# Comparison of conventional and seat-integrated belt restraints and associated injury patterns by frontal crash directions and classifications.


Seattle CIREN

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# Background –Seatbelt Designs

- Passenger vehicles in the United States generally utilize two seat belt designs: frame-mounted/conventional restraints, and seat-mounted/seat-integrated restraints.
- Lap and shoulder conventional seat belt use reduced mortality by 72%. Combined air bag and seat belt use reduced mortality by more than 80%.


- Crandall, C. S., L. M. Olson and D. P. Sklar (2001). "Mortality reduction with air bag and seat belt use in head-on passenger car collisions." Am J Epidemiol **153**(3): 219-224.

# Background - SIRS

- Safety benefits of three-point integrated seat belts over conventional seat belts, most research to date has been confined to computer modeling or dummy testing.
- Study in rollovers showed no statistically significant difference in ejection, fatal and serious injuries rates between vehicles with conventional seat belts and vehicles with Seat Integrated Restraint System (SIRS).
  - Did not separate results by seating position or row, used police reported injury scores


Rashidy M, Deshpande B, Gunasekar TJ, et al. Analytical evaluation of an Advanced Integrated Safety Seat Design in frontal, rear, side, and rollover crashes. In: *ESV: 17th International Technical Conference on the Enhanced Safety of Vehicles,.*; 2001.

Kuppa S, Saunders J, Fessahaie O. *Rear seat occupant protection in frontal crashes.*; 2005. doi:10.1017/S1431927603444851.

Gavelin A. Seat Integrated Safety Belts A Parametric Study Using Finite Element Simulations. 2006. Available at: http://epubl.ltu.se/1402-1757/2006/21/.

Padmanaban, J. and R. A. Burnett (2008). "Seat integrated and conventional restraints: a study of crash injury/fatality rates in rollovers." Ann Adv Automot Med **52**: 267-280.

# Background –Frontal Offset Configurations

- Piraeus and Lindquist examined chest injuries in frontal small overlap/oblique crash tests and models to assess the impact of yaw and intrusion. Intrusion influenced injury, yaw influenced interaction with frontal air bag.
- Pinter, et al. – Evaluated AIS 3 or greater injuries in frontal narrow, offset, and corner impacts, grouping together 11 through 1 o'clock direction of force. "The risk of injury was defined as the number of injured occupants divided by the number of crashes in a given CDC classification." Also noted vehicle rotation and occupant movement may be a factor with air bag interaction.

Piraeus J, Lindquist M. Influence of vehicle kinematic components on chest injury in frontal-offset impacts. Traffic InjuryPrev. 2014;15 Suppl 1:S88-95. doi: 10.1080/15389588.2014.933477.

Frank A. Pintar, Narayan Yoganandan, and Dennis J. Maiman - Injury Mechanisms and Severity in Narrow Offset Frontal Impacts Ann Adv Automot Med. 2008; 52: 185–192.

# NHTSA New 5 Star rating crash test

- New laboratory test procedure for oblique offset moving deformable barrier impact test document -July 22, 2015.
- 150722 Oblique Test Procedure, defines the collision deformation classification for the test to be:
  - 15 degree 35% left oblique offset that typically results in a CDC of 11FYEW_
- Our study's aim was to evaluate the frontal angled impacts and classifications.

# Research Aims

- Comparing the effect of 12 o'clock direction of force in frontal crashes to 11 and 1 o'clock directions on occupant outboard and inboard movements, and the resultant odds of specific body region injuries.
- Further examine the effect of BMI in modifying the impact of each frontal directions of force (11-12-1) on injury odds
- Among belted front occupants with a frontal airbag deployment, compare full-frontal impacts to other frontal crash configurations (offset, corners, using CDC classifications) to examine the odds of injury severity by body region
- Further evaluate integrated seatbelts compared to conventional seatbelts in the influence of 12 o'clock frontal versus to 11 and 1 o'clock directions.

# Methods: Data Source

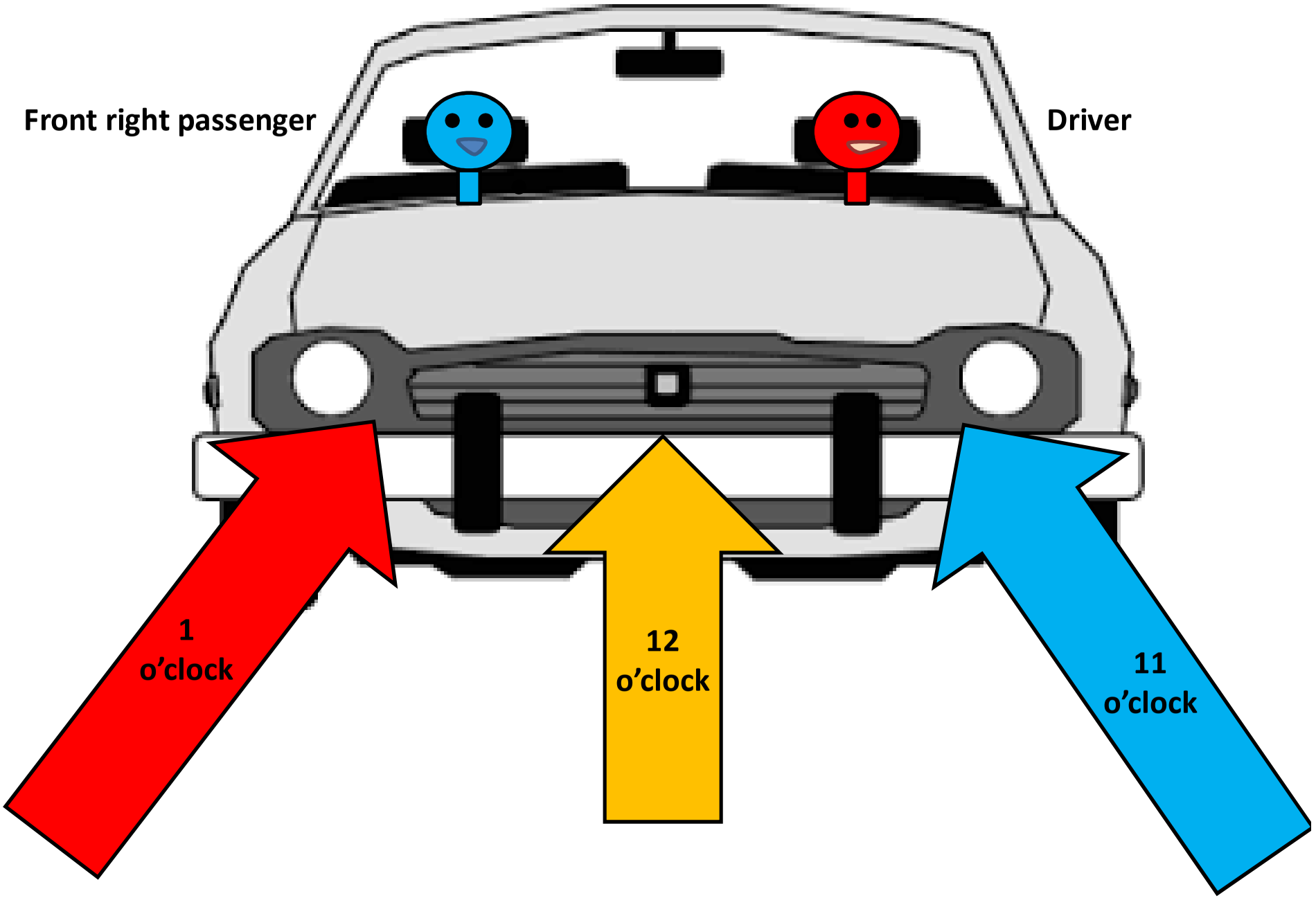
- National Automotive Sampling System Crashworthiness Data System (NASS CDS)
  - A national sample of motor vehicle crashes
- Weighted data from 2003 to 2014
- Crash Injury Research and Engineering Network (CIREN) – Case Studies

# Methods: inclusion criteria

- Vehicle:
  - Vehicle model year 2000 and later
  - Passenger vehicles only
- Crash:
  - Frontal crashes (DOF1 at 11, 12, 1 o'clock)
  - General area of damage (GAD1) as frontal
  - Crash delta V known and above 9mph
  - Rollovers were excluded
- Occupant:
  - Front outboard seat (11 and 13 positions)
  - Three point belt was present and in use
  - Age 16 and above

# Methods: analysis

- Descriptive statistics
- Weighted logistic regression on the odds of a severe injury (AIS 0-1 vs. 2-6) and any injury (AIS 0 vs. 1-6) for the head, face, neck, abdomen, thorax, C-spine, T-spine, and L-spine for each frontal direction of force (11,12,1), stratified by seat position.
  - Unadjusted and adjusted for delta V, age, and BMI
  - All analyses were limited to crashes where the frontal airbag deployed in each occupant position
  - Sub-analysis on the interaction of BMI group and integrated seatbelts, and frontal crash classifications.
- Did not evaluate upper and lower extremities

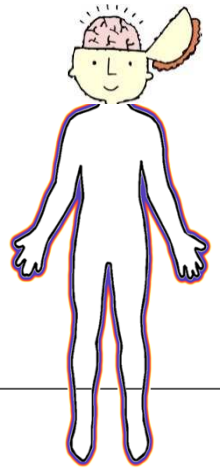

Front right passenger
Driver
1
o'clock
12
o'clock
11
o'clock

# Table 1a: Crash Characteristics

| | | Driver | | Front Right Passenger | |
|---|---|---|---|---|---|
| | | N | % | N | % |
| Crash | 11 o'clock | 170,000 | 16.92 | 39,000 | 17.34 |
| | 12 o'clock | 660,000 | 67.49 | 160,000 | 69.53 |
| | 1 o clock | 150,000 | 15.59 | 30,000 | 13.13 |
| Delta V | 16 -30 KMPH | 820,000 | 83.44 | 180,000 | 80.64 |
| | 31-45 KMPH | 140,000 | 14.11 | 38,000 | 16.66 |
| | 46-60 KMPH | 17,000 | 1.71 | 5,430 | 2.4 |
| | 61 + KMPH | 7,325 | 0.74 | 664 | 0.29 |

# Table 1b: Demographic Breakdown

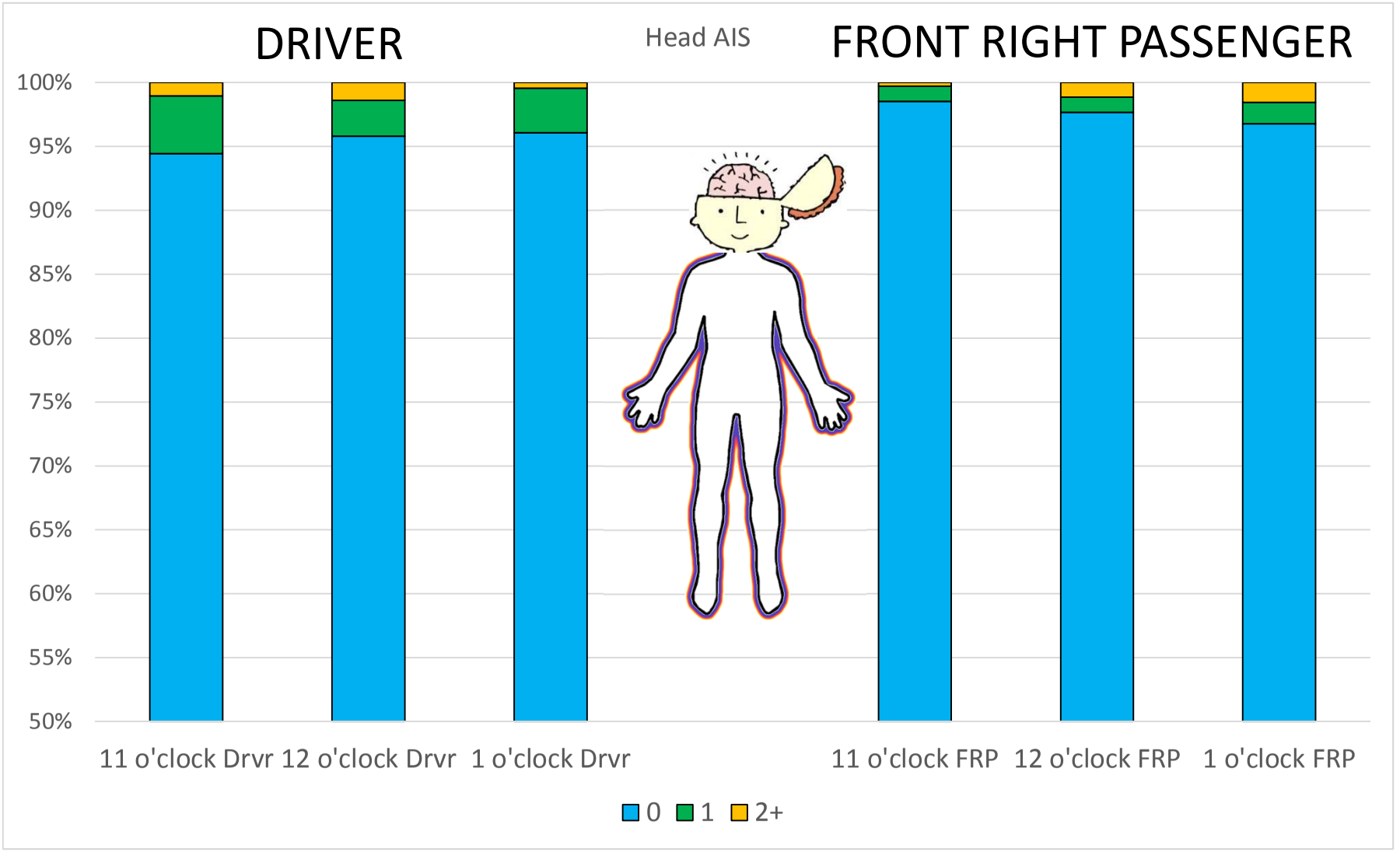
| | | Driver | | Front Right Passenger | |
|---|---|---|---|---|---|
| | | N | % | N | % |
| Male | | 410,000 | 42.04 | 130,000 | 55.48 |
| Age group | 16-25 | 320,000 | 32.18 | 130,000 | 56.23 |
| | 26-35 | 200,000 | 19.95 | 33,000 | 14.61 |
| | 36-55 | 300,000 | 30.26 | 33,000 | 14.82 |
| | 56-65 | 87,000 | 8.82 | 9772 | 4.34 |
| | 66 and above | 87,000 | 8.79 | 23,000 | 9.99 |
| BMI | <18.5 | 20,000 | 2.04 | 3,616 | 1.6 |
| | 18.5-24.9 | 390,000 | 39.67 | 79,000 | 35.07 |
| | 25-29.9 | 360,000 | 36.46 | 120,000 | 51.64 |
| | 30 and above | 210,000 | 21.83 | 26,000 | 11.69 |
| Frontal airbag deployed | | 690,000 | 69.95 | 130,000 | 57.33 |
| Integrated seat belts | | 78,000 | 7.95 | 5,617 | 2.49 |



# Head AIS score by driver and front right passenger

| | DRIVER | | | FRONT RIGHT PASSENGER | | |
|---|---|---|---|---|---|---|
| head AIS | 11 o'clock | 12 o'clock | 1 o'clock | 11 o'clock | 12 o'clock | 1 o'clock |
| 0 | 120,000 | 410,000 | 120,000 | 26,000 | 74,000 | 27,000 |
| 1 | 5,730 | 12,000 | 4,372 | 313 | 905 | 466 |
| 2 | 1,229 | 4,914 | 545 | 74 | 583 | 436 |
| 3 | 73 | 606 | 0 | 0 | 280 | 0 |
| 4 | 32 | 466 | 0 | 0 | 0 | 0 |
| 5 | 0 | 17 | 0 | 0 | 0 | 0 |

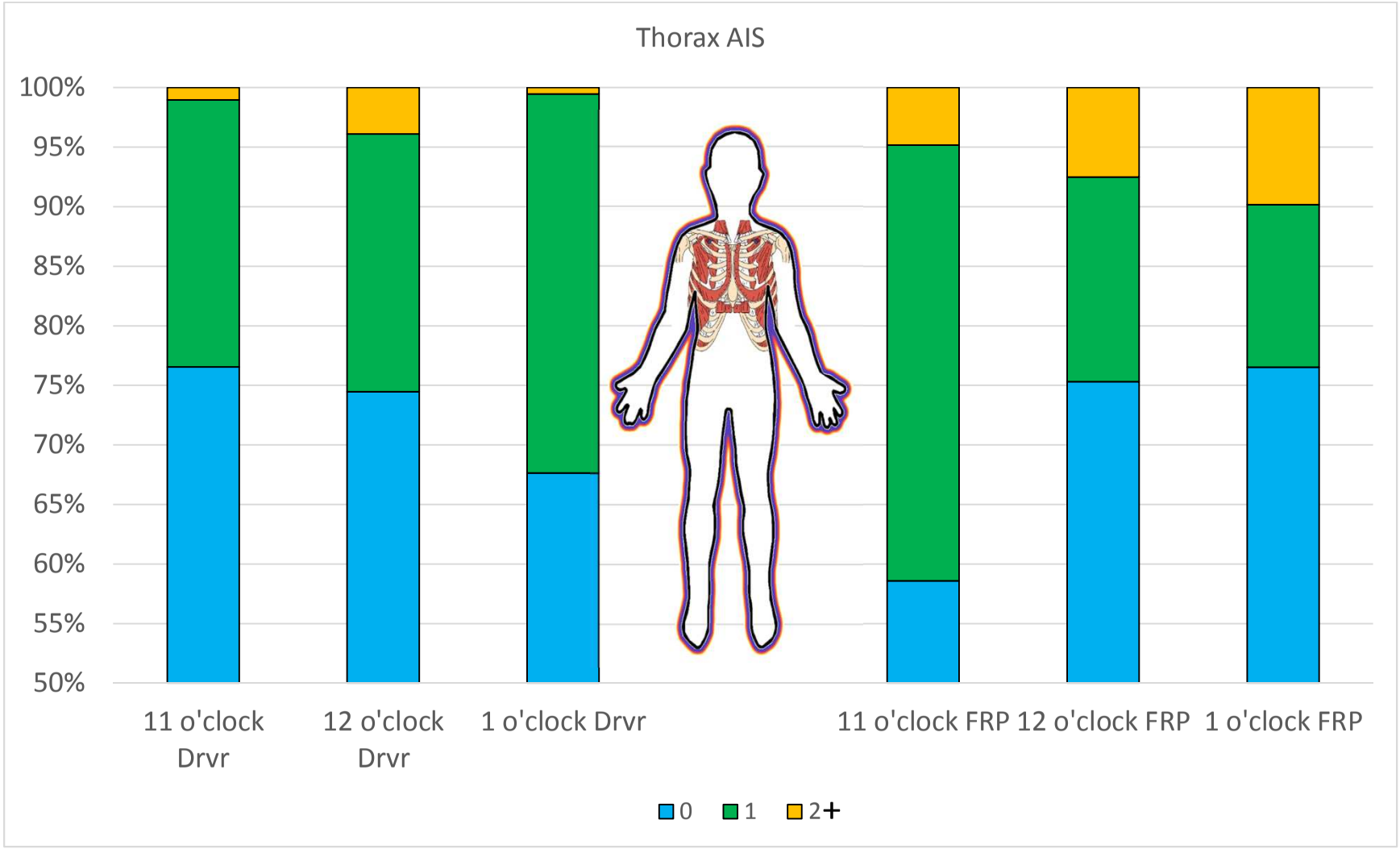
# Head AIS score
# by driver and front right passenger



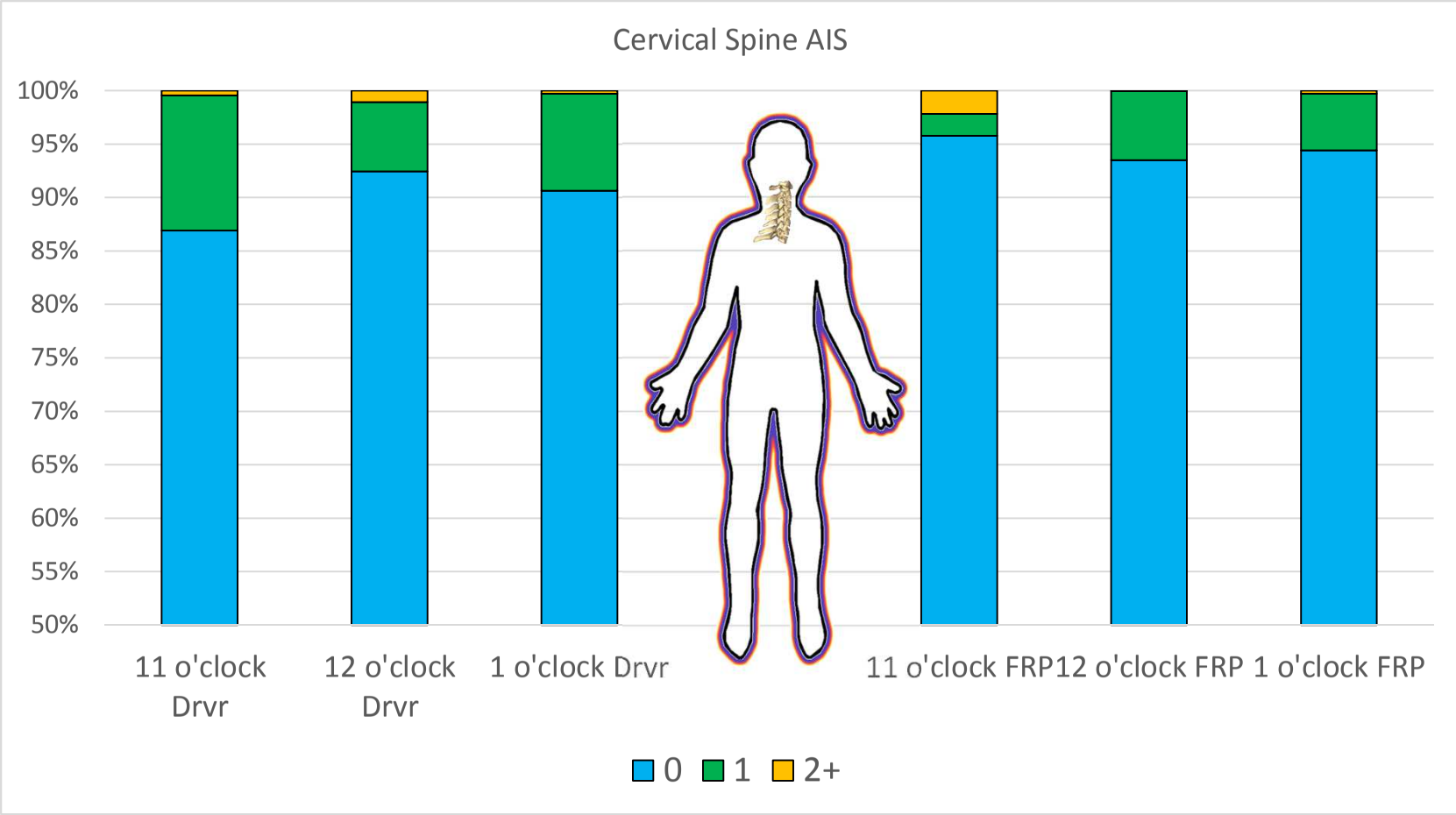
# Thorax AIS score
# by driver and front right passenger

| | DRIVER | | | FRONT RIGHT PASSENGER | | |
|---|---|---|---|---|---|---|
| thorax AIS | 11 o'clock Drvr | 12 o'clock Drvr | 1 o'clock Drvr | 11 o'clock FRP | 12 o'clock FRP | 1 o'clock FRP |
| 0 | 99,000 | 320,000 | 85,000 | 15,000 | 57,000 | 21,000 |
| 1 | 29,000 | 93,000 | 40,000 | 9,364 | 13,000 | 3,743 |
| 2 | 559 | 10,000 | 370 | 639 | 4,727 | 8 |
| 3 | 637 | 5,706 | 303 | 573 | 724 | 2,692 |
| 4 | 128 | 997 | 0 | 22 | 232 | 0 |
| 5 | 0 | 31 | 0 | 0 | 0 | 0 |

# Thorax AIS score
# by driver and front right passenger



# Cervical spine AIS score by driver and front right passenger



# Simple unadjusted regression, split at AIS 0 vs 1-6, driver

| | 12 o'clock | 11 o'clock (OR) | 1 o'clock (OR) |
|---|---|---|---|
| head | Ref | 1.16 | 0.84 |
| face | ref | 0.83 | 1.41 |
| neck | Ref | **0.32** | **0.24** |
| thorax | Ref | 0.91 | 1.42 |
| abdomen | Ref | 0.82 | 1.50 |
| C spine | ref | **1.77** | 1.24 |
| L spine | ref | 0.73 | 1.14 |
| T spine | ref | 1.23 | 1.16 |

# Logistic regression, adjusted for age, delta V, BMI group, split at 0 vs 1-6, Driver

| | 12 o'clock | 11 o'clock (OR) | 1 o'clock (OR) |
|---|---|---|---|
| head | ref | 1.51 | 1.10 |
| face | ref | 0.86 | 1.52 |
| neck | ref | **0.33** | 0.24 |
| thorax | ref | 1.08 | **1.69** |
| abdomen | ref | 0.99 | 1.92 |
| C spine | ref | **2.10** | 1.46 |
| L spine | ref | 0.85 | 1.39 |
| T spine | ref | 1.35 | 1.31 |

# Simple unadjusted regression, split at 0 vs 1-6, front right passengers

| | 12 o'clock | 11 o'clock (OR) | 1 o'clock (OR) |
|---|---|---|---|
| head | ref | 0.54 | 1.21 |
| face | ref | **0.19** | 0.87 |
| neck | ref | 1.04 | 1.01 |
| thorax | ref | **2.14** | 0.94 |
| abdomen | ref | 0.91 | 0.67 |
| C spine | ref | 0.64 | 0.84 |
| L spine | ref | **0.21** | 0.49 |
| T spine | ref | **3.12** | 0.61 |

# Logistic regression, adjusted for age, delta V, BMI group, split at 0 vs 1-6, front right passengers

| | 12 o'clock | 11 o'clock (OR) | 1 o'clock (OR) |
|---|---|---|---|
| head | ref | 0.44 | 1.29 |
| face | ref | **0.13** | 0.76 |
| neck | ref | 0.72 | 0.83 |
| thorax | ref | **2.36** | 1.12 |
| abdomen | ref | 1.12 | 0.99 |
| C spine | ref | 0.48 | 0.76 |
| L spine | ref | 0.26 | 0.94 |
| T spine | Ref | 2.56 | 0.50 |

# Interaction between BMI and DOF

Among drivers:

- Overweight drivers have a significant interaction with thoracic injuries at 11 o'clock (OR = 2.314)
- Underweight drivers have a significant interaction with C-spine injuries at 11 o'clock (OR = 20.89)

Among front right passengers:

- Overweight front right passengers have a significant interaction with thoracic injuries at 1 o'clock (OR = 14.97)
- Underweight front right passengers have a significant interaction with C-spine injuries at 11 o'clock (OR = 8.61)

# Odds ratios for logistic regression (0 vs 1-6 AIS) by **collision deformation classification** coding adjusted for delta V at 12 o'clock, driver

| | C | D | L | R | Y | Z |
|---|---|---|---|---|---|---|
| head | na | Ref | **153.23** | Na | 5.99 | na |
| neck | na | Ref | na | Na | na | na |
| abdomen | na | Ref | na | 0.24 | 0.39 | na |
| thorax | na | Ref | 0.10 | 0.11 | **0.08** | 0.06 |
| face | na | Ref | na | Na | 0.18 | 0.58 |
| C spine | na | Ref | na | Na | **0.02** | 6.52 |
| L spine | na | Ref | na | 39.26 | 15.09 | 27.86 |
| T spine | na | Ref | na | Na | na | na |

# Odds ratios for logistic regression (0 vs 1-6 AIS) by **collision deformation classification** coding adjusted for delta V at 12 o'clock, front right passenger

| | C | D | L | R | Y | Z |
|---|---|---|---|---|---|---|
| head | na | Ref | 0.67 | **0.021** | 0.50 | **2.88** |
| neck | 2.46 | Ref | 0.78 | 4.60 | 0.84 | 0.048 |
| abdomen | **7.62** | Ref | 2.59 | 0.29 | 0.99 | 3.42 |
| thorax | 0.43 | Ref | 0.15 | 1.27 | 1.27 | 1.47 |
| face | 1.02 | Ref | 4.64 | **0.29** | 1.18 | 1.64 |
| C spine | 1.63 | Ref | 0.33 | na | 1.51 | 0.82 |
| L spine | na | Ref | 1.78 | na | 4.12 | 0.19 |
| T spine | 6.12 | Ref | na | na | Na | Na |

# Integrated Seat Belt

| | Integrated (N) | Non-integrated (N) | Unknown (N) |
|---|---|---|---|
| Convertible | 4758 | 16000 | 0 |
| 2dr Sedan/Ht/Cpe | 903 | 68000 | 134 |
| 3dr/2dr Hatchbak | 0 | 22000 | 0 |
| 4-Dr Sedan/Hdtop | 9442 | 590000 | 72 |
| 5dr/4dr Hatchbak | 224 | 44000 | 0 |
| Station Wagon | 0 | 27000 | 0 |
| Other Automobile | 0 | 241 | 0 |
| Auto Base Pickup | 0 | 82 | 0 |
| Truck Based Utility | 48000 | 150000 | 9 |
| Large Utility | 3773 | 65000 | 0 |
| Utility Stationwagon | 273 | 646 | 0 |
| 3-Door Coupe | 0 | 1234 | 0 |
| Minivan | 0 | 53000 | 0 |
| Large van | 0 | 4788 | 0 |
| Compact pickup | 0 | 33000 | 0 |
| Large pickup | 16000 | 46000 | 14 |

# Adjusted odds of injury associated with having an integrated seat belt compared to conventional belt, drivers

| | OR | P-value |
|---|---|---|
| head | 0.706 | 0.657 |
| face | 0.467 | 0.400 |
| neck | 0.522 | 0.609 |
| thorax | **0.339** | **0. 004** |
| abdomen | na | na |
| C spine | 0.314 | 0.262 |
| L spine | **0.112** | **0.027** |
| T spine | **0.295** | **0.074** |

# Adjusted odds of injury associated with having an integrated seat belt compared to conventional belt, front right passengers

| | OR | P-value |
|---|---|---|
| head | 3.37 | 0.339 |
| face | **0.093** | **0.059** |
| neck | 0.33 | 0.249 |
| thorax | 2.705 | 0.288 |
| abdomen | **0.165** | **0.017** |
| C spine | 0.269 | 0.253 |
| L spine | na | na |
| T spine | na | Na |

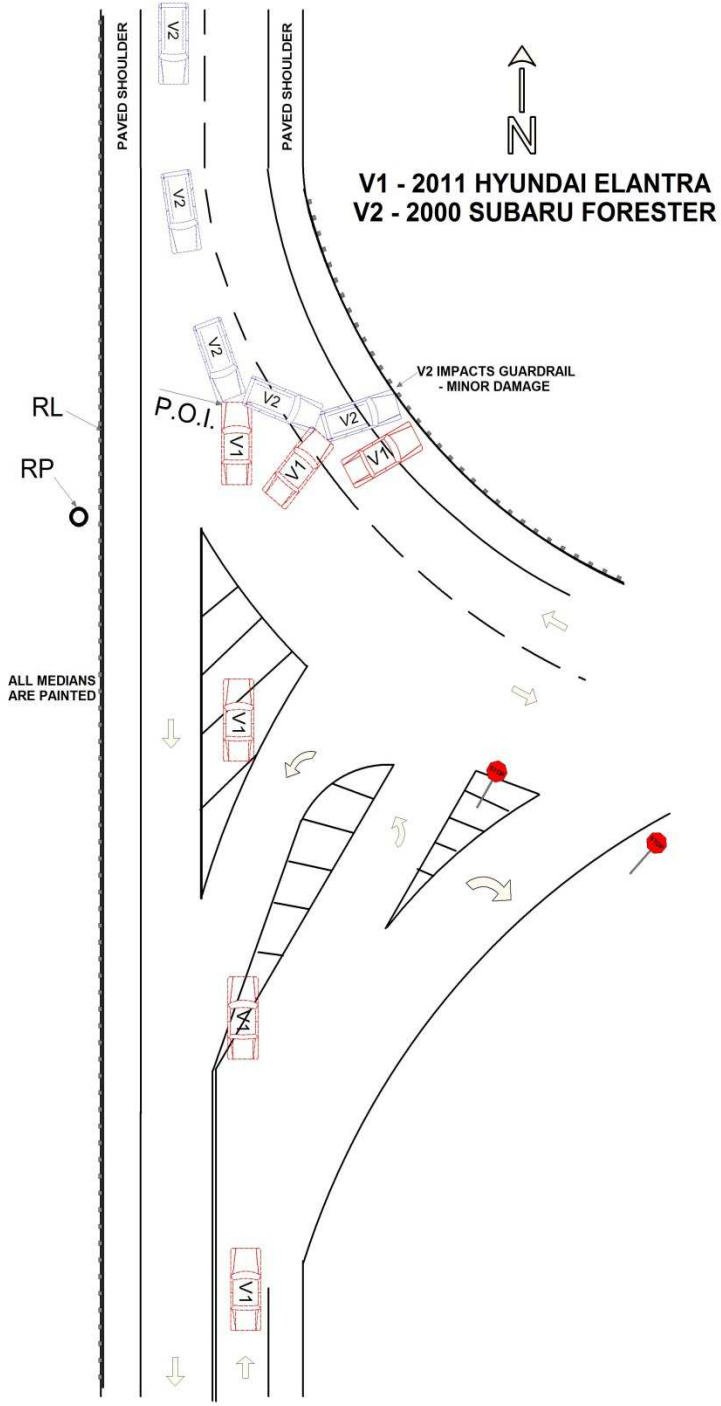
# Adjusted odds of injury for drivers, stratified by seatbelt type

| Integrated seat belt | | | | Non-integrated seat belt | | | |
|---|---|---|---|---|---|---|---|
| | 12 o'clock | 11 o'clock | 1 o'clock | | 12 o'clock | 11 o'clock | 1 o'clock |
| head | ref | 14.522 | 0.162 | head | ref | 1.328 | 1.034 |
| face | ref | 0.116 | 0.491 | face | ref | 0.809 | 1.477 |
| neck | ref | 2.571 | 0.336 | neck | ref | **0.307** | 0.241 |
| thorax | ref | 4.014 | 0.201 | thorax | ref | 0.929 | **1.702** |
| abdomen | ref | 0.555 | 0.855 | abdomen | ref | 0.897 | 1.849 |
| C spine | ref | 0.908 | 0.299 | C spine | ref | **1.865** | 1.374 |
| L spine | ref | na | 3.063 | L spine | ref | 0.773 | 1.296 |
| T spine | ref | 3.198 | na | T spine | ref | 1.150 | 1.237 |

# CIREN Case Study 1

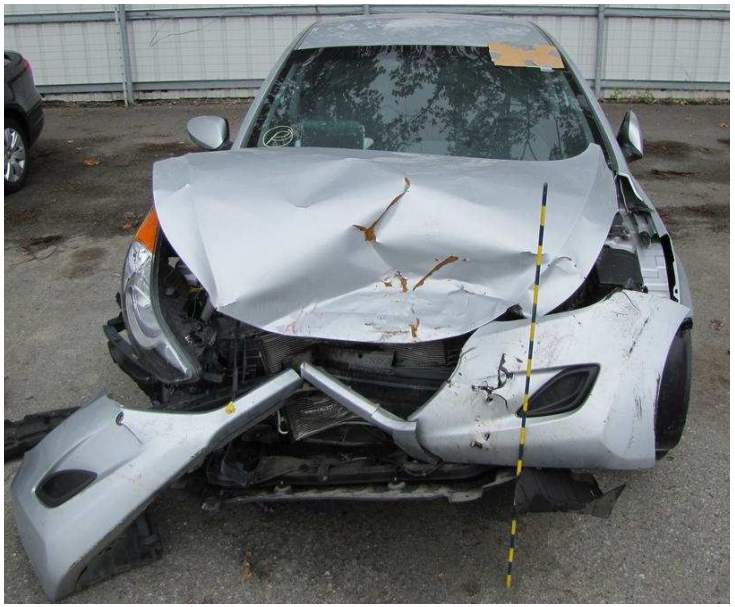
# Scene

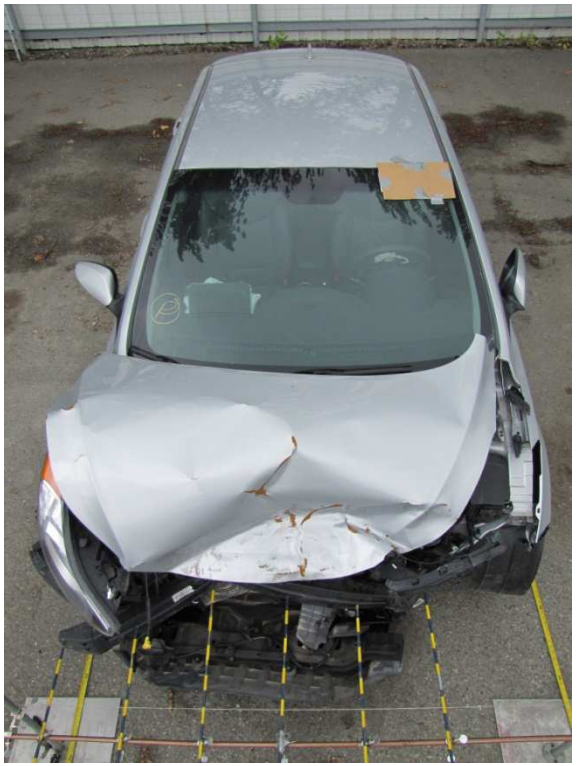
- Case vehicle
  - 2011 Hyundai Elantra (4-door sedan, hardtop)
- Frontal
- Object struck
  - V2 (2000 Subaru Forester)
- Daylight, Clear, Dry roadway
- Female front right passenger
- 75 yrs.
- 5’5”, 142lbs
  - Seated height = 24”/61cms



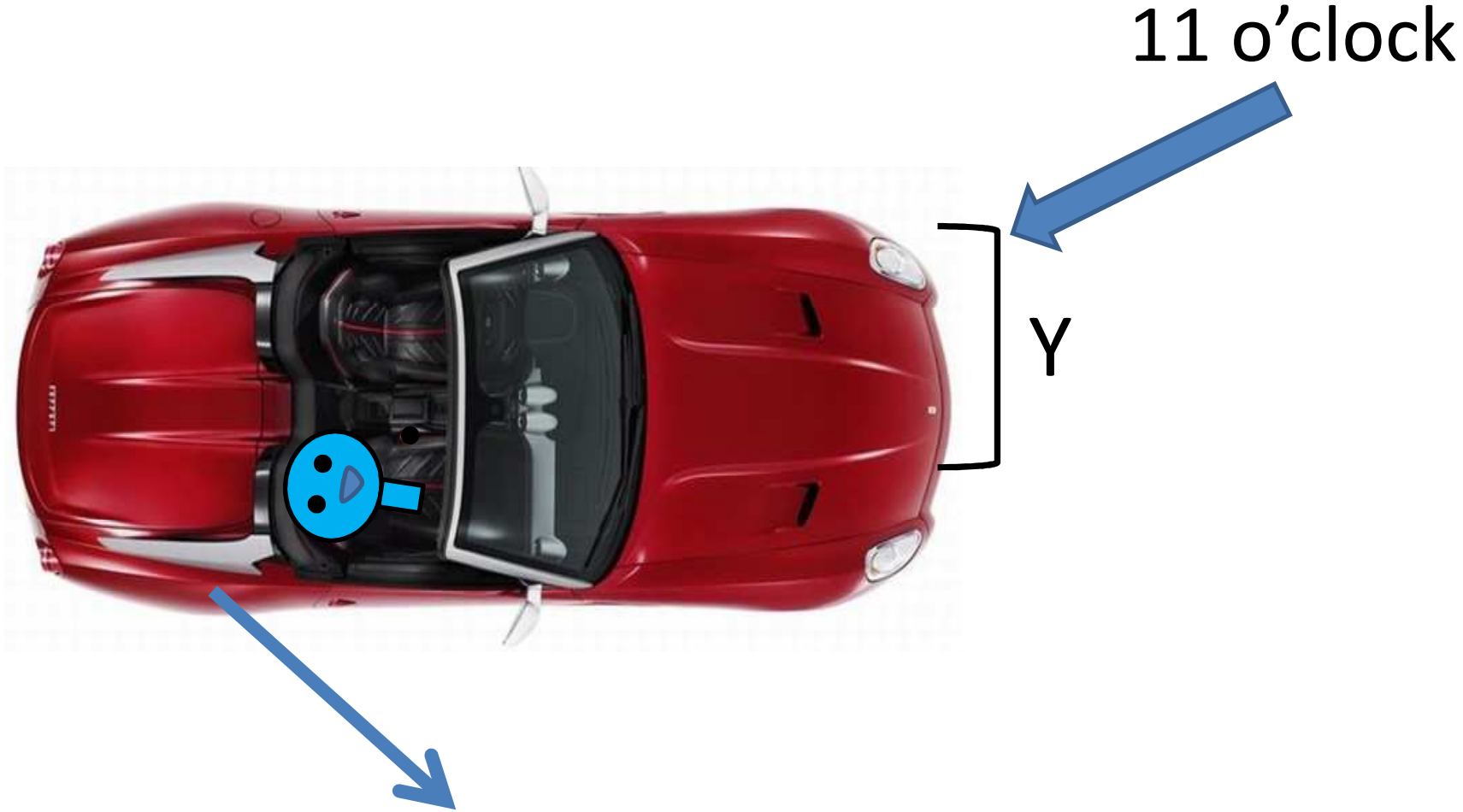
# Impact

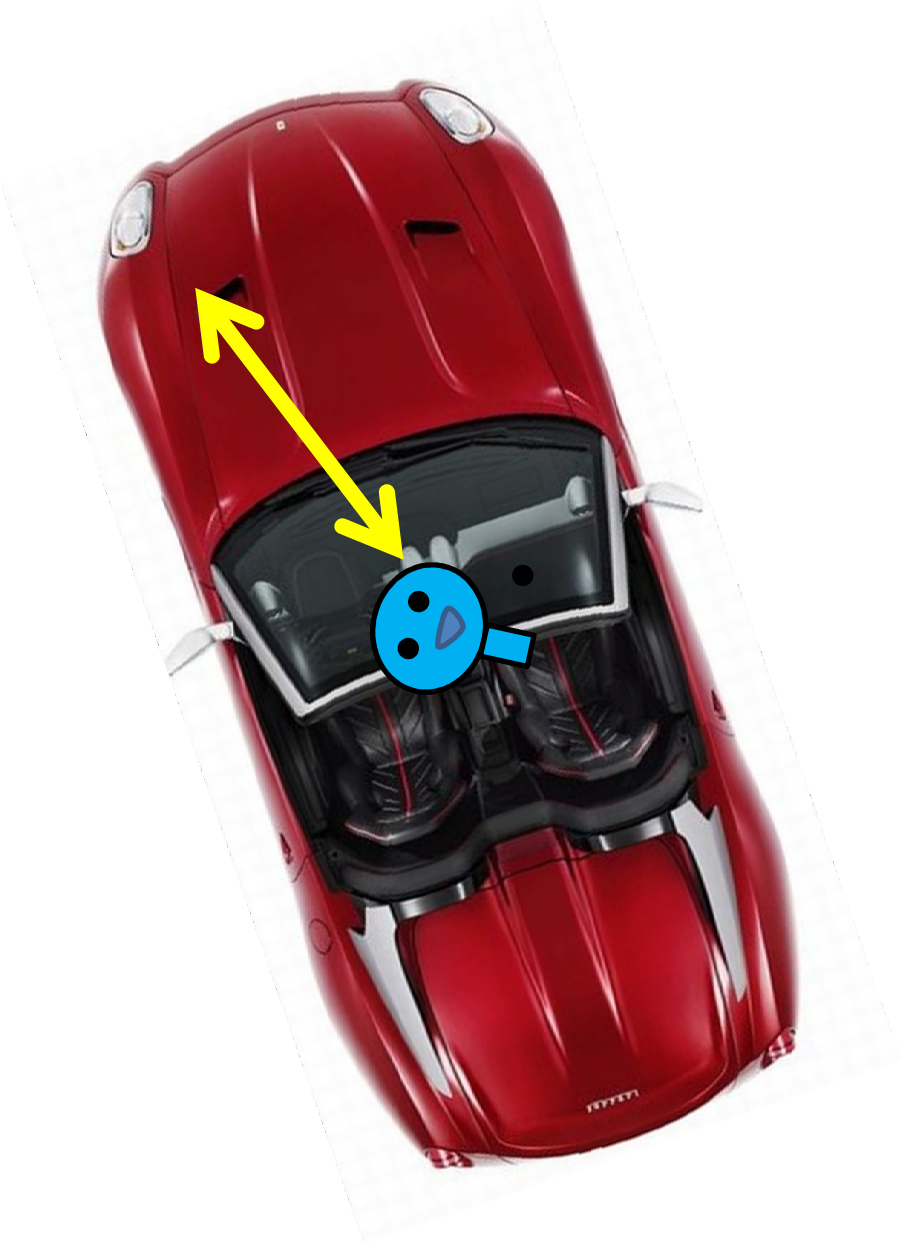
- PDOF = 340
- CDC – 71FYEW03 (Event #1)
- Delta V
  - Total = 29mph /47kmph
  - Long = -27mph/-44kmph
  - Lateral = 10mph/16kmph
  - EDR not supported
- Manual lap/shoulder belt with seat belt retractor pretensioner actuation
- Frontal air bag deployed





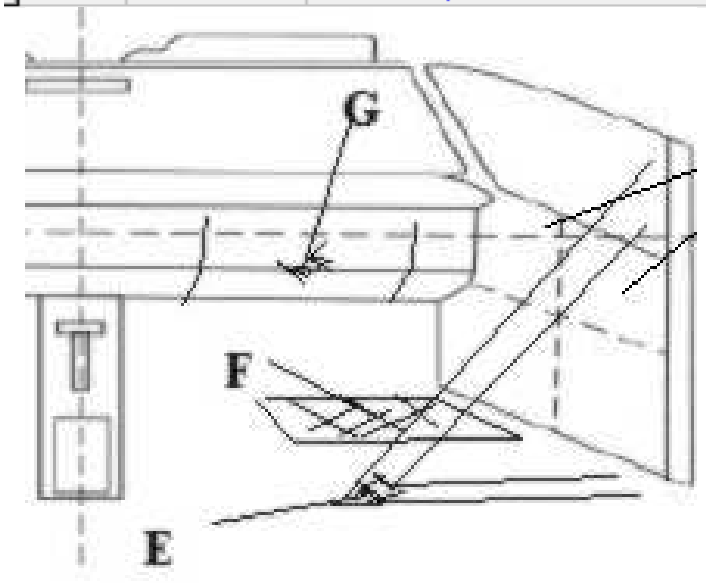
# No Intrusion


11 o’clock
Y



# Contacts

| Contact | Area | Component | Occ # | Body Region | Evidence | Confidence |
|---|---|---|---|---|---|---|
| E | Interior | Belt restraint webbing/buckle | 2 | Multiple Regions (spe | Combination (Specify) | Certain |
| F | Interior | Seat, back support | 2 | Buttock - Both | Deformed | Certain |
| G | Front | Glove compartment door | 2 | Knee - Right | Scuffed | Probable |

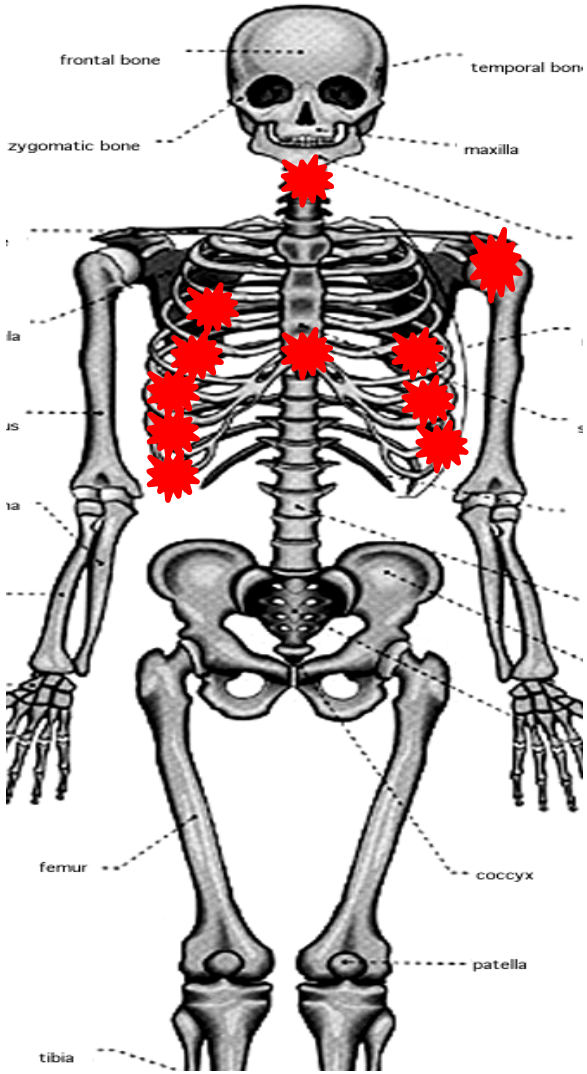


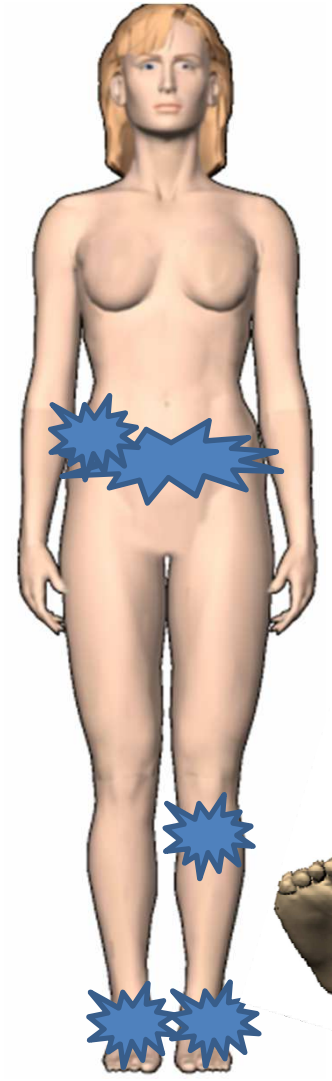

# Hospital Course

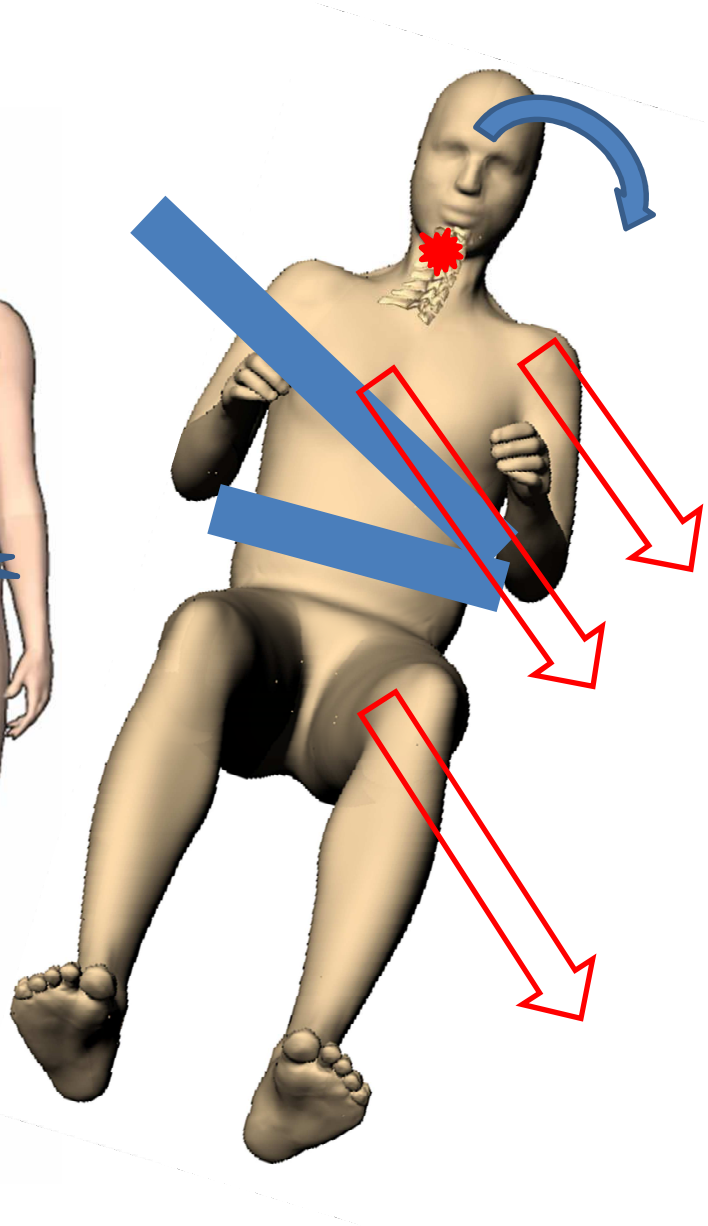
- Radiology / Diagnosis
  - *CT: C spine-* C2 dens fx., C2 body/lateral mass fx.
  - *CT:Chest-* L humeral fx.-greater tuberosity, sternal fx., R-3rd-7th rib fx.x & L-4th, 6th & 7th rib fx.s,
  - *CT: L spine-* L4 vertebral body fx.
  - *Xray: L foot-*L- 5th metatarsal fx.
  - *Xray: R hand-* R- radial styloid fx., R-4th phalanx fx.

# Injury

| AISCODE | Aspects | Description | BT | Notes: |
|---|---|---|---|---|
| 650228.3 | Posterior/back<br>Dorsal-*Unstable* | C2 dens fx. Type III | X | |
| 650217.2 | Posterior/back<br>Dorsal-*Unstable* | L-C2 vertebral body and lateral mass fx. | X | |
| 650634.3 | Inferior/Lower<br>*Unstable* | L4 vertebral body fx. ~ 20-25% height loss | X | |
| 450804.2 | Central | Sternal fx. | X | |
| 450203.3 | Bilateral | Rib fx.'s<br>L-AL-4th, 6th & 7th<br>R-Lat. 3rd & AL 4th-7th | X | |
| 751151.2 | Left | Humeral fx.-greater tuberosity-extra articular | X | |
| 752351.2 | Right | Radial styloid fx. | X | |
| 752653.1 | Right | 4th distal phalanx f | | |
| 858163.2 | Left | 5th metatarsal fx.(*intraarticular* | | |
| 510402.1 | Inferior/lower front | Contusions | | |
| 810402.1 | R hip | Contusions | | |
| 810402.1 | L hip | Contusions | | |
| 810402.1 | L lower leg | Contusions | | |
| 810402.1 | Left foot | Contusions | | |
| 810402.1 | Right foot | Contusions | | |


frontal bone
temporal bon
zygomatic bone
maxilla
femur
coccyx
patella
tibia





Case-684

# 751151.2 - Left Humeral fx.-greater tuberosity-extra articular

BRC = Shoulder

IPC 1.1= Center Instr. panel

CONF = PO

IPC 1.2=

CONF =

IPC Evid

Unknown

Component Contact-pick | Other-sp | Pre-Impact Braking

Related Contact Inj-pick | Partial Eject-sp | IPC Contact via AB

Injury Type-sp | Inferred Occ Contact | Tall Stature | Short stature | Occ Prox to IPC

ICS# 1

BRI= Shoulder

SOE= CRASH-Rank1

Contributing Factor

ICS Description: shoulder possibly impacted center IP

ICS_Evid

- Imp Rest Use-sp
- Non-op Postur-sp
- Veh Dynam-sp: PDOF, rotation, moved occupant inboard out of shoulder belt
- Other-sp
- Cont Indicat kinematic-pick
- Other Injury-pick
- Incr Excur Unbelted | Belt use | Unknown/None

Contributing Factor

- Intrusion | High DV
- Partial Ejection | Unbelt OTHER occ
- Unbelt Case Occ | SB Payout LL
- Pretensioner | None
- Loose cargo | Unknown
- Elderly-sp
- SB Interaction-sp
- Comorbidity-pick
- Late AB Deploy-sp
- CRS Imp Use-sp
- Other-sp

CRITICAL Intrusion

ICS – CONF= PR

Reg Mech Primary- compression

Secondary- unk

Rad Img(FX) | Ext Img | Occ Kin | Other -

Rad Img(INJ) | PDOF | SB Use | Unknown

Org Mech Primary- unk

Notes: need some direct contact to the left shoulder. possible she made it to CIP. She is only 5'5", and already loading seat cushion and belts? possible into driver area from rotation.

Case-684

# 650228.3 - Posterior/back Dorsal-*Unstable* C2 dens fx. Type III

BRC = Chest | IPC 1.1= seatbelt | CONF = PO

IPC 1.2= | CONF = | IPC Evid | Unknown

- [x] Component Contact-pick: Ebelts
- [ ] Related Contact Inj-pick:
- [x] Injury Type-sp: sternal fracture
- [ ] Other-sp:
- [ ] Partial Eject-sp:
- [ ] Inferred Occ Contact | [ ] Tall Stature | [ ] Short stature
- [ ] Pre-Impact Braking
- [ ] IPC Contact via AB
- [ ] Occ Prox to IPC

ICS# 1 | BRI= C-Spine | SOE= CRASH-Rank1

**ICS Description**: seatbelt restrained torso, lat bend-flexion of C spine

**ICS_Evid**

- [ ] Imp Rest Use-sp:
- [ ] Non-op Postur-sp:
- [x] Veh Dynam-sp: inboard movement due to PDOF, and rotation
- [ ] Other-sp:
- [x] Cont Indicat kinematic-pick: knee contact to glove box
- [ ] Other Injury-pick:
- [ ] Incr Excur Unbelted | [ ] Belt use | [ ] Unknown/None

ICS – CONF= PO

**Contributing Factor**

- [ ] Intrusion
- [ ] Partial Ejection
- [ ] Unbelt Case Occ
- [ ] Pretensioner
- [ ] Loose cargo
- [ ] High DV
- [ ] Unbelt OTHER occ
- [ ] SB Payout LL
- [ ] None
- [ ] Unknown
- [ ] CRITICAL Intrusion
- [ ] Elderly-sp:
- [ ] SB Interaction-sp:
- [x] Comorbidity-pick: osteo
- [ ] Late AB Deploy-sp:
- [ ] CRS Imp Use-sp:
- [ ] Other-sp:

**Reg Mech** Primary- flexion; Secondary- lateral bending

- [x] Rad Img(FX) | [ ] Ext Img | [ ] Occ Kin | [ ] Other -
- [ ] Rad Img(INJ) | [ ] PDOF | [ ] SB Use | [ ] Unknown

**Org Mech** Primary- unk

**Notes:** Unable to locate any evidence of contact to head to cause compression, the CT shows no marks, and on interview no injuries to external face/head. Just coded this as lateral bending/flexion from torso restrained with inboard movement due to PDOF and rotation of vehicle. (also we need to impact her left shoulder)

Case-684

# 650228.3 - Posterior/back Dorsal-*Unstable* C2 dens fx. Type III

BRC = Chest | IPC 1.1= airbag | CONF = PO

IPC 1.2= | CONF = | IPC Evid | Unknown

- Component Contact-pick | Other-sp | Pre-Impact Braking
- Related Contact Inj-pick | Partial Eject-sp | IPC Contact via AB
- Injury Type-sp | Inferred Occ Contact | Tall Stature | Short stature | Occ Prox to IPC

ICS# 2 | BRI= C-Spine | SOE= CRASH-Rank1

**Contributing Factor**

**ICS Description**: head impacts airbag cause compression, flexion

CRITICAL Intrusion

**ICS_Evid**

- Imp Rest Use-sp
- Non-op Postur-sp
- Veh Dynam-sp
- Other-sp
- Cont Indicat kinematic-pick: knee contact to glove box
- Other Injury-pick
- Incr Excur Unbelted | Belt use | Unknown/None

Intrusion | High DV

Partial Ejection | Unbelt OTHER occ

Unbelt Case Occ | SB Payout LL

Pretensioner | None

Loose cargo | Unknown

- Elderly-sp
- SB Interaction-sp
- Comorbidity-pick: osteopenic
- Late AB Deploy-sp
- CRS Imp Use-sp
- Other-sp

ICS – CONF= PO

**Reg Mech** Primary-: compression

Secondary-: flexion

Rad Img(FX) | Ext Img | Occ Kin | Other -

Rad Img(INJ) | PDOF | SB Use | Unknown

**Org Mech** Primary-: unk

Notes:

Case-684

# 650634.3 - Inferior/Lower *Unstable* L4 vertebral body fx. ~ 20-25% height loss

BRC (IPC 1) = Pelvis

**CRITICAL IPCs**

BRC (IPC 2) = Pelvis

IPC 1.1= seat cushion/pan | CONF = C

IPC 2.1= belts | CONF = C

IPC 1.2= | CONF =

IPC 2.2= | CONF =

- [x] [ ] [x] [ ] Comp Cont-pick: F - seatpan; E-belts
- [ ] [ ] [x] [ ] Rel Cont Inj-pick: Hip contusions
- [ ] [ ] [ ] [ ] Partial Eject-sp
- [x] [ ] [ ] [ ] Injury Type-sp: axial loading type,
- [ ] [ ] [ ] [ ] Other-sp
- [ ] [ ] [ ] [ ] Infer Occ Cont
- [ ] [ ] [ ] [ ] Short stature
- [ ] [ ] [ ] [ ] Pre-Impact Braking
- [ ] [ ] [ ] [ ] Tall Stature
- [ ] [ ] [ ] [ ] Occ Prox to IPC
- [ ] [ ] [ ] [ ] IPC Contact via AB
- [ ] [ ] [ ] [ ] Unknown

ICS#= 1 | BRI= L-Spine | SOE= CRASH-Rank1

**ICS Description**: pelvis loads seat cushion and belts cause L spine

**ICS Evid**

- [ ] Imp Rest Use-sp
- [ ] Non-op Postur-sp
- [ ] Veh Dynam-sp
- [ ] Other-sp
- [x] Cont Indicat kinematic-pick: G - knee to glove box
- [ ] Other Injury-pick
- [ ] Incr Excur Unbelted [ ] Belt use [ ] Unknown/None

ICS – CONF= C

**Contributing Factor**

- [ ] Intrusion
- [ ] Partial Ejection
- [ ] Unbelt Case Occ
- [ ] Pretensioner
- [ ] Unbelt OTHER occ
- [ ] Elderly-sp
- [ ] SB Interaction-sp
- [ ] Comorbidity-pick
- [ ] Late AB Deploy-sp
- [ ] CRS Imp Use-sp
- [ ] Other-sp
- [ ] High DV
- [ ] Loose cargo
- [ ] SB Payout LL
- [x] None
- [ ] Unknown
- [ ] CRITICAL Intrusion

**Reg Mech** Primary- compression; Secondary- unk

- [x] Rad Img(FX) [ ] Ext Img [ ] Occ Kin [ ] Other -
- [ ] Rad Img(INJ) [ ] PDOF [ ] SB Use [ ] Unknown

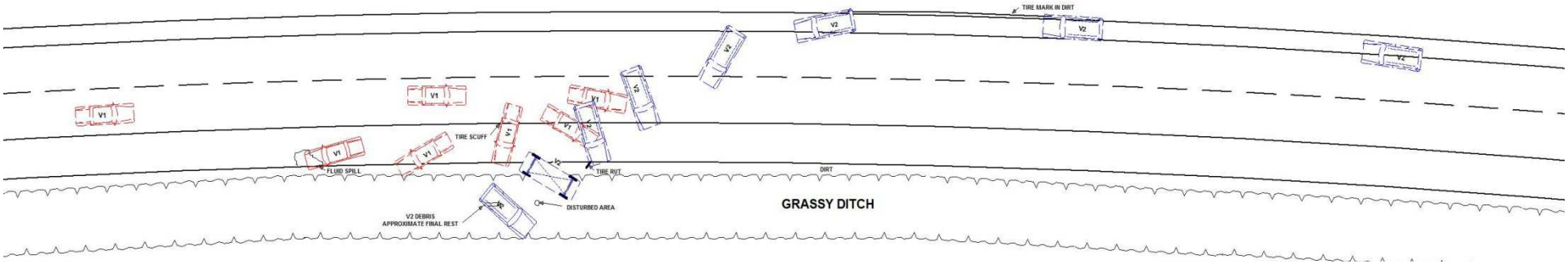
**Org Mech** Primary- unk

Notes:

# CIREN Case Study 2

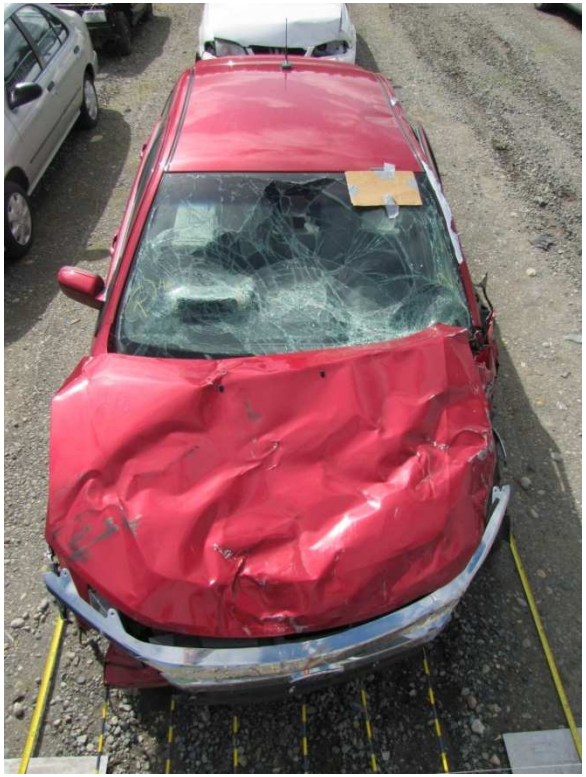
# Scene

- Case vehicle
  - 2011 Ford Fusion (4-door sedan, hardtop)
- Front to side (L) - angle
- Object struck
  - V2 – 2000 Dodge Durango (Large utility)
- Daylight, Overcast, Dry roadway
- Female front right passenger
- 67 yrs.
- 5’5”, 125lbs
  - Seated height = 26”/66cms



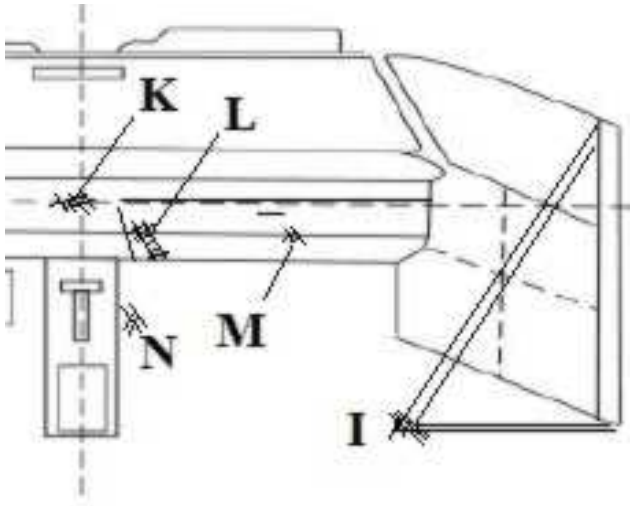
# Impact

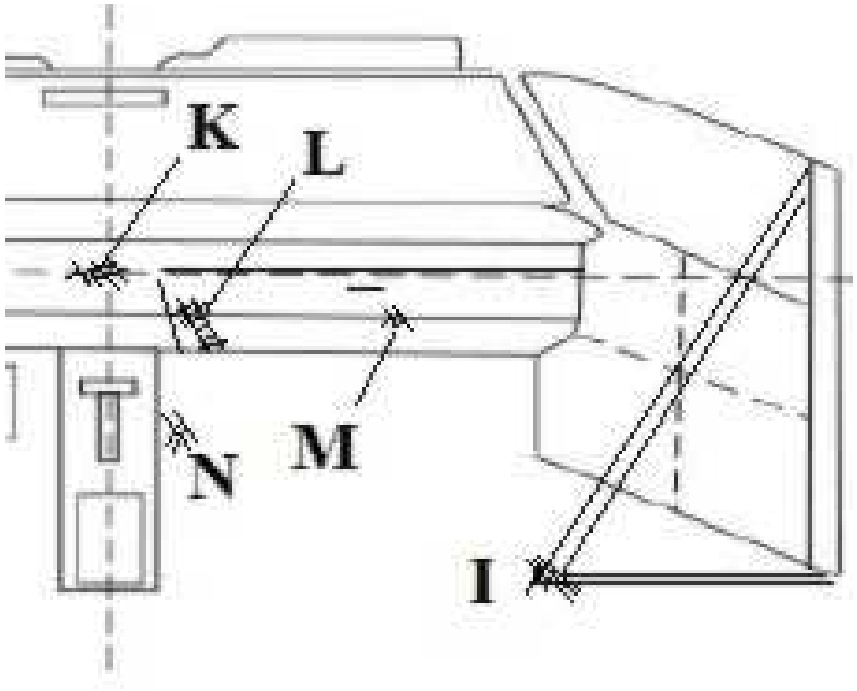
- PDOF = 340
- CDC – 11FDAW02
- Delta V
  - Total = 23mph /37kmph
  - Long = -22mph/-35kmph
  - Lateral = 8mph/13kmph
  - EDR – Max Long = -37.25mph
  - EDR – Max Lat = -12.23mph
- Manual lap/shoulder belt with seat belt retractor pretensioner actuation
- Frontal, seat mounted, roof rail curtain air bags deployed



# Contacts

| Contact | Area | Component | Occ # | Body Region | Evidence | Confidence |
|---|---|---|---|---|---|---|
| I | Interior | Belt restraint webbing/buckle | 2 | Multiple Regions (spe | Other (Specify) | Certain |
| J | Interior | Seat, back support | 2 | Buttock - Both | Deformed | Certain |
| K | Front | Center Instrument Panel | 2 | Multiple Regions (spe | Scuffed | Probable |
| L | Front | Glove compartment door | 2 | Lower Leg - Left | Scuffed | Certain |
| M | Front | Glove compartment door | 2 | Lower Leg - Right | Scuffed | Certain |
| N | Interior | Other interior object (specify) | 2 | Ankle - Left | Scuffed | Possible |



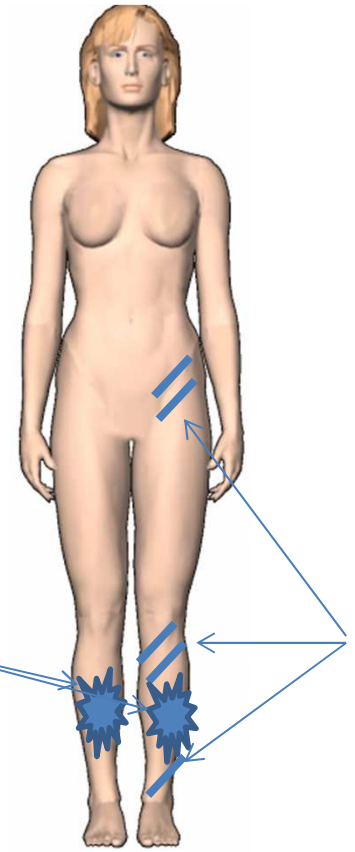


K
L
N
M
I


AIRBAG OFF

# Injury

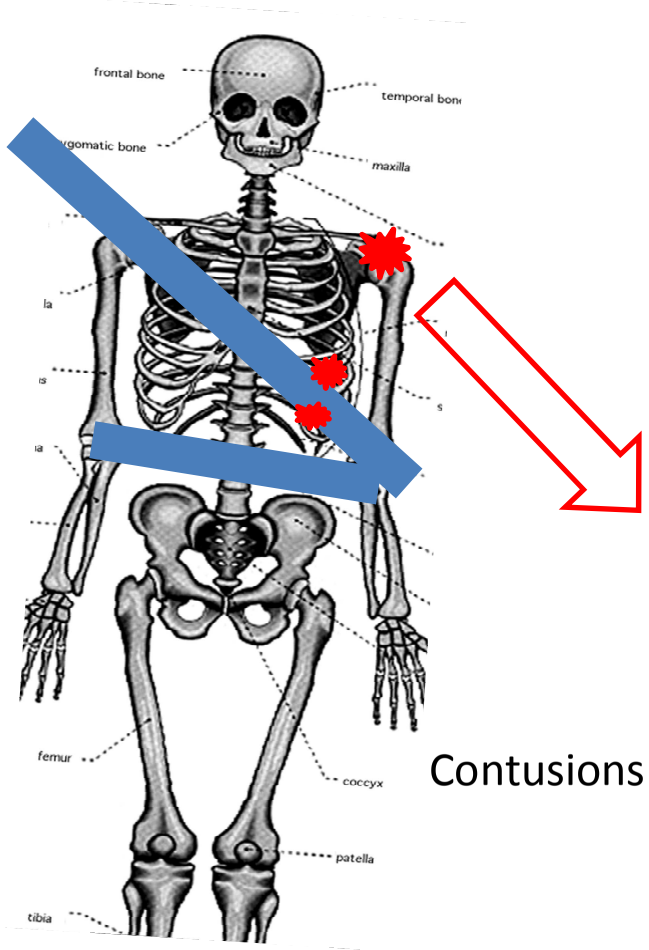
| AISCODE | Aspects | Description | BT | Notes: |
|---|---|---|---|---|
| 450203.3 | Left lateral/posterior lateral | Rib fx's 8th lat., 10th lat., & | X | |
| 650632.2 | Inferior/Lower-*Stable* | L5 endplate fx.< 20% | X | |
| 771030.2 | Left | L gleno-humeral joint dislocation | X | |
| 751151.2 | Left | Greater tuberosity fx. | X | |
| 858253.1 | Left | 2nd phalanx fx. | | |
| 858263.1 | Left | 3rd phalanx fx. | | |
| 858263.1 | Left | 4th phalanx fx. | | |
| 858253.1 | Left | 5th phalanx fx. | | |
| 810202.1 | Left hip | abrasions | | |
| 810402.1 | Left lower leg | contusions | | |
| 810202.1 | Left lower leg | abrasions | | |
| | | | | |

Biotab coded: Vehicle dynamics coded as inboard movement due to PDOF and rotation



Contusions

Abrasions




Contusions

# Conclusions

- There is evidence of increased odds of thoracic injuries among drivers (OR=1.69) in 1 o'clock crashes and front right passengers in 11 o'clock (OR=2.14), both inboard movements.
- Front offsets, corner type classifications in 12 o'clock directions showed no overall informative increase in the odds of injuries as compared to full frontal impacts.
- Classification of Front Left (FL) showed an extreme increase in the odds of head injuries for driver's, but reached only marginal significance. Further analysis is necessary.

# Conclusions

- Overweight or obese individuals sustained increased odds of thorax injuries during outboard movements (drivers OR=2.31, and front passengers OR=14.97)
- Integrated seat belts seemed to control occupant movement compared to conventional belt design and in all frontal crash directions, reducing odds of injury in the spine, abdomen, face, and thorax.

# Next Steps

- For all frontal directions, and BMI groups, further assess belt shoulder anchor adjustments (up, mid, down).
- Further evaluate C-spine injuries among short statured occupants since underweight group had increased odds of injury.
    - Underweight front right passengers, OR=8.61 for C-spine injuries with 11 o'clock, inboard
    - Underweight drivers, OR=20.89 C-spine 11 o'clock, outboard
- Further evaluate BMI for outboard PDOFs with significant odds for thoracic injury for overweight in both drivers and front right passengers

# Next Steps

- Further analyze front crash directions (11 and 1 o'clock) with the frontal impact classifications.
- Conduct integrated belts versus conventional belts in rollovers using AIS, other study used police reported injury severity.
- Assess upper and lower extremities in relation to frontal crash directions.

Questions?