



Mary Seventy in Side Impact Mismatch

San Diego CIREN Team Washington, DC April 3, 2003

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Today's Presentation

Definition of the Topic
Car Driver Injuries in the NASS/CDS Data
Case Studies

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Vehicle Compatibility Defined as a combination of it's:

 Crashworthiness (ability to protect occupants within the vehicle)

 Aggressivity (potential to harm occupants within the collision partner)

Crashworthiness

Evaluated through crash tests

Focus on minimizing injuries in the subject vehicle

Minimizing injuries in one vehicle potentially accentuate injuries in the collision partner

Aggressivity Comparison of Cars to LTV's

Mass – LTV's are 900 pounds heavier than cars on average

Stiffness – LTV's frequently use stiff frame rail design, as opposed to unibody design favored by cars

Geometry – LTV's ride higher than cars

Gabler, Hampton C. and Hollowell, William T., "The Aggressivity of Light Trucks and Vans in Traffic Crashes," SAE Paper No. 980908, Detroit, March 1998

Vehicle Aggressivity By Category In Side Impacts

	Full size vans -	2.47	
\succ	Full-size Pickups -	2.31	
	Sport-utility Vehicles -	1.91	
\succ	Small Pickups -	1.53	Driver fatalities in the Struck Vehicle per 1000 Police-
\triangleright	Minivans -	1.48	Reported Crashes
\succ	Large Cars -	1.15	
\triangleright	Midsize Cars -	.70	
\triangleright	Compact Cars -	.58	
	Subcompact Cars -	.45	

Gabler, Hampton C. and Hollowell, William T., "The Aggressivity of Light Trucks and Vans in Traffic Crashes," SAE Paper No. 980908, Detroit, March 1998

The Problem

LTV's currently account for over one-third of registered U.S. passenger vehicles (and 48 % of new sales. Polk 1980-1999)

Collisions between cars and LTV's account for over one half of all fatalities in light vehicle to vehicle crashes

In these crashes, over 80% of the resulting fatalities are to occupants of the passenger vehicles

Jeffrey W. Rungee, M.D., Committee On Commerce, Science And Transportation, United States Senate, February 26, 2003

Gabler, Hampton C. and Hollowell, William T., "The Aggressivity of Light Trucks and Vans in Traffic Crashes," SAE Paper No. 980908, Detroit, March 1998

Ratio Of Fatally Injured Drivers in LTV-to-Car Left Side Impacts

The front of: The driver side of: Fatalities: > Pickup - to - Car = 1:26 > SUV - to - Car = 1:16 > Van - to - Car = 1:13

Car-to-Car = 1:6.6
 Car-to-LTV = 1:1

William T. Hollowell, Stephen M. Summers, Aloke Prasad, "NHTSA's Research Program For Vehicle Aggressivity And Fleet Compatibility", June 2001 ✓ 1999 Volkswagen New Beetle vs 1994
 Ford Explorer

- ✓ 8:00 PDOF @ 260 degrees
- ✓ DV *44 kmph (27 mph)





✓ 1999 Volkswagen New Beetle vs 1994
 Ford Explorer

- ✓ 8:00 PDOF @ 260 degrees
- ✓ DV *44 kmph (27 mph)







Occupant 33 yr. old female driver, 5'3", 132 lbs

- Basilar skull fracture
- Laceration of midbrain
 Brainstem detached above the pons
- Basilar artery tear
- Scattered SAH
- Left pulmonary laceration
- > Bilateral rib fractures
- Liver laceration
- Splenic laceration
- Left clavicle fracture
- Bilateral pubic rami fractures
- Right sacroiliac fracture



Car Driver Injuries in Near Side Impact Collisions with LTVs in the NASS/CDS Data

> R. M. Van Auken, J. W. Zellner Dynamic Research, Inc. 3 April 2003

NASS/CDS Data Analysis

> Objectives

Technical approach
 Assumptions
 CDS data query criteria



Objectives

Assess the distributions of struck car driver injuries in near side impacts in NASS/CDS collisions:

- Striking vehicle: Light truck or van
 - Size: small, large
- Struck vehicle: Passenger car
 - Size: small, large
 - Side impact protection
 - Dynamic FMVSS 214
 - (assumed to begin for all cars in 1995 for this analysis)
 - Side-impact airbag

Assumptions

>NASS/CDS case sampling

 Passenger cars are sampled from tow-away crashes with equal probability

 Light trucks and vans are sampled from towaway crashes with equal probability

NASS/CDS Data Query Criteria

> Two vehicle crashes with:

- Left side struck passenger car
- Striking LTV
- Driver and exterior vehicle record for each vehicle

Calendar years: 1993-2001
1993 - first year for AIS 90 coding
2001 - most recent data available

Left Side Struck Car Criteria Deformation location: Left > NASS body types: > Model years: \succ Driver age: Size categories: • Small: • Large:

1-9 (automobiles) 1985-2001 <u>16-55 years</u>

wheelbase < 265 cm* (e.g., subcompact, compact) wheelbase > 265 cm* (e.g., intermediate, large)

*based on NASS definitions of vehicle class

Striking LTV Criteria

- Deformation location: Front
- > NASS body types:
- > Model years:
- > Driver age:
- Size categories:*
 - Small:
 - Large:

14-39 (utilities, vans, pickups) 1985-2001 all

compact utility, pickup, or minivan large utility, pickup, or van

* based on the NASS body type

NASS/CDS Data Analysis Results

NASS/CDS Vehicle Involvement

Striking	Number of Struck Vehicles			
Vehicle	Small	Large	Total	
	Car	Car	Car	
Small LTV	143	88	231	
Large LTV	57	50	107	
Total LTV	200	138	338	

Sources and Notes: 1993-2001 NASS/CDS data 1985-2001 Model year vehicles Table does not include 8 cases with unknown LTV size

Specific vehicle size combinations (eg., large LTV-small car crash) are not significantly underor over-represented in these data

- $X^2 = 1.9$ (with Yates adjustment)
- Probability value = 0.17
- Consistent with assumptions

Struck Car Driver Injury Distributions

Struck		Number of NASS/CDS Cases							
Car									
Driver	Head	Face	Neck	Thorax	Abdom	Spine	Upper	Lower	Any
MAIS							Ext.	Ext.	Region
0 - No Injury	187	207	328	209	258	263	167	154	38
1 - Minor	65	129	18	51	30	66	130	100	130
2 - Moderate	53	10	0	7	27	14	38	44	56
3 - Serious	10	0	0	42	20	1	11	48	64
4 - Severe	15	0	0	27	7	1	0	0	30
5 - Critical	12	0	0	5	4	0	0	0	18
6 - Maximum	4	0	0	5	0	1	0	0	10
Total	346	346	346	346	346	346	346	346	346

Sources and Notes:

1993-2001 NASS/CDS data 1985-2001 Model year vehicles

> Head and thorax have more severe injury potential

Note: more severe and fatal injuries may be over-represented in the unweighted NASS/CDS case counts due to the stratified NASS/CDS crash sampling criteria

Head Injury Severity vs Striking LTV Size

Struck	Number of			
Car Driver	Striking Vehicles			
Head	Small Large Total			
MAIS	LTV	LTV	LTV	
0 - No Injury	136	49	185	
1 - Minor	42	22	64	
2 - Moderate	30	22	52	
3 - Serious	8	1	9	
4 - Severe	6	8	14	
5 - Critical	7	4	11	
6 - Maximum	2	1	3	
Total	231	107	338	

MAIS>2 head injuries associated with "large striking LTVs" are overrepresented in these data

- X²=3.8
- P=0.05

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes) 1985-2001 Model year vehicles

Table does not include 8 cases with unknown LTV size

Head Injury Severity vs Striking LTV Size

Struck	Number of			
Car Driver	Stril	king Vehi	cles	
Head	Small Large Total			
MAIS	LTV	LTV	LTV	
0 - No Injury	170	71	240	
1 - Minor	ΙΙΟ		249	
2 - Moderate				
3 - Serious				
4 - Severe	53	36	89	
5 - Critical				
6 - Maximum				
Total	231	107	338	

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes)

1985-2001 Model year vehicles

Table does not include 8 cases with unknown LTV size

Shading indicates over represented factor at the 5% level of significance

Large striking
 LTVs are
 associated with:

- 32% of the striking LTV cases
- 40% of the striking LTV cases with struck car driver MAIS>2 head injuries

Head Injury Severity vs Struck Car Size

Struck	Number of			
Car Driver	Stru	uck Vehic	cles	
Head	Small Large Total			
MAIS	Cars	Cars	Cars	
0 - No Injury	106	81	187	
1 - Minor	38	27	65	
2 - Moderate	37	16	53	
3 - Serious	7	3	10	
4 - Severe	9	6	15	
5 - Critical	7	5	12	
6 - Maximum	2	2	4	
Total	206	140	346	

Head injuries in large or small cars are not over- or underrepresented in these data

Sources and Notes:

1993-2001 NASS/CDS data (towaway crashes)

1985-2001 Model year vehicles

Shading indicates over represented factor at the 5% level of significance

Head Injury Severity vs Struck Car Model Year

Struck	Number of			
Car Driver	Stru	uck Vehic	cles	
Head	'85-'94	'95-'01	Total	
MAIS	Cars	Cars	Cars	
0 - No Injury	114	73	187	
1 - Minor	48	17	65	
2 - Moderate	39	14	53	
3 - Serious	7	3	10	
4 - Severe	12	3	15	
5 - Critical	11	1	12	
6 - Maximum	3	1	4	
Total	234	112	346	

 MAIS≥2 head injuries in 1985-94 (pre Dynamic FMVSS 214) struck cars are overrepresented in these data
 X²=4.2

• P=0.04

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes) 1985-2001 Model year vehicles

Head Injury Severity vs Struck Car Model Year

Struck	Number of			
Car Driver	Stru	uck Vehic	cles	
Head	'85-'94 '95-'01 Total			
MAIS	Cars	Cars	Cars	
0 - No Injury	162	00	252	
1 - Minor	102	90	202	
2 - Moderate				
3 - Serious				
4 - Severe	72	22	94	
5 - Critical				
6 - Maximum				
Total	234	112	346	

1985-94 model year cars are associated with:

- 68% of the struck car cases
- 77% of the struck car cases with struck car driver MAIS>2 head injuries

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes) 1985-2001 Model year vehicles

Shading indicates over represented factor at the 5% level of significance

Injury Severity vs Side Impact Airbag

Only one struck car had a side-impact airbag

Insufficient data to discern injury trends

Thorax Injury Severity vs Striking LTV Size

Struck	Number of			
Car Driver	Stril	king Vehi	cles	
Thorax	Small Large Total			
MAIS	LTV	LTV	LTV	
0 - No Injury	144	62	206	
1 - Minor	31	18	49	
2 - Moderate	6	1	7	
3 - Serious	33	8	41	
4 - Severe	11	15	26	
5 - Critical	3	2	5	
6 - Maximum	3	1	4	
Total	231	107	338	

MAIS 4 thorax injuries associated with large striking LTVs are overrepresented in these data

- X²=6.1
- P=0.01

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes) 1985-2001 Model year vehicles

Table does not include 8 cases with unknown LTV size

Thorax Injury Severity vs Striking LTV Size

Struck	Number of			
Car Driver	Stril	king Vehi	cles	
Thorax	Small Large Total			
MAIS	LTV	LTV	LTV	
0 - No Injury				
1 - Minor	04.4	00	202	
2 - Moderate	214	09	303	
3 - Serious				
4 - Severe				
5 - Critical	17	18	35	
6 - Maximum				
Total	231	107	338	

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes)

1985-2001 Model year vehicles

Table does not include 8 cases with unknown LTV size

Shading indicates over represented factor at the 5% level of significance

Large striking
 LTVs are
 associated with:

- 32% of the cases with striking LTV
- 51% of the cases with striking LTV and struck car driver MAIS>4 thorax injuries

Overall Maximum Injury Severity vs Striking LTV Size

Struck	Number of			
Car Driver	Stril	king Vehi	cles	
MAIS	Small Large Total			
(all regions)	LTV	LTV	LTV	
0 - No Injury	30	8	38	
1 - Minor	90	39	129	
2 - Moderate	36	18	54	
3 - Serious	46	17	63	
4 - Severe	15	14	29	
5 - Critical	9	8	17	
6 - Maximum	5	3	8	
Total	231	107	338	

MAIS > 4 injuries due to striking by large LTVs are overrepresented in these data

• P=0.02

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes) 1985-2001 Model year vehicles

Table does not include 8 cases with unknown LTV size

Overall Maximum Injury Severity vs Striking LTV Size

Struck	Number of			
Car Driver	Stril	king Vehi	cles	
MAIS	Small Large Total			
(all regions)	LTV	LTV	LTV	
0 - No Injury				
1 - Minor	202	82	284	
2 - Moderate	202			
3 - Serious				
4 - Severe				
5 - Critical	29	25	54	
6 - Maximum				
Total	231	107	338	

Sources and Notes:

1993-2001 NASS/CDS data (tow away crashes)

1985-2001 Model year vehicles

Table does not include 8 cases with unknown LTV size

Shading indicates over represented factor at the 5% level of significance

Large striking
 LTVs are
 associated with:

- 32% of the cases with striking LTV
- 46% of the cases with striking LTV and struck car driver MAIS>4 injuries

Summary of NASS/CDS Data Analysis Results > Examined effects of:

Striking LTV

Size: Large vs small

Left Struck Car

Size: Large vs small

Side impact protection: 1985-94 vs 1995-01 model year (1995-01 assumed to meet Dynamic FMVSS 214 requirements)

Summary of NASS/CDS Data Analysis Results (contd)

> Results:

- Striking LTV size
 - Large LTVs are associated with a greater risk of the following struck car driver injuries in near side collisions:
 - Head MAIS>2
 - Thorax MAIS>4
 - Upper Extremity MAIS>1
 - Overall MAIS>4

No statistically significant effects on injuries to other body regions were observed in these data

Summary of NASS/CDS Data Analysis Results (contd)

> Results:

• Struck car size

 No statistically significant effects on struck car driver injuries were observed in these data

- Struck car side impact protection
 - Struck car drivers of 1985-94 model year cars (pre Dynamic FMVSS 214) have increased risk of head MAIS>2 injury in near side collisions
 No statistically significant effects on injuries to other body regions were observed in these data

CIREN Case Studies

Steve Erwin, Sharon Pacyna San Diego CIREN 3 April 2003

San Diego Case Studies

Side impact

- Subject vehicles as passenger cars
- Striking vehicle as LTV

Bullet Vehicle:

- ✓ 3 cases of light trucks
- 2 cases of vans
- 2 more cases of SUV





✓ 1997 Honda Accord vs 1979 GMC "pick up"
✓ 9:00 PDOF @ 280 degrees
✓ 20 kmph 13 mph



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Occupant 53 yr. old male driver, 5'7", 185 lbs

Concussion

- Left pulmonary contusion
- > Left rib fractures
- Left glenohumeral dislocation
- Left scapula fracture

	<u>}</u>
}	

✓ 1999 Saturn SL1 vs 1985 Ford F350
 ✓ 9:00 PDOF @ 280 degrees
 ✓ DV 42 kmph* (26 mph)



✓ 1999 Saturn SL1 vs 1985
 Ford F350
 ✓ 9:00 PDOF @ 280 degrees
 ✓ DV 42 kmph* (26 mph)





Occupant 18 yr. old female driver, 5'7", 125 lbs

- > Basilar skull fracture
- > Right frontal hematoma
- Ruptured spleen
- Left scapula fracture
- Left ischial ramus fracture extending into anterior acetabulum
- > Left sacral fracture
- Left symphysis pubis fracture



✓ 2000 Pontiac Grand Prix vs 1997 Chevrolet Astro van
✓ 10:00 PDOF @ 290
✓ DV 24 kmph (15 mph)





Occupant 42 yr. old male driver, 6', 200 lbs.

Concussion

Left rib fractures with left pneumothorax

Left small lung contusion

Partial tear posterior urethra @ level of pelvic fracture

Left inferior/superior pubic rami fracture



✓ 1997 Honda Civic vs
1999 Ford "van"
✓ 10:00 PDOF @ 290

✓ *DV 39 kmph (27mph)

degrees







Occupant 27 yr. old male driver, 5'7", 150 lbs.

Fracture foramen magnum

> Cerebral contusion

SAH of basal cisterns



✓ 2000 Audi TT vs 1998 Ford Explorer
 ✓ 10:00 PDOF @ 290 degrees
 ✓ DV 26 kmph (16 mph)





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Occupant 23 yr. old female driver, 5'4", 110 lbs

- Left pulmonary contusion
- Left rib fractures with pneumothorax
- > Multiple splenic lacerations





Occupant 34 yr. old female driver, 5'5", 165 lbs

- > Multifocal SAH
- Right temporal contusion
- Left basal ganglia hematomas
- Intraventricular hemorrhage
- Left dissected internal carotid artery



Summary

Striking LTV size

- Many CIREN cases with large strike LTVs
 - Head injuries, e.g.,
 - Concussion
 - Basilar skull fracture
 - Thorax injuries, e.g.,
 - Pulmonary contusion
 - Rib fracture
 - Upper Extremity
 - Scapula fracture, left
 - Clavicle fracture, left

Struck car size

 Both large and small struck cars are represented in the CIREN data