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Effects of Occupant Age on AIS 3+ Injury Outcome Determined from Analyses of Fused NASS/CIREN Data

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Background

1. Population is getting older—Currently 14% of population (40M people) is over 65. By 2020 this will increase to 16% of the population (55M people).

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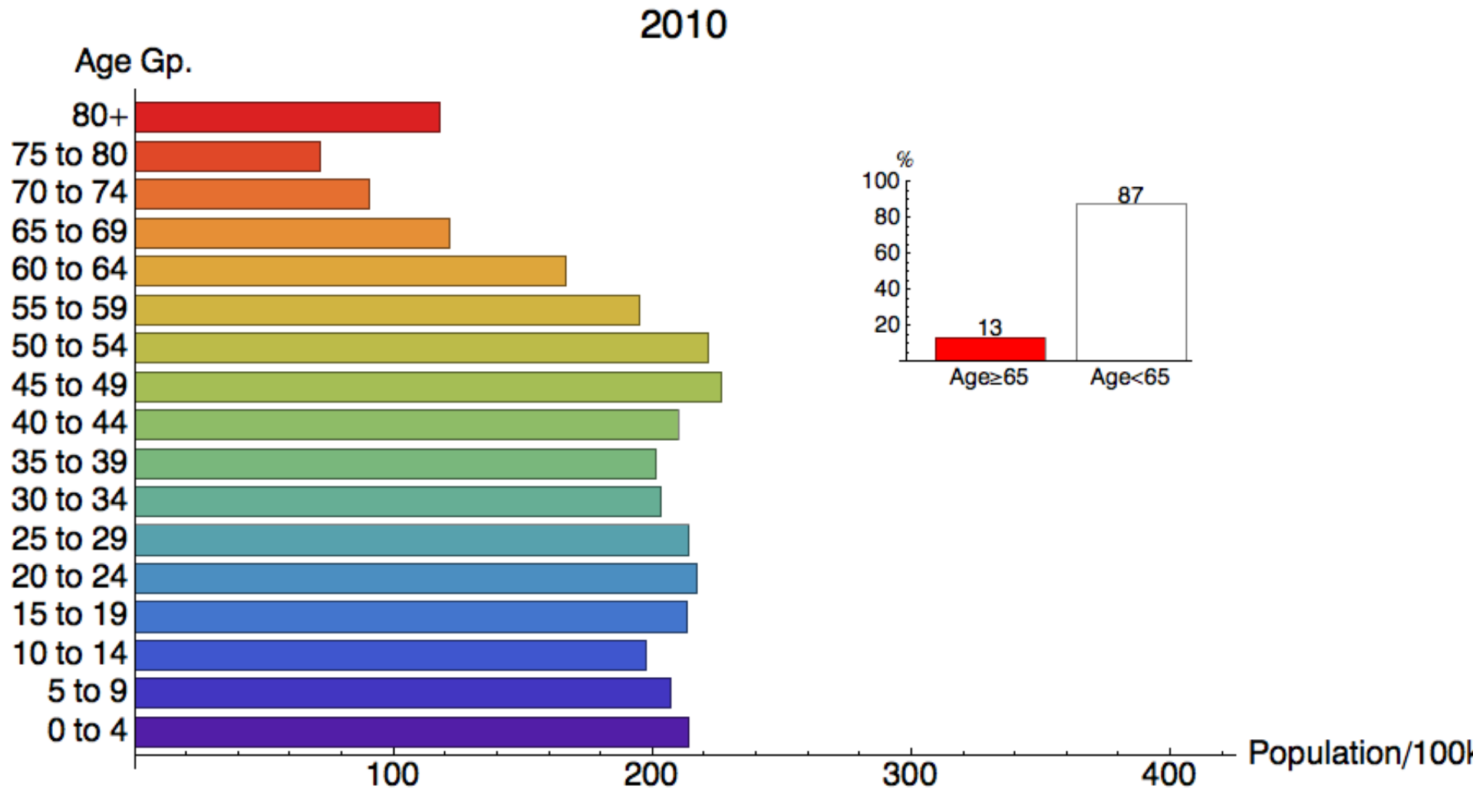
2010
Age Gp.
80+
75 to 80
70 to 74
65 to 69
60 to 64
55 to 59
50 to 54
45 to 49
40 to 44
35 to 39
30 to 34
25 to 29
20 to 24
15 to 19
10 to 14
5 to 9
0 to 4
100
200
300
400
Population/100k
%
100
80
60
40
20
13
87
Age≥65
Age<65

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Background

1. Population is getting older—Currently 14% of population (40M people) is over 65. By 2020 this will increase to 16% of the population (55M people).
2. Many studies have looked into the effects of age on the risk of serious injury in crashes, however, these studies have typically focused on a particular injury and crash mode (most commonly head and thoracic injury in frontal crashes).
3. No studies have looked at aging effects on a body region level across crash modes.
4. No studies have compared the effects of age on AIS 3+ injury risk to the effects of gender and obesity.

Analysis Methods

- Fused NASS (1998-2008) with pseudoweighted CIREN (1998-2008)
- Used only completed CIREN cases
- Limited fused dataset to:
  - MY≥1992
  - Age≥16
  - Front outboard seating location
  - Frontal, Nearside, Farside, Rollover crashes
  - Passenger car, van, lt. truck, utility vehicle
  - 15 kg/m^2 ≤ BMI ≤ 85 kg/m^2
  - Belt use known

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Analysis Methods, cont.

- Used multivariate logistic regression to characterize the effects of the following parameters on AIS 3+ injury by crash mode:
  - Age
  - Gender
  - BMI
  - deltaV (frontal, nearside, farside only)
  - # qt turns (1-2, 3-6, 7-10, 11-13, ≥14)
  - Belt use (3pt, other, none)
  - Seat position (driver/passenger)
  - Multiple severe events (secondary event extent ≥ 3)
  - L-Type/T-type (middle 1/3 of vehicle damaged-side impact only)
  - Interrupted rollover
  - Occupant seating location relative to direction of rollover

Analysis Methods, cont.

- Considered second order effects for age, BMI, gender, and vehicle type.
- Used a reverse stepwise approach to model development.

Numbers of Occupants with AIS 3+ Injuries Meeting Selection Criteria--Unweighted

	Head	Face	Neck	Thorax	Spine	Abdomen	UX	LX
Farside	306	22	3	327	84	70	64	107
Frontal	663	100	22	1313	358	351	699	1770
Nearside	573	42	7	1011	237	224	111	641
Other	2	3	1	43	6	8	21	42
Rear	38	0	1	33	16	6	6	6
Rollover	933	83	25	1066	362	306	348	478

Not enough data

Face and neck injuries and rear impact crashes and crashes with unknown/other crash modes were excluded because of low numbers of AIS 3+ injured occupants.

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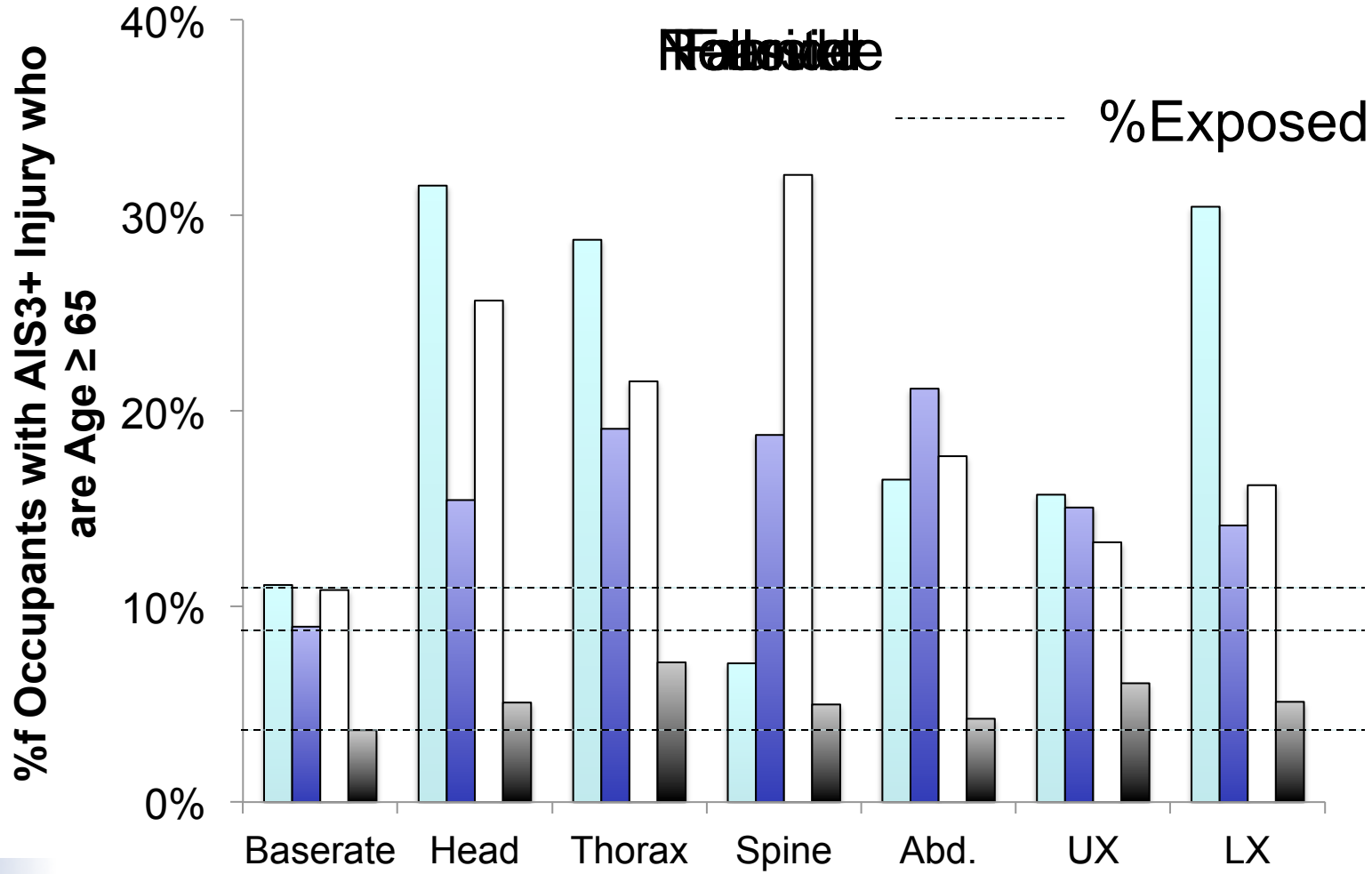
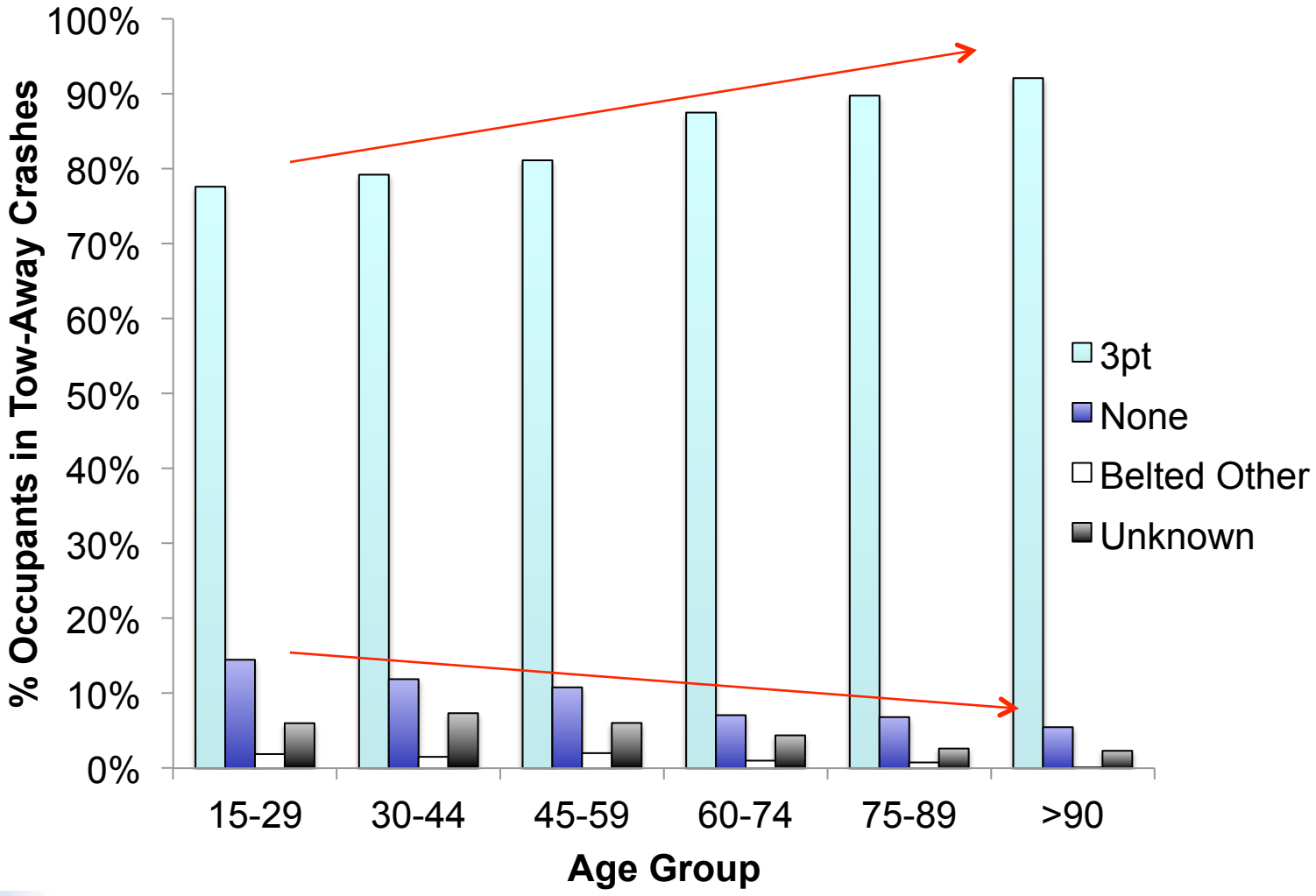
%Exposed Age≥65 vs. % Injured Age≥65 by Body Region and Crash Mode



Belt Use Rates vs. Age



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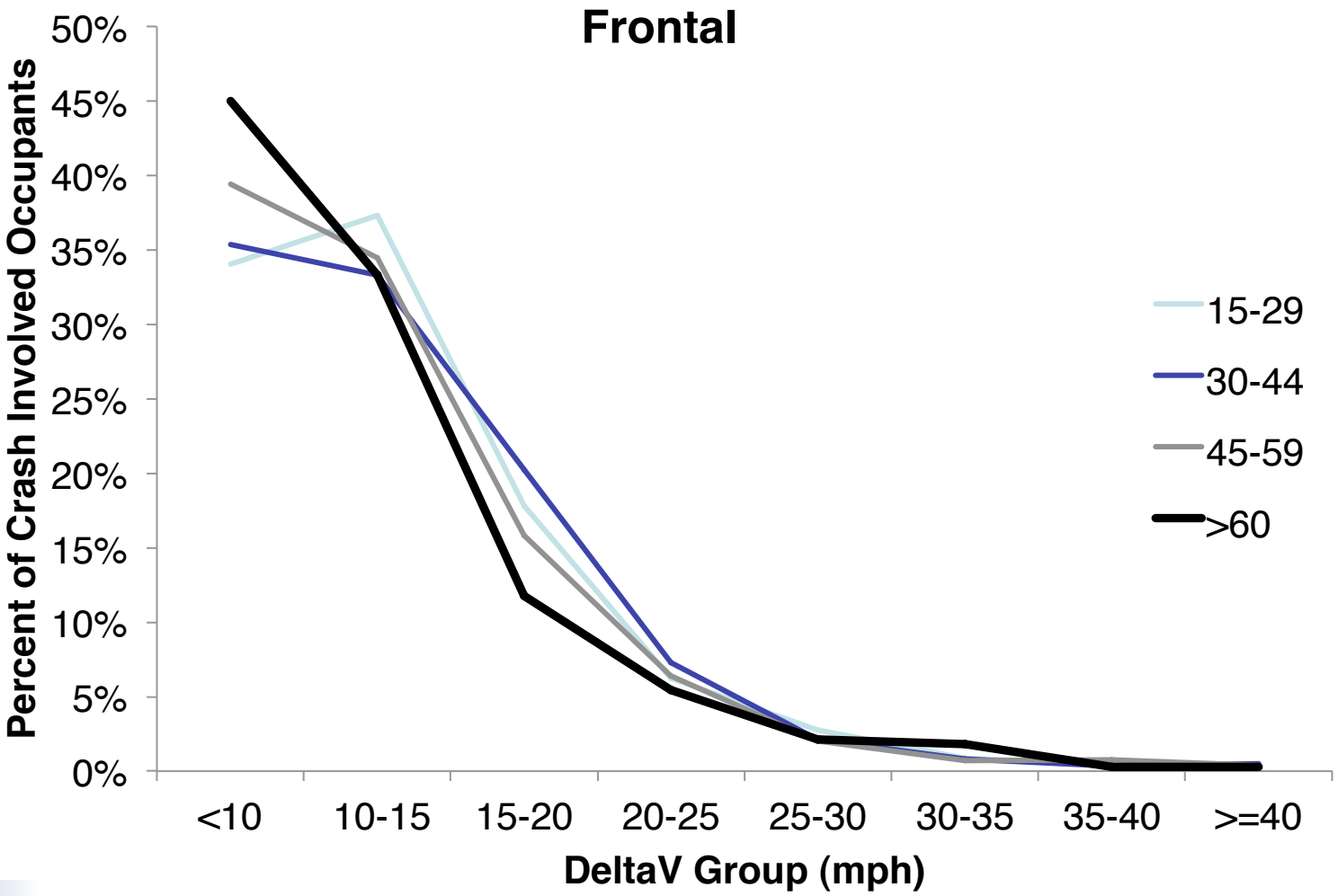
ΔV vs age



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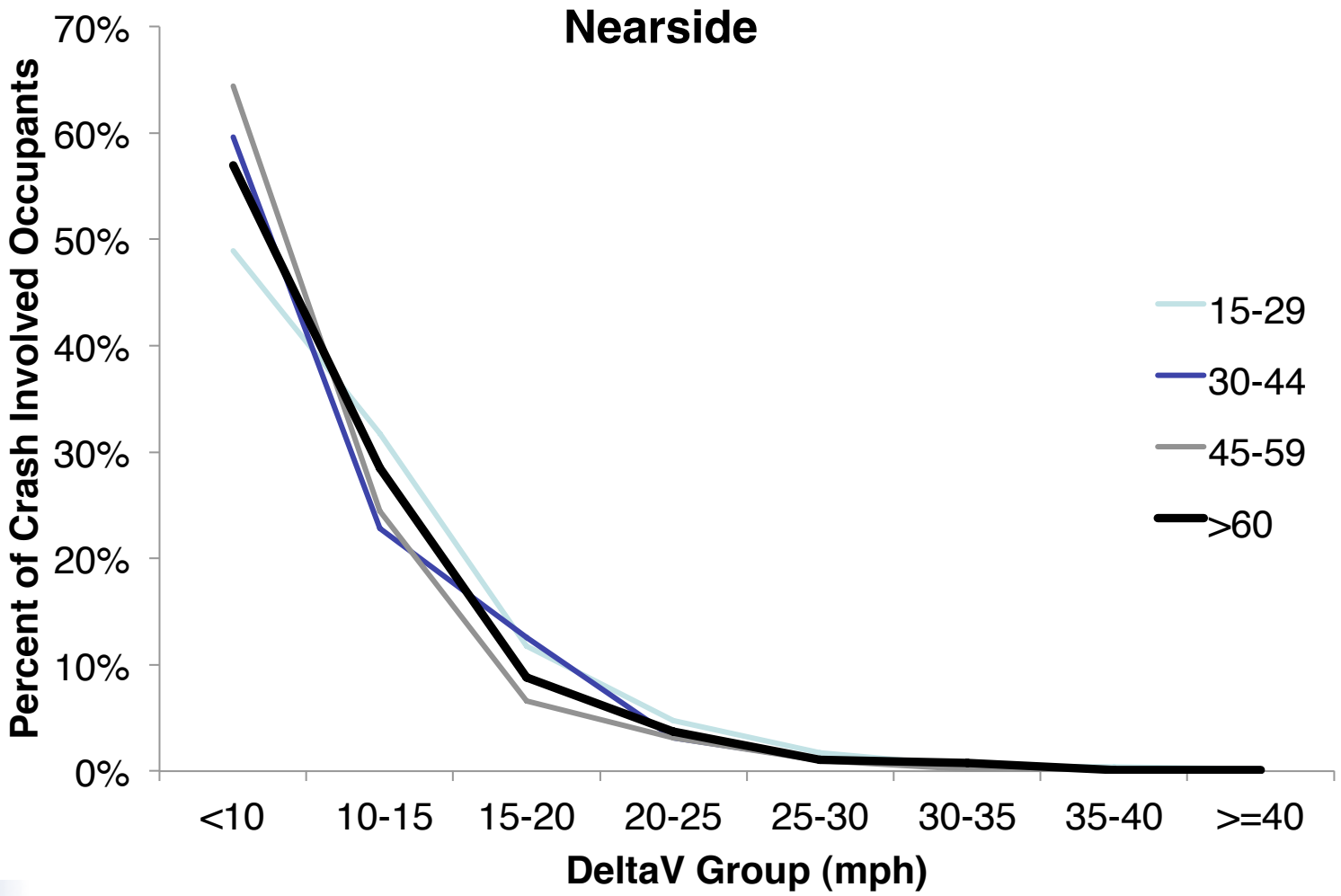
ΔV vs age



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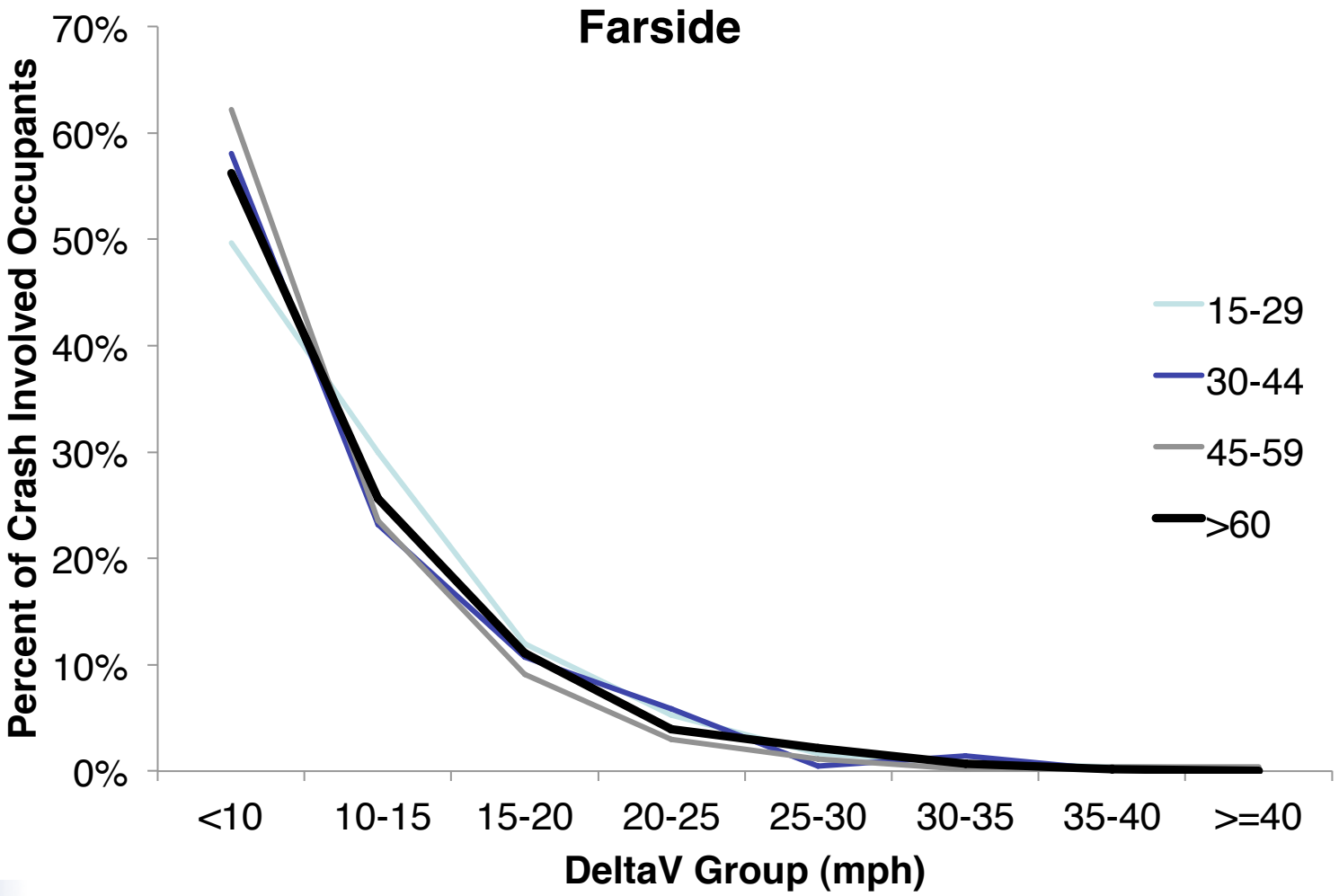
ΔV vs age



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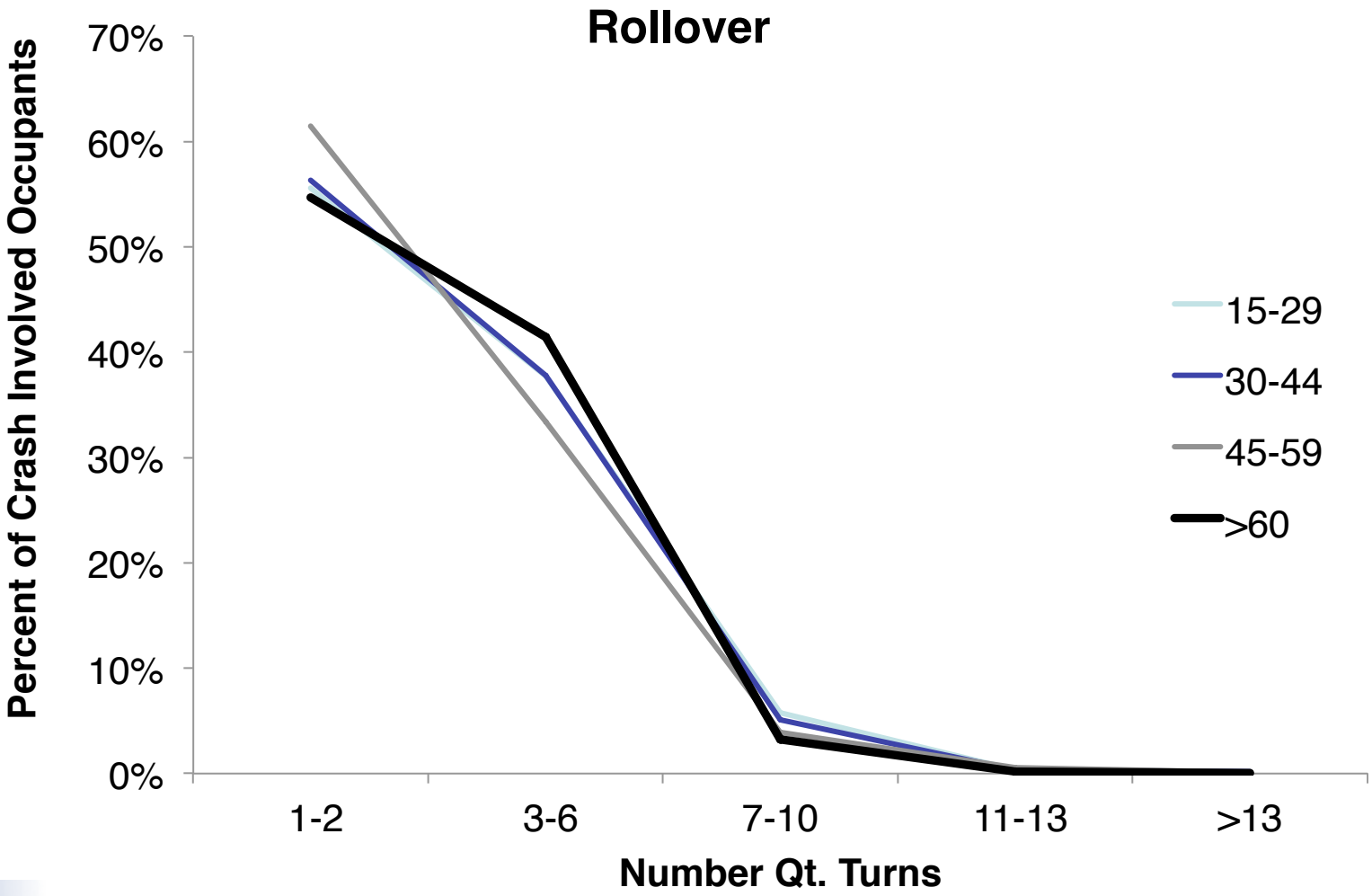
#Quarter Turns



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Odds Ratios and 95% CI for Significant Age Effects by Body Region and Crash Mode

	Head	Thorax	Spine	Abdomen	UX	LX
Frontal	4.68*** (3.07,6.75)	Male:11.59 Female:37.63	5.77*** (3.24,10.77)	7.11*** (3.60,13.94)	2.62** (1.54,4.44)	4.00*** (2.49,6.41)
Nearside	4.93*** (2.91,8.76)	6.08*** (3.24,11.34)	8.17* (2.01,33.18)	8.17* (2.01,33.18)	4.93*** (2.76,8.76)	2.91* (1.11,7.89)
Farside	9.22*** (3.24,27.09)	12.58** (5.20,29.98)	NS	–	–	NS
Rollover	4.00* (1.00,16.26)	5.48*** (2.76,11.34)	NS	Male:0.23 Female 0.05	5.48*** (4.22,7.11)	Male: 1.82 Female: 5.60

NS= Not Significant, * p<0.05, **p<0.001, ***p<0.0001

All odds ratios are based on increasing age from the 5th to the 95%ile of the adult front seat crash-involved population (i.e., 17 to 71 yr.)

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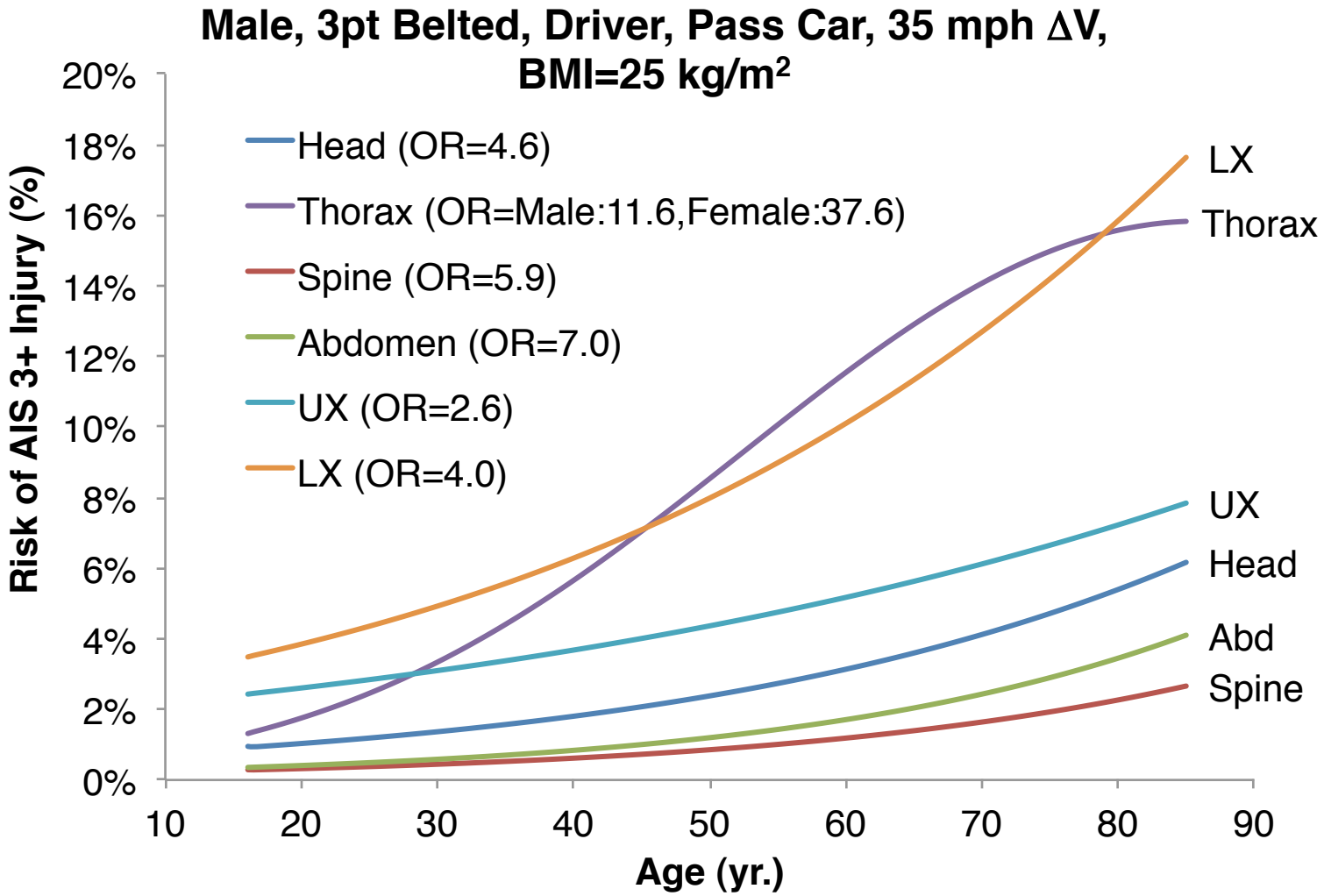
Age Effects-Frontal Crashes



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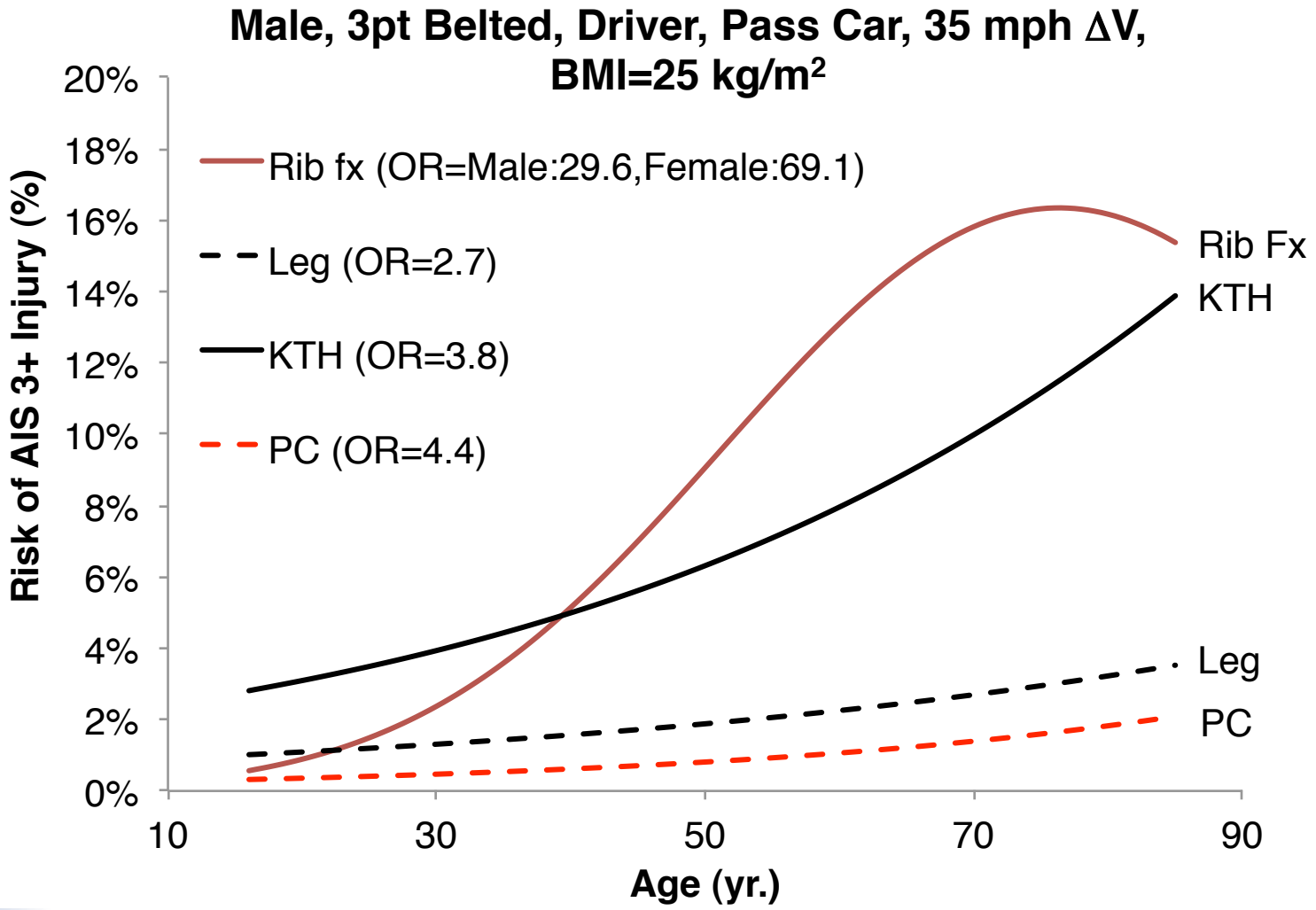
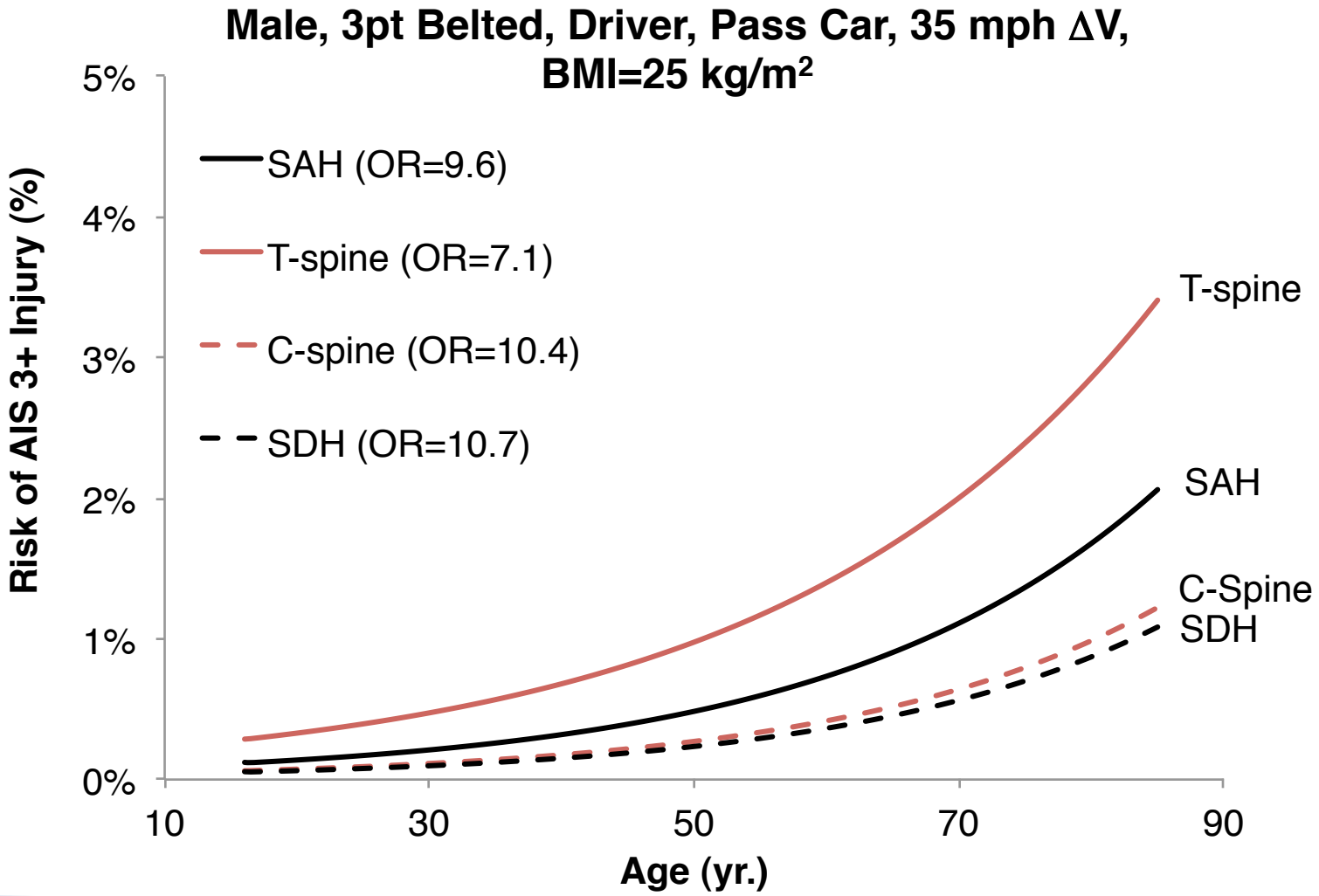
Age Effects for LX and Thorax Components in Frontal Crashes



Age Effects for Spine and Head Components in Frontal Crashes



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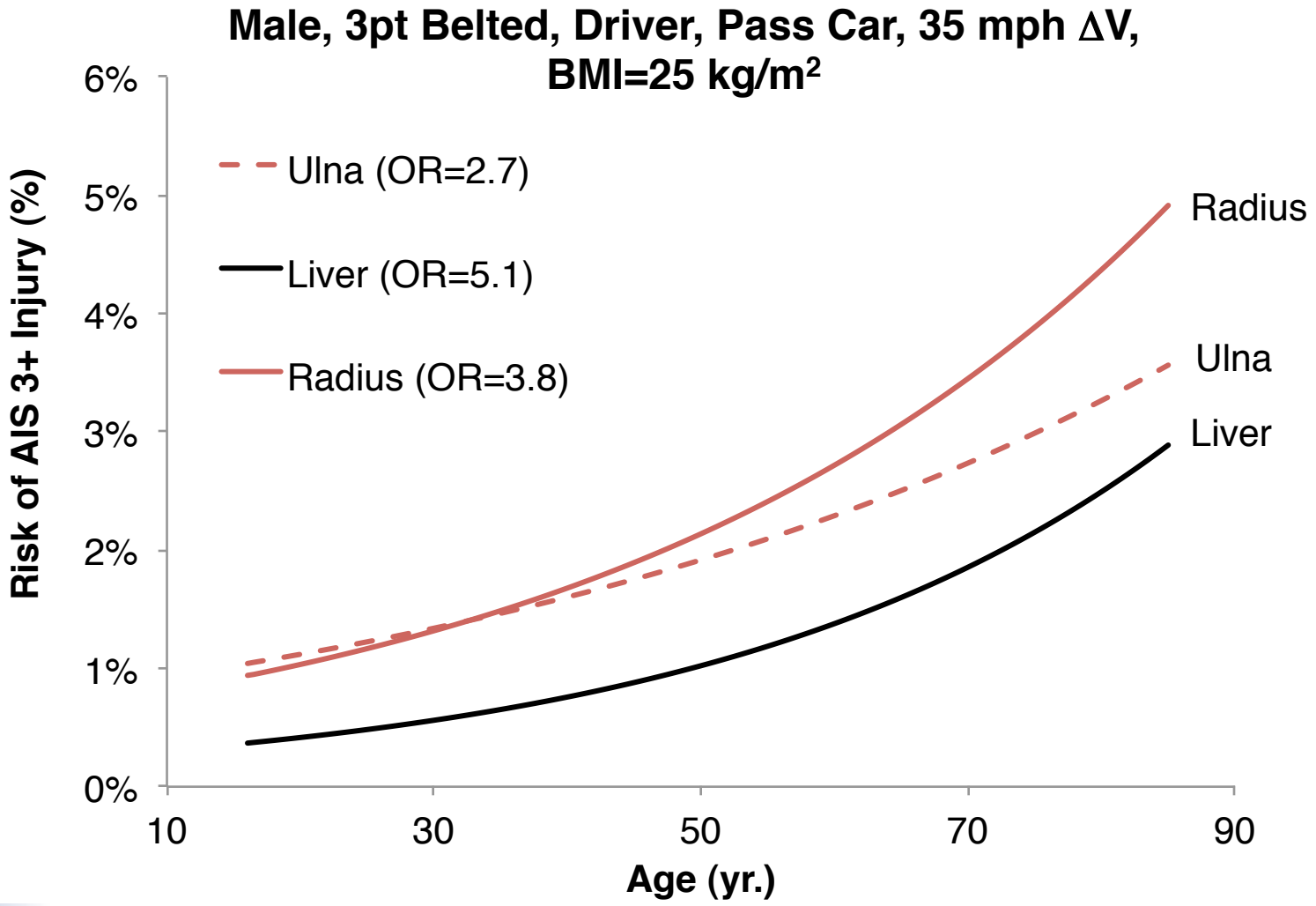
Age Effects for UX and Abdomen Components in Frontal Crashes



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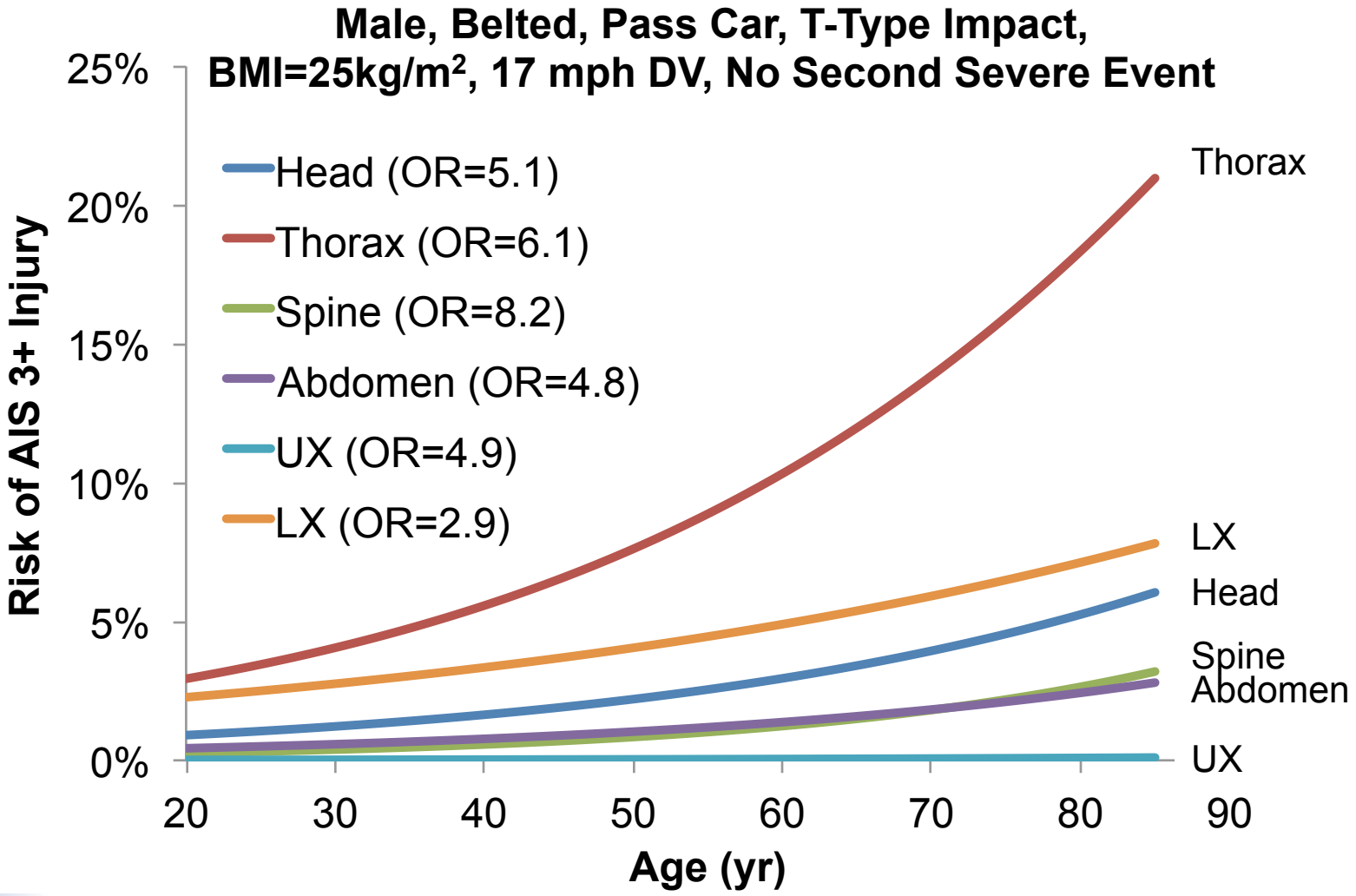
Age Effects-Nearside Crashes



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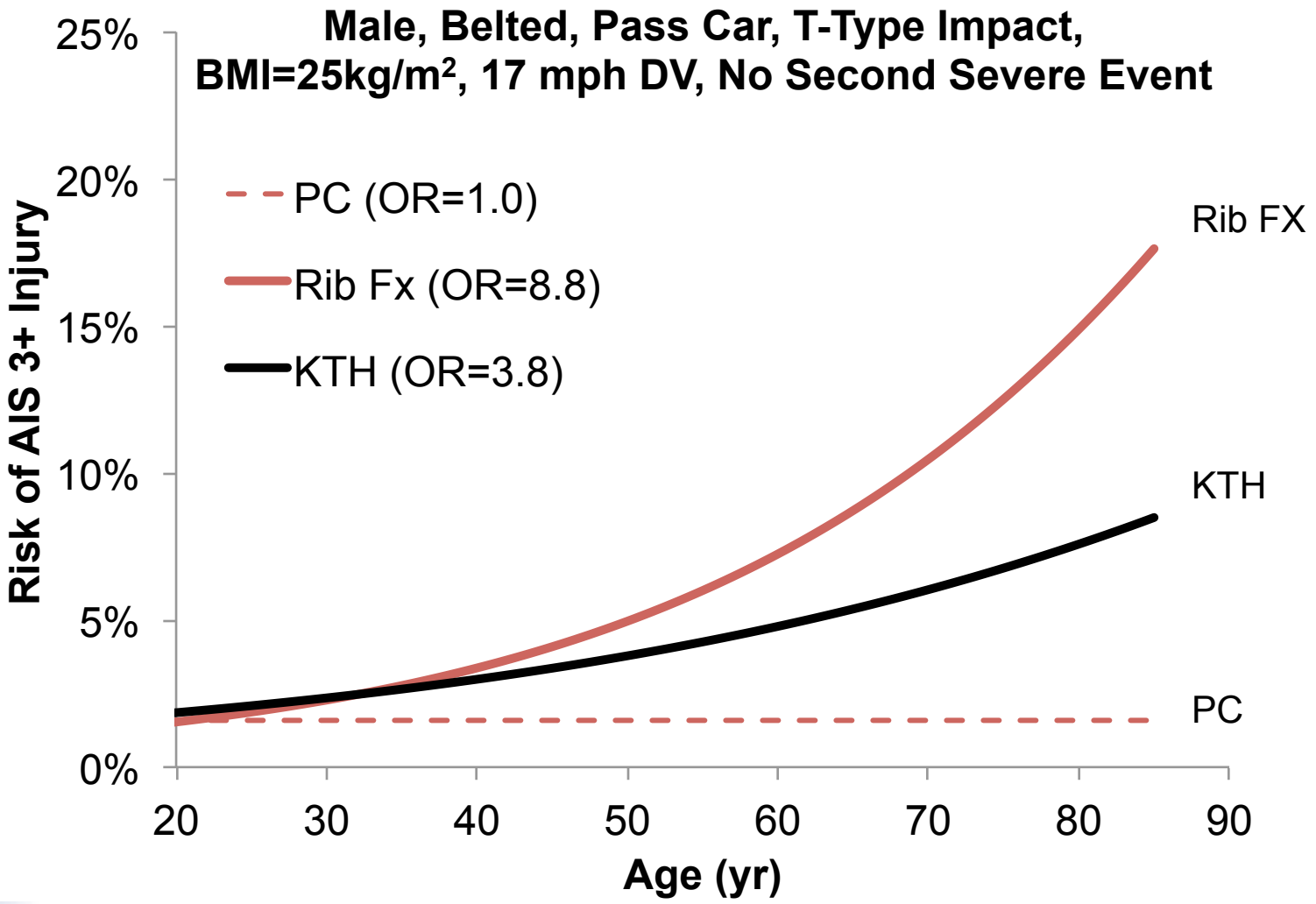
Age Effects-Nearside Crashes



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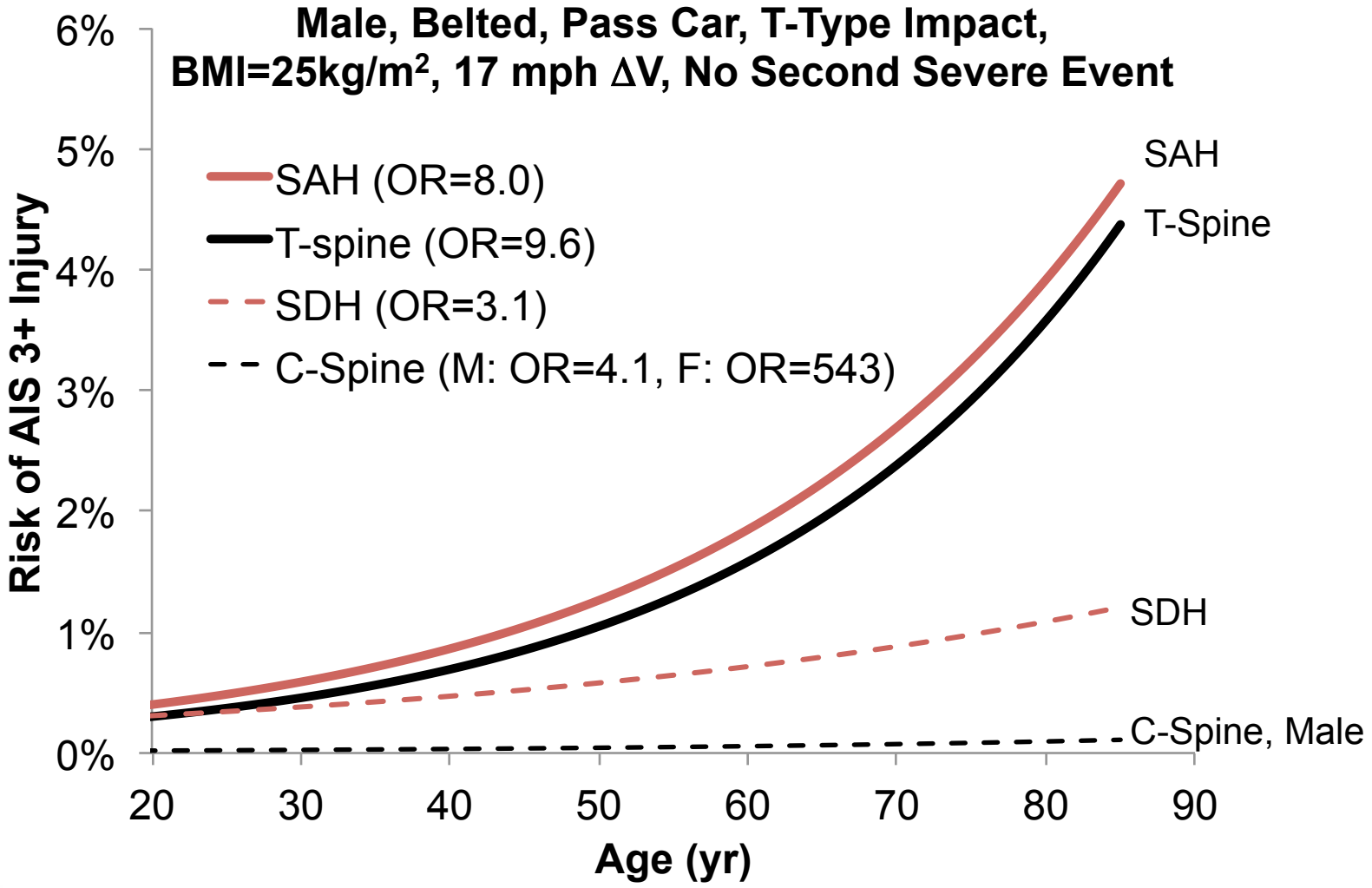
Age Effects for LX and Thorax Components in Nearside Crashes



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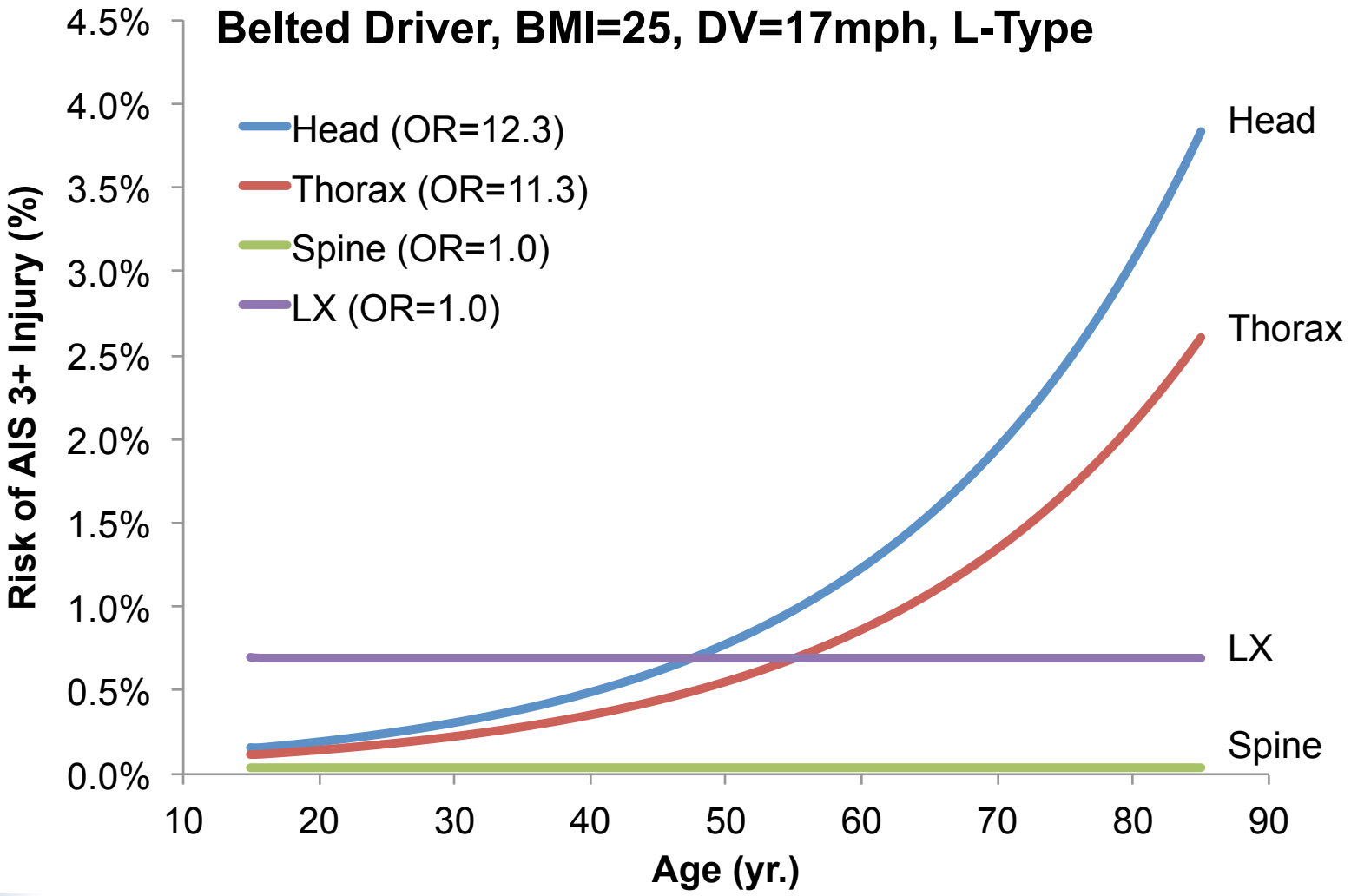
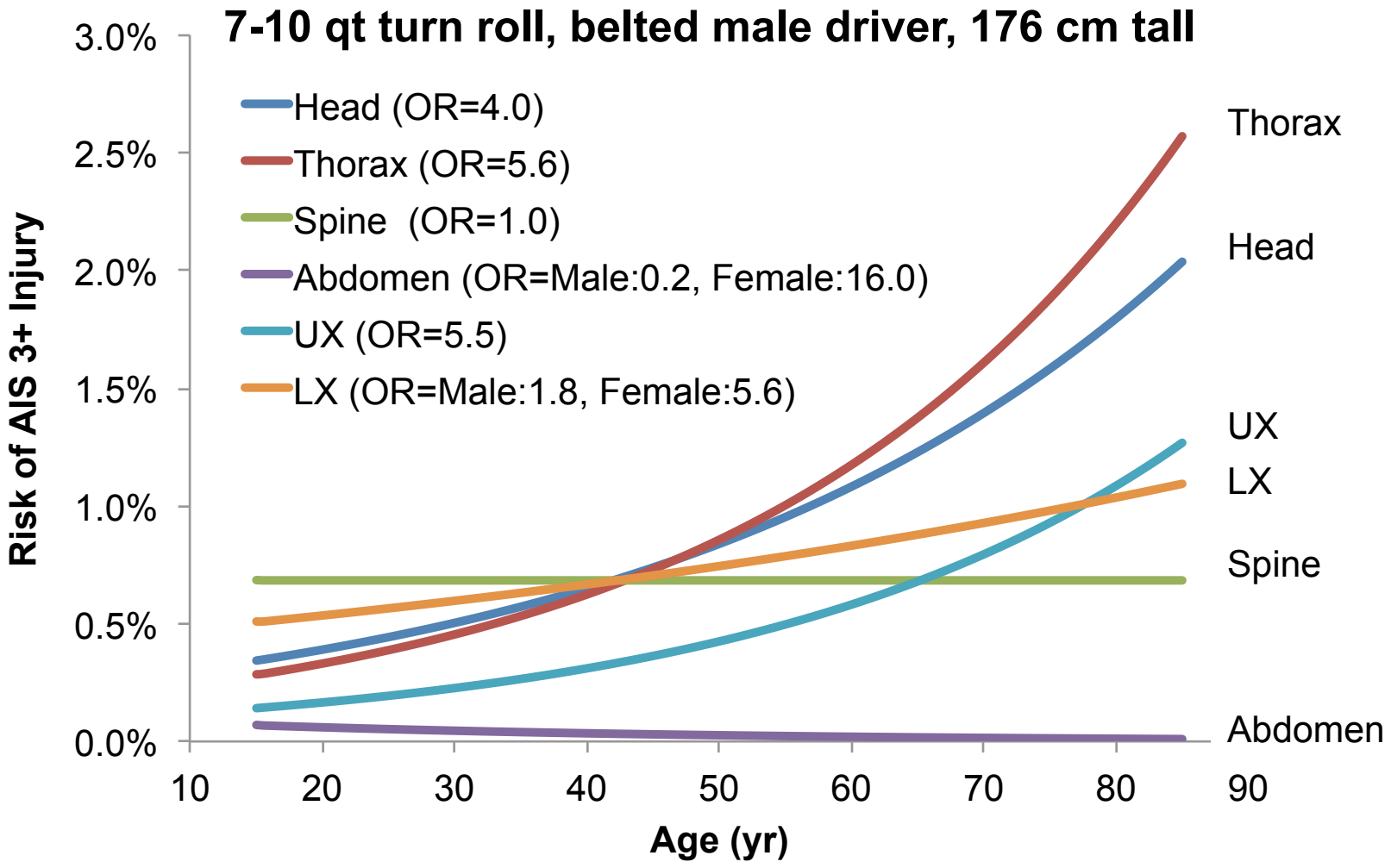
Age Effects-Farside Crashes



Age Effects-Rollovers



How does the age effect compare to the effects of BMI and gender?

Odds Ratios and 95% CI for Significant Age Effects by Body Region and Crash Mode

	Head	Thorax	Spine	Abdomen	UX	LX
Frontal	4.68***	Male:11.59 Female:37.63	5.77***	7.11***	2.62**	4.00***
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All odds ratios are based on increasing age from the 5th to the 95%ile of the adult front seat crash-involved population (i.e., 17 to 71 yr.)

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Odds Ratios and 95% CI for Significant BMI Effects by Body Region and Crash Mode

	Head	Thorax	Spine	Abdomen	UX	LX
Frontal	NS	NS	M: 43.89*** F: 1.96***	M: 2.91* F: 0.62*	M: 4.48*** F: 1.30***	2.76***
Nearside	NS	NS	NS	NS	M: 5.52** F: 1.63**	0.45***
Farside	NS	NS	NS	–	–	NS
Rollover	NS	NS	NS	NS	NS	NS

NS= Not Significant, * $p<0.05$, ** $p<0.001$, *** $p<0.0001$

All odds ratios are based on increasing BMI from the 5th to the 95%ile of the adult front seat crash-involved population (i.e., 19 to 37 kg/m^2)

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Odds Ratios and 95% CI for Significant Gender Effects by Body Region and Crash Mode

	Head	Thorax	Spine	Abdomen	UX	LX
Frontal	NS	NS	2.14***	2.01*	2.66***	4.00***
Nearside	NS	NS	NS	NS	2.78**	NS
Farside	NS	NS	NS	–	–	NS
Rollover	NS	NS	NS	Male:1.46 Female:0.42		Male: 1.42 Female:1.97

NS= Not Significant, * p<0.05, **p<0.001, ***p<0.0001

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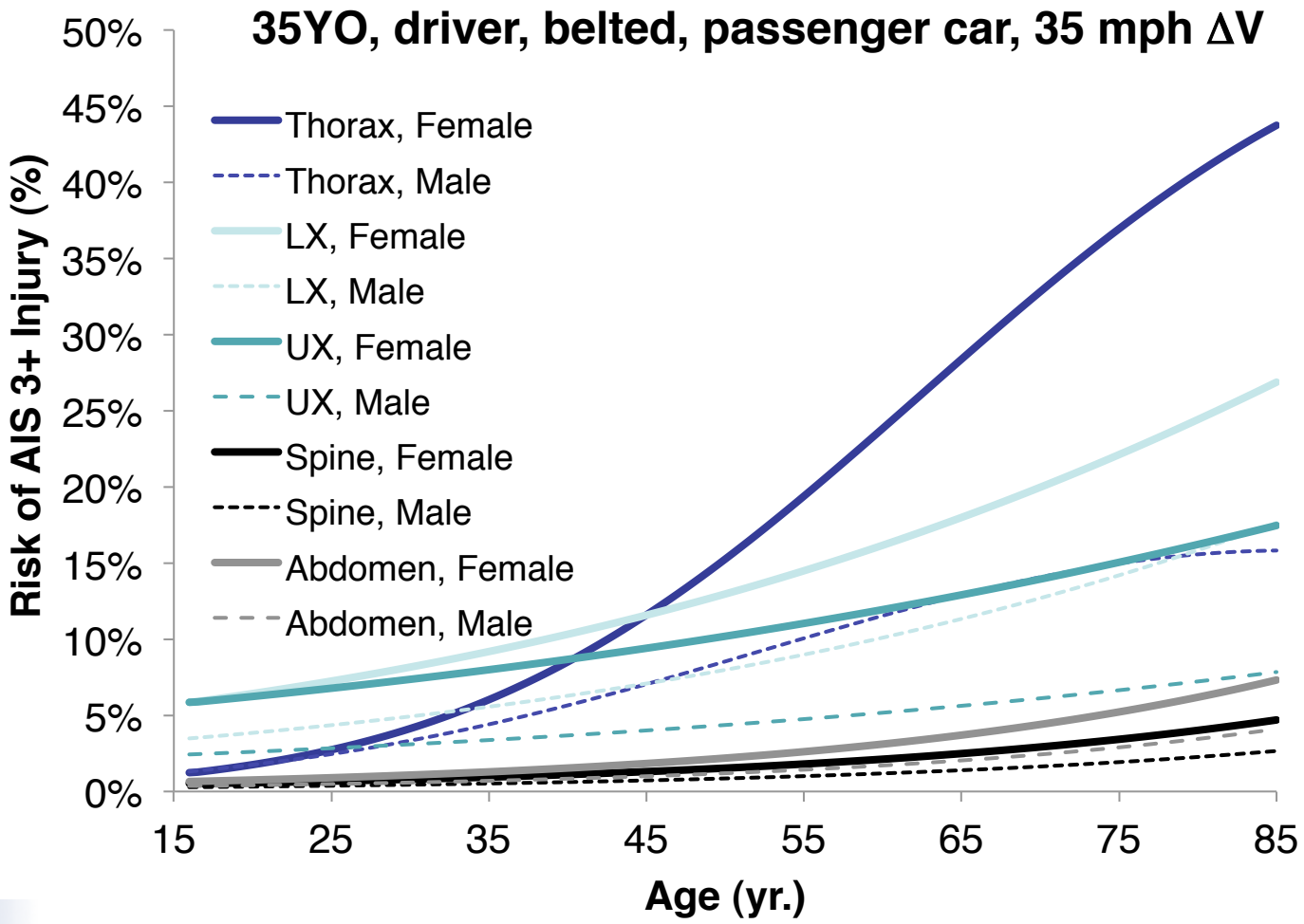
Age vs. Gender Effects—Frontal Crashes



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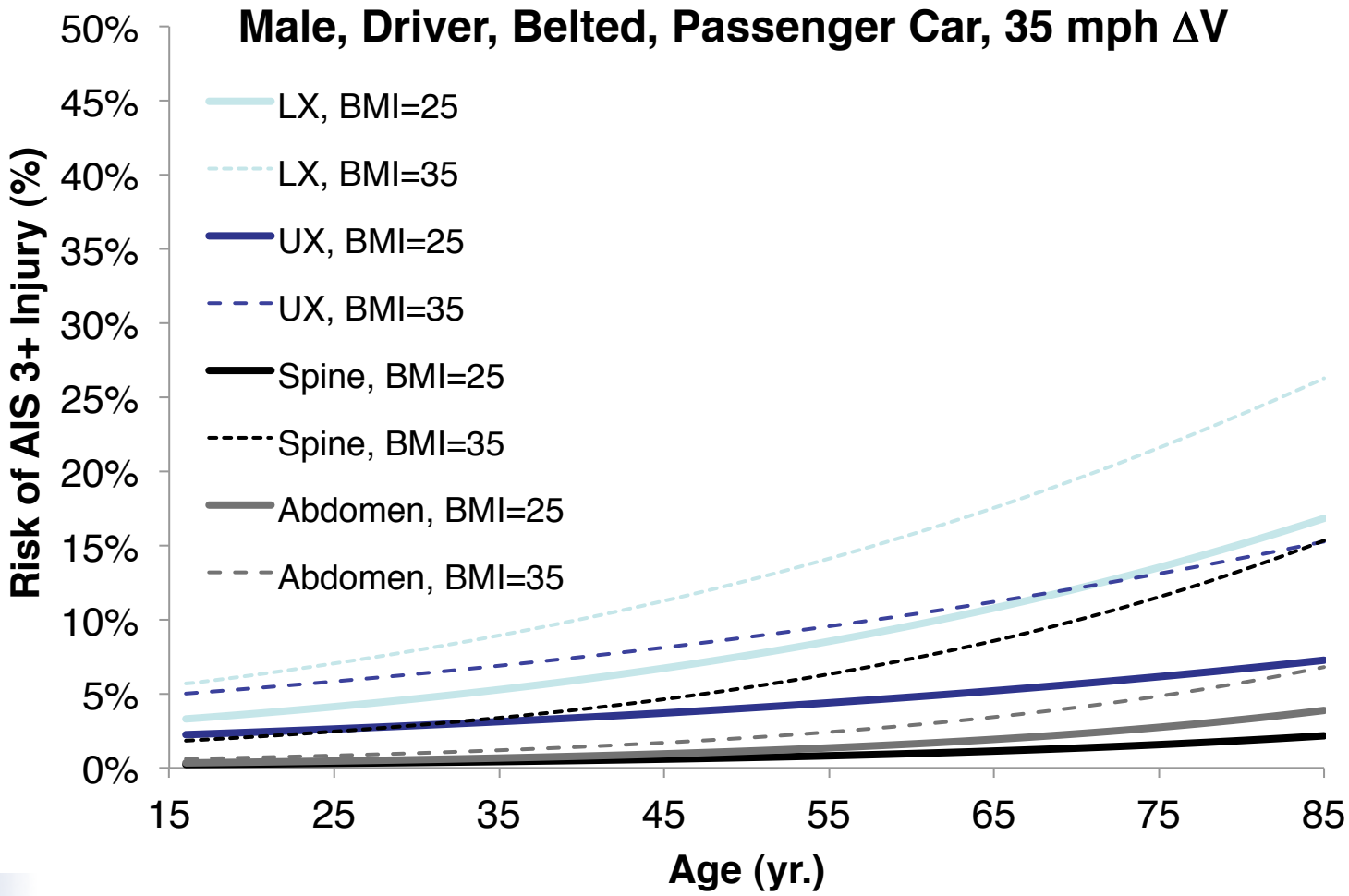
Age vs. BMI Effects—Frontal Crashes



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Numbers of Occupants With AIS 3+ Injuries Associated with Age, BMI, and Gender

- Used Risk Saturation Approach similar to Kent et al. (2009).
  - Applied models to NASS 2007-2008 data to predict risk of injury to head, thorax, spine, abdomen, LX, and UX for each occupant.
  - Weighted risk for each occupant using NASS case weight and then calculated the sum of these weighted risks.
  - Repeated process while limiting maximum age or BMI or setting gender to male.
  - Calculated % change in weighted risk as occupant age/gender/BMI limit was varied. Multiplied this value by the total number of people with AIS 3+ injuries to a body region to estimate the number injured body regions associated with age.
- Limitations
  - Assumes cases with missing data are similar to those that were used in model development.
  - Estimates apply to injured body regions, not injuries.
  - Did not account for changes in exposure variables associated with age, gender, and BMI.

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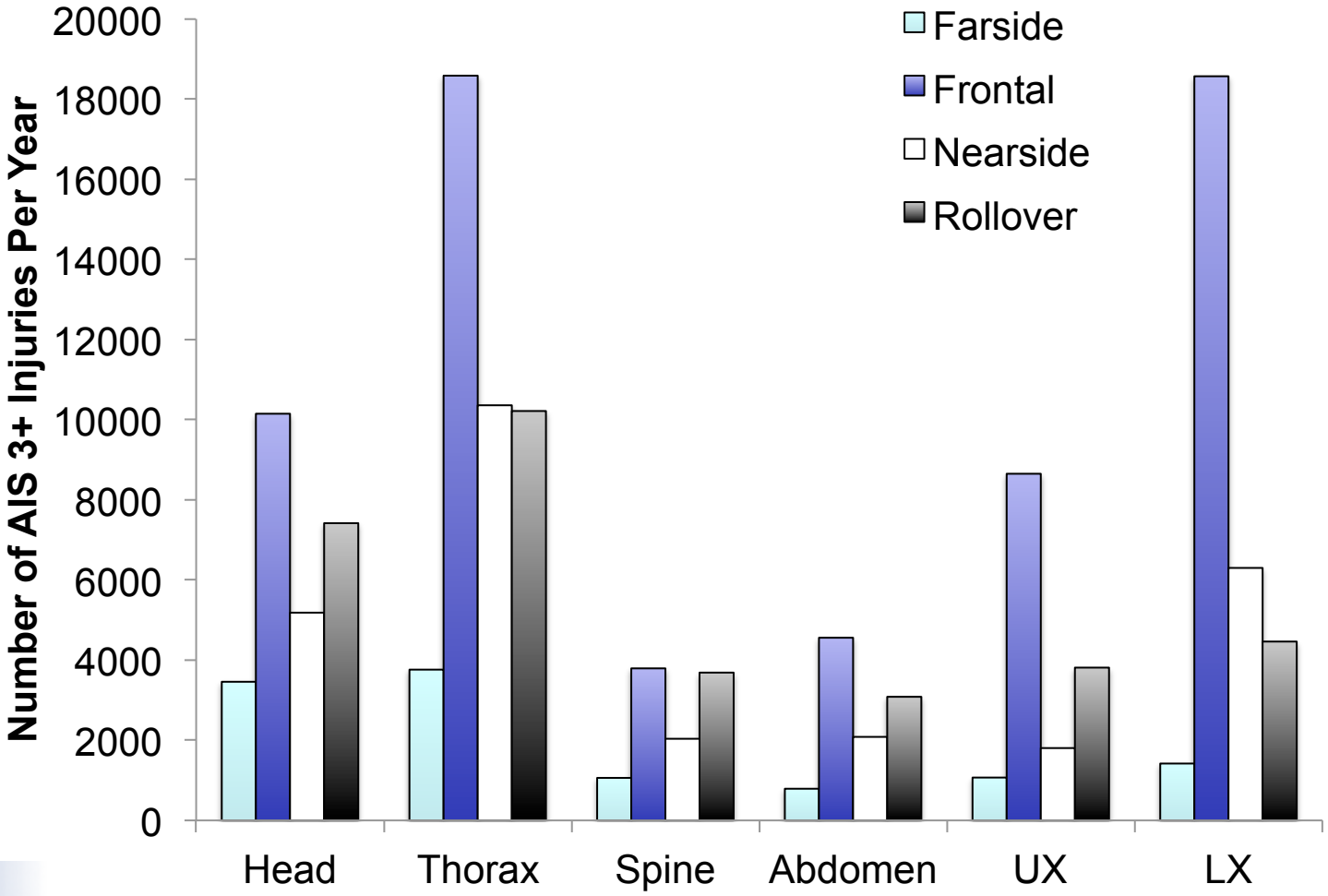
Distribution of AIS 3+ Injuries by Body Region and Crash Mode in Fused Dataset



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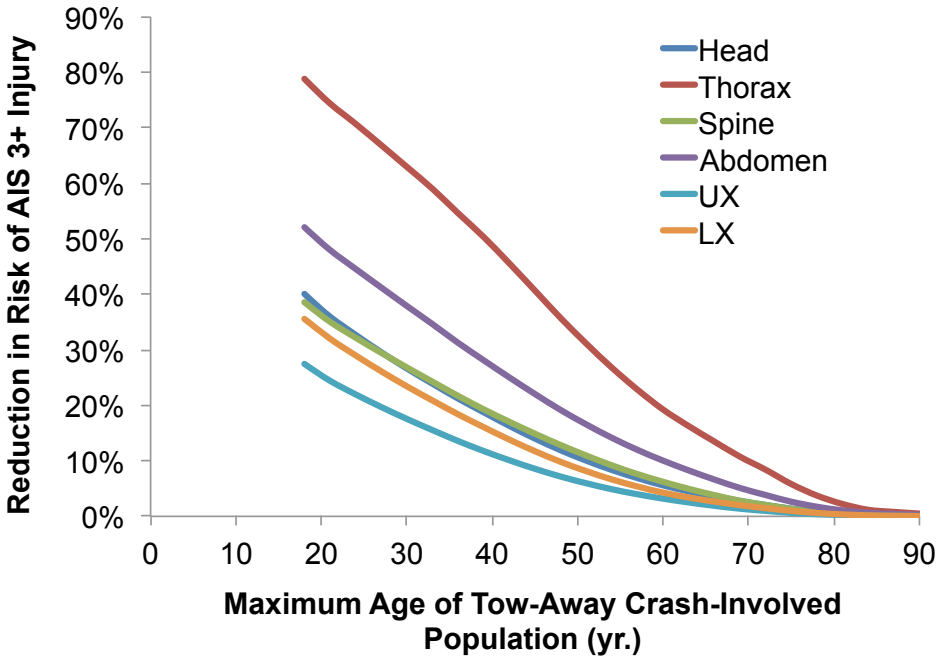
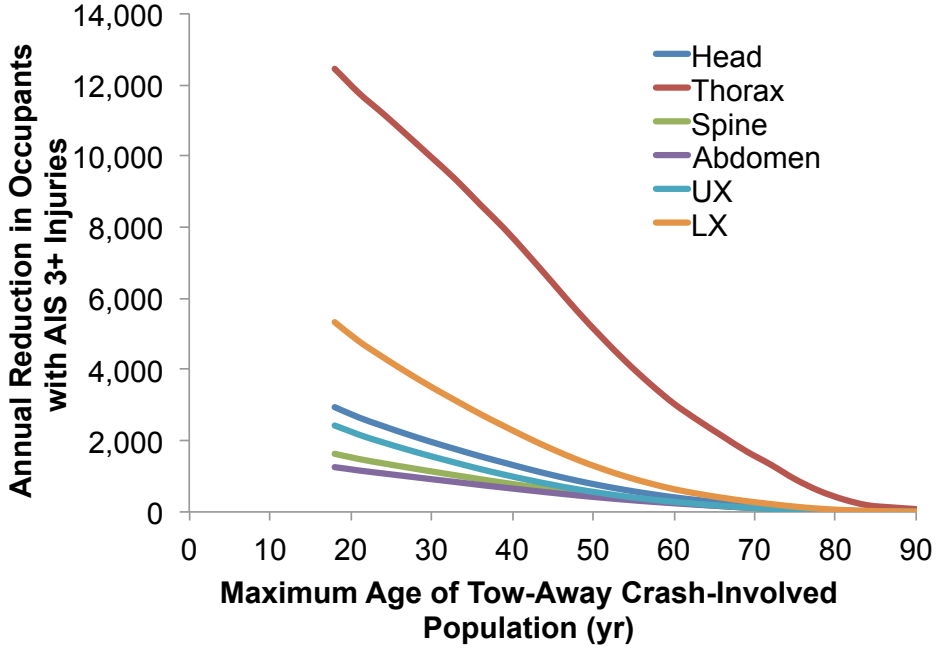
Numbers of AIS 3+ Injuries Associated with Aging in Frontal Crashes





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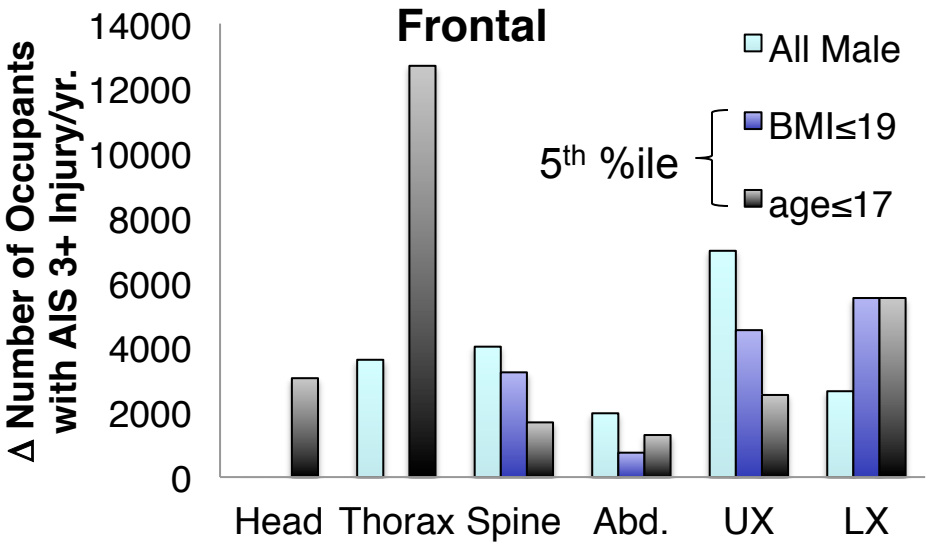
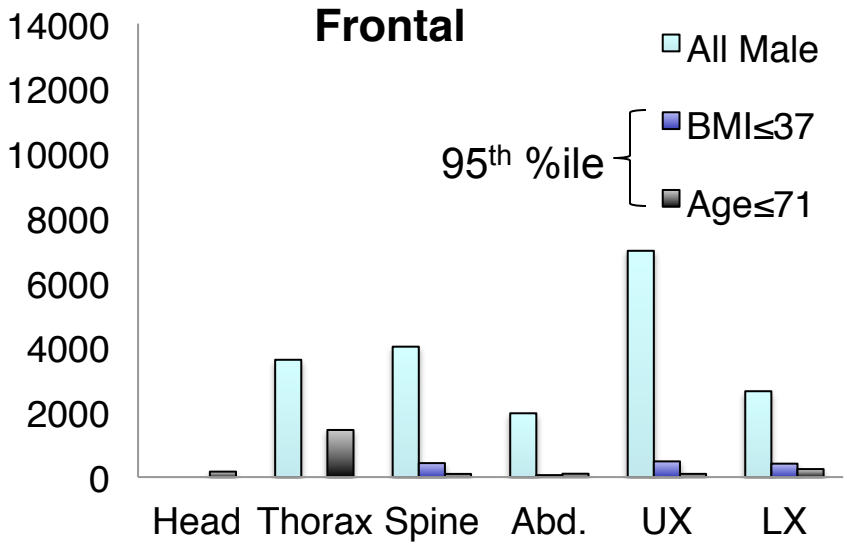
Effects of Age, Gender, and BMI on Frequency of AIS 3+ Injury





- Age effect is larger than gender or BMI effects across all body regions in frontal crashes.
- However, gender and/or BMI effects are greater than those associated with age for the spine, abdomen, UX and LX .

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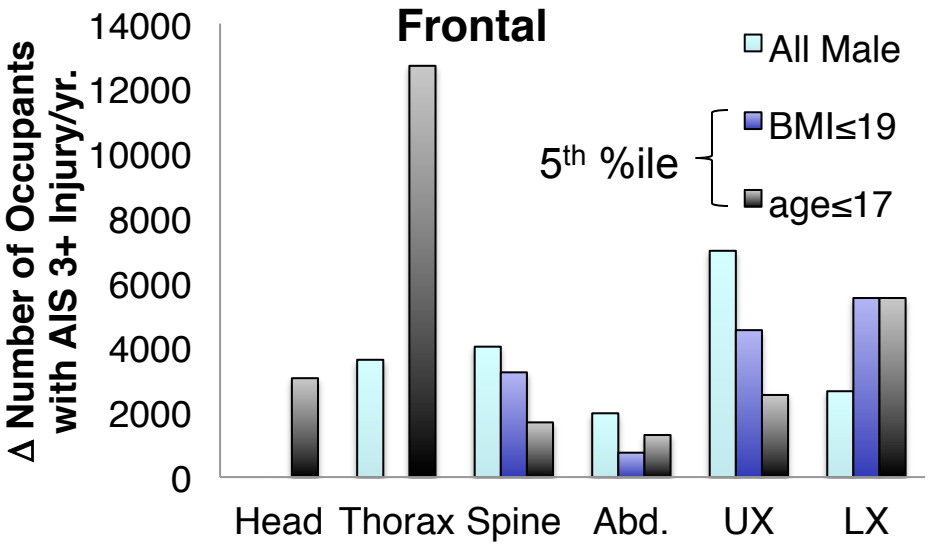
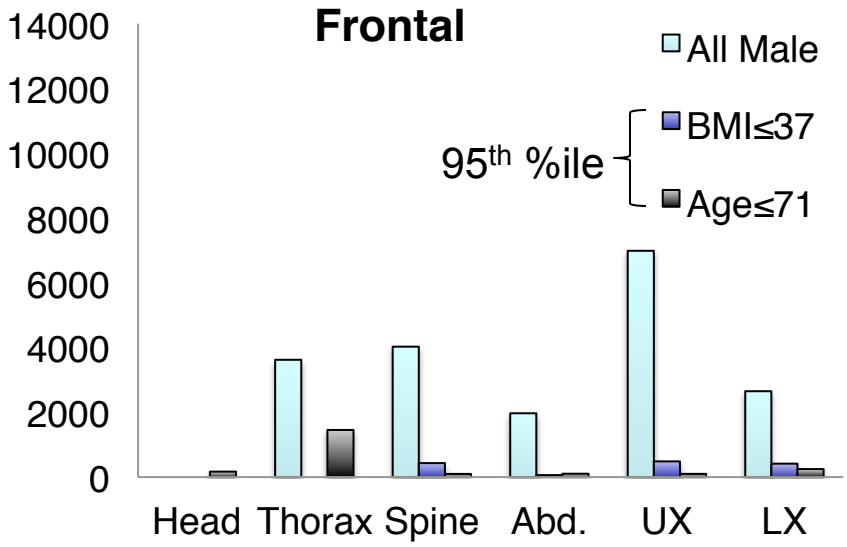
Effects of Age, Gender, and BMI on Frequency of AIS 3+ Injury





- Total occupants prevented from having a body region with AIS 3+ injury in frontal crashes:
- Age ≤ 17: 26.8k (42% of all AIS 3+ injured body regions)
- Age ≤ 71: 2.2k
- BMI ≤ 19: 14.1k (22% of all AIS 3+ injured body regions)
- BMI ≤ 37: 1.4k
- All male: 19.2k (30% of all AIS 3+ injured body regions)

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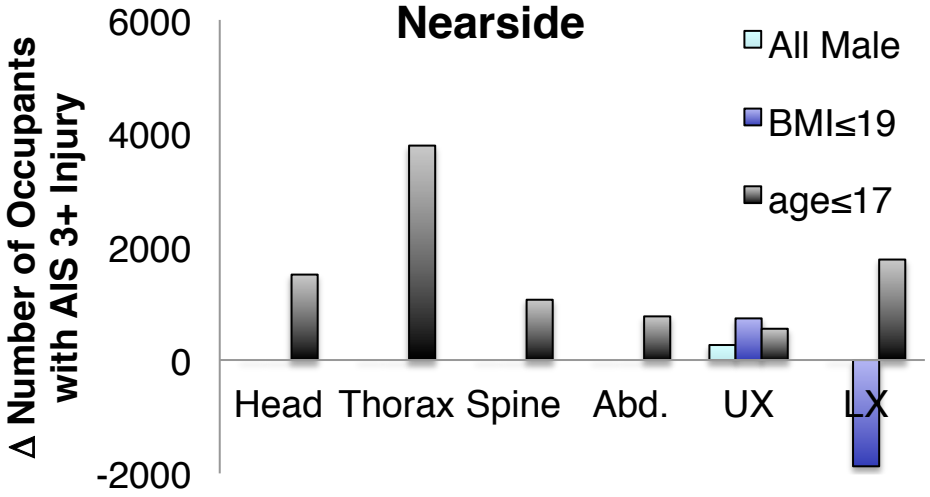
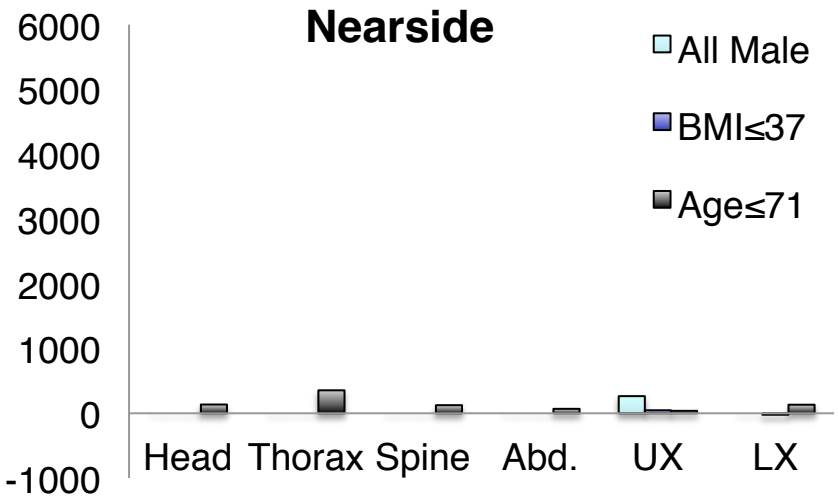
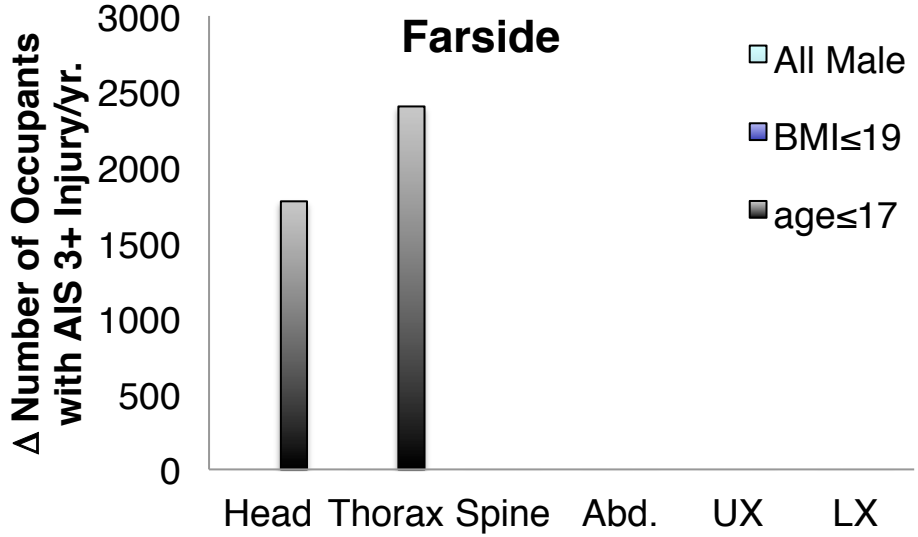
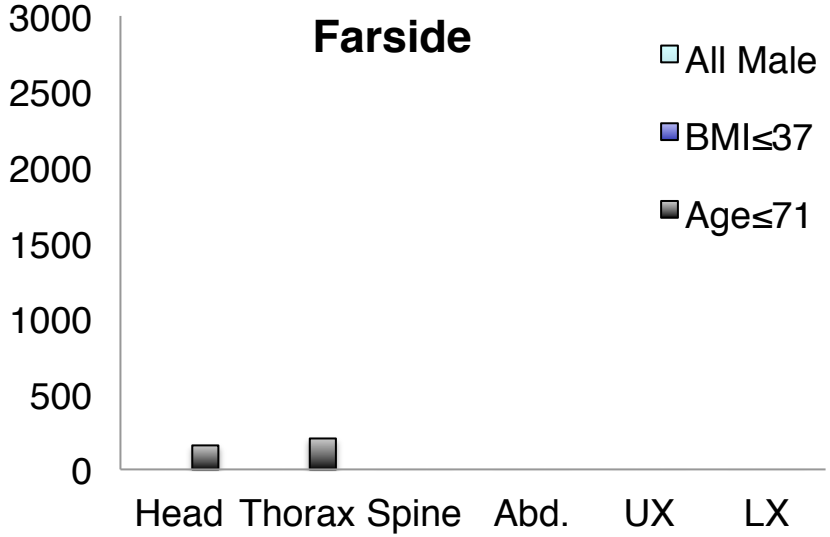
Effects of Age, Gender, and BMI on Frequency of AIS 3+ Injury

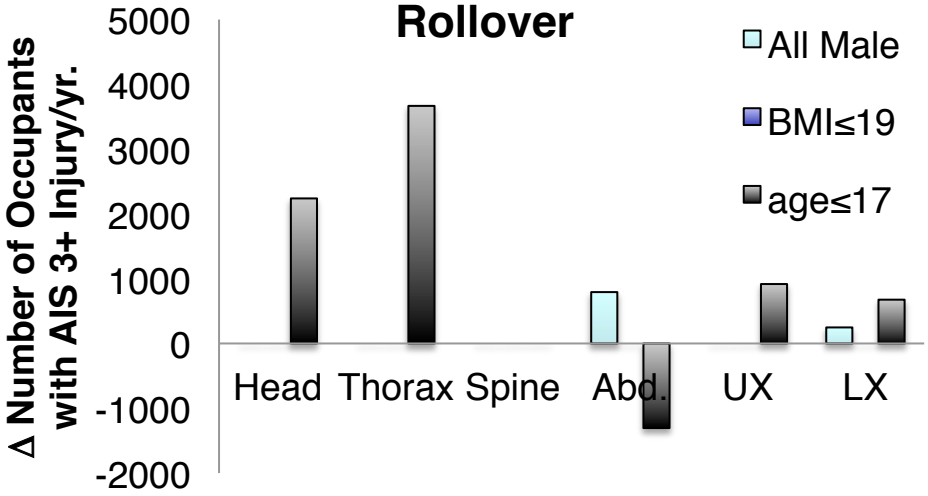


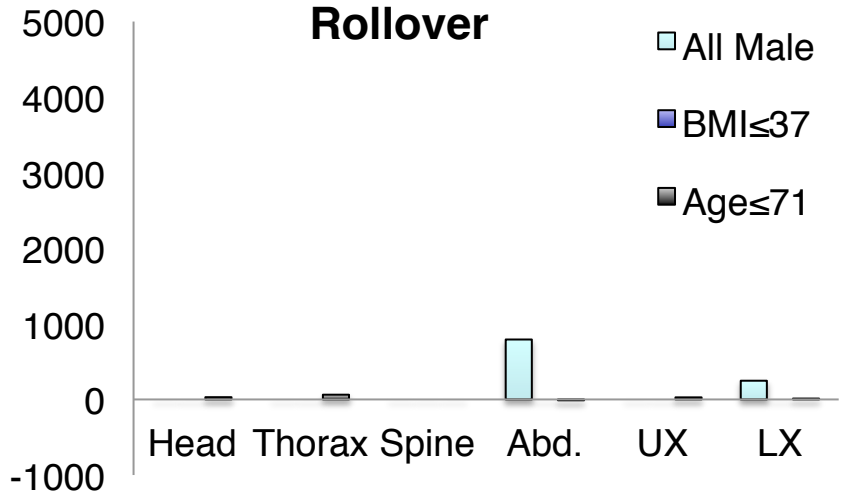


Effects of Age, Gender, and BMI on Frequency of AIS 3+ Injury









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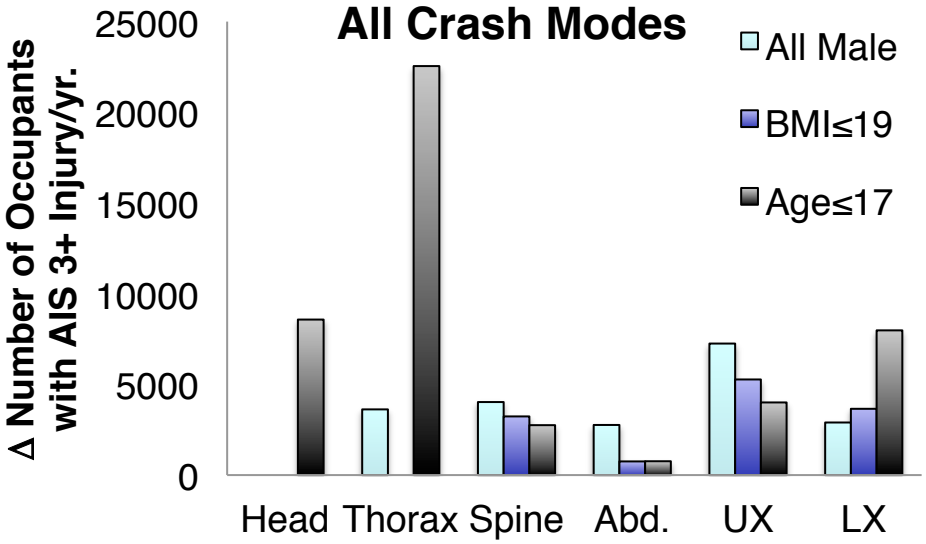

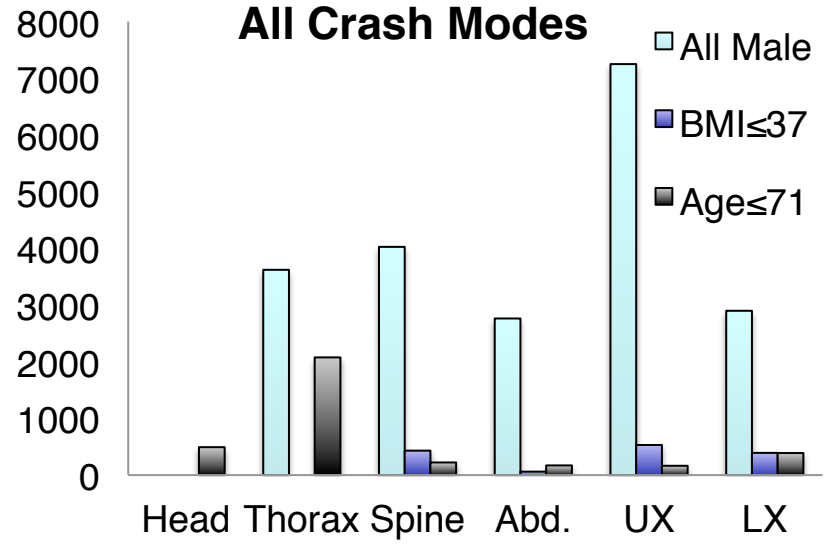

Total occupants prevented from having a body region with AIS 3+ injury:

- Age ≤ 17: 46.6k or 34% of all AIS 3+ injured body regions
- Age ≤ 71: 3.5k
- BMI ≤ 19: 12.9k or 9% of all AIS 3+ injured body regions
- BMI ≤ 37: 1.2k
- All male: 20.6k or 15% of all AIS 3+ injured body regions

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Summary

- Increasing age increases the risk of AIS 3+ injury to almost every body region in every crash mode.
- The body regions for which the age effect is the most meaningful are the thorax and lower extremities in frontal crashes. Of all thorax and lower extremity injuries, the age effect is the most pronounced for the ribs and KTH complex.
- Although the effect of age is potentially large, the effects of BMI and gender are still important and should not be neglected when optimizing safety systems.

Thanks for your attention.

This work was funded by the National Highway Traffic Safety Administration under contract DTNH22-10-H-00288.

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