

CRASH MODES AND INJURY PATTERNS IN REAL-WORLD NARROW OBJECT FRONTAL CRASHES

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ABSTRACT

Data collected from the National Automotive Sampling System (NASS) and Fatality Analysis Reporting System (FARS) were used to determine the crash and occupant injury characteristics for real-world frontal crashes into narrow objects like trees and poles. These data were used to summarize trends in driver death rates, impact point distributions, crash severities, and injury patterns.

Keywords: FRONTAL IMPACTS, NARROW OBJECT, TREE, POLE, NASS, FARS

Years of regulatory and consumer information crash tests have led to much better vehicle designs for occupant protection in frontal crashes. However, it is not clear that improved designs are addressing crashes into narrow objects such as trees and poles. These crashes are of particular interest because they present concentrated load paths on the fronts of vehicles compared with full-frontal and offset crash tests and thus may require unique strategies to ensure good occupant protection. The present study reports trends in driver death rates, impact point distributions, crash severities, and injury patterns in narrow object crashes. Corresponding research focused on laboratory crash tests and detailed NASS case reviews will be published separately.

METHODS

Data from FARS and NASS were analyzed to determine crash and occupant injury characteristics for frontal impacts into narrow objects (National Highway Safety Administration, 2005a, 2005b). Frontal crashes were defined in FARS as impacts with an area of damage ranging from 11 to 1 o'clock; NASS cases were limited to vehicles with a frontal deformation classification and principal direction of force values ranging from 11 to 1 o'clock. Both datasets were limited to crashes with belted drivers and without subsequent rollover event. NASS cases were further restricted to towaway crashes of modern vehicles (1998 model years and later) into trees more than 10 cm in diameter or non-breakaway posts 10-30 cm in diameter. All of the NASS results presented in this study are based on weighted case data.

The 1998-2004 NASS database contained a total of 41,342 police-reported crashes involving at least one passenger car, pickup truck, or minivan. Of these cases, 23,063 involved vehicles with front damage. Restricting the cases to narrow object crashes limited the data files to 1,965 cases. Of these case vehicles, 1,903 were towed due to damage and 1,819 involved cars, minivans, and sport utility vehicles. Of the 1,819 cases, 1,017 involved belted drivers and 518 of these had estimated delta Vs.

DRIVER DEATH RATE

For each calendar year, data on fatal crashes of 1-3-year-old vehicles were extracted from FARS to determine driver death rates per 10 million registered passenger vehicles. Death rates were obtained from FARS for narrow object frontal crashes and all other frontal crashes between 1988 and 2004, and U.S. vehicle registration counts were obtained from R.L. Polk and Company (2005). As shown in Figure 1, driver death rates for narrow object frontal crashes decreased 44 percent (from 111 to 62 deaths per 10 million registered vehicles) between 1988 and 2004, whereas death rates for all other frontal crashes dropped 56 percent (from 492 to 214 deaths per 10 million registered vehicles).

CRASH MODE DISTRIBUTION

NASS cases were categorized based on the type of object struck for all frontal crashes and for frontal crashes in which drivers sustaining serious (MAIS 3+) injuries. A similar analysis was conducted using the FARS data. As shown in Table 1, the distribution of objects struck indicates that crashes into posts, poles, and trees accounted for approximately one-quarter of frontal crashes involving serious injuries and fatalities.

Figure 1. Driver death rates in frontal crashes, 1988-2004 FARS

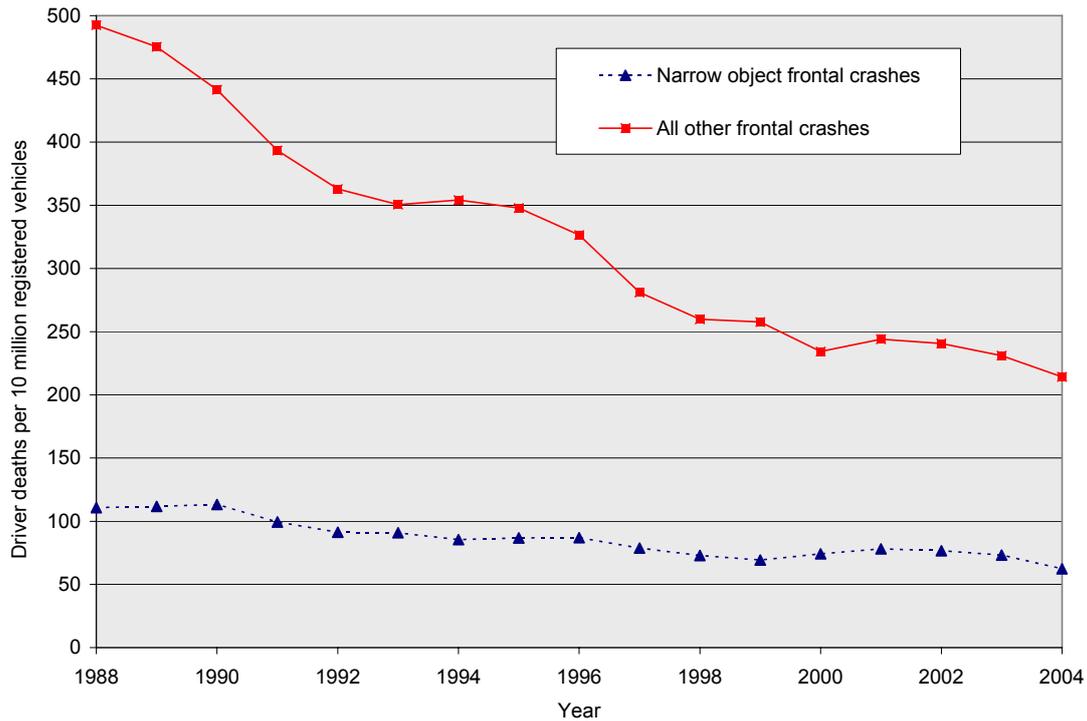


Table 1. Distribution of objects struck in frontal crashes, 1998-2004 NASS and FARS

Object Struck	Percentage of frontal crashes		
	NASS (all non-fatal crashes)	NASS (non-fatal MAIS 3+)	FARS
Another motor vehicle	73	61	59
Motor vehicle not in transport	1	1	2
Pole or post	6	13	5
Tree	5	15	19
Pole/post/tree combined	11	28	24
Other fixed object	14	10	11
Other non-fixed object	1	0	2
Non-collision/unknown	n/a*	n/a*	2

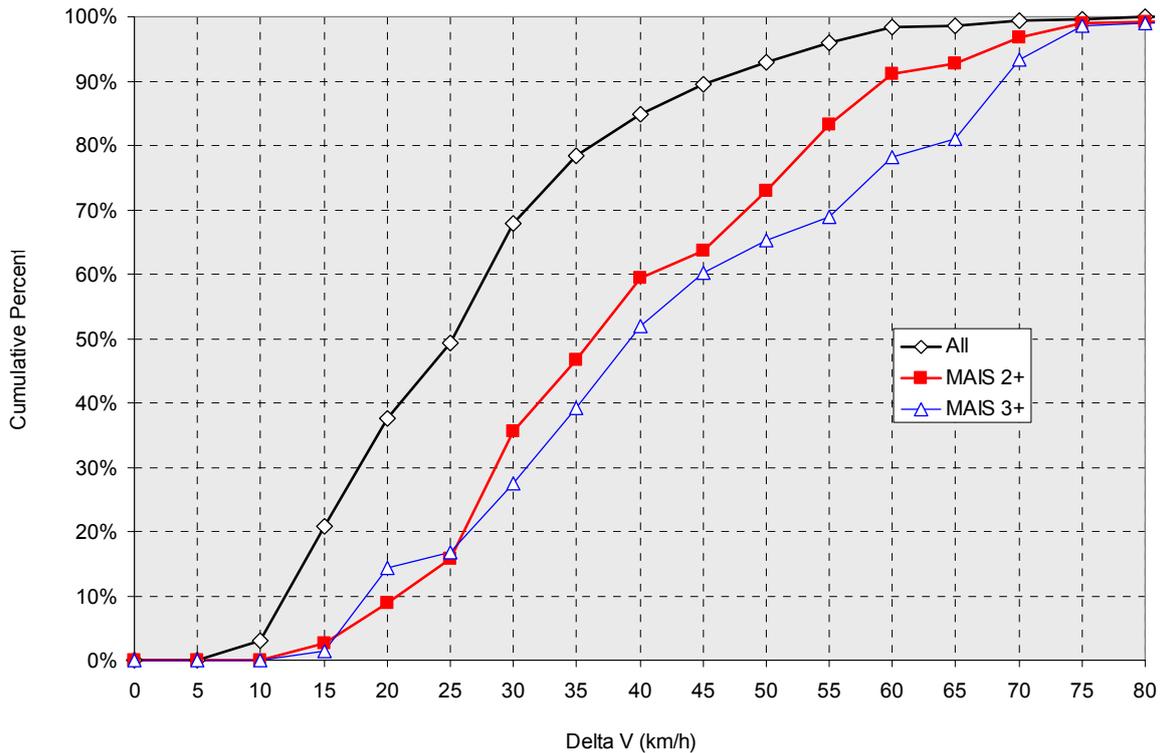
*Non-collision/unknown classification only exists in FARS

CRASH CHARACTERISTICS

IMPACT LOCATION: Narrow object crashes in NASS were analyzed to determine the offset of the impact location relative to the vehicle centerline. A negative offset value represents an impact toward the driver/left side of the vehicle; the recorded magnitude is the offset distance divided by the vehicle's precrash front-end width expressed as a percentage. Seventy-nine percent of narrow object frontal crashes involving serious (MAIS 3+) driver injuries had impacts centered within ± 20 percent of the vehicle centerline, with a nearly equal distributions to the left and right. For most vehicles, this offset range places the center of the narrow object inboard of the front longitudinal structural members.

CRASH SEVERITY: Delta Vs reported in NASS cases were used as the primary indicator of crash severity. Delta Vs from crashes with at least one occupant injury were used to establish a distribution curve of injury severity versus delta V. As shown in Figure 2, 50 percent of the narrow object crashes in which a belted driver sustained at least one injury tended to occur at delta Vs below 25 km/h. For crashes with serious (MAIS 3+) injuries, approximately 50 percent occurred at delta Vs at or below 40 km/h. For crashes with MAIS 3+ injuries, 80 percent occurred at delta Vs at or below 65 km/h.

Figure 2. Distribution of injury severity by crash severity, 1998-2004 NASS



INJURY PATTERNS

Driver injuries in the non-fatal NASS sample were analyzed to determine the distribution of driver injuries and injury rates for frontal crashes. Results are presented in Table 2, with crashes separated by crash type: narrow object, single vehicle (distributed/non-narrow object), and vehicle to vehicle. Each crash type was further subdivided by injury severity. Further analysis of injury distributions for low- versus high-severity (delta V) crashes was not conducted due to the limited number of raw cases available in NASS.

Table 2. Distribution of driver injury and injury rates for frontal crashes, 1998-2004 NASS

Injury severity	Frontal crash type					
	Narrow object		Single vehicle (non-narrow object)		Vehicle-to-vehicle	
	MAIS 2	AIS 3+	MAIS 2	AIS 3+	MAIS 2	AIS 3+
Injury distribution by body region (%)						
Head	27	12	23	25	16	8
Torso	28	21	22	41	32	25
Upper Extremity	25	38	33	22	29	27
Lower Extremity	21	30	22	13	24	40
Raw data counts						
Injuries	1,093	93	1,571	88	8,296	358
Crashes	276	47	493	49	2,599	201
Weighted data counts						
Injuries	169,410	6,957	440,632	11,689	2,029,129	25,175
Crashes	60,453	3,919	159,017	8,868	752,603	15,341
<i>Avg. injuries/crash</i>	<i>2.8</i>	<i>1.8</i>	<i>2.8</i>	<i>1.3</i>	<i>2.7</i>	<i>1.6</i>

For narrow object crashes, the proportions of torso injuries in moderate (MAIS 2) and serious (AIS 3+) injury crashes essentially were similar (28 and 21 percent, respectively), but head injuries decreased from 27 to 12 percent. The majority of injuries in moderate injury narrow object crashes occurred to vital body regions (head and torso), whereas upper and lower extremity injuries were dominant in serious injury crashes. The decrease in head and torso injury rates also occurred in vehicle-to-vehicle crashes; however, a majority of the injuries occurred to the extremities in both moderate and serious injury crashes. In crashes with AIS 3+ injuries, the distribution of torso injuries increased considerably (19 percent) in single-vehicle crashes. In looking at the average number of injuries per driver in serious injury crashes, it appears that narrow object and vehicle-to-vehicle crashes have similar injury rates (1.6 and 1.8 injuries per crash); the moderate injury rates for all three frontal crash modes are very similar at approximately three injuries per crash.

DISCUSSION

Real-world data indicate that crashes into narrow objects account for about one-quarter of serious injuries and fatalities to drivers in frontal crashes. Driver death rates for frontal crashes have dropped steadily during the past 16 years, but a closer look at different crash modes reveals that the rate of decline for narrow object crashes is lower than that for all other frontal crash modes combined. In the present study, driver death rates for narrow object frontal crashes and all other frontal crashes were compared over a 17-year period. Although a majority of the fatalities in all other frontal crashes occurred in vehicle-to-vehicle crashes, approximately 15 percent occurred in single-vehicle collisions into fixed or non-fixed objects.

In real-world narrow object crashes with serious injuries, the impact locations had nearly equal distributions to the left and right of vehicle centerlines, and a majority of these impacts occurred between the front longitudinal structural members. Half of the serious injury crashes had delta Vs at or below 40 km/h. However, unpublished data from the Insurance Institute for Highway Safety's (2004) pole crashes indicate the SMASH program used in NASS tends to underestimate impact velocity by approximately 23 percent. Therefore, it is very likely that impact velocities in real-world crashes are considerably higher than delta V estimates would suggest.

Injuries to vital body regions such as heads and torsos comprise more than half of moderate injuries and one third of all serious injuries. The distribution of serious injuries to these regions for narrow object frontal crashes share some trends with vehicle-to-vehicle frontal crashes. The real-world data also indicate that crashes into narrow objects result in an average of two serious driver injuries per crash, which is similar to vehicle-to-vehicle crashes and slightly greater than other single-vehicle (non-narrow object) crashes.

CONCLUSIONS

Analysis of real-world crash data show that narrow object frontal impacts contribute significantly to occupant deaths and injuries and that the fatality rate (per registered vehicle) for these crashes are declining more slowly than the rate for all other frontal crashes. This suggests that crash protection strategies effective in government compliance and consumer information frontal crash tests may be less effective in narrow object crashes. However, further research is required to take into account other factors that may effect driver fatality rates such as changes in traffic usage patterns over time.

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