Slide 1.

Higher Body Mass Index Decreases Risk of Pelvic Fracture in Nearside Impacts
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Slide 2. Background

- Side impacts are the second most common crash type
- FMVSS 214 establishes performance standards to protect occupants in side impacts
- Occupants sustain pelvic fractures in nearside impacts due to compression, shear, bending or crushing of the pelvic ring
- Pelvic fractures may require not only emergent medical and surgical intervention but also long-term rehabilitation
- This study builds upon previous research by other CIREN Centers
- Research question: Is BMI a predictor of pelvic fractures during nearside impacts?

Slide 3. Previous Research on Pelvic Fractures

Occupant Factors
Female gender
Age
Body stature
BMI, obesity, subcutaneous fat depth

Vehicle/crash Factors
Nearside impact
Intrusion
High delta V impact
Car body type
High, rigid center console

Slide 4. San Diego CIREN Case Example

Photograph of downtown San Diego

Slide 5. Case Example

- 19 year old female (5 feet, 7 inches tall, 134 lbs, “normal” BMI)

- Using safety belt, but no side airbag available
- Driver of Toyota Corolla struck by Jeep Wagoner in intersection
- Nearside impact (PDOF 10 o'clock) with 35 cm of door panel intrusion
- delta V: 36 kmph (22 mph)
- Sustained multiple pelvic fractures (and other injuries)

Slide 6.

Photograph showing intrusion of door panel into passenger compartment.

Slide 7.

Three photographs showing intrusion of door panel into passenger compartment.

Slide 8. Pelvic injuries.

- Left sacral fracture - comminuted fracture of the left sacrum with extension into the posterior elements (involving left neural foramen and central sacral canal)
- Right inferior pubic ramus comminuted fracture with extension into the right superior pubic ramus
- Left superior pubic ramus minimally displaced fracture
- SI joint diathesis (right > left)
- Right superior pubic rami fracture
- Left inferior pubic ramus nondisplaced fracture

Slide 9. Radiology image showing pelvic fractures

1. Comminuted left sacral fracture,
2. SI joint diathesis right>left,
3. Bilateral superior and inferior pubic rami fx's
4. Bilateral symphysis pubis fx w/ diathesis

Slide 10. CT image showing some of the pelvic fractures

1. Comminuted left sacral fracture
2. SI joint diathesis right > left

Slide 10. Methods

- Data Source: CIREN database (1997-2007)
  - Compared occupants with pelvic fractures and those without pelvic fractures
- Case Criteria:
  - First row drivers and outboard passengers
  - Adults (>13 years old)
  - Nearside impact ranked #1 impact

  - PDOF = 8,9,10 o'clock (drivers) or 2,3,4 o'clock (passengers)
- Bivariate analyses and Logistic Regression

Slide 11. Body Mass Index

- Numeric measurement classifying people on weight scaled to height
- Considered age and gender independent
- Categories (based on WHO):
  Normal: 18.5 – 24.9
  Overweight: 25 – 29.9
  Obese: > + 30

Slide 12. CIREN Occupants in Nearside Impacts

There were 424 occupants meeting study criteria. Over half (57.5%) had pelvic fractures. These were compared to 180 occupants (42.5%) without pelvic fractures.

Slide 13. CIREN Occupants in Nearside Impacts

Statistically significant difference between BMI and whether the occupant had a pelvic fracture. Odds Ratio = 1.80 (1.09, 2.98)
Occupants who are normal BMI have almost twice the odds of having a pelvic fracture compared to overweight and obese occupants. This is true when normal BMI is compared to just overweight BMI or when Normal is compared to just obese BMI or Normal is compared to both overweight and obese BMI.

127 normal occupants with had pelvic fractures.
79 overweight occupants had pelvic fractures.
39 obese occupants had pelvic fractures

Slide 14. Pelvic Fracture Severity by BMI

Most pelvic fractures were AIS 2 (moderate) severity regardless of BMI category. About 64% of normal occupants had AIS2 pelvic fractures and the other 46% were AIS 3+. About 68% of overweight occupants had AIS 2 pelvic fractures and the other 32% were AIS 3 or above. About 45% of obese occupants had AIS 2 pelvic fractures and the rest were AIS 3 or above.

Greater proportion of pelvic fractures in obese occupants were greater severity. Statistically significant difference (Chi square=10.9, p=0.006) between severity (AIS 2 vs AIS 3+) comparing the 3 BMI categories.

AIS 2: Closed/NFS pelvic fx
AIS 3: Open/displaced/comminuted/sacroilium/symphysis pubis
AIS 4+: Substantial deformation/displacement with vascular disruption

Slide 15. Occupants with Pelvic Fracture by Door Panel Intrusion

As magnitude of intrusion of door panel increases, the proportion of occupants with pelvic fracture increases for overweight and obese. The proportion increases for normal BMI occupants and then levels off.

Comparing BMI categories normal vs. overweight/obese at different levels of intrusion, the only almost significant difference is at 15 to <30 cm (normal BMI Odds ratio=1.94 (1.01, 3.74). There is only this significant different probably because of the small numbers of occupants in each category when stratified by door panel intrusion categories.

Slide 16. Sources of pelvic fracture by BMI status

There is a statistically significant difference for source of pelvic fracture: overweight and obese are almost 4 times more likely to have pelvic fractures sourced to the door/door hardware/armrest. Other includes B-pillar, knee bolster, other interior object, instrument panel. About 80% of normal occupants had pelvic fractures sourced to the door or door hardware. This is compared to almost 90% of overweight and obese occupants. Normal weight occupants had about 8% of pelvic fractures sourced to the center console and about 12% caused by other sources. For overweight/obese occupants only about 2% were sourced to the center console and about 5% to other sources.

Overweight and obese collapsed into single category because of small numbers.

Slide 17. Preliminary Results

	Odds Ratio	95% Confidence Limits
"Normal" BMI	1.80	1.09, 2.98
Female Gender	2.41	1.61, 3.59
Case vehicle = car	2.79	2.59, 4.90
Door panel intrusion >15cm	1.80	1.09, 2.98
High delta V impact	3.18	1.21, 8.33
Co-morbidity	1.05	0.60, 1.84
Age	1.06	0.68, 1.63
Deployed side airbag*	1.43	0.74, 2.76
Safety belt use	0.98	0.63, 1.54

Normal BMI, female gender, being in a passenger vehicle, door panel intrusion >15 cm and high delta V were all (statistically significantly) associated with pelvic fractures overall. P-values would be 0.05 or less.

There was no statistical association with co-morbidity, age, side airbags, safety belt use. (Odds ratio confidence limits include "1.00" so the p-value would be greater than 0.05

Slide 18. Multivariate Results

	Odds Ratio	95% Confidence Limits
"Normal" BMI	1.81	1.17, 2.86
Case vehicle = car	1.98	2.06, 3.74
Door panel intrusion >15cm	1.06	0.85, 1.33
High delta V impact	1.03	1.01, 1.05
Female Gender	1.13	0.96, 1.35
Co-morbidity	1.02	0.40, 2.59
Age	1.01	1.00, 1.02
Deployed side airbag*	1.80	0.86, 3.77
Safety belt use	1.00	0.61, 1.64

Only BMI and riding in a passenger vehicle were predictive of the occupant sustaining a pelvic fracture. All factors in the table were included in the model. *Only a small proportion of vehicles had side airbags.

Occupants who were normal BMI had almost twice the odds of getting a pelvic fracture even when controlling for other factors.
Occupants who were in a passenger vehicle also had almost twice the odds of getting a pelvic fracture.

Other factors were not significantly predictive of pelvic fracture when potential confounders were controlled for in the logistic regression models.

Slide 19. Why is Bigger Better?

- ? Protective layer of subcutaneous fat overlying pelvis
- ? Larger occupant may not move out of position laterally in the seat during impact

  - More pelvic fractures in “normal” occupants sourced to center console compared to overweight/obese who have pelvic fractures caused by hard contact with the door and hardware
  - Greater pelvic fracture severity for overweight/obese occupants who do sustain pelvic fractures (greater compression?)
- ? Other reasons

Slide 20. Conclusions

- This study supports using anthropomorphic crash dummies of varying height/weight for crash testing (especially due to the change in the average American BMI during the last decade)

- Occupants who are “normal” BMI or who are riding in a car are almost twice more likely (compared to overweight/obese occupants) to have a pelvic fracture in a nearside impact

- Pelvic fractures increase with increasing door panel intrusion (although not an independent predictive factor)

- Contact with the door, hardware, armrests, center console causes most pelvic fractures during nearside impacts (varies by BMI status)

- Future research is needed on the role and design of side airbags in preventing pelvic fracture (as more vehicles with side thorax-pelvis airbags become available)

Slide 20. Limitations

- CIREN is not a representative database of all occupants in nearside impacts
- Database limitations (no OTA codes)
- Magnitude of intrusion is based on residual intrusion measurements (actual magnitude may have been greater)
- Small number of occupants in nearside impacts in vehicles with side airbags

Slide 21. San Diego CIREN Team

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