambulance
- NFPA 1917 Standard for Automotive Ambulances 20XX Edition
- CDC
- NIOSH
Strategy for Impact

• With funding support from Dept. of Homeland Security and partnerships with industry we will:
  – Validate proposed AMD standards through full scale testing
  – Design, manufacture and qualify new seats, restraints, gurneys, patient restraints and equipment mounts to the proposed AMD standards
  – Quantify the price impact of change to the industry and end user
  – Address human factors/interior layout concerns (NIST)

• Use data from development of AMD standards to influence change in NFPA national consensus standard – 2nd revision
Current Standards Development Activities

- Seating & Worker Restraints
- Litter & Patient Restraints
- Equipment Mounting
- Patient Compartment Integrity
- Interior Delethalization
- Human Performance/Tolerance Definition
- Patient Compartment Arrangement
- Frequency of Task Performance
- EMT Required Tasks
- Vehicle Crash Response
SAE Recommended Practice – Crash Pulse Envelope for Frontal and Side Impact Testing
(Society of Automotive Engineers Approved)

- Based on NIOSH Testing
- Reviewed by Ford, GM, NHTSA, and 3 independent test labs
Seat and Worker Restraint Team

Language completed for AMD 026

Key Elements:

• Seat should remain attached to vehicle without structural failure using new crash pulses

• Reduce worker excursion to eliminate impacts

• Do so without driving patient loading in head, neck, chest beyond accepted human tolerance limits
Reducing Lethality of Interior Structure

Impact Direction

Lap Belt

FIGURE D.
(Side facing seat)

Stay Away Zone
Head Path

Maximum Travel Distance
Foremost Seat Plane

FRONT OF VEHICLE

Seat adjusted to foremost position relative to the front of the seat
Foremost seat back retaining bolt
Existing Mobile Restraint Systems
Forward Barrier Crash, 30 mph, 1993 Type III

Impact Direction
Language completed for AMD 004

Key Elements:

- Remain attached to vehicle without structural failure using new crash pulses
- Reduce patient excursion to eliminate impacts
- Do so without driving patient loading in head, neck, chest beyond accepted human tolerance limits
Patient Restraint Issues: Current Production Configuration

Data from this test used to develop new SAE Crash Pulse
- Excursion distance greater than 30 inches
- Head, neck, chest, and pelvis loading within published limits
Patient Restraint Issues: Reduced Excursion Testing

- Used new SAE Published Frontal Crash Pulse
- Excursion distance of 8.42 inches
- Head, neck, chest, and pelvis loading within published limits
Draft language completed

Key Elements:

• Equipment weighing 3 lbs or greater must be mounted or be located in an enclosed cabinet

• Mount should retain equipment under frontal and side impact pulses (working on a translation to static load test)

• Equipment in cabinets must remain in cabinets

• Cabinet doors and latches must remain latched
Equipment Mounting Cabinet Latching Issues

Prior to crash equipment and gurney either mounted or stowed in cabinets

Post crash equipment and gurney positions drastically changed
Body Integrity and Mounting Standards
Development Team

Key questions currently under discussion:

• Can we devise a test to ensure patient compartment structural integrity – especially during side impact or under rollover conditions?

• Can testing be conducted in a quasi static fashion versus full vehicle crash test?

• Goal – meet or exceed US automotive testing requirements and international ambulance standards
Body Integrity and Mounting Standards

- Frontal edge of patient compartment took hit
- Side sheared off
- Very different from pure side impact
Both organizations possess engineers and scientists with expertise in human factors and work station design

Understand the tasks EMS worker must perform

Understand the context in which they perform their tasks

Identify and analyze worker and performance risks associated with task performance

Identify emerging technologies and products that may be incorporated into future ambulance patient compartments
Human Factors Research - NIST & DHS

- Identify user interface design requirements for key medical and communication systems to reduce injury risks and enhance patient care

- Develop HMI/UI design concepts for patient compartments that address compartment/equipment configurations and identified design requirements

- Evaluate concepts through modeling and/or mockups and perform design tradeoffs

- Document final design concepts and criteria in a preliminary design guidance document
Completed NIOSH Modeling Work

• Compared the standard GSA layout to the City of Winter Park FD Design using digital human modeling

• Developed representative models of ambulance interiors

• Created accurate human reach envelopes using different sized workers

• Identified and evaluated opportunities for design improvement
Digital Human Modeling – Improvements to Compartment and Seating Design

Typical

Modified

Modeled and Evaluated
Communications Access Current vs. New Designs

Current Design

New Design
Closing Thoughts:
What could be improved?

- Develop list of required tasks, equipment used, & frequency
- Think about compartment layout based on task frequency
- Work closely with ambulance builder to locate equipment
- Consider improved seating and worker restraints
Other Thoughts to Consider

- New patient compartment configurations, seating and restraint types are coming on the market that improve a worker’s ability to remain restrained while performing job tasks.
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