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FOUNDATION FOR TRAFFIC SAFETY

The Safety Impact of Road Debris: Updated Prevalences of Crashes, Injuries, and Deaths in the United States, 2018–2023

Road debris is a traffic safety concern for all road users. While there is no singular definition of road debris, it generally refers to any object on a roadway that does not belong in the driving environment. Common examples include unsecured cargo that fell from a vehicle or parts that separated from a vehicle. Road debris can contribute to crashes in three main ways: (a) one vehicle may be struck by debris that fell from or was set in motion by another vehicle; (b) a vehicle may strike debris on the roadway; or (c) a driver may crash into another road user or object after trying to avoid debris in the road. The current study seeks to quantify the contribution of road debris to motor vehicle crashes, injuries, and deaths in the United States using the most recent available data. The current study performed an in-depth analysis of police crash report narratives and diagrams from crashes that occurred in the state of Michigan in years 2018 through 2023 to examine the role of road debris in crashes with general characteristics suggestive of possible debris involvement, and then used those results in conjunction with national-level crash data to estimate how many crashes, injuries, and deaths nationwide were attributable to road debris. Results suggest that road debris was a factor in an average of 53,000 police-reported crashes resulting in 5,467 injuries and 72 deaths in each year from 2018 through 2023. This Research Brief discusses the role of road debris in traffic crashes, the nature and sources of the debris, and actions that both transportation professionals and the general public can take to reduce the risk of crashes involving road debris.

METHODS

The primary objective of the current study was to estimate the numbers of crashes, injuries, and deaths in the United States that involve road debris. A secondary objective was to describe the characteristics of road debris, and identify its sources, in order to provide insight into potential countermeasures.

The sources of nationwide crash data used to quantify crashes, injuries, and deaths lack sufficient detail to ascertain whether a crash involved road debris. Thus, the general approach to this study was as follows:

1. Specify characteristics of crashes suggestive of possible debris involvement
2. Conduct an in-depth review of crash reports from a sample of crashes with characteristics suggestive of possible debris involvement, to ascertain whether each crash actually involved debris
3. Quantify crashes with characteristics suggestive of possible debris involvement nationwide
4. Estimate the numbers of debris-related crashes, injuries, and deaths nationwide in years 2018 through 2023 by using the results of (2) and (3)

In-depth analysis of crash reports was based on police crash reports from the state of Michigan,

which to the best of the research team's knowledge is the only state whose full police crash reports, including narratives and diagrams, are made publicly available. Police reports (with all personal identifying information redacted) were retrieved using the Michigan Traffic Crash Facts (MTCF) Data Query Tool (michigantrafficcrashfacts.org).

Numbers of crashes, injuries, and deaths nationwide with characteristics suggestive of possible debris involvement were estimated using two national crash databases, the Fatality Analysis Reporting System (FARS) and the Crash Report Sampling System (CRSS). Both of these databases are maintained by the National Highway Traffic Safety Administration (NHTSA). FARS includes data on all U.S. crashes that involve a motor vehicle, occur on public roads, and result in the death of a person within 30 days. CRSS includes data on a geographically stratified sample of all police-reported crashes in the United States, regardless of severity. Both FARS and CRSS are available to the public in the form of downloadable databases designed for statistical analysis. The data and additional information are available at cdan.dot.gov/.

Crash Characteristics Suggestive of Debris Involvement

Crash characteristics suggestive of debris involvement were specified based on previous literature and available data. To be usable in the current study, it was necessary for such characteristics to be identifiable in both the Michigan crash data and in the national crash databases. In a previous study, Forbes and Robinson (2004) identified two main road debris crash types: (a) crashes in which debris strikes or is struck by a road user, and (b) crashes in which debris is involved indirectly (e.g., a driver swerves to avoid debris in the road and then crashes into something else). In a follow-up study, Tefft (2016) divided the former into two subtypes: (a) crashes in which the debris was actively falling (i.e., still airborne) or had just fallen as a part of the same chain of events, and (b) crashes in which the debris had already come to rest in the road.

While "debris" is not typically identified as such in coded crash data elements, analogous crash types involving "non-fixed objects" are identifiable in all the databases used in the current study. Thus, for the purpose of the current study, the following three crash types were considered possibly debris-related:

- **Struck/struck by falling object:** A vehicle struck or was struck by a non-fixed object falling from or set in motion by another vehicle.
- **Struck non-fixed object in road:** A vehicle struck a non-fixed object that had come to rest in the roadway.
- **Crashed after avoiding object:** A vehicle avoided a non-fixed object in the roadway and then crashed.

In-Depth Review of Michigan Crash Reports

The MCTF Data Query Tool was used to identify possible debris-related crashes with the characteristics listed above that occurred in years 2018 through 2023. The queries (listed in Table 1) yielded a total of 24,375 crash reports. To reduce the number of reports to a more manageable number, the research team sampled the following for review:

- 100% of fatal (K) crashes
- 100% of suspected serious injury (A) crashes
- 20% of suspected minor injury (B) crashes
- 10% of possible injury (C) crashes
- Approximately 1% of non-injury (O) crashes

Ultimately 901 crash reports were sampled for review.

The research team reviewed the police officer's narrative description of each crash as well as the scene diagram to determine whether or not each crash actually involved debris. A crash was classified as debris-related if the narrative and/or diagram indicated that the crash fell into one

Table 1. Total Number of Possible Debris-Related Crashes Identified in Michigan Crash Data and Number of Crash Reports Reviewed

	Crash Severity Crash Reports Sampled for Review *(Total Number of Crashes)*					
Query	**K**	**A**	**B**	**C**	**O**	**Total**
Sequence of Events 1 = Collision with Non-Fixed Object–Cargo Falling/ Shifting/Set in Motion by a Motor Vehicle	10 *(10)*	31 *(31)*	19 *(99)*	15 *(150)*	33 *(2,961)*	108 *(3,251)*
Sequence of Events 1 = Collision with Non-fixed Object–Other Non-Fixed Object	28 *(29)*	161 *(163)*	100 *(491)*	66 *(655)*	190 *(16,989)*	545 (18,327)
Road Condition = "Debris"[a]	0 *(0)*	17 *(17)*	26 *(26)*	27 *(27)*	38 *(378)*	108 *(448)*
Action Prior to Crash = Driver/Cyclist Action–Avoiding Object	7 *(7)*	53 *(54)*	33 *(162)*	27 *(268)*	20 *(1,858)*	140 *(2,349)*
Total	**45 *(46)***	**262 *(265)***	**178 *(778)***	**135 *(1,100)***	**281 *(22,186)***	**901 *(24,375)***

[a] Crashes identified using this query were sampled at a higher rate due to their low number.

of the three above-described crash types. A crash was not considered debris-related if the debris was directly attributable to a previous event in the same crash or another crash immediately preceding it (e.g., broken glass caused by the crash itself) or if the debris was located outside of the travel lanes or in a work zone. Objects that are ordinarily fixed (e.g., trees, road signs) were not considered debris if they fell directly onto or into the path of a vehicle; however, they were considered debris if they had fallen previously and were at rest in the travel lanes of the road prior to the crash. Dead animals lying in the roadway ("roadkill") were considered debris; live animals and people were not.

The Michigan police crash report narratives were also used to characterize the types and sources of debris involved in crashes.

Quantifying Possible Debris-Related Crashes

The numbers of crashes nationwide with characteristics suggestive of debris involvement were estimated by querying the CRSS and FARS databases to identify the three possible debris-related crash types described previously. These queries differed from those used in the Michigan data due to differences in the database structure and variables; however, they were intended to identify the same crash types as nearly as possible. Queries were based on variables including crash sequence of events, critical event pre-crash, attempted avoidance maneuver, pre-impact location, and driver-related contributing factors. Fatalities in CRSS were excluded to avoid double-counting.

Estimating Numbers of Debris-Related Crashes, Injuries, and Deaths

To estimate the numbers of debris-related crashes, injuries, and deaths nationwide, possible debris-related crashes were grouped by crash type and severity, and the numbers in each group were then multiplied by the

corresponding percentage confirmed to be debris-related in the in-depth review of case reports.

Crash types and severities in which the proportion confirmed to be debris-related did not differ significantly were combined to increase statistical precision. Differences were assessed using a general linear model of debris involvement in relation to crash type, severity, and their interaction, with weights to account for differences in the proportions of crash reports sampled, followed by post hoc pairwise comparisons.

RESULTS

In-Depth Review of Michigan Crash Reports

Table 2 shows confirmed debris-related crashes as a percentage of possible debris-related crashes among the 901 Michigan police crash reports reviewed, by crash type and severity. Across all severities, crashes in which a vehicle struck or was struck by a falling object were the most likely to be confirmed debris-related, followed by those in which a vehicle struck a non-fixed object that had come to rest in the road. Across all crash types, the likelihood of confirmed debris involvement among possible debris-related crashes was negatively related to crash severity (i.e., the likelihood that the crash involved debris was lower in crashes that were more severe).

The percentages shown in Table 2 were then applied to all possible debris-related crashes in the United States to estimate the number of crashes, injuries, and deaths that actually involved road debris. The proportion confirmed to be debris-involved did not differ significantly between fatal and suspected serious injury crashes (P=0.67), thus when estimating the numbers of crashes nationwide that involved debris, fatal and suspected serious injury crashes were combined.

Table 2. Percentage of Crashes Confirmed Debris-Related, by Crash Type and Severity.

Severity	Struck/Struck by Falling Object	Struck Non-Fixed Object in Road	Crashed After Avoiding Object	Total[a]
	% Confirmed Debris-Related (Number of Reports Reviewed)			
K	33.3% (9)	17.9% (28)	71.4% (7)	29.3% (44)
A	28.1% (32)	28.6% (178)	22.6% (53)	27.4% (263)
Total K & A	**29.3% (41)**	**27.1% (206)**	**28.2% (60)**	**27.6% (307)**
B	47.4% (19)	42.0% (126)	21.2% (33)	38.4% (178)
C	60.0% (15)	57.1% (93)	37.0% (27)	52.6% (135)
O	87.9% (33)	72.9% (228)	65.0% (20)	74.2% (281)
Overall Total[a]	**84.6% (108)**	**70.9% (653)**	**57.8% (140)**	**71.5% (901)**

Source: Sample of 901 police reports from possible debris-related crashes reviewed by the research team, State of Michigan, 2018–2023.
[a] Percentages shown in the total row and total column are based on data weighted to reflect differences in the percentage of crash reports reviewed. The research team reviewed 100% of K and A, 20% of B, 10% of C, and ~1% of O crashes.

Table 3. Crashes with Characteristics Suggesting Possible Debris Involvement, by Crash Type and Most Severe Injury in Crash, United States, 2018–2023.

Most Severe Injury in Crash		Struck/Struck by Falling Object	Struck Non-Fixed Object in Road	Crashed After Avoiding Object
K	Crashes	325	422	650
	Deaths	344	451	744
A	Crashes	2,650	2,311	2,143
	Injuries	3,008	2,768	4,351
B	Crashes	7,361	8,219	8,303
	Injuries	9,380	10,188	11,614
C	Crashes	11,868	9,995	9,450
	Injuries	13,493	10,656	12,356
O	Crashes	145,909	185,965	43,902
	Injuries	–	–	–

Quantifying Possible Debris-Related Crashes

The number of possible debris-related crashes in the United States over the study period, as well as the numbers of people injured and killed in those crashes, were estimated from the FARS and CRSS databases and are shown in Table 3. Note that the data in Table 3 do not reflect the final estimates of the actual numbers of debris-related crashes.

Estimating Numbers of Debris-Related Crashes, Injuries, and Deaths

There were an estimated 319,724 police-reported crashes involving road debris nationwide in years 2018 through 2023. These crashes resulted in an estimated 32,802 injuries and 433 deaths in total over the study period. These estimates were derived by multiplying the numbers of possible debris-related crashes (Table 2) by the estimated proportion of all debris-related crashes confirmed to be debris-related in the in-depth review of Michigan crash reports (Table 1). These estimates equate to annual averages of 53,287 crashes, 5,467 injuries, and 72 deaths involving road debris.

The relationship between crash type and severity is notable. While nearly 90% of all debris-related crashes featured a vehicle striking or being struck by a non-fixed object (falling or already at rest in the road), 25% of injuries and 49% of deaths involved a vehicle that crashed after avoiding an object in the road.

Types of Road Debris Involved in Crashes

The in-depth review of Michigan crash reports was also used to categorize the general types of debris involved in crashes. Seven categories were created to summarize similar types of debris involved in crashes. These are shown in Table 5.

The types of debris reported in crash narratives were grouped into categories based on their descriptions: vehicle parts, miscellaneous cargo, tools and building materials, natural debris, road construction materials, miscellaneous other debris, and unknown debris. In the overwhelming majority of cases, debris categorized as vehicle parts consisted of tires, though various other vehicle parts such as wheels and bumpers were also noted. Miscellaneous cargo referred to large

Table 4. Estimated Total Crashes, Injuries, and Deaths Involving Road Debris, United States, 2018–2023.

	Struck/Struck by Falling Object	Struck Non-Fixed Object in Road	Crashed After Avoiding Object	Total
2018–2023 Total				
Deaths	101	122	210	433
Injuries	13,419	11,114	8,269	32,802
Crashes	139,701	145,436	34,586	319,724
Annual Average (95% Confidence Interval)				
Deaths	17 (8–25)	20 (15–25)	35 (21–49)	72 (55–89)
Injuries	2,237 (1,744–2,729)	1,852 (1,614–2,091)	1,378 (1,042–1,715)	5,467 (4,825–6,109)
Crashes	23,284 (19,407–27,160)	24,239 (19,769–28,709)	5,764 (4,944–6,584)	53,287 (47,314–59,260)

items that fell from moving vehicles, including furniture like sofas and mattresses, recreational equipment like kayaks and paddleboards, and items such as barbecue grills. Tools and building materials included items associated with construction work, such as ladders, lumber, pallets, and wheelbarrows. Natural debris consisted of materials from the environment, including trees or branches, dirt, and roadkill. Road construction materials included substances commonly used in roadwork, such as concrete, gravel, and rocks. Miscellaneous other debris referred to objects that did not clearly fall into one of the other categories and were often

Table 5. Types of Debris Involved in Sample of 426 Michigan Crash Reports.

Type of Debris	Examples	Number of Police Reports	Weighted % of Crashes
Vehicle parts	Tires, wheels, bumpers	116	28.8%
Misc. cargo	Furniture (sofa, mattress, chair), kayak, paddleboard, BBQ grill	67	18.7%
Tools & building materials	Ladder, lumber, pallet, wheelbarrow	35	8.8%
Natural	Trees/branches, pile of dirt, roadkill	55	7.7%
Road construction materials	Concrete, gravel, rocks	50	6.9%
Misc. other	"Large object," "large piece of metal," "metal debris"	29	8.5%
Unknown	N/A (reported as unknown)	74	20.6%

described as "large object," "large piece of metal," or "metal debris." Unknown debris was typically listed as such in crash reports, with narratives often stating, "unknown object," "unknown debris," or "roadway obstruction."

DISCUSSION

This research sought to estimate the number of crashes, injuries, and deaths in the United States that involve road debris, and to describe the characteristics and sources of debris to inform potential countermeasures. However, no single source of national-level data provides sufficient detail to ascertain whether a crash involved road debris. Thus, the current study first performed an in-depth review of police crash reports from the State of Michigan, to determine the percentage of crashes actually involving debris among those whose general characteristics were suggestive of possible debris involvement. Crashes with similar characteristics were then identified in national-level crash databases, and these percentages were then used to estimate the number of crashes, injuries, and deaths likely to have involved road debris nationwide. Results suggest that road debris contributed to an average of approximately 53,000 crashes, 5,500 injuries, and 72 deaths each year from 2018 through 2023. While the vast majority of these crashes involved a vehicle striking or being struck by debris, approximately one in four injuries and nearly half of all deaths occurred when drivers crashed after having first performed some sort of evasive action (in most cases swerving) to avoid debris in the road.

A previous study by the AAA Foundation for Traffic Safety estimated a similar number of crashes, but slightly higher numbers of injuries and deaths involving road debris in years 2011 through 2014 (Tefft, 2016). However, the results of the current study should not be compared to those previous results due to differences in methodology. While both the current and previous studies used a similar conceptual approach, the current study benefitted from the availability of all police crash reports from the State of Michigan, complete with investigating officers' narrative descriptions and diagrams of the crashes. To estimate the percentage of actual road debris involvement among the subset of crashes with characteristics suggestive of possible debris involvement, the research team performed in-depth review of 901 crash reports, including 44 reports from fatal crashes and 263 from crashes that resulted in suspected serious injuries. The previous study, in contrast, examined only 132 reports from a national sample of in-depth crash investigations. While the crash reports reviewed in the previous study provided rich, detailed information and were drawn from a nationally representative sample, the number of severe crashes was too small for meaningful analysis, thus crashes of all severities were grouped together. With the current study's larger sample, it was possible to examine debris involvement in relation to crash severity, and it was clear that that debris was relatively more prevalent in lower-severity crashes than in higher-severity crashes with similar characteristics. This is why the current study estimates lower numbers of injuries and deaths in debris-related crashes compared with the previous study, despite very similar estimates of the total number of debris-related crashes overall.

The safety impact of road debris is an understudied issue. While the AAA Foundation for Traffic Safety has previously studied this road safety topic (Forbes and Robinson, 2004; Tefft, 2016), literature on the topic is sparse. A 2012 report by the U.S. Government Accountability Office (GAO) revealed critical challenges in national data collection as well as in enforcement of laws intended to prevent road debris. The report noted that data from NHTSA suggested

that approximately 440 deaths in 2010 involved road debris; however, it emphasized that federal and state data systems lacked the ability to distinguish debris attributable to unsecured loads versus natural causes (GAO, 2012). Another study examined crashes with objects in the roadway using in-vehicle video data collected in a large-scale naturalistic driving study (Hao et al., 2020). While the study did not focus on road debris per se and reports results pertaining to crashes and near-crashes with roadway and roadside objects and obstacles more generally, it illustrates the potential of in-vehicle video as a source of data to provide additional insights into crashes involving road debris in the future.

Recent studies and reports have highlighted both technological advances and policy gaps in addressing roadway debris hazards. Ramaiah and Kundu (2022) developed a stereo vision–based detection system for vehicles that accurately identified small static road debris with 90% accuracy. Such work could potentially help future generations of Advanced Driver Assistance Systems to avoid becoming involved in debris-related crashes. Concas and Kamrani (2019) examined kinematic information shared between connected vehicles and found that swerving behavior could be detected with very high accuracy, which potentially be used to alert road authorities and/or upstream drivers of possible debris in the road. Debris clearance strategies and mitigation of risks to workers performing debris removal operations have been examined as well (Gong et al., 2024; Strong & Vasques, 2014).

Most recent research focuses on debris detection and mitigation strategies, but often does not specify the specific types of debris or their origin. The current study's examination of crash narratives made it possible to document specific types of road debris, as it was often specified in the police narrative. This provides insight into the types of items that are repeatedly seen on roadways and contribute to crashes. The specific origin of road debris was rarely specified on crash reports—the exceptions were cases in which victim or witness statements corroborated the origin. It could reasonably be inferred in some cases (e.g., a sofa in the travel lanes of a highway presumably fell from a vehicle), but not in others (e.g., a tree branch in the travel lane could have fallen from a nearby tree or from a landscaping contractor's vehicle).

The majority of crashes examined in the current study involved debris that clearly or likely originated from another vehicle. The single most common category of debris was vehicle parts that had separated from another vehicle on the road. There were 68 occurrences of crashes with tires in the sample of Michigan data reviewed. This was the most common debris object across the entire study. Other examples included tire treads, hubcaps, mufflers, engine components, car hoods, trailer hitches, and even trailers themselves. The second most common category of debris was vehicle cargo, which took many forms including furniture, sporting equipment, and other miscellaneous objects. Large debris items, specifically items related to the home, were oftentimes only documented in a small number of cases, but the implications of colliding with these objects are significant. Couches/sofas (n=6), chairs (n=6), mattresses/boxsprings (n=7), and kayaks (n=5) were mentioned more than once in reviewed crash reports. Other large debris objects included a kitchen table, barbecue grill, child's playhouse, mailbox, bicycle, chicken coop, cattle trough, and a golf cart in tow. Various smaller household debris was also noted. Tools and building materials also featured prominently in the road debris, and in many cases likely fell from a vehicle. Together these three types of debris comprised more than half of all debris-related crashes examined and more than 70% of those in which the type of debris was known. Various other sources of debris included "natural" debris (e.g., downed trees, fallen tree branches, roadkill) and materials likely left behind after road work (e.g., concrete, gravel, large metal plates).

Limitations

This research has limitations that should be noted. The general approach of the study was to estimate the number of crashes, injuries, and deaths involving road debris nationwide based on the general characteristics of crashes nationwide in conjunction with more in-depth data from a sample of crashes with similar characteristics in the State of Michigan. If practices for coding the variables used in the current study to identify possible debris-related crashes differ between states, the true contribution of road debris to traffic crashes, injuries, and deaths could be larger or smaller than the current study estimates. For example, while it would seem that virtually all crashes in which a vehicle was struck by an object that fell from another vehicle would have involved road debris, in-depth review of Michigan police crash reports found that many of these crashes—and the majority of those that were more severe—did not. (Many of them involved debris generated by a previous event in the same crash or another crash immediately prior. For the purpose of the current study these were not considered road debris-related crashes.) However, if this finding is a statistical anomaly or is unique to Michigan, the true numbers of fatalities and serious injuries attributable to road debris nationally could be higher.

Implications

A dedicated effort is required to further address this important yet understudied road safety concern from the perspectives of both everyday drivers and road safety professionals. For national and state government agencies, enacting effective countermeasures is pivotal for reducing crashes, injuries, and deaths related to road debris. Better standardized documentation of the role of road debris in crashes would help ensure more uniformity in reporting at both the national and state levels and enhance the ability to monitor road debris as a safety issue, track progress, and identify adverse trends. At the state level, the prioritization of debris removal would limit drivers' exposure to debris in the road environment. Law enforcement officials need both education and enforcement efforts to help maintain road users' safety. All 50 states and the District of Columbia have laws regarding unsecured loads that may lead to road debris crashes; however, efforts are needed to educate drivers about these laws and about the potential risks of unsecured loads.

Drivers can reduce their own risk of causing or becoming involved in a debris-related crash by ensuring that any cargo they are carrying is properly secured, being consistent with recommended vehicle maintenance, and being aware of their surroundings while behind the wheel. NHTSA provides tips for properly securing cargo, which includes fully tying down and covering items, not overloading a vehicle, and double-checking that every load is secure (NHTSA, n.d.). While these countermeasures are important for drivers to implement, the cause of a road debris-related crash does not always originate from an unsecured load; the most common type of debris identified in the current study consisted of vehicle parts (e.g., tires) that became detached or separated from vehicles. While detachment is not always preventable (e.g., it may occur as the result of a crash), following a recommended and regular maintenance schedule (e.g., ensuring proper tire inflation, replacing worn tires) may help to reduce the risk of such an event. In addition, defensive driving strategies (e.g., adhering to the speed limit, keeping a safe following distance, maintaining space to maneuver) may help a driver to avoid crashing in the event they encounter debris in the road. Finally, while acknowledging that in many cases a split-second decision is required, it is important to note that in some situations, striking debris in the road may be less hazardous than attempting to perform a sudden evasive maneuver.

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The AAA Foundation for Traffic Safety is a 501(c)(3) nonprofit, publicly supported charitable research and education organization. It was founded in 1947 by the American Automobile Association to conduct research to address growing highway safety issues. The organization's mission is to identify traffic safety problems, foster research that seeks solutions, and disseminate information and educational materials. AAA Foundation funding comes from voluntary, tax-deductible contributions from motor clubs associated with the American Automobile Association and the Canadian Automobile Association, individual AAA club members, insurance companies and other individuals or groups.

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