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The Prevalence of Motor Vehicle Crashes Involving Road Debris, United States, 2011–2014

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Title

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About the Sponsor

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Founded in 1947, the AAA Foundation in Washington, D.C. is a not-for-profit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, from individual members, from AAA-affiliated insurance companies, as well as from other organizations or sources.

Abstract

Previous research by the AAA Foundation for Traffic Safety found that debris deposited on the roadway by motor vehicles contributed to an estimated 25,000 crashes which resulted in 81-90 deaths in the year 2001 (Forbes & Robinson, 2004). The purpose of this study was to update the previous study with the most recent data available.

This study examined three publicly-available sources of data on motor vehicle crashes in the United States to estimate the number of crashes that involved debris on the roadway. Debris-related crashes were defined as crashes in which a vehicle struck or was struck by an object that fell or became detached from another vehicle, struck a non-fixed object on the roadway, or crashed after swerving to avoid an object on the roadway. Crashes that involved live animals, trees falling onto vehicles, debris associated with a recent previous crash, construction-related debris in work zones, or debris outside of the travel lane were not counted as debris-related crashes.

Results suggest that road debris was a factor in an estimated average of 50,658 police-reported crashes (95% Confidence Interval: 42,066 – 59,250) which resulted in 9,805 injuries (7,714 – 11,896) and 125 deaths (104 – 144) annually in the United States over years 2011 – 2014.

Compared with crashes that did not involve debris, debris-related crashes were approximately 4 times as likely to occur on Interstate highways. Compared with all drivers involved in crashes, drivers who struck or were struck by debris were approximately 20% more likely to be men.

Methods

Data

Data analyzed in this study were obtained from the National Highway Traffic Safety Administration (NHTSA) National Automotive Sampling System Crashworthiness Data System (NASS CDS, 2015), General Estimates System (GES, 2015) and Fatality Analysis Reporting System (FARS, 2015) databases.

The NASS CDS database contains data from a stratified sample of crashes in which a passenger vehicle (car, pickup truck, van, minivan, or SUV) was towed from the scene due to damage. The GES database contains data from a stratified sample of all police-reported crashes nationwide. Data in CDS and GES include weights that are used to project statistics based on sampled crashes onto all crashes in their respective sampling frames nationwide. The FARS database contains data from all motor vehicle crashes that occur on public roadways in the United States and result in a death within 30 days of the crash. The FARS, GES, and NASS CDS data are available to the public in the form of databases designed for statistical analysis. Additional in-depth documentation including a narrative description of each crash and photos of crash scenes and involved vehicles are also available for NASS CDS cases.

Analysis

The overall approach of the study was to query NASS CDS data to identify crashes in which coded data suggested that debris might plausibly have been a factor (hereafter *possible debris-related* crash), and then manually review narrative descriptions and diagrams from those crashes to confirm whether or not each possible debris-related crash actually involved debris. Next, the FARS & GES databases were queried to identify possible debris-related crashes in those databases. The proportion of possible debris-related crashes that were confirmed debris-related in NASS CDS was then used to adjust the number of possible debris-related crashes in FARS & GES to estimate the total number of crashes, injuries, and deaths nationwide that actually involved debris.

Because key changes to variables GES needed for this study were implemented in 2011, and 2014 was the most recent year of FARS & GES data available at the time of the study, FARS & GES data from years 2011 – 2014 were used to estimate the number of debris-related crashes, injuries, and deaths. NASS CDS data from years 2010 was also included to increase the number of cases available for in-depth analysis.

A crash was considered to have been debris-related if it involved:

1. A vehicle that struck or was struck by an object that fell from another vehicle.

2. A vehicle that struck a non-fixed object in the travel lane of the roadway.

3. A vehicle that attempted to avoid a non-fixed object in the travel lane of the roadway and subsequently crashed.

These are referred to hereafter as *Type 1*, *Type 2*, and *Type 3* crashes, respectively.

Type 1 crashes included crashes in which vehicles parts (e.g., tires), cargo, or a trailer became detached and fell from one vehicle and struck or were struck by another vehicle. A crash was not considered to have been debris-related if the debris involved in the crash was directly attributable to a previous event in the same crash or a recent previous crash; if a tree or other roadside object that was usually fixed fell onto a vehicle; or if the objects involved in the crash were located outside of the travel lanes of the roadway or in a work zone.

NASS CDS

Data from NASS CDS were used to investigate and confirm the involvement of debris in crashes identified as possible debris-related crashes through a query of a coded crash database. NASS CDS data from years 2010 – 2014 included records of 18,996 sampled crashes.

Possible debris-related crashes in NASS CDS were identified by examination of variables reflecting the sequence of events in the crash, object contacted, pre-impact location, and initial pre-crash critical event. Specifically, crashes were classified as possible debris-related crashes if the crash sequence of events and object contacted variables indicated that the first object contacted in the crash was an object that fell from a motor vehicle in transport or other non-fixed object and the pre-impact location was on the roadway, or if the pre-crash critical event was a non-fixed object in the road. A crash was not considered to have been debris-related if the event that would have otherwise led to classification as a debris-related crash (impact with a non-fixed object or attempt to avoid a non-fixed object) occurred subsequent to a collision or non-collision crash event (e.g., rollover), occurred subsequent to a road departure event, or occurred off of the roadway or in a work zone.

The above-described query yielded 132 records of possible debris-related crashes. For those 132 crashes, the narrative portion of the crash report and in some cases scene diagrams[1] were reviewed manually to determine whether or not each crash met the study criteria for classification as a debris-related crash.

Crashes were stratified into the three categories of debris-related crashes defined previously (Type 1, Type 2, Type 3), and the proportion of possible debris-related crashes confirmed to have involved debris was calculated for each stratum (Table 1). In some cases, the crash report narrative and diagram suggested that a crash should have been placed in a different stratum; however, these crashes were left in the stratum assigned in the original database query, because the purpose of this step of the analysis was to determine the proportion of possible debris-related crashes of each type—as identified by information available in FARS and GES as well as in NASS CDS—that were confirmed to have involved debris.

The proportions of possible debris-related crashes in NASS CDS that were confirmed debris-related were then used to adjust data from FARS and GES, to estimate the number of actual debris-related crashes from among the possible debris-related crashes identified

[1] Crash narratives, diagrams, and other data are available online at www.nhtsa.gov/NASS.

through queries of the FARS and GES databases. Proportions were calculated with cases weighted to account for the stratified sample design of NASS CDS.

Narratives were also used to gain insight into whether the debris originated from a vehicle or from other sources. Debris was coded as vehicle-related if it was a vehicle part, if the narrative stated that the item fell from a vehicle, or if the totality of circumstances strongly suggested that the debris must have originated from a vehicle (e.g., a garbage can in close proximity to a residence or a business could have been placed there or blown by wind from a nearby yard and thus would not have been assumed to have fallen from a vehicle; however, a garbage can lying in the travel lane of a limited-access highway far from any residences or businesses would have been assumed to have fallen from a vehicle). The proportion of confirmed debris-related crashes that involved vehicle-related debris was calculated for each crash type, to compare results to those of the previous AAA Foundation study.

GES and FARS

Data from GES and FARS were used to estimate the total number of police-reported crashes and the numbers of people injured and killed in crashes that involved debris. GES data from years 2011 – 2014 included records of 204,587 sampled police-reported crashes; FARS data from years 2011 – 2014 included records of all 121,065 fatal crashes that occurred in the US during the study period.

Possible debris-related crashes in GES and FARS were identified by examining variables reflecting vehicles' pre-impact location, pre-crash avoidance maneuver, and crash sequence of events. Crashes were classified as possible debris-related crashes if the crash sequence of events and object contacted variables indicated that the first object contacted in the crash was an object that fell from a motor vehicle in transport or other non-fixed object and the pre-impact location was on the roadway, or if the driver was coded as having made a pre-crash avoidance maneuver to attempt to avoid an object on the roadway. FARS contained additional relevant data in variables indicating driver-related contributing factors (swerving to avoid an object in the road) and crash-related contributing factors (scene of previous crash nearby). A crash was not considered to have been debris-related if the event that would have otherwise led to classification as a debris-related crash (impact with a non-fixed object or attempt to avoid a non-fixed object) occurred subsequent to a collision or non-collision crash event (e.g., rollover), occurred subsequent to a road departure event, occurred off of the roadway or in a work zone, or (in FARS only) data indicated that a previous crash scene was nearby.

Unlike in NASS CDS, crash narratives and diagrams were not available for crashes in the GES & FARS databases. To estimate the proportion of possible debris-related crashes in GES & FARS that actually involved debris, possible debris-related crashes in these databases were stratified into the same three strata as were the NASS CDS crashes and were then multiplied by the fraction of possible debris-related crashes in each stratum in NASS CDS that was confirmed as debris-related (from Table 1).

Cases in GES were weighted to project the GES sample onto the total population of police-reported crashes nationwide. Standard errors and 95% confidence intervals were calculated using the first-order delta method to account for the stratified sample design of GES,

random variability in the number of fatal crashes, and the sampling error in the proportion of possible debris-related crashes that actually involved debris as estimated from NASS CDS.

Results

Review of Possible Debris-Related Cases in NASS CDS

The query of the NASS CDS database yielded records of 132 possible debris-related crashes in the NASS CDS sample that occurred in years 2010 – 2014. Manual review of crash narratives and diagrams confirmed that 92 met the study criteria for debris-related crashes (Table 1).

Examples of possible debris-related crashes determined not to have met the study criteria for debris-related crashes included crashes in which the debris was attributable to a previous crash or previous event in the same crash, crashes that occurred in work zones, crashes in which a tree, pole, or other fixed roadside object fell onto a vehicle, and crashes in which the narrative and diagram contained no indication that any debris or other non-fixed object played any role in the crash. The characteristics of crashes confirmed to have been debris-related, as well as those possible debris-related crashes found not to have met the study criteria, are summarized in Table A1 (in Appendix).

Debris was vehicle-related in 36% of Type 2 crashes and 94% of Type 3 crashes that were confirmed debris-related (derived from weighted analysis of data in Table A1, in Appendix); debris was vehicle-related by definition in all Type 1 crashes that were confirmed debris-related. Vehicle-related debris involved in crashes mainly consisted of vehicle parts such as wheels, tires, or rarely other parts that became detached from one vehicle and struck or were struck by another (Table A1, in Appendix). Several crashes also involved vehicle cargo such as furniture (e.g., a sofa) or appliances (e.g., a refrigerator) that fell onto the road and were struck by other vehicles. Another common crash scenario involved a trailer becoming detached from the vehicle that was towing it and striking another vehicle. Non-vehicle-related sources of debris mainly consisted of fallen trees, branches, or limbs. Rocks and boulders were prevalent sources of debris in one specific jurisdiction in the NASS CDS sample, but were not found frequently elsewhere. Several crashes involved debris or objects of unspecified origin (e.g., crash report narrative indicated that driver "swerved to avoid debris in the road"), debris in some such crashes may have been vehicle-related but was not counted as such.

Table 1. Possible and Confirmed Debris-Related Crashes in a Sample of Police-Reported Crashes in Which a Passenger Vehicle was Towed Due to Damage, United States, 2010 – 2014.

	Possible Debris-Related[a]	Confirmed Debris-Related[b]
Crash type	N	Unweighted N (Weighted %)
Type 1:Vehicle struck or struck by object that fell from other vehicle	35	33 (97.3%)
Type 2: Vehicle struck non-fixed object on roadway	55	37 (75.0%)
Type 3: Attempted to avoid non-fixed object on roadway	42	22 (81.1%)
Total	132	92 (87.4%)

Data: National Automotive Sampling System Crashworthiness Data System (National Highway Traffic Safety Administration).
a. Possible debris-related crashes were identified on the basis of crash sequence of events, object contacted, pre-impact location, and initial pre-crash critical event.
b. Confirmed debris-related crashes are possible debris-related crashes in which crash narrative or diagram confirmed that crash met study criteria for a debris-related crash.

Estimating Total Number of Debris-Related Crashes, Injuries, and Deaths

The query of the GES database yielded records of 1,902 possible debris-related crashes, which were weighted to represent an estimated 243,413 police-reported crashes in the United States in years 2011 – 2014. Those crashes resulted in injuries to an estimated 33,003 people. The query of the FARS database yielded records of 576 fatal crashes which resulted in 616 deaths nationwide over the study period.

Table 2 shows the estimated number of possible debris-related crashes, injuries, and deaths each year in each crash type, as well as the estimated total numbers of debris-related crashes, injuries, and deaths estimated by multiplying the numbers of possible debris-related crashes in each category by the proportions of possible debris-related crashes that were confirmed debris-related in each corresponding category in NASS CDS. Results suggest that approximately 50,658 police-reported crashes annually in years 2011 – 2014 involved road debris, and those crashes resulted in approximately 9,805 injuries and 125 deaths annually.

Crashes in which road debris was indicated as a pre-crash critical event or in which the driver attempted to avoid road debris, while less prevalent than crashes in which a vehicle struck or was struck by debris, were more likely to result in injuries or fatalities when they occurred; every 1,000 of these crashes resulted in an estimated 426 injuries and 5.9 deaths. In contrast, crashes in which a vehicle struck or was struck by an object that fell from another vehicle resulted in 163 injuries and 1.4 deaths per 1,000 crashes, and crashes in which a vehicle struck a non-fixed object in the travel lane resulted in 141 injuries and 2.2

deaths per 1,000 crashes (derived from data shown in Table 2). This is likely due to other harmful events that occurred subsequent to a driver maneuvering to attempt to avoid debris on the road – frequent crash scenarios resulting in injuries included rollovers and crashes with trees, guardrails, concrete barriers, or another vehicle subsequent to the driver's initial attempt to avoid debris in the road.

Characteristics of Debris-Related Crashes

Debris-related crashes were over 4 times as likely as non-debris-related crashes to occur on Interstate highways (33% vs. 8%; Table 3). Atmospheric conditions did not differ meaningfully between debris-related crashes and non-debris-related crashes; the prevalence of adverse weather conditions was similar in both types of crashes. Debris-related crashes were slightly more likely than non-debris-related crashes to occur between the hours of 9 PM and 5:59 AM. Debris-related crashes were more likely than non-debris-related crashes to result in property damage only; debris-related crashes were roughly half as likely as non-debris-related crashes to result in injury or death.

Drivers involved in debris-related events in debris-related crashes were slightly less likely to be under age 20 and slightly more likely to be aged 30-49 compared with drivers involved in non-debris-related crashes. Drivers involved in debris-related events in debris-related crashes (i.e., struck or were struck by debris) were 20% more likely to be men than were drivers involved in non-debris-related crashes (67% vs. 56%).

Discussion

This study estimated that road debris played a role in more than 50,000 police-reported crashes which result in over 9,800 injuries and approximately 125 deaths in the United States each year from 2011 through 2014. These results suggest that debris is a factor in a somewhat larger number of crashes than the previous AAA Foundation study by Forbes & Robinson (2004), which estimated that approximately 25,000 crashes and 81-90 deaths involved road debris in the United States in 2001. However, the definitions of road debris varied somewhat between the previous study and the current study. The previous study by Forbes & Robinson sought to estimate the number of crashes that involved *vehicle-related* road debris, defined in that study specifically as fallen cargo or vehicle parts that had been unintentionally discharged onto the roadway, a matter that is highly relevant to policies regarding vehicle maintenance and load securement.

The current study also included debris not specifically attributable to vehicular sources, such as fallen trees that had not been cleared from the roadway. To compare the results of the current study to those of the previous study, an additional analysis was performed to estimate the proportion of all crashes in this study in which the debris was vehicle-related. Applying the proportions of confirmed debris-related crashes of each type in NASS CDS in which the debris was found to have been vehicle-related (100% of Type 1, 36.4% of Type 2, and 94.2% of Type 3) to the total number of crashes of each type, results suggest that approximately 35,000 crashes, 7,500 injuries, and 89 deaths annually involved vehicle-related road debris, very similar to the 25,000 crashes and 81-90 deaths estimated by Forbes & Robinson.

The current study deliberately took a broader view of the issue of road debris, in contrast to the previous study by Forbes & Robinson, as debris from any source including but not limited to vehicles can pose a significant safety hazard. Nonetheless, examination of NASS CDS cases suggested that approximately two-thirds of debris-related crashes involved debris that was vehicular in origin. Vehicle-related debris most frequently observed in confirmed debris-related NASS CDS cases reviewed in the present study included vehicle parts (e.g., wheels, tires, driveshaft, hood) that became detached from vehicles, trailers that separated from the vehicles towing them, and various cargo including furniture, appliances, and other unspecified items that fell from vehicles and either struck another vehicle or remained on the roadway and contributed to a subsequent crash. Non-vehicle-related debris most often consisted of large rocks or boulders as well as trees that fell onto the roadway and remained on the roadway until ultimately being struck by a vehicle.

Debris-related crashes were much more likely than non-debris-related crashes to occur on Interstate highways. This is likely related to the high speeds associated with driving on Interstate highways. High speeds likely increase the risk of cargo falling from vehicles and parts such as wheels or tires separating from vehicles, and also decrease other drivers' time available to react to hazards created by airborne debris or debris lying on the road.

Compared with drivers involved in non-debris-related crashes, drivers who crashed into or were struck by debris were substantially more likely to be men. The reasons for this are unclear. While the proportion of men's crashes that occurred on Interstate highways was slightly greater than the corresponding proportion of women's crashes that occurred on

Interstate highways (10% vs 8%), the extent to which men were over-represented in debris-related crashes was actually greater on other road types than on Interstates. Other research has shown that men were more likely than women to speed (AAA Foundation, 2016a, unpublished analysis by author) and to tailgate other drivers on purpose (AAA Foundation, 2016b), both of which would decrease a driver's opportunity to react to a situation in which debris falls from another vehicle or is encountered on the road. However, it is also possible that the over-representation of men in debris-related crashes is related to other differences in driving exposure that were not examined in the current study.

Limitations

The general approach of this study was to identify possible debris-related crashes based on data available in three national crash databases, review detailed narrative descriptions and scene diagrams from possible debris-related crashes in one database (NASS CDS) to estimate the proportion of possible debris-related crashes that actually involved debris, and then apply that proportion to the total number of possible debris-related crashes in two other databases (GES & FARS) to estimate the proportion of those crashes that actually involved debris. Crashes in NASS CDS are from 24 primary sampling units (PSUs, which are cities, counties, or groups of counties) nationwide, and crashes in GES are drawn from 60 PSUs (data in FARS are from all jurisdictions), which were weighted to project these samples onto all crashes nationwide. The proportion of possible debris-related crashes that were confirmed debris-related varied significantly across the PSUs in NASS CDS (P=0.0482 for test of homogeneity of proportion across all PSUs); further investigation revealed that the heterogeneity across PSUs in the proportion confirmed debris-related crashes occurred only in crashes classified in this study as Type 2, i.e., crashes in which a vehicle struck a non-fixed object in the roadway, proportions confirmed debris-related were similar across PSUs for other crash types. While the confidence intervals presented for the final estimates explicitly accounted for the designs of the NASS CDS & GES, it is possible that inclusion of different jurisdictions might have yielded different results.

In addition, the inclusion criteria for the three databases examined differ. NASS CDS only includes crashes that involve at least one car, pickup truck, van, minivan, or SUV that was towed due to damage, GES is a representative sample of all police-reported crashes nationwide, and FARS includes records of every crash that results in a death within 30 days. It is possible that the prevalence of crashes involving debris differs between crashes that result in damage so minor that no vehicle is towed (the majority of all crashes), crashes in which a vehicle is towed, and in fatal crashes. However, results would remain unbiased unless the proportion of possible debris-related crashes that actually involved debris differed by crash severity within each crash type examined. An attempt was made to investigate whether this was the case in the NASS CDS cases examined, however, there were too few cases for analysis by both crash type and crash severity (e.g., only 8 of the 132 possible debris-related crashes examined in the NASS CDS data were fatal).

Similarly, descriptive statistics regarding the characteristics of debris-related crashes are valid if the probability that a possible-debris-related crash was actually debris-related was independent of the characteristics examined (road type, time of day, atmospheric conditions, and driver age and sex) within each stratum of crash type. However, bias could

be present if the probability of debris-involvement varied in relation to these characteristics within each stratum of possible-debris-related crash type.

Finally, the specific type of debris involved in crashes could only be investigated in crashes in the NASS CDS database, for which narrative descriptions and scene diagrams were available. Only 92 actual cases (before weighting) involving debris were identified in the years of data examined; thus, while vehicle parts and cargo were the predominant sources of debris in the crashes examined, firm conclusions cannot be drawn regarding the types and sources of debris involved in all debris-related crashes nationwide.

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Tables

Table 2. Possible and Estimated Total Debris-Related Crashes, Injuries, and Deaths, United States, 2011 – 2014.

	Possible Debris-Related Crashes				Estimated Total Debris-Related Crashes				
	Type 1	Type 2	Type 3	Total	Type 1	Type 2	Type 3	Total (95% Confidence Interval)	
				Number of Police-Reported Crashes					
2011	15,579	31,365	8,049	54,993	15,161	23,522	6,530	45,213	(35,784 – 54,642)
2012	20,117	33,954	8,654	62,725	19,577	25,464	7,021	52,062	(41,547 – 62,577)
2013	15,156	29,168	10,229	54,553	14,749	21,875	8,299	44,922	(34,250 – 55,594)
2014	28,494	30,905	11,743	71,142	27,729	23,177	9,527	60,433	(50,060 – 70,807)
Total	79,346	125,392	38,676	243,413	77,216	94,038	31,377	202,631	(168,262 – 237,000)
Average	19,837	31,348	9,669	60,853	19,304	23,509	7,844	50,658	(42,066 – 59,250)
				Number of Injuries					
2011	1,689	6,222	4,105	12,016	1,644	4,666	3,330	9,640	(6,025 – 13,256)
2012	2,520	3,419	4,520	10,459	2,452	2,564	3,667	8,683	(6,398 – 10,969)
2013	2,163	4,148	4,215	10,526	2,105	3,111	3,420	8,635	(5,345 – 11,926)
2014	6,543	3,927	3,635	14,105	6,367	2,945	2,949	12,261	(9,194 – 15,329)
Total	12,915	17,716	16,475	47,106	12,568	13,286	13,366	39,220	(30,857 – 47,583)
Average	3,229	4,429	4,119	11,777	3,142	3,322	3,341	9,805	(7,714 – 11,896)
				Number of Deaths					
2011	38	90	56	184	37	67	45	150	(120 – 180)
2012	20	66	59	145	19	49	48	117	(90 – 143)
2013	21	57	60	138	20	43	49	112	(86 – 137)
2014	31	64	54	149	30	48	44	122	(96 – 148)
Total	110	277	229	616	107	208	186	501	(417 – 584)
Average	28	69	57	154	27	52	47	125	(104 – 146)

Data: General Estimates System & Fatality Analysis Reporting System (National Highway Traffic Safety Administration).
Type 1: First crash event = vehicle struck or struck by object that fell from other vehicle.
Type 2: First crash event = vehicle struck non-fixed object on the roadway.
Type 3: Pre-crash maneuver = attempted to avoid non-fixed object on the roadway.
a. Possible debris-related crashes were identified on the basis of crash sequence of events, object contacted, pre-impact location, and initial pre-crash critical event.
b. Estimated total debris-related crashes were derived by adjusting number of possible debris-related crashes using ratios of confirmed debris-related crashes to possible debris-related crashes in National Automotive Sampling System Crashworthiness Data System, 2010 – 2014 (National Highway Traffic Safety Administration) as multipliers. Multipliers were 0.973 for crash Type 1, 0.750 for crash Type 2, and 0.811 for crash Type 3.

Table 3. Characteristics of Debris-Related Crashes vs. Non-Debris-Related Crashes, United States, 2011 – 2014.

	Crashes	
	Debris-Related	Non-Debris-Related
	Weighted Column %	
Road type		
Interstate highway	33.4	8.4
Other road type	66.6	91.6
Atmospheric conditions		
Rain	10.9	9.5
Sleet/hail/freezing rain	0.4	0.7
Snow	1.2	3.4
Fog	0.6	0.4
Other conditions	2.3	0.2
No adverse conditions	85.2	86.1
Time of day		
6:00 AM - 9:59 AM	14.9	17.3
10:00AM - 3:59 PM	35.6	35.3
4:00PM - 8:59 PM	29.5	31.7
9:00 PM - 5:59 AM	20.1	15.7
Maximum injury severity in crash		
Property damage (no injury)	85.6	71.2
Injured	14.2	28.3
Killed	0.2	0.5
	Drivers	
	Debris-Related*	Non-Debris-Related
Age (years)		
<20	5.7	10.1
20-34	34.1	35.6
35-49	29.0	25.3
50-69	26.5	23.3
70+	4.7	5.7
Sex		
Male	67.4	55.9
Female	32.5	44.1

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

* Drivers of vehicles involved in a debris-related event (struck debris, struck by debris, or crashed after attempting to avoid debris) in a debris-related crash; excludes other drivers involved in same crash (e.g., driver of vehicle struck by a different vehicle that had swerved to avoid debris).

Appendix

Table A1. Abbreviated Descriptions of Crashes Confirmed Debris-Related vs. Not Debris-Related, Based on Manual Review of Crash Report Narratives from Possible-Debris Related Crashes (N=132) in a Sample of Police-Reported Crashes in Which a Passenger Vehicle was Towed Due to Damage, United States, 2010 – 2014.

Crash Type	Confirmed Debris-Related	Not Debris-Related
Type 1: A vehicle struck or was struck by an object that fell from another vehicle.	V1 was struck by a wheel/tire that had become detached from another vehicle (n=9)	V1 struck a semi trailer that was extended laterally across the roadway while unloading.
	Wheel became detached from V1 and struck V2, V3, V4, and V5.	V1 was towing another vehicle, began to rotate, towed vehicle disconnected and struck V1.
	Tire became detached from trailer of V1 and struck V2.	
	V1 contacted debris from blown tire of V2, then V1 departed roadway, struck V2, and rolled over.	
	The hood of a vehicle became detached, went airborne, and struck V1.	
	V1 was struck by a trailer that became detached from another vehicle. (n=4)	
	V1 was struck by a trailer hitch that became detached from other vehicle and was bouncing on the roadway.	
	V1 struck a boat trailer that had become detached from another vehicle and had come to rest in the travel lane.	
	V1 struck a sofa that was lying in the roadway (n=2)	
	V1 swerved to avoid a sofa that fell from another vehicle, V1 struck the median barrier, V2 struck sofa	
	V1 was hauling a large payloader; payloader impacted railroad overpass, became dislodged, and fell on top of V2.	
	V1 struck a chair on the roadway, then departed road, struck guardrail	
	V1 appied brakes to avoid a swing set lying in the roadway, V1 struck swing set, V2 rear-ended V1, V3 rear-ended V2	
	V1 struck a bicycle lying on the road, departed lane, and struck V2 in adjacent lane, V2 departed roadway and rolled over	
	V1 struck a barrel that had fallen from a farm trailer.	
	V1 was struck by a large vehicle component that fell from a tow truck; V1 veered off the road and struck a guardrail.	
	V1 struck a vehicle jack that had fallen from another vehicle.	
	V1 and V2 struck a tire that had fallen from the bed of a pickup truck.	
	An object fell from a tractor/trailer and struck V1.	
	V1 struck debris dropped from vehicle in front of it, then struck concrete barrier.	
	V1 struck an object that fell from another vehicle travelling in the opposite direction.	
	V1 struck a rock/boulder on the roadway (n=14)	Tree/branches/limbs fell onto V1 (n=5)
	V1 struck a fallen tree/branches/limbs on the roadway (n=5)	A pole fell from the side of the road onto V1.
	V1 struck rocks and branches in the roadway.	V2 struck construction barrels (work zone) and then struck V1.

Type 2: A vehicle struck a non-fixed object in the travel lane of the roadway.	Wheel became detached from V1 and struck V2 (n=2)	V1 struck portable warning sign and construction materials in work zone.
	V1 struck piece of tire on roadway, rolled over	V1 contacted a metal plate in a construction zone.
	V1 struck a tractor/trailer tire lying on the roadway.	V1 drove through barricade into work zone, struck pile of concrete in work zone.
	V1 contacted a piece of tire tread in the roadway	V1 fell into a hole in a construction zone.
	V1 struck a tire rim that was lying in the roadway.	V1 struck a construction barrel.
	Driveshaft became detached from V1, V1 ran over driveshaft, driveshaft became airborne, struck V2, V3, V4, and V5.	V1 departed the roadway and struck a construction sign.
	V1 struck a metal ramp that had fallen from a trailer and was lying on the roadway.	V1 struck portable traffic barrier behind medium/heavy truck, then struck the rear of the truck.
	V1 struck a steel beam lying on the roadway	V1 drove through activated railroad gate, gate struck V1, V1 continued onto tracks and was struck by train.
	V1 ran over large piece of metal debris, rotated, and contacted concrete barrier.	
	V1 contacted a pole that was lying in the roadway.	V1 struck concrete median barrier moved into its lane due to prior crash.
	V1 struck large plastic barrel, departed roadway, rolled over, and struck pole.	Tire tread of V1 separated from tire causing V1 to depart the road.
	Unknown object struck and entered windshield of V1, driver lost control and struck guardrail	V1 struck a dead animal that was lying in the roadway.
	V1 ran over an unknown object in the roadway, damaging undercarriage of vehicle	
	V1 struck unspecified debris on the roadway.	
	V1 swerved to avoid debris in travel lane, contacted other debris, lost control, and struck V2.	
	V1 struck unknown non-fixed object, departed road, contacted concrete barrier.	
Type 3: A vehicle attempted to avoid a non-fixed object in the travel lane of the roadway and subsequently crashed.	V1 attempted to avoid a refrigerator in the roadway, struck concrete median barrier.	Tree fell into roadway and V1 contacted the tree.
	V1 attempted to avoid an object in the roadway, contacted concrete bridge rail.	V1 departed the roadway, drove down an embankment, and struck a tree.
	V1 avoided a construction barrel that was lying in the roadway; departed roadway; struck barrier wall.	V1 steered to avoid prior accident in the roadway, struck concrete barrier.
	V1 struck boxes that were lying in the roadway; departed the roadway, struck concrete barrier, rebounded, and was struck by V2.	V1 struck a pothole with its undercarriage.
	V1 swerved to avoid an object, crossed over 3 lanes, struck concrete barrier, rolled over. V2 stopped to avoid V1 and was rear-ended by V3.	V1 drove onto median and struck metal pole; V2 drove over debris from V1 crash into pole.
	V1 struck tree lying on roadway (n=2)	V1 departed roadway, struck median wall, then struck V2 (no indication of debris).
	V1 swerved to avoid object in roadway, struck telephone pole	V1 was struck by a train (no indication of debris) (n=2)
	V1 swerved to avoid object in roadway, rolled over	V1 struck a railroad crossing gate, continued through the gate, and was struck by a train.
	V1 swerved to avoid object in roadway, struck concrete wall	V1 departed roadway, struck two trees, and rolled over (no indication of debris).
	V1 struck fallen tree/limb lying on roadway	V1 rolled over; V2 struck debris from V1.
	V1 swerved to avoid garbage can in roadway, crossed 3 lanes, struck guardrail	V1 struck V2; V1 rolled over (no indication of debris).
	V1 swerved to avoid garbage can in roadway, departed roadway, rolled over	V1 struck parked vehicle and rolled over (no indication of debris).
	V1 swerved to avoid a pole and sign that fell from another vehicle, departed roadway, contacted concrete barrier	V1 entered a railroad crossing and struck a train (no indication of debris).
	V1 swerved to avoid an object that fell from another vehicle, departed roadway, struck a sign post.	V1 struck a pothole and a wheel became detached.
	Driver swerved to avoid fallen trees lying in roadway, departed roadway, traveled down an embankment and struck several trees.	V1 contacted a gate used to close the roadway.
	V1 swerved to avoid debris in travel lane, lost control, struck barrier.	Ball rolled into roadway, V2 braked, V1 rear-ended V2.

	V1 swerved to avoid an unknown object in the roadway, struck a culvert, and rolled over.	V1 contacted a large tree branch that fell directly in front of it during a storm, departed the roadway, and contacted a utility pole.
	V1 struck a rock/boulder on the roadway	V1 struck V2 and V3, then caught fire (no indication of debris)
	V2 slowed because of debris in roadway, V1 rear-ended V2.	Driver of V1 steered to the left, departed roadway, struck concrete median barrier, departed right side of roadway, struck guardrail (no indication of debris).
	V1 swerved to avoid a cooler in the roadway, V2 struck left side of V1.	
	V2 and V3 both maneuvered to avoid debris on the roadway, departed the roadway, re-entered the roadway. V2 struck V3 and also struck V1.	
	V1 steered to avoid tire tread that separated from tractor trailer in front of V1; V1 traveled onto median and struck several shrubs, small trees, and rocks.	