

The Injury Risk from Objects Impacted Before and During Rollovers

Kennerly Digges,
The George Washington University
Ana María Eigen,
NHTSA

Requirements for a Crash Severity Metric

- Measurable from post-crash data
- Related to crash energy
- Injury rate relating to metric

Initial Data Sources

- NASS/CDS
- Years: 1995 – 2004
- Vehicle Classes (all available model years)
 - Passenger Cars
 - SUVs
 - Minivans
 - Pickups
- Belted Front Seat Occupants
- Age 12+ Years Old

Definition of Vehicle Inversion

- Frequency that the vehicle roof faces the ground (May or may not actually impact)
- Vehicle Inversions to quarter turns
 - 0 vehicle inversions = 1 quarter turn
 - 1 vehicle inversion = 2, 3, 4, or 5 quarter turns
 - 2 vehicle inversions = 6, 7, 8, or 9 quarter turns
 - 3+ vehicle inversions = 10+ quarter turns

For Belted, Not-Ejected Front Seat Occupants

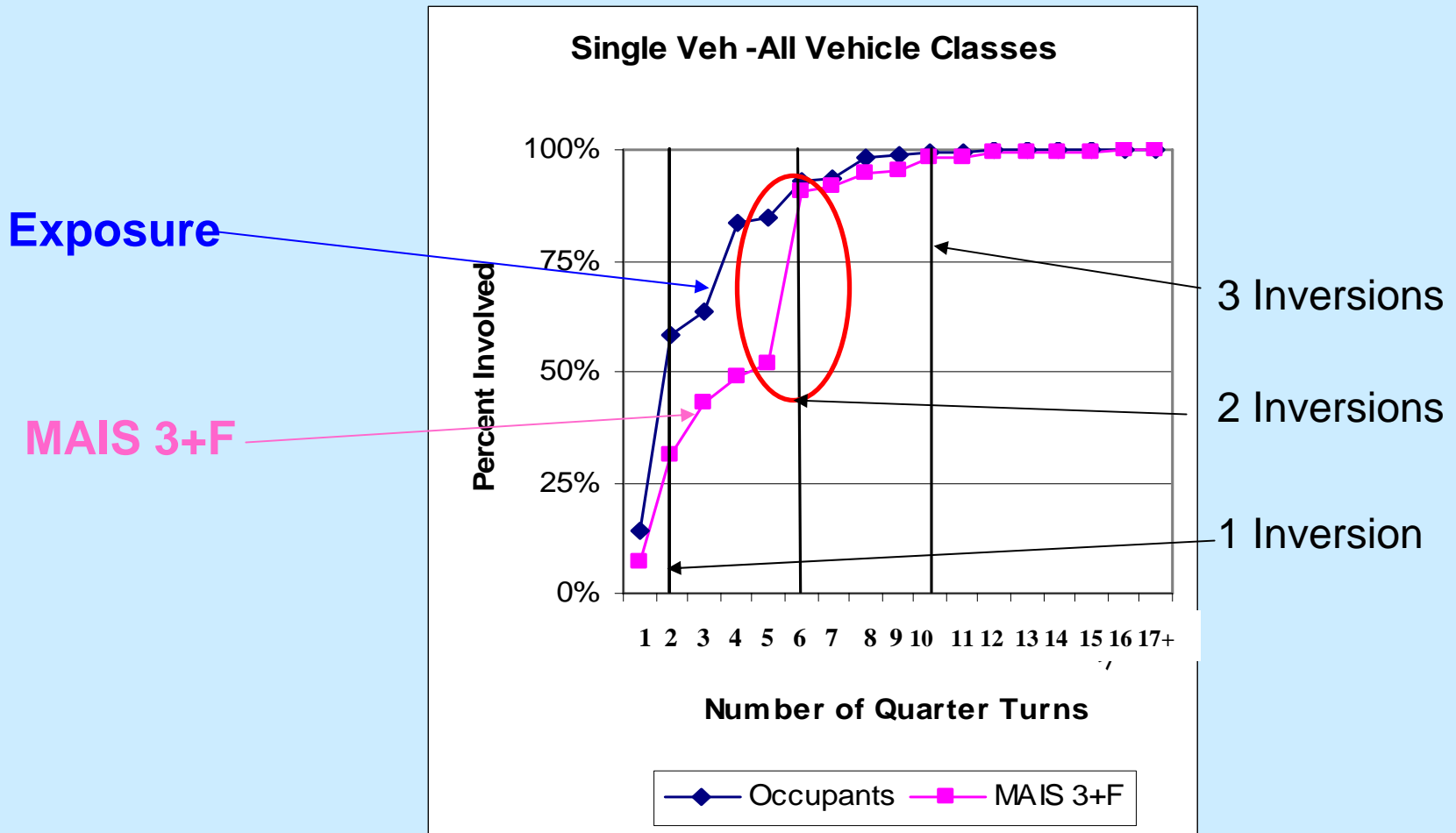
Examine

Single Vehicle Rollovers

(with no Planar Impacts prior to
Rollover)

Belted – Non Ejected Single Vehicle

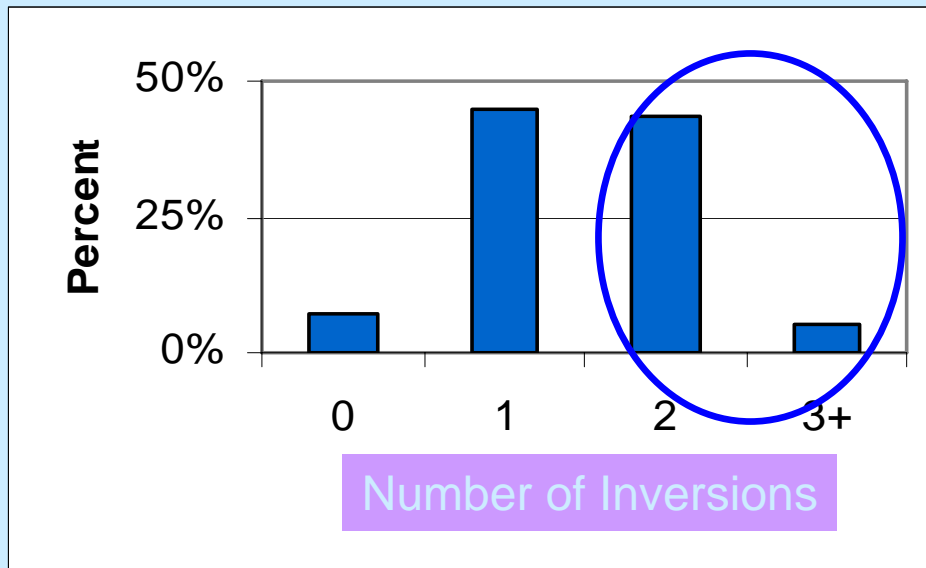
Front Seat Occupants 12+ and MAIS 3+ Injuries by Nr Quarter Turns – Cumulative Percentage based on Weighted Data



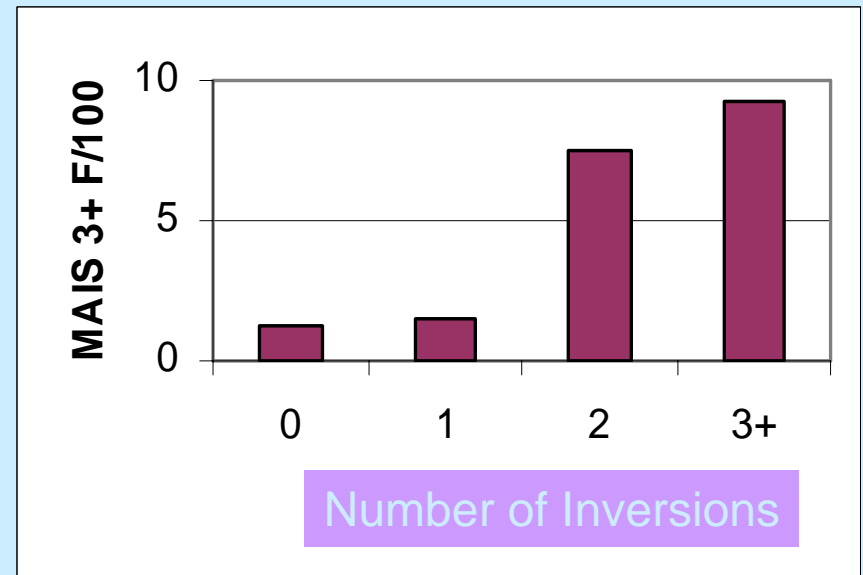
2nd vehicle inversion⁶ increases injury rate

Belted – Not Ejected Occupants Single Vehicle based on Weighted Data

MAIS 3+ F Injuries



Injury Risk



48% MAIS 3+F in rollovers with more than 1 vehicle inversion

**Number of inversions is a good severity measure for belted occupants
(Not-ejected in Single-vehicle Crashes)**

Observations

The number of vehicle inversions is a good severity metric for grouping quarter-turns

Applicable to belted occupants in single vehicle rollovers without planar impacts

The Challenges of Multi-impact Rollovers

- How do you group multi-impact rollovers?
 - Multi-vehicle crashes; impacts with fixed objects
- Which multi-impacts have higher risks?
 - Not all planar impacts contribute to the injuries

NASS/CDS Classification by Planar Crash Severity & Roll Type

- Planar crash severity – extent of damage & delta-v
 - Minor
 - Moderate
 - Severe
- Classification of rollover type by:
 - Rollover only
 - Rollover followed by impact
 - Non-fixed object impact prior to rollover
 - Fixed object impact prior to rollover

Research Question

How to combine

- ≡ 3 categories of damage,
- ≡ 4 categories of impact types

With

- ≡ 3 categories of vehicle inversions

Result:

- ≡ Combine fixed & non-fixed object impacts
- ≡ Combine all other single vehicle rollovers
- ≡ Combine moderate and severe damage

Research Approach

- Look at:
 - Distribution of MAIS 3+F injured
 - Rate of MAIS 3+ injured per 100 exposed to the same crash type and severity
 - Examine belted front seat adults

Injuries by Rollover Type and Damage Extent

Planar Damage Extent	Distribution of MAIS 3+ (%)		
	Roll 1st	Obj 1st	Total
Minor & Moderate	28.2%	38.7%	66.8%
Severe	10.9%	22.3%	33.2%
Total	39.1%	60.9%	100.0%
Planar Damage Extent	Injury Rate per 100 Exposed		
	Roll 1st	Obj 1st	Total
Minor & Moderate	2.34	2.88	2.63
Severe	3.39	10.26	6.16
Total	2.56	3.91	3.24

Obj 1st– Impact with fixed or non-fixed object prior to roll

Higher Injury Rate

Observations

- Crashes with severe planar damage have much higher injury rates than all other rollovers (22.3%).
- These crashes should be separated from the others when considering the injury risk associated with the rollover.

Statistical Significance of Metrics

For the remaining rollovers (77.7%) the relationship between the number of vehicle inversions and the presence of MAIS 3+ injuries produced a **p** value of .022

Injury rate related to vehicle inversions

Conclusions

Disaggregation of Rollovers for Severity

- (1) Rollovers preceded by impacts with fixed and non-fixed objects and with severe vehicle damage (22.3% of MAIS 3+);
- (2) All other rollovers, separated by 0, 1, and 2+ vehicle inversions (77.7% of MAIS 3+)

The authors wish to thank the
Santos Family Foundation
for the funding support that led to
this research

The End