RITA Bureau of Transportation Statistics

Technical Report

U.S. Department of Transportation
Research and Innovative Technology Administration

September 2010

Factors Involved in Fatal Vehicle Crashes

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For every vehicle crash, there are numerous factors contributing to its severity. In 2008, 37,261 people were killed in an estimated 5.81 million police-reported motor vehicle crashes[1]. While fatal crashes are not the most prevalent, they are the most consequential from a safety standpoint, making it vital to understand factors common to fatal incidents.

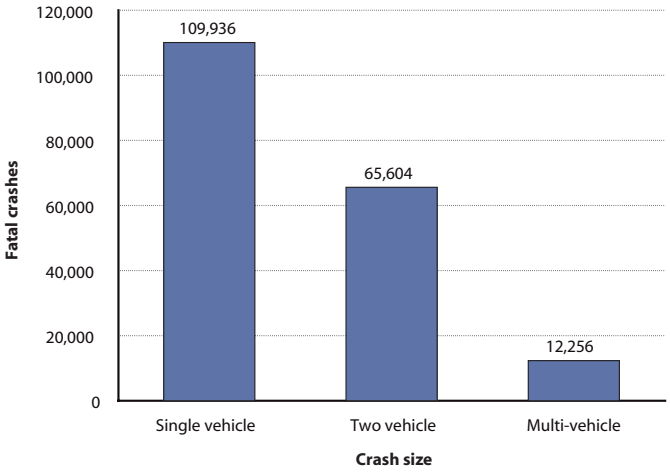
This report examines factors that contribute to fatal crashes involving a motor vehicle (e.g., car, truck, or bus)[2]. Accident level data was obtained from the National Highway Traffic Safety Administration's (NHTSA's) Fatality Analysis Reporting System (FARS) database for 2004–2008[3]. Analysis of the FARS database shows:

- Single-vehicle crash fatalities are the most prevalent.
- The main factors in single-vehicle fatal crashes involve the functionality of traffic controls and the first harmful event in a crash (e.g., rollover, traffic barrier, or ditch).
- With regard to two-vehicle fatal crashes, main factors are traffic controls and the characteristics of the roadway (e.g., roadway alignment or surface type).
- In multi-vehicle (three or more) fatal crashes, road characteristics, vehicle speed, and road type (e.g., interstate or country road) are the main factors involved.

The FARS Database

FARS has been operational since 1975 and is a yearly census of fatal traffic crashes within the 50 States, the District of Columbia, and Puerto Rico[4]. Every vehicle crash on a public roadway that results in at least one fatality is recorded in the FARS database with information retrieved from Police Accident Reports (PARs). FARS analysts utilize the PARs to determine which variables to record for a given crash. NHTSA has a cooperative agreement with an agency in each state government to provide information on fatal crashes in a standard format based on data from PARs and accident investigations.

Figure 1: Fatal Crashes by Crash Size, 2004–2008



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

For this analysis, data were broken into three groups, dependent on the number of vehicles involved in the crash[5] (see figure 1). Single-vehicle crashes account for more than half (58.5 percent) of all fatal crashes in the time period studied. In contrast, two-vehicle crashes account for 34.9 percent and multi-vehicle crashes account for 6.5 percent during the same time span.

Recently, many researchers have focused on single-vehicle crashes to define factors related to fatal crashes. However, analyzing factors by the number of vehicles involved reveals overall similarities and differences among the crash groups; allowing the relative importance of each factor to be explored further.

[1] NHTSA 2008 Traffic Safety Facts Annual Report - http://www-nrd.nhtsa.dot.gov/pubs/811172.pdf
[2] For this report, a motor vehicle is defined as a vehicle in transport (i.e., not towed, pushed, or parked).
[3] Refer to ftp://ftp.nhtsa.dot.gov/FARS for FARS database.
[4] Further analysis excludes data from Puerto Rico
[5] All following mentions of "crash" are defined as crashes where at least one fatality occurred.

Table 1: Top Eight Factors Involved in Fatal Crashes by Crash Size, 2004–2008

Factor	All fatal crashes	Single vehicle	Two vehicle	Multi-vehicle (three or more)
1	Traffic controls	Crash characteristics	Traffic controls	Road characteristics
2	Speed and route type	Traffic controls	Road characteristics	Speed and route type
3	Road characteristics	Speed and route type	Speed and route type	Road classification
4	Weather impacts	Weather impacts	Road classification	Traffic controls
5	Traffic flow	Road characteristics	Location of crash	Weather Impacts
6	Crash characteristics	Traffic flow	Weather impacts	Drunk driving/light condition
7	Road classification	Road classification	Drunk driving/light condition	Persons
8	Persons	Persons	Persons	Location of crash

NOTES: "Crash characteristic" relates to the crash's relation to the roadway and the first harmful event which occurred; "Persons" relates to the relationship between the number of persons involved in a fatal crash and fatality counts; "Drunk driving/light condition" is driven by the relationship between the FARS variables associated with drunk driving and the time of day.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009

FARS Analysis

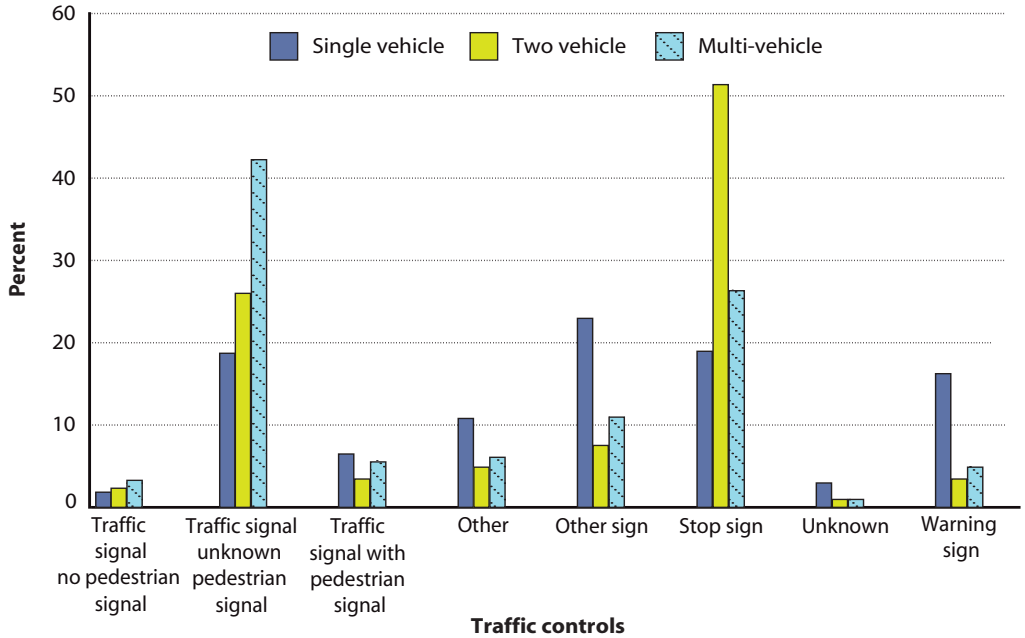
Principal component analysis, a statistical analysis technique, was used to define factors that influence fatal crashes. Table 1 depicts the top eight factors for each of the three groups and for all crashes combined. Here, factor order corresponds to the weight the factor has on fatal crashes. For example, when examining all fatal crashes, the functionality of traffic controls carries the most weight, and potential, in understanding fatal crashes.

As seen in table 1, several factors appear frequently across the board, regardless of the number of vehicles involved. This report will focus on the factors that load highly across all fatal crash sizes as they have the most potential influence in understanding the precursors of fatal crashes. These common factors will be defined as either transportation-related or human-related (e.g., due to human error or behavior) and their relationship with fatal crashes will be examined further.

Transportation-Related Factors

Transportation-related factors generally refer to either the elements of the roadway infrastructure or external factors such as weather conditions. Rather than examine all transportation-related factors listed in table 1, the five leading factors (based on weight) will be evaluated further.

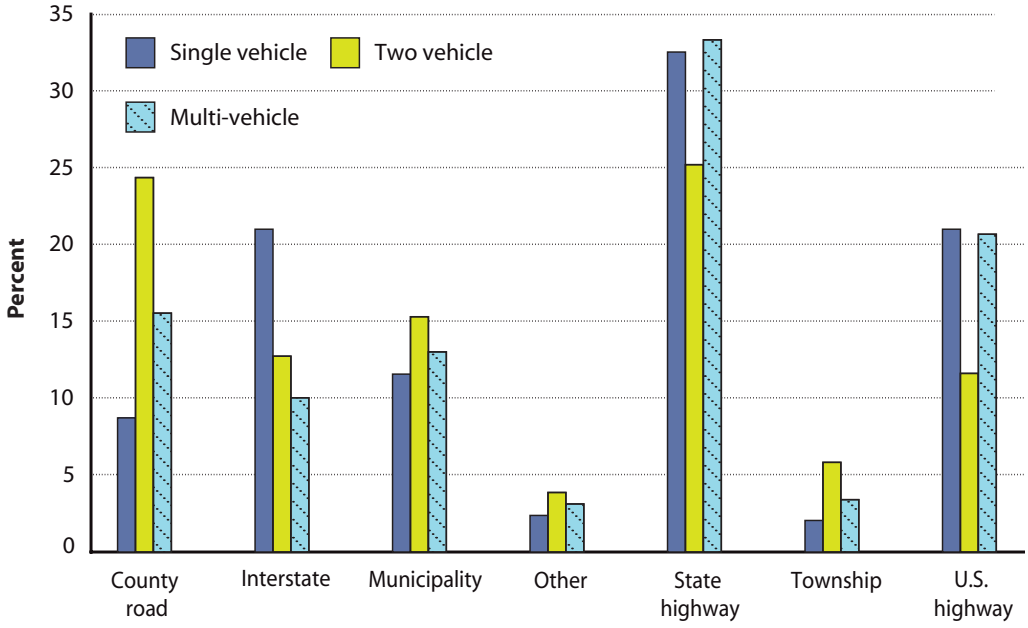
Figure 2: Traffic Controls Present at Crash Location by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)



NOTES: "Other" includes all traffic controls accounting for less than 1 percent of total. Figure 2 omits data where no traffic controls were present.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

Figure 3: Route Type by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

These factors are defined as being the most influential across all groups (see table 1):

- traffic controls,
- speed and route type,
- road characteristics,
- weather impacts, and
- road classification.

Traffic Controls

In the FARS database, a traffic control device is defined as any type of signage or signal with the goal of influencing traffic flow (e.g., stop, yield, or warning signs). In single-vehicle crashes, 86.3 percent occured in areas where there are no traffic controls; in contrast to 63.9 percent in two- and 70.9 percent in multi-vehicle crashes. Where present, at least 95 percent of traffic controls were functioning properly (95.9 percent single, 98.2 percent two, and 98.2 percent multi-vehicle). Figure 2 depicts the type of traffic control present at the time of a crash. Where a traffic control existed, a high proportion of crashes occurred in areas where a stop sign or traffic signal (e.g., traffic light) was present.

Speed and Route Type

As seen in figure 3, a large proportion of fatal crashes, regardless of size, occurred on a state highway. With regard to speed limits, the greatest percentage of fatal crashes occurred in a 55 mile-per-hour (mph) zone: 27.7, 33.1, and 29.9 percent of single-, two- and multi-vehicle fatal crashes, respectively. Following in frequency, a high proportion of fatal crashes took place in a 45 mph zone (13.5, 15.7, and 14.9 percent, respectively).

While the speed and route type factor is transportation related, it is also heavily influenced by human behavior. Transportation officials can set appropriate speed limits for routes or roadways, however it is ultimately the driver who controls the vehicle and the speed. Further analysis is needed to understand the role human behavior plays in driving this factor.

Table 2: Alignment of Roadway, 2004–2008

Roadway alignment	Frequency	Percent
Single vehicle		
Straight	72,109	65.7
Curved	36,984	33.6
Unknown	843	0.8
Two vehicle		
Straight	54,006	82.3
Curved	11,345	17.3
Unknown	253	0.4
Multi-vehicle		
Straight	10,457	85.3
Curved	1,738	14.2
Unknown	61	0.5

NOTE: Percents may not add to 100 due to rounding.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

Road Characteristics

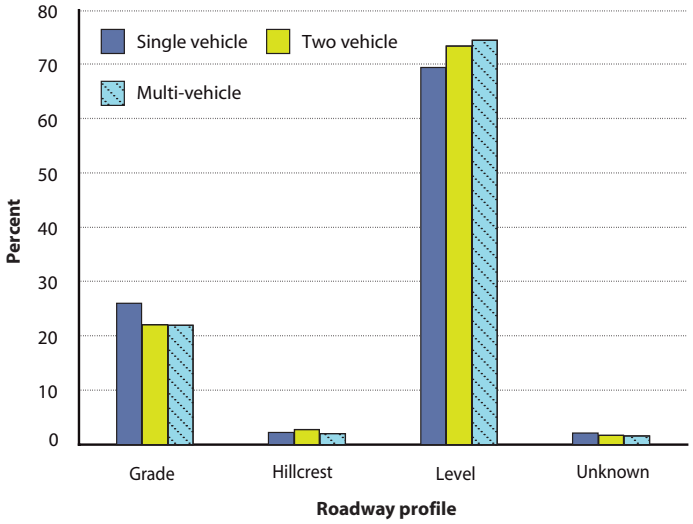
The road characteristics factor could potentially be influenced by federal or state highway policies. The main variables driving the road characteristics factor are:

- roadway alignment,
- roadway profile, and
- pavement type.

As seen in table 2, most fatal crashes occurred on straight roadways. While fewer than 20 percent of fatal crashes involving two or more vehicles occurred on a curved roadway, one-third of single-vehicle crashes took place on a curve. A large proportion of crashes—86.9 percent of single-, 88.7 percent of two- and 85.8 percent of multi-vehicle crashes—-occured on roadways paved with bituminous (coded in FARS as "blacktop")[6].

Figure 4 looks at the distribution of roadway profiles among the three crash sizes (see box A). A large percentage of fatal accidents occurred on level or grade roadways. With regard to single-vehicle crashes, 44.5 percent occurred on roadways that were straight, level, and paved with bituminous (compared to 57.4 percent of two- and 57.3 percent of multi-vehicle crashes). An additional 16.5 percent of single-vehicle crashes occurred on curved, level, bituminous roadways; in contrast to 8.2 percent of two- and 6.6 percent of multi-vehicle crashes.

Figure 4: Roadway Profiles at Fatal Crash Site by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)



NOTE: "Sag" removed as it accounts for less than 1% of total crashes

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

[6] A large percent of roadways are defined simply as 'paved' or 'unpaved.' Based on 2008 roadway miles: 32.6% of roadways were unpaved and 67.4% were paved. Of those paved, 32% were bituminous (blacktop), 2% concrete and the final 65% were paved but unknown if with bituminous or concrete. (See: http://www.fhwa.dot.gov/policyinformation/statistics/2008/hm12.cfm)

Box A: Roadway Profiles

In FARS, roadways that fatal crashes occur on are assigned one of five profiles:

1. Grade – a sloped roadway
2. Level – a flat roadway
3. Hill crest – the top of a hill
4. Sag – a drop in the roadway
5. Unknown

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Analytic Reference Guide 1975-2008 (http://www-nrd.nhtsa.dot.gov/Pubs/811137.PDF)

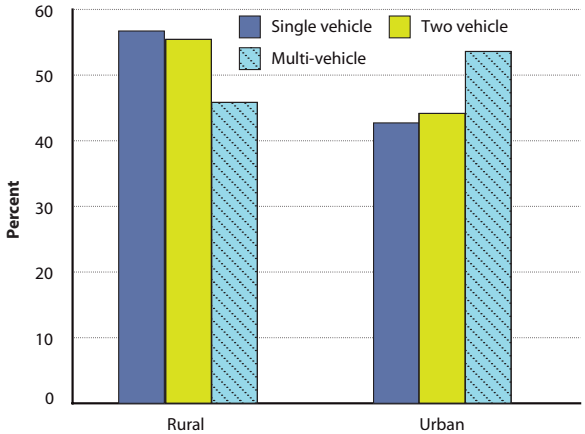
Weather Impacts

The weather impacts factor depicts the relationship between weather and roadway surface conditions. While the majority of fatal crashes (82.7, 82.6, and 81.6 percent for the three fatal crash sizes, respectively) occurred on dry roads under normal conditions, further analysis by region may provide a deeper understanding of how this factor relates to fatal accidents.

Road Classification

Figure 5 depicts the distribution of fatal crashes by roadway function and crash size. In both single- and two-vehicle crashes, a greater proportion of crashes occurred in rural than in urban settings. With multi-vehicle crashes, a greater percentage occurred in urban settings.

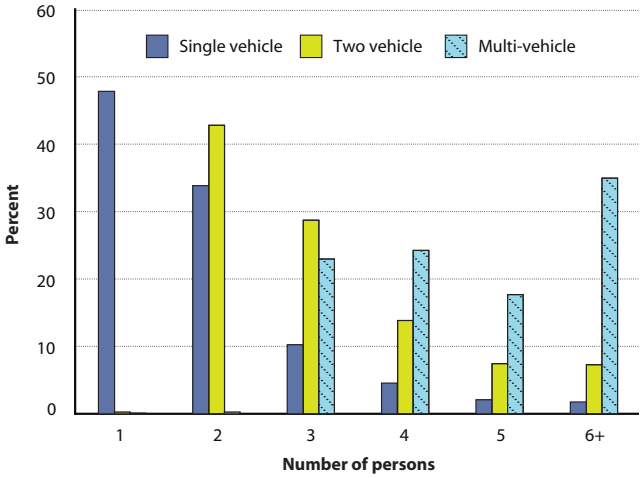
Figure 5: Roadway Function by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)



SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

The road classification factor is also influenced by whether or not the road is part of the National Highway System (NHS). The NHS includes the Interstate Highway System as well as other roads important to the nation's economy, defense, and mobility[7]. The majority of fatal crashes occurred on roads not classified as NHS – 72.6, 65.96, and 50.4 percent for single-, two-, and multi-vehicle crashes respectively.

Figure 6: Number of Persons Involved in Crash by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)



NOTE: Involved Persons includes all persons involved in a crash; fatalities, injured parties, and otherwise involved persons such as uninjured occupants.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

Human-Related Factors

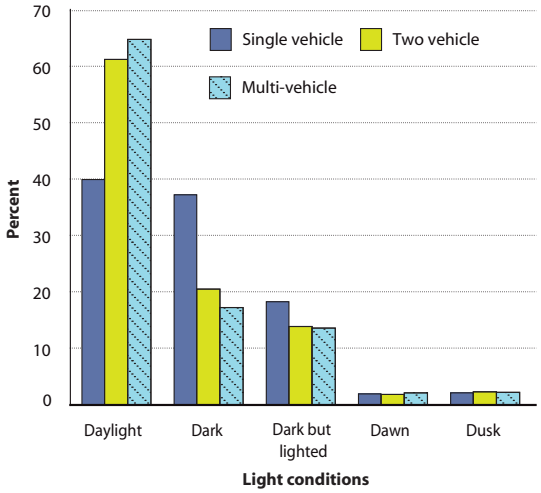
This analysis defines human-related factors as events contributing to a crash due to human influence, behavior, or error. As stated above, factors such as speed and route type are heavily influenced by the actions of individual drivers. The relative impact of human behavior should be considered when exploring possible solutions for similar transportation-related factors. Only two of the factors listed in table 1 can be defined as human-related:

- persons, and
- drunk driving/light condition.

Persons

The persons factor depicts the relationship between the number of persons in a crash and the number of fatalities. Figure 6 examines the number of persons involved (includes all fatalities, injured parties, or otherwise involved persons such as uninjured occupants) by fatal crash size. In both single and two vehicle fatal crashes, the majority of vehicles involved were single occupancy (47.8 and 42.7 percent, respectively). With regards to fatalities, the majority of fatal crashes resulted in only one fatality (94.5 percent in single-vehicle, 88.2 percent in two-vehicle and 83.95 percent in three-vehicle fatal crashes).

Figure 7: Light Conditions at Time of Crash by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)

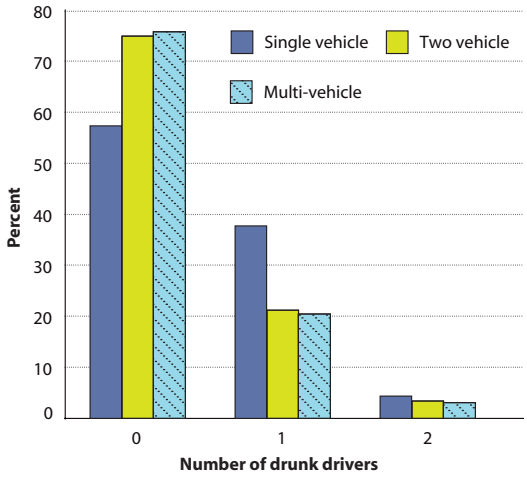


SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

Drunk Driving/Light Condition

The drunk driving/light condition factor involves the relationship between driving under the influences of alcohol and current light conditions. In the FARS database, "drunk

Figure 8: Percent of Drunk Drivers by Crash Size, 2004–2008
(as a percent of fatal crashes by crash size)



NOTES: Categories greater than 2 were omitted as they accounted for less than 1 percent. Alcohol data is underreported in FARS, true distribution may vary.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009.

[7] For more information on NHS, refer to http://www.fhwa.dot.gov/planning/nhs//

driver" is a derived variable and is pulled from police reports; for this reason such alcohol data may be underrepresented in the database. Figure 7 examines the occurrence of fatal crashes by light conditions. As seen, regardless of crash size, the greatest proportion of fatal crashes occurred during the daylight hours (39.9, 61.2, and 64.7 percent for the three crash groups, respectively).

Figure 8 examines the number of reported drunk drivers involved in a crash by group. As seen, a large proportion of fatal crashes did not involve a drunk driver. Single-vehicle crashes were more likely to involve a drunk driver than those involving two or more vehicles.

Table 3 portrays, for single-, two-, and multi-vehicle fatal crashes, the percent that occur in each lighting condition with no or one drunk driver. For each group, the majority of fatal crashes occur during the daylight and do not involve drunk drivers (31.4, 53.23, and 55.9 percent, respectively, for the three crash size groups). Fatal crashes involving drunk drivers occurred most frequently in the dark (28.3, 13.2, and 11.6 percent, respectively, for the three crash size groups)[8]. Single-vehicle crashes after dark were more likely than not to involve a drunk driver (28.3 v. 23.0 percent of all single-vehicle crashes). In contrast, both two- and multi-vehicle crashes were more likely to not involve a drunk driver.

Table 3: Percentage of Drunk Drivers by Light Condition

	Single vehicle	Two vehicle	Multi-vehicle
Daylight			
No drunk drivers	31.39	53.29	55.93
1 drunk driver	7.79	7.22	7.81
Dark			
No drunk drivers	15.05	11.39	9.89
1 drunk driver	19.43	7.56	6.11
Dark but Lighted			
No drunk drivers	7.92	6.9	6.71
1 drunk driver	8.89	5.58	5.49
Dawn			
No drunk drivers	1.35	1.57	1.72
1 drunk driver	0.48	0.26	0.32
Dusk			
No drunk drivers	1.24	1.68	1.48
1 drunk driver	0.8	0.56	0.57

NOTE: Percents may not add to 100 as fatal crashes can occur under any light conditions with more than one drunk driver.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, FARS Database as of December 2009

Data Issues

Both human-related factors - persons and drunk driving/light condition - can greatly influence fatal crashes. However, they do not carry as much weight as transportation-related factors in table 1. This, in part, reflects that variables which influence human-related factors are often under-reported in the FARS database due to the way crash data are obtained—a key limitation of the database. NHTSA[9] notes that while many variables on the police reports are concrete across the jurisdictions, it is possible to have inconstancies. Often these inconsistencies are found in variables regarding human behavior, such as distraction, which are hard to quantify.

There is still much to learn to get a complete picture of the factors that influence fatal crashes. Unlike transportation-related factors, such as traffic controls, human-related factors cannot be categorized and are difficult to measure. Further examination of variables that address human behavior can provide more information on the role human-related factors play in fatal crashes. Additionally, further analysis of higher ranked factors, such as roadway characteristics, may prove useful in developing strategies to address roadway fatalities.

[8] Includes both the Dark and Dark but Lighted categories. Dark but Lighted refers to crashes that occur during hours of darkness, on a stretch of roadway that is artificially lighted (e.g.-street lights.)

[9] NHTSA Research Note: An Examination of Driver Distraction as Recorded in NHTSA Databases- http://www-nrd.nhtsa.dot.gov/Pubs/811216.pdf

About this report

This report was prepared by Jenny Guarino, Mathematical Statistician at the Bureau of Transportation Statistics (BTS) and Amrut Champaneri, Director of the Office of Statistical Quality at BTS. BTS is a component of the U.S. Department of Transportation's Research and Innovative Technology Administration (RITA).

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Data –

This report is based on data from NHTSA's Fatality Analysis Reporting System (FARS) Database.

- ftp://ftp.nhtsa.dot.gov/FARS

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- *Improving Highway Safety by Identifying High Risk Rural Road Segments and Safety Countermeasures*, April 2010
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