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# **Motor** Vehicle Crashes, Injuries, and Deaths in Relation to Weather Conditions, United States, 2010-2014

*January 2016*



## **Title**

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Motor Vehicle Crashes, Injuries, and Deaths in Relation to Weather Conditions,  
United States, 2010 – 2014. (*January 2016*)

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## **About the Sponsor**

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## Executive Summary

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The purpose of this study was to investigate the number of motor vehicle crashes, injuries, and deaths that occurred in the United States in years 2010 – 2014 in relation to the weather conditions and weather-related roadway surface conditions present at the time of the crash. The data examined were a representative sample of all police reported crashes and a census of all fatal crashes that occur on public roads in the United States. The average number of injuries and fatalities per 1,000 crashes was computed as a measure of the severity of crashes that occur under various weather and surface conditions. Poisson regression was used to adjust crash-based rates of injuries and fatalities for other factors associated with crash severity.

Nationwide, an average of 1,179,253 police-reported crashes, 425,103 injuries, and 5,137 deaths occurred in adverse weather and/or roadway surface conditions annually, representing 21.0% of all crashes, 18.5% of all injuries, and 15.6% of all fatalities during the study period. Crashes that occurred in adverse weather or on slippery roads were more likely to be single-vehicle crashes than crashes that occurred in clear weather and on dry roads. A larger proportion of all crash-involvements of younger drivers than of older drivers occurred in adverse weather and/or roadway surface conditions.

Crashes that occurred in adverse weather and/or roadway surface conditions were less likely to result in injuries or fatalities than crashes on dry that occurred in clear weather and on dry roads. After adjustment for other factors related to crash severity, crashes that occurred on snow-covered roads resulted in 31% fewer injuries per crash and 47% fewer fatalities per crash than crashes that occurred on dry roads; crashes that occurred on ice-covered roads resulted in 19% fewer injuries per crash and 29% fewer fatalities per crash than crashes that occurred on dry roads. The only weather condition associated with a statistically elevated rate of fatalities per crash was fog—crashes that occurred in fog resulted in 155% more fatalities per crash than crashes that occurred in clear weather after adjustment for other factors associated with crash severity.

An important limitation of this study is that it did not investigate effect of adverse conditions on the risk of crashes occurring; only the number and severity of crashes could be investigated due to limitations of available data. The finding that crashes that occur in adverse conditions tend to be less severe than crashes that occur in clear weather and on dry roads may be attributable to drivers driving more slowly and carefully in bad weather and on slippery roads, however, it is also possible that adverse conditions increase the risk of crashes of all severities but disproportionately increase the risk less severe crashes. Other studies suggest that precipitation is generally associated with increased crash rates, and that the increase in lower-severity crashes is larger than the increase in higher-severity crashes.

Given the large number and proportion of crashes, injuries, and deaths that occur in adverse weather conditions, more effort is needed to educate motorists regarding safe driving practices in inclement weather and to develop and implement vehicle technologies to improve the safety of driving in inclement weather.

## Methods

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### *Data*

Data analyzed in this study were obtained from the National Highway Traffic Safety Administration (NHTSA) National Automotive Sampling System General Estimates System (GES, 2015) and Fatality Analysis Reporting System (FARS, 2015) databases. The GES database contains data from approximately 50,000 crashes each year which are drawn from a statistically representative stratified sample of all police-reported crashes nationwide. Crashes in the GES database include weights that are used to project statistics derived from analysis of sampled crashes onto all police-reported crashes nationwide. The FARS database contains data from every motor vehicle crash that occurs on public roadways in the United States and results in a death within 30 days of the crash. Data from years 2010 – 2014 were examined.

### *Analysis*

This study examined the annual average number of police-reported crashes, number of people injured, number of people killed, and rates of injuries and deaths per 1,000 crashes in relation to weather conditions and roadway surface conditions present at the time of the crash.

Weather conditions investigated were rain, snow, sleet, fog, and clear (no adverse conditions). The FARS & GES databases could indicate up to two weather conditions; in cases when two conditions were specified (e.g., rain and sleet), conditions were coded according to the following hierarchy for the purpose of this study:

1. Sleet was always coded if sleet was present;
2. Snow was coded if snow was present and sleet was not present;
3. Rain was coded if rain was present and neither snow nor sleet was present;
4. Fog was coded if fog was present and no precipitation was present;
5. Other weather conditions (e.g., severe crosswinds) were coded as “other” if neither fog nor precipitation was present;
6. Conditions were coded as clear if no adverse conditions were present. (Cloudy weather was coded as clear in the absence of precipitation or fog.)

Roadway surface conditions examined were: dry, wet, snow, ice, and other. Roadway surface conditions were unknown in 360,114 crashes (1.3% of all crashes); analyses of roadway surface conditions excluded these crashes.

Given natural variation in the prevalence of various weather conditions by season of year and region of the country, data were analyzed in relation to region and season. Regions were:

- Northeast (PA, NJ, NY, NH, VT, RI, MA, ME, CT),
- Midwest (OH, IN, IL, MI, WI, MN, ND, SD, NE, IA, MO, KS),
- South (MD, DE, DC, WV, VA, KY, TN, NC, SC, GA, FL, AL, MS, LA, AR, OK, TX),
- West (MT, ID, WA, OR, CA, NV, NM, AZ, UT, CO, WY, AK, HI).

Crashes were grouped according to meteorological seasons (spring: March 1 – May 31; summer: June 1 – August 31; fall: September 1 – November 31; winter: December 1 – February 28) rather than astronomical seasons because the purpose of the study was to examine crashes in relation to weather conditions.

The rates of injuries and deaths per 1,000 crashes were computed to assess average crash severity in relation to weather and roadway surface conditions. Poisson regression was used to compute adjusted ratios of rates of injuries and deaths per 1,000 crashes controlling for the associations of injury and fatality rates with season, region, year, time of day, day of week, roadway type, vehicle type, and driver age. Time of day, roadway type, vehicle type, and driver age were unknown a small number of crashes (<1% of all crashes); adjusted rate ratios were estimated with these crashes excluded.

Analysis of injuries was based on weighted data from the GES database. Analyses of fatalities were based on data from FARS. Analyses of all crashes were based weighted data from non-fatal crashes in the GES database combined with data from fatal crashes in FARS.

## Results

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The majority of all crashes over the study period (86.2%) occurred in clear weather (Table 1). Among crashes that did not occur in clear weather, the condition present in the greatest proportion of crashes was rain (9.2%). Snow (3.4%), sleet (0.6%), fog (0.4%), and other conditions (0.2%) were much less common. Similarly, most crashes (79.3%) occurred on dry roads, 14.2% occurred on wet roads, 3.0% occurred on snow-covered roads, 2.6% on roads with ice, and 0.9% in other conditions (Table 2). The representation of various weather and surface conditions exhibited very little yearly variation: the annual proportion of crashes that occurred in clear weather ranged from a low of 85.0% to a high of 87.4%; the proportion that occurred on dry roads ranged from a low of 78.1% to a high of 81.7%.

Weather conditions present in crashes varied substantially by region (Table 3). Adverse weather conditions were present in 18.3% of all crashes in the Midwest and 16.8% of crashes in the Northeast, whereas they were present in only 11.6% of crashes in the South and 8.8% of crashes in the West. The proportion of crashes that occurred in rain was greatest in the Northeast (11.1%); the proportion that occurred in snow was greatest in the Midwest (7.8%). Similarly, the proportion of crashes that occurred in adverse roadway conditions was greatest in the Midwest (30.2%) and lowest in the West (13.2%) (Table 4). The proportion that occurred on wet roads was greatest in the Northeast (16.5%) and the proportion that occurred on roads covered in snow and ice was greatest in the Midwest (6.7% and 6.2%, respectively).

The proportions of crashes that occurred in clear weather and on dry roads, respectively, were greatest in the summer (91.9% in clear weather, Table 2; 88.7% on dry roads, Table 3). Rain was present in the greatest proportion of crashes in the fall (10.6%), and the greatest proportions of crashes involving snow (10.6%), sleet (1.7%), and fog (0.7%) occurred in winter (Table 3). As expected, the proportions of crashes that occurred on roads that were wet (17.0%) or that were covered in snow (9.8%) or ice (8.2%) were all greatest in winter (Table 4).

Table 5 shows the number and proportion of crashes that occurred under any adverse weather and/or roadway surface conditions (i.e., any conditions other than clear weather and dry roads) by region and season. Variation was extensive: while an average of 21% of all crashes (all seasons, all regions) occurred in adverse weather conditions, the proportion ranged from 5.7% of crashes in the West in the summer to 57.8% in the Midwest in the winter.

There was little variation in the prevalence of weather conditions by time of day. Fog, while uncommon, was more prevalent in crashes that occurred in the overnight or early morning hours than during the day (Table 3). Crashes that occurred on ice-covered roads accounted for a greater proportion of crashes in the overnight and morning hours than during the day (Table 3).

Crashes on Interstate highways were slightly more likely than crashes on other types of roads to occur under adverse weather conditions (18.6% vs. 13.4%) and on wet roads (17.2% vs. 14.0%).

A greater proportion of non-collisions (i.e., single vehicle crashes) than multiple-vehicle collisions occurred in adverse weather conditions (Table 2) and on slippery roads (Table 3). Head-on crashes, while rare (2.3% of all crashes) were more likely than other multi-vehicle crashes to occur in snow or sleet (Table 2) and on snow- or ice-covered roads (Table 3).

The proportions of driver crash involvements that occurred in adverse weather conditions and roadway surface conditions were higher among drivers younger than years of age than among any other age group (Tables 3 & 4). Although highest for the youngest drivers, these proportions decreased with increasing age across the entire age distribution. The vast majority of motorcycle crashes occurred in clear weather conditions (96.1%) and on dry roads (92.7%). Weather conditions present in crashes of heavy trucks and buses were similar to those present in crashes of cars and light trucks.

With the major exception of crashes that occurred in fog, crashes that occurred in adverse weather conditions resulted in fewer fatalities per crash than did crashes that occurred in clear weather (Table 6). Crashes that occurred in rain, snow, and sleet resulted in 4.3, 2.8, and 3.9 fatalities per 1,000 crashes, respectively, compared with 6.1 fatalities per 1,000 crashes in clear weather. Crashes that occurred in fog resulted in 17.3 fatalities per 1,000 crashes, significantly more than in any other weather condition. After adjustment for other factors that influence crash severity, crash-based fatality rates in snow and sleet were not statistically different from those in clear weather, rain was associated with 14% fewer fatalities per 1,000 crashes compared with clear weather (aRR = 0.86), and fog was associated with 155% more fatalities per 1,000 crashes compared with clear weather (aRR = 2.55). Crashes that occurred on roads that were wet or snow- or ice-covered resulted in significantly fewer fatalities per 1,000 crashes than did crashes that occurred on dry roads (Table 7); crashes on snow- and ice-covered roads were also associated with lower rates of injury. Rates of injuries did not differ significantly in relation to weather conditions after controlling for other factors related to crash severity (Table 6).

## Discussion

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An average of 1,179,253 police-reported crashes, 425,103 injuries, and 5,137 deaths occurred in adverse weather and/or roadway surface conditions annually from 2010 through 2014, representing 21.0% of all police-reported crashes, 18.5% of all injuries in crashes, and 15.6% of all fatalities in crashes in the United States during the study period. Results show that with the exception of fog, crashes that occurred in adverse weather and/or roadway surface conditions tended to be less severe than those that occurred in clear weather and on dry roads. Compared with crashes that occurred in clear weather, crashes that occurred in fog resulted in 2.55 times as many fatalities per crash. A previous AAA Foundation study reported that fog-related crashes were substantially over-represented among multi-vehicle pileups, with fog present in nearly 20% of crashes that involved 10 or more vehicles, compared with less than 1% of all crashes (Hamilton et al., 2014).

An important limitation of this study is that it did not investigate the effect of weather conditions or roadway surface conditions on the risk of a crash occurring due to data limitations. The data examined in this study were derived from police reports of motor vehicle crashes. These data do not include information about drivers' exposure to various weather and roadway surface conditions (e.g., number of miles driven in various weather and surface conditions). Thus, the finding that crashes in adverse conditions (other than fog) resulted in lower rates of injuries and deaths per crash than crashes that occurred in clear weather and on dry roads may be attributable to drivers exercising more caution and driving more slowly in these conditions and thus reducing the severity of any crashes occur under these conditions. However, it is also possible that some adverse weather and/or roadway surface conditions actually increase the risk of all crashes (including those that result in injuries or fatalities), but that they disproportionately increase the risk of types of crashes that tend to be less severe, which would also decrease the average number of injuries and deaths per crash in crashes that occur under adverse conditions compared with crashes that occur in clear and dry conditions—numerous other studies suggest that this is likely to be the case.

Two previous studies analyzed daily U.S. state-level motor vehicle crash data in conjunction with daily precipitation data. Eisenberg (2004) found that after controlling for other factors, rain was associated with a small increase in the number of fatal crashes and a larger increase in the number of non-fatal crashes. Eisenberg & Warner (2005) found that snow was associated with increased numbers of non-fatal crashes but decreased numbers of fatal crashes, with the exception that the first snowfall of the year, which was associated with an increase in fatal crashes as well. Those studies also lacked data on driver exposure (e.g., miles driven) in relation to precipitation, however, assuming that drivers do not drive more miles in inclement weather than in good weather, those studies suggest that rain and snow are associated with increased crash risk, and that the increase in risk is greatest among the relatively lower-severity crashes. Studies of daily crashes in relation to weather conditions and traffic volumes in the Netherlands (Brijs et al., 2008) and in Australia (Keay & Simmonds, 2005) both reported that rainfall was associated with elevated crash rates even after accounting for traffic volumes. A systematic review and meta-analysis of relevant research published between 1967 and 2005 concluded that precipitation was generally associated with increased crash rates, that snow was associated with larger

increases in crash rates than rain, and that the increase in the overall crash rate was larger than the increase in the rate of injuries (Qiu & Nixon, 2008).

In summary, this study quantified the number of crashes, injuries, and deaths in relation to weather conditions and weather-related roadway conditions in the United States, and examined the relationship between weather conditions and crash severity. Results indicate that an average of 1,179,253 police-reported crashes, 425,103 injuries, and 5,137 deaths occur in adverse weather and/or roadway surface conditions annually, and that with the exception of fog, adverse weather and surface conditions are associated with decreased crash severity (fog is associated with significantly increased crash severity). While the current study was not able to examine the relationship between weather conditions and crash risk, other research suggests that rain and snow are associated with increased crash risk. Given the large number and proportion of crashes, injuries, and deaths that occur in adverse weather conditions, more effort is needed to educate motorists regarding safe driving practices in inclement weather and to develop and implement vehicle technologies to improve the safety of driving in inclement weather.

## Tables

**Table 1.** Annual Number of Police-Reported Crashes, Injuries, and Deaths in Relation to Weather Conditions, United States, 2010 – 2014.

	Weather condition						Total
	Clear	Rain	Snow	Sleet	Fog	Other	
<i>Estimated number of crashes (Row %)</i>							
2010	4,692,870 (86.6)	443,798 (8.2)	220,482 (4.1)	28,303 (0.5)	19,426 (0.4)	14,566 (0.3)	5,419,445
2011	4,593,241 (86.1)	518,073 (9.7)	156,453 (2.9)	36,868 (0.7)	19,316 (0.4)	13,876 (0.3)	5,337,829
2012	4,905,472 (87.4)	522,211 (9.3)	132,615 (2.4)	20,713 (0.4)	24,029 (0.4)	10,005 (0.2)	5,615,045
2013	4,833,013 (85.0)	574,752 (10.1)	197,528 (3.5)	49,375 (0.9)	21,849 (0.4)	10,374 (0.2)	5,686,892
2014	5,209,412 (85.9)	532,683 (8.8)	240,001 (4.0)	47,197 (0.8)	23,458 (0.4)	11,466 (0.2)	6,064,217
Total	24,234,008 (86.2)	2,591,517 (9.2)	947,080 (3.4)	182,456 (0.6)	108,078 (0.4)	60,288 (0.2)	28,123,427
Average	4,846,802 (86.2)	518,303 (9.2)	189,416 (3.4)	36,491 (0.6)	21,616 (0.4)	12,058 (0.2)	5,624,685
<i>Estimated number of injuries (Row %)</i>							
2010	1,974,360 (87.8)	188,930 (8.4)	61,164 (2.7)	8,738 (0.4)	6,623 (0.3)	8,759 (0.4)	2,248,574
2011	1,951,869 (87.6)	206,052 (9.2)	42,052 (1.9)	12,983 (0.6)	9,614 (0.4)	5,216 (0.2)	2,227,786
2012	2,100,091 (88.6)	213,449 (9.0)	37,256 (1.6)	7,244 (0.3)	7,564 (0.3)	4,152 (0.2)	2,369,756
2013	2,012,780 (86.8)	224,223 (9.7)	54,750 (2.4)	14,497 (0.6)	7,490 (0.3)	6,032 (0.3)	2,319,773
2014	2,052,973 (87.6)	199,714 (8.5)	61,114 (2.6)	14,758 (0.6)	9,543 (0.4)	5,201 (0.2)	2,343,303
Total	10,092,073 (87.7)	1,032,369 (9.0)	256,336 (2.2)	58,219 (0.5)	40,835 (0.4)	29,359 (0.3)	11,509,191
Average	2,018,415 (87.7)	206,474 (9.0)	51,267 (2.2)	11,644 (0.5)	8,167 (0.4)	5,872 (0.3)	2,301,838
<i>Number of deaths (Row %)</i>							
2010	29,651 (89.9)	2,160 (6.5)	616 (1.9)	139 (0.4)	336 (1.0)	97 (0.3)	32,999
2011	29,150 (89.8)	2,229 (6.9)	496 (1.5)	159 (0.5)	358 (1.1)	87 (0.3)	32,479
2012	30,512 (90.3)	2,264 (6.7)	395 (1.2)	81 (0.2)	413 (1.2)	117 (0.3)	33,782
2013	29,338 (89.2)	2,314 (7.0)	556 (1.7)	174 (0.5)	401 (1.2)	111 (0.3)	32,894
2014	29,238 (89.5)	2,230 (6.8)	551 (1.7)	164 (0.5)	361 (1.1)	131 (0.4)	32,675
Total	147,889 (89.7)	11,197 (6.8)	2,614 (1.6)	717 (0.4)	1,869 (1.1)	543 (0.3)	164,829
Average	29,578 (89.7)	2,239 (6.8)	523 (1.6)	143 (0.4)	374 (1.1)	109 (0.3)	32,966

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

**Table 2.** Annual Number of Police-Reported Crashes, Injuries, and Deaths in Relation to Roadway Surface Conditions, United States, 2010 – 2014.

	Roadway surface condition <sup>a</sup>					Total
	Dry	Wet	Snow	Ice	Other	
<i>Estimated number of crashes (Row %)</i>						
2010	4,238,470 (79.4)	719,337 (13.5)	183,939 (3.4)	153,114 (2.9)	46,196 (0.9)	5,341,056
2011	4,139,858 (78.5)	796,919 (15.1)	135,878 (2.6)	149,550 (2.8)	49,757 (0.9)	5,271,962
2012	4,534,758 (81.7)	775,612 (14.0)	95,008 (1.7)	93,706 (1.7)	48,389 (0.9)	5,547,473
2013	4,415,743 (78.6)	845,641 (15.1)	169,846 (3.0)	132,011 (2.4)	53,720 (1.0)	5,616,962
2014	4,675,688 (78.1)	814,482 (13.6)	239,615 (4.0)	206,073 (3.4)	50,002 (0.8)	5,985,860
Total	22,004,517 (79.3)	3,951,991 (14.2)	824,286 (3.0)	734,454 (2.6)	248,064 (0.9)	27,763,313
Average	4,400,903 (79.3)	790,398 (14.2)	164,857 (3.0)	146,891 (2.6)	49,613 (0.9)	5,552,663
<i>Estimated number of injuries (Row %)</i>						
2010	1,825,779 (81.9)	298,075 (13.4)	44,932 (2.0)	44,120 (2.0)	15,893 (0.7)	2,228,798
2011	1,804,577 (81.5)	308,486 (13.9)	34,478 (1.6)	46,071 (2.1)	21,358 (1.0)	2,214,970
2012	1,957,884 (83.0)	325,762 (13.8)	24,352 (1.0)	29,012 (1.2)	22,409 (0.9)	2,359,418
2013	1,888,034 (81.6)	325,405 (14.1)	40,542 (1.8)	40,171 (1.7)	19,990 (0.9)	2,314,142
2014	1,893,389 (81.3)	310,974 (13.3)	58,498 (2.5)	50,278 (2.2)	17,181 (0.7)	2,330,320
Total	9,369,663 (81.8)	1,568,702 (13.7)	202,802 (1.8)	209,652 (1.8)	96,831 (0.8)	11,447,648
Average	1,873,933 (81.8)	313,740 (13.7)	40,560 (1.8)	41,930 (1.8)	19,366 (0.8)	2,289,530
<i>Number of deaths (Row %)</i>						
2010	27,898 (85.1)	3,605 (11.0)	434 (1.3)	532 (1.6)	324 (1.0)	32,793
2011	27,543 (85.4)	3,522 (10.9)	379 (1.2)	503 (1.6)	298 (0.9)	32,245
2012	28,988 (86.3)	3,719 (11.1)	251 (0.7)	326 (1.0)	298 (0.9)	33,582
2013	27,625 (84.5)	3,854 (11.8)	391 (1.2)	480 (1.5)	325 (1.0)	32,675
2014	27,428 (84.7)	3,657 (11.3)	415 (1.3)	633 (2.0)	267 (0.8)	32,400
Total	139,482 (85.2)	18,357 (11.2)	1,870 (1.1)	2,474 (1.5)	1,512 (0.9)	163,695
Average	27,896 (85.2)	3,671 (11.2)	374 (1.1)	495 (1.5)	302 (0.9)	32,739

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

a. Crashes, injuries, and deaths that occurred unknown roadway surface conditions were excluded (n=360,114 crashes, 1.3% of all crashes; n=61,543 injuries, 0.5% of all injuries; n=1,134 deaths, 0.7% of all deaths).

**Table 3. Characteristics of Crashes in Relation to Weather Conditions, United States, 2010 – 2014.**

	Weather condition						Total crashes (5-year-average)
	Clear	Rain	Snow	Sleet	Fog	Other	
	<i>Row %</i>						
<b>All crashes</b>	86.2	9.2	3.4	0.6	0.4	0.2	5,624,685
<b>Region</b>							
Northeast	83.2	11.1	4.3	1.0	0.3	0.1	1,005,632
Midwest	81.7	9.0	7.8	0.7	0.5	0.3	1,484,157
South	88.4	9.8	0.8	0.4	0.5	0.2	2,263,413
West	91.2	6.1	1.4	0.8	0.2	0.3	871,482
<b>Season</b>							
Spring	88.3	9.4	1.3	0.5	0.3	0.2	1,338,144
Summer	91.9	7.8	<0.1	<0.1	0.1	0.1	1,323,567
Fall	87.5	10.6	1.0	0.3	0.4	0.2	1,487,865
Winter	77.7	8.9	10.6	1.7	0.7	0.4	1,475,110
<b>Day of week</b>							
Mon-Fri	86.2	9.3	3.3	0.6	0.4	0.2	4,329,686
Sat-Sun	86.2	8.8	3.7	0.7	0.4	0.2	1,294,999
<b>Time of day<sup>a</sup></b>							
6-9:59AM	84.1	9.2	4.4	0.9	1.1	0.2	965,222
10AM-3:59PM	87.7	8.3	3.2	0.5	0.1	0.2	1,991,405
4-8:59PM	86.6	9.7	2.8	0.5	0.2	0.2	1,780,528
9PM-5:59AM	84.0	10.1	3.9	0.9	0.8	0.3	887,308
Road type							
Interstate highway	81.4	12.9	4.3	0.8	0.3	0.2	477,094
Other road type	86.6	8.9	3.3	0.6	0.4	0.2	5,146,308
<b>Manner of collision<sup>a</sup></b>							
Non-Collision	81.8	10.2	5.7	1.2	0.7	0.4	1,764,178
Rear-End	88.1	9.3	1.9	0.3	0.2	0.1	1,817,141
Sideswipe	89.0	7.9	2.4	0.4	0.2	0.1	578,258
Angle	88.0	8.6	2.5	0.4	0.3	0.1	1,237,234
Head-on	84.9	9.2	4.4	0.9	0.3	0.2	128,377
Other	89.4	6.9	2.6	0.7	0.2	0.2	85,010
							<b>Total drivers (5-year-average)</b>
<b>All drivers</b>	87.0	9.1	2.9	0.5	0.3	0.2	9,948,946
<b>Driver age (years)<sup>a</sup></b>							
<20	85.8	10.1	3.1	0.5	0.3	0.1	1,014,909
20-24	85.9	10.0	3.1	0.6	0.3	0.2	1,424,537
25-39	86.9	9.2	2.9	0.5	0.4	0.2	2,960,012
40-64	87.2	8.8	2.9	0.6	0.3	0.2	3,619,063
65-79	89.6	7.4	2.3	0.3	0.2	0.2	719,429
80+	90.3	7.2	1.6	0.4	0.3	0.2	187,192
<b>Vehicle type<sup>a</sup></b>							
Car / Light Truck	86.9	9.2	2.9	0.5	0.3	0.2	9,433,843
Large Truck / Bus	87.4	8.0	3.2	0.6	0.6	0.3	397,987
Motorcycle	96.1	3.3	<0.1	<0.1	0.2	0.3	104,971
Other	94.6	2.7	1.5	0.4	0.3	0.6	11,501

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

a. Crashes/drivers with unknown values for row variable excluded from tabulations for row variables that were unknown. Unknowns n (%): time of day: 1,108 crashes (0.02%); road type: 6,415 crashes (0.02%); manner of collision: 72,440 crashes (0.26%); driver age: 119,026 drivers (0.2%); vehicle type: 3,217 vehicles (0.01%).

**Table 4. Characteristics of Crashes in Relation to Roadway Surface Conditions, United States, 2010 – 2014.**

	Roadway surface condition <sup>a</sup>					Total crashes (5-Year average)
	Dry	Wet	Snow	Ice	Other	
<b>All</b>	79.3	14.2	3.0	2.6	0.9	5,552,663
<b>Region</b>			Row %			
Northeast	76.1	16.5	4.5	1.9	1.0	997,026
Midwest	69.8	15.9	6.7	6.2	1.4	1,445,540
South	83.8	14.0	0.5	1.1	0.6	2,253,063
West	86.8	9.3	1.4	1.7	0.8	857,034
<b>Season</b>						
Spring	83.6	13.7	1.0	1.0	0.8	1,322,149
Summer	88.7	10.7	<0.1	<0.1	0.6	1,307,855
Fall	82.8	15.1	0.7	0.9	0.6	1,466,560
Winter	63.3	17.0	9.8	8.2	1.6	1,456,098
<b>Day of week</b>						
Mon-Fri	79.2	14.4	2.8	2.7	0.8	4,276,137
Sat-Sun	79.3	13.6	3.4	2.6	1.1	1,276,526
<b>Time of day<sup>b</sup></b>						
6-9:59AM	74.2	15.5	3.9	5.5	1.0	953,419
10AM-3:59PM	81.4	12.9	2.9	1.8	0.9	1,973,720
4-8:59PM	80.8	14.4	2.3	1.7	0.7	1,755,718
9PM-5:59AM	76.8	15.6	3.3	3.3	1.0	869,626
<b>Road type<sup>b</sup></b>						
Interstate highway	75.2	17.2	2.9	3.5	1.2	473,676
Other road type	79.6	14.0	3.0	2.6	0.9	5,077,996
<b>Manner of collision<sup>b</sup></b>						
Non-Collision	72.4	15.5	5.0	5.1	1.9	1,713,795
Rear-End	82.7	14.2	1.5	1.3	0.3	1,806,776
Sideswipe	83.4	12.3	2.2	1.6	0.5	573,425
Angle	81.8	13.6	2.5	1.6	0.5	1,232,564
Head-on	76.8	15.0	4.2	3.3	0.8	128,038
Other	82.5	11.3	3.1	2.3	0.8	84,474
						<b>Total drivers (5-Year average)</b>
<b>All drivers</b>	80.6	14.0	2.5	2.2	0.7	9,854,423
<b>Driver age (years)<sup>b</sup></b>						
<20	78.4	15.5	2.8	2.4	0.9	1,005,988
20-24	79.4	14.9	2.7	2.2	0.8	1,411,516
25-39	80.4	14.1	2.5	2.3	0.7	2,932,555
40-64	80.9	13.8	2.6	2.1	0.7	3,581,688
65-79	84.0	11.9	1.9	1.6	0.6	713,456
80+	85.4	11.2	1.7	1.2	0.5	185,638
<b>Vehicle type<sup>b</sup></b>						
Car / Light Truck	80.4	14.2	2.6	2.2	0.7	9,343,889
Large Truck / Bus	81.5	12.8	2.8	2.2	0.6	394,278
Motorcycle	92.7	5.3	<0.1	0.1	1.9	104,270
Other	83.4	7.7	3.5	2.4	3.1	11,407

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

a. Crashes/drivers with unknown roadway surface condition were excluded (n=360,114 crashes, 1.3% of crashes; 472,614 vehicles/drivers, 1.0% of vehicles/drivers).

b. Crashes/drivers with unknown values for row variable excluded from tabulations for row variables that were unknown.

Unknowns n (%): time of day: 1,108 crashes (0.02%); road type: 6,415 crashes (0.02%); manner of collision: 72,440 crashes (0.26%); driver age: 119,026 drivers (0.2%); vehicle type: 3,217 vehicles (0.01%).

**Table 5.** Annual Average Number and Proportion of Crashes, Injuries, and Deaths that Occurred in Adverse Weather or Roadway Surface Conditions, by Region and Season, United States, 2010 –2014.

	Spring	Summer	Fall	Winter	All Seasons
<i>Estimated number (%) of crashes in adverse weather or roadway conditions</i>					
All Regions	223,140 (16.7)	152,077 (11.5)	259,940 (17.5)	544,097 (36.9)	1,179,253 (21.0)
Northeast	45,922 (19.8)	30,913 (12.6)	53,965 (20.3)	110,570 (41.9)	241,369 (24.0)
Midwest	74,683 (22.6)	37,442 (11.2)	86,409 (22.0)	246,923 (57.8)	445,457 (30.0)
South	78,491 (14.0)	72,022 (13.4)	90,736 (15.0)	134,090 (24.0)	375,339 (16.6)
West	24,044 (11.2)	11,701 (5.7)	28,829 (12.8)	52,514 (23.3)	117,088 (13.4)
<i>Estimated number (%) of injuries in adverse weather or roadway conditions</i>					
All Regions	86,966 (15.3)	67,247 (11.6)	100,924 (16.8)	169,965 (30.9)	425,103 (18.5)
Northeast	19,470 (18.8)	14,180 (12.1)	22,506 (19.7)	36,038 (35.4)	92,194 (21.1)
Midwest	23,843 (22.1)	14,808 (11.9)	27,041 (21.9)	63,001 (54.8)	128,693 (27.3)
South	32,596 (13.1)	32,720 (13.8)	37,264 (14.8)	51,551 (22.1)	154,131 (15.9)
West	11,058 (10.3)	5,539 (5.4)	14,112 (12.5)	19,375 (19.2)	50,084 (11.8)
<i>Number (%) of deaths in adverse weather or roadway conditions</i>					
All Regions	1,076 (13.5)	777 (8.6)	1,252 (14.2)	2,032 (28.2)	5,137 (15.6)
Northeast	155 (17.1)	118 (10.2)	214 (19.8)	325 (37.6)	812 (20.3)
Midwest	276 (18.4)	165 (8.4)	310 (17.0)	613 (45.9)	1,364 (20.6)
South	482 (12.1)	418 (10.2)	511 (12.4)	776 (21.7)	2,187 (13.9)
West	162 (10.3)	77 (4.3)	217 (12.3)	319 (22.5)	775 (11.8)

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

Crashes were counted as occurring in adverse weather or roadway surface conditions if weather conditions were other than clear or roadway surface conditions were other than dry.

**Table 6.** Injuries, Deaths, and Rate per 1,000 Crashes in Relation to Weather Conditions, United States, 2010–2014.

	Weather condition				
	Clear	Rain	Snow	Sleet	Fog
<b>Deaths</b>					
Number of deaths (5-year average)	29,578	2,239	523	143	374
Rate per 1,000 crashes	6.1	4.3	2.8	3.9	17.3
Rate Ratio (95% CI) <sup>a</sup>	Reference	0.71 (0.61–0.83)	0.45 (0.36–0.57)	0.64 (0.46–0.89)	2.83 (2.16–3.72)
Adjusted Rate Ratio (95% CI) <sup>b</sup>	Reference	0.86 (0.77–0.96)	0.97 (0.84–1.12)	1.05 (0.81–1.37)	2.55 (1.87–3.48)
<b>Injuries</b>					
Number of injuries (5-year average)	2,018,415	206,474	51,267	11,644	8,167
Rate per 1,000 crashes	416	398	271	319	378
Rate Ratio (95% CI) <sup>a</sup>	Reference	0.96 (0.90–1.02)	0.65 (0.57–0.73)	0.77 (0.64–0.92)	0.91 (0.77–1.07)
Adjusted Rate Ratio (95% CI) <sup>b</sup>	Reference	0.99 (0.93–1.04)	0.98 (0.88–1.09)	0.98 (0.82–1.16)	1.00 (0.85–1.18)

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

a. Rate of injuries or deaths per 1,000 crashes for weather condition shown relative to rate in clear weather.

b. Rate Ratio adjusted for year, region, season, time of day, day of week, Interstate highway, types of vehicles, ages of drivers, and roadway surface conditions.

**Table 7.** Injuries, Deaths, and Rate per 1,000 Crashes in Relation to Roadway Surface Conditions, United States, 2010–2014.

	Roadway surface condition			
	Dry	Wet	Snow	Ice
<b>Deaths</b>				
Number of deaths (5-year average)	27,896	3,671	374	495
Rate per 1,000 crashes	6.3	4.6	2.3	3.4
Rate Ratio (95% CI) <sup>a</sup>	Reference	0.73 (0.63–0.86)	0.36 (0.29–0.44)	0.53 (0.42–0.68)
Adjusted Rate Ratio (95% CI) <sup>b</sup>	Reference	0.90 (0.77–1.06)	0.53 (0.44–0.67)	0.71 (0.55–0.93)
<b>Injuries</b>				
Number of injuries (5-year average)	1,873,932	313,740	40,561	41,930
Rate per 1,000 crashes	426	397	246	285
Rate Ratio (95% CI) <sup>a</sup>	Reference	0.93 (0.88–0.99)	0.58 (0.52–0.64)	0.67 (0.58–0.78)
Adjusted Rate Ratio (95% CI) <sup>b</sup>	Reference	0.99 (0.93–1.05)	0.69 (0.61–0.79)	0.81 (0.72–0.91)

Data: General Estimates System & Fatality Analysis Reporting System; National Highway Traffic Safety Administration (2015).

a. Rate of injuries or deaths per 1,000 crashes for roadway surface condition shown relative to rate on dry roads.

b. Rate Ratio adjusted for year, region, season, time of day, day of week, Interstate highway, types of vehicles, ages of drivers, and weather conditions.

## References

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Brijs T, Karlis D, Wets G. 2008. Studying the effect of weather conditions on daily crash counts using a discrete time series model. *Accident Analysis & Prevention*, 40(3): 1180-1190.

Eisenberg D. 2004. The mixed effects of precipitation on traffic crashes. *Accident Analysis & Prevention*, 36(4): 637-647.

Eisenberg D, Warner KE. 2005. Effects of snowfalls on motor vehicle collisions, injuries, and fatalities. *American Journal of Public Health*, 95(1): 120-124.

Fatality Analysis Reporting System [Data files]. 2015. Washington, DC: U.S. Department of Transportation. (Updated December 14, 2015. Accessed December 15, 2015. Available at: <ftp://ftp.nhtsa.dot.gov/fars>)

General Estimates System. [Data files]. 2015. Washington, DC: U.S. Department of Transportation. (Updated November 24, 2015. Accessed December 15, 2015. Available at: <ftp://ftp.nhtsa.dot.gov/ges>)

Hamilton B, Tefft B, Arnold L, Grabowski J. 2014. *Hidden Highways: Fog and Traffic Crashes on America's Roads*. Washington, DC: AAA Foundation for Traffic Safety.

Keay K, Simmonds I. 2005. The association of rainfall and other weather variables with road traffic volume in Melbourne, Australia. *Accident Analysis & Prevention*, 37(1): 109-124.

Qiu L, Nixon WA. 2008. Effects of adverse weather on traffic crashes: Systematic review and meta-analysis. *Transportation Research Record: Journal of the Transportation Research Board*, No 2055: 139-146.