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Review of NMVCCS Rollover Variables in Support of Rollover Reconstruction

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13. ABSTRACT (Maximum 200 words)
This report represents a component of data summarization in support of rollover research on-going at the National Highway Traffic Safety Administration. The goal of the summarizations is to understand the vehicle and occupant kinematics pursuant to rollover initiation. Further, pre-crash elements might serve as important input parameters for the rollover crash reconstruction models. Currently, The National Automotive Sampling System (NASS) has been queried for its nationally representative data. The NASS data sets studied to date are the General Estimates System (GES), Crashworthiness Data System (CDS), and National Motor Vehicle Crash Causation Study (NMVCCS). The study of GES and CDS will appear in a subsequent conference paper.

The NMVCCS summarization considers the variables and attributes relevant to potential parameter inputs for rollover reconstruction models.

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1 inch (in)	=	2.5 centimeters (cm)	1 millimeter (mm)	=	0.04 inch (in)
1 foot (ft)	=	30 centimeters (cm)	1 centimeter (cm)	=	0.4 inch (in)
1 yard (yd)	=	0.9 meter (m)	1 meter (m)	=	3.3 feet (ft)
1 mile (mi)	=	1.6 kilometers (km)	1 meter (m)	=	1.1 yards (yd)
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1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)	1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)	1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)	1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)	10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)			
MASS - WEIGHT (APPROXIMATE)			**MASS - WEIGHT (APPROXIMATE)**		
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1 pound (lb)	=	0.45 kilogram (kg)	1 kilogram (kg)	=	2.2 pounds (lb)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)	1 tonne (t)	=	1,000 kilograms (kg)
				=	1.1 short tons
VOLUME (APPROXIMATE)			**VOLUME (APPROXIMATE)**		
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1 tablespoon (tbsp)	=	15 milliliters (ml)	1 liter (l)	=	2.1 pints (pt)
1 fluid ounce (fl oz)	=	30 milliliters (ml)	1 liter (l)	=	1.06 quarts (qt)
1 cup (c)	=	0.24 liter (l)	1 liter (l)	=	0.26 gallon (gal)
1 pint (pt)	=	0.47 liter (l)			
1 quart (qt)	=	0.96 liter (l)			
1 gallon (gal)	=	3.8 liters (l)			
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)	1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)	1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)			**TEMPERATURE (EXACT)**		
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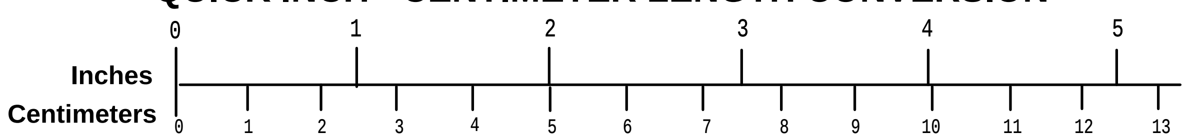

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°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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Executive Summary

This report addresses the on-going National Highway Traffic Safety Administration (NHTSA) rollover research initiative. In order to understand the rollover crash causation, and vehicle kinematics, the publicly-available data sets of the National Center for Statistics and Analysis (NCSA) have been reviewed and potential descriptors identified.

Between January 1, 2005 and December 31, 2007, NCSA, under Congressional mandate, compiled 6,949 light passenger vehicle crashes. Of these, 79 percent comprise the nationally representative sample of precrash data. The remaining crashes were compiled as part of the sampling plan formulation and retained for anecdotal research. The data has been stored as coded elements, crash summaries, photographic and schematic graphics, vehicle information, and, event data recorder downloaded crash data, when available.

This summarization highlights the strengths of the National Motor Vehicle Crash Causation Study (NMVCCS) and its interrelationship with roadway design, vehicle, and occupant involvement. This is also a larger interaction as typified by the interaction of Federal Highway Administration and NHTSA. The study of a traveling vehicle interacting with diverse design geometries and the outcome of the occupant involved in crashes within this system has been used as the frame work for this summary.

Background

As part of the exhaustive data analysis effort in support of rollover research, this is one of several installments. The goal is to amass all available information and either to populate the parameters required to accurately run a multiple-parameter rollover crash model or to identify missing attributes deemed useful. Some missing attributes, constrained by recording time and storage size, may be technologically impossible to obtain owing to the state-of-the-art present in the vehicle fleet. Other information, however, is currently available or could be made available, in the absence of privacy concerns, from the current fleet of electronic data recorders (EDRs).

Introduction

The study of rollover crashes has been hampered by posterior data collection occasionally supplemented by on-board data recorders. Each dataset of very good quality for its original motivation, however, short of real time data collection, much engineering acumen must be exercised in rollover crash problem solving.

Since 1995, National Automotive Sampling System (NASS) Crashworthiness Data System (CDS) has provided the most accurate crash description of rollover crashes pursuant to onsite investigation and linkage to the vehicle and occupant outcomes. It also places rollover crashes within the context of all tow away crashes by way of a nationally representative estimation of tow away crashes occurring on a yearly basis. From an injury reporting perspective, Crash Injury Research Engineering Network (CIREN) surpasses CDS; however, it lacks national representation. With this, much more widely framed queries have been made in NASS CDS to determine national relevance. With relevant issues identified, CIREN data could be queried to aid in a clinical understanding of injury causation at the event level. This is a forward looking and retrospective process with the advent of BioTab. This work has been reported at Association for the Advancement of Automotive Medicine (AAAM) and International Research Council on the Biomechanics of Injury (IRCOBI).

The National Motor Vehicle Crash Causation Survey (NMVCCS) has filled a void in immediate post crash access to the roadway environment, vehicle occupants, and emergency responders. In environments where the crash evidence might disappear owing to climatologically induced events or recovery efforts, this serves to provide an accurate description of the roadway geometry, roadside furniture, and any aberrations that might not be noted upon a later visit. Benefit also exists with freshness of memory of interviewees, as well as willingness to speak prior to legal consultation. As a sacrifice, the injury description is limited to a visual assessment of injury severity. The gain is the behavioral information, avoidance maneuvering, and vehicle responses to maneuvers. Further, an on-scene assessment can be made with respect to the driver impairment induced by physiological or chemical means. In context, National Automotive Sampling System, Crashworthiness Data collection could occur months after the crash whereas NMVCCS is uniquely positioned to capture fresh, on-scene crash data. As further clarification, crash causation from an engineering standpoint has not been considered in this data set. Instead, NMVCCS has compiled descriptive statistics from precrash data collection within the context of the behavioral aspects leading to the crash. This will allow an additional, untapped facet of rollover crash information to be considered in NHTSA rollover research activities.

The following summarization reviews NMVCCS rollover crashes and describes them by crash environment, vehicle, and occupant parameters. Although other variables exist that might shed a qualitative understanding of the rollover problem, the parameters selected are those that have been available through NASS CDS but are more robust owing to on-scene investigation. The subsequent sections try to understand the roadway geometry and roadside furniture to assess any commonalities with respect to potential travel speeds and roadway hazard. Resources such as the American Association of State Highway and Transportation Officials (AASHTO) guidance and the Highway Capacity Manual (HCM) were consulted. The District of Columbia Roadway Design Guide was consulted, as it was free, provided on line, and based upon the AASHTO design guide.

General Data Parameters

Over the reporting life of NMVCCS, approximately 3.9 million crashes were estimated to have occurred for which on scene investigation was undertaken with nearly 12 percent of these crashes resulting in rollover. There are crashes which carry a zero weight and could not be resolved into the sampling plan. At the beginning of the study, owing to statistical accommodation of time blocks, cases collected at that time were retained for anecdotal study but could not be weighted to form part of the crash estimates.

The table disaggregates NMVCCS crashes into vehicle attitude, planar or rollover. The rollover crashes are further resolved by an aggregation of vehicle quarter turns, referenced as roof contacts. Roof contacts are the number of times a vehicle roof subjected to rollover touches, brushes, or merely faces the ground. In the graph, vehicle attitude is subsumed into planar, rollover, or unknown. For purposes of the graph, non-planar vehicle attitude subsumes rotation about the lateral or longitudinal axis.

Table 1.
Number of NMVCCS Reported Crashes, Weighted

Vehicle Attitude or Number of Roof Contacts	Frequency
Planar (0 Quarter Turns)	3,438,218
Zero (1 Quarter Turn)	106,804
One (2,3,4, or 5 Quarter Turns)	287,440
Two Plus (6+ Quarter Turns)	52,007
End over end	4,964
Unknown	5,075
Total	3,894,507

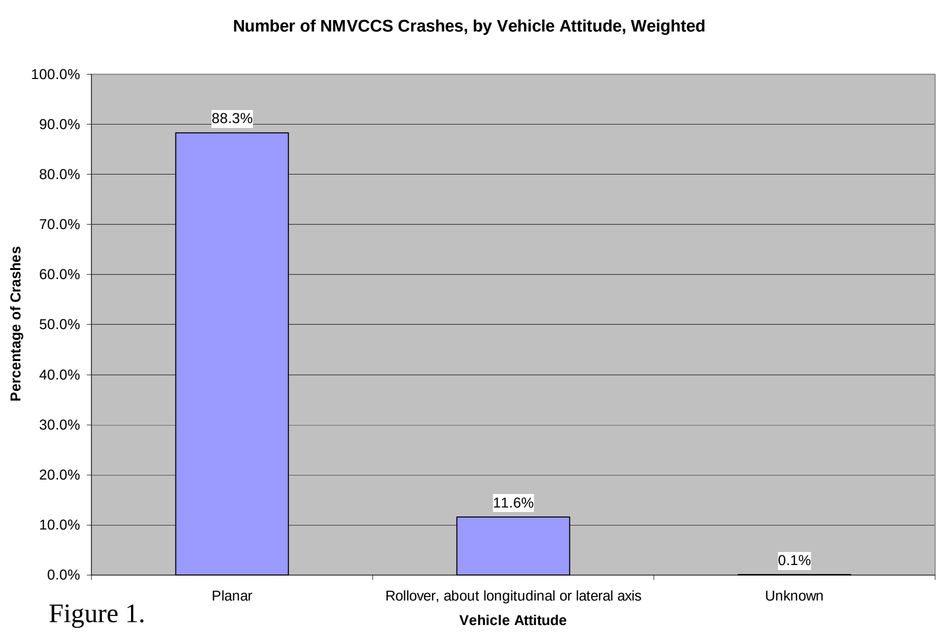


Figure 1.

NMVCCS Rollover Data General Parameters

Temporal Parameters

Minor spikes in the rollover crash data occur during holiday periods. Hours of peak volume or exposure, morning, lunch, and evening hours, seem to be related with increased percentage of rollover crashes. This spike may be due to the incomplete calendar year at the start of the project or true increases in the holiday travel. No statistical significance testing was done at this time.

Table 2.
NMVCCS Crashes, by Hourly Blocks and Month Ranges, Weighted

Time (Hour)	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total
6:00 - 6:59	2.6%	0.6%	3.3%	2.1%	8.6%
7:00 - 7:59	2.8%	1.9%	1.5%	2.0%	8.3%
8:00 - 8:59	0.5%	1.5%	2.2%	2.8%	7.0%
9:00 - 9:59	0.3%	0.4%	1.0%	0.8%	2.4%
10:00 - 10:59	1.1%	0.7%	0.7%	0.6%	3.1%
11:00 - 11:59	0.5%	0.3%	0.9%	1.3%	3.0%
12:00 - 12:59	1.3%	4.0%	2.8%	3.4%	11.5%
13:00 - 13 :59	1.1%	1.3%	1.7%	2.1%	6.1%
14:00 - 14:59	0.5%	2.0%	2.5%	2.6%	7.5%
15:00 - 15:59	0.4%	1.8%	1.3%	2.4%	5.9%
16:00 - 16:59	0.8%	0.7%	1.4%	1.2%	4.1%
17:00 - 17:59	0.7%	0.8%	0.4%	0.7%	2.6%
18:00 - 18:59	3.8%	1.0%	1.5%	2.3%	8.5%
19:00 - 19:59	3.2%	1.1%	4.1%	0.7%	9.0%
20:00 - 20:59	0.7%	1.5%	2.2%	0.5%	4.9%
21:00 - 21:59	0.5%	0.7%	0.8%	1.3%	3.3%
22:00 - 22:59	0.5%	1.1%	1.0%	0.4%	2.9%
23:00 - 23:59	0.4%	0.3%	0.3%	0.3%	1.3%
Total	21.6%	21.6%	***29.4%***	27.4%	100.0%

By observation, concentrations were noted during presumed peak volume times. These were loosely described as morning, lunch, and evening rush hours. It should be noted that these will vary from collection site-to-collection site, however, the grouping provide some context for larger percentages of rollover crashes. Based upon concentrations of rollover crashes occurring from 6:00 – 8:59, this was deemed the morning peak. Again, during from 12:00 – 12:59, a lunch time peak was observed. Finally, during the evening, a peak was observed from 18:00 – 19:59. It should be noted that the hours comprising these blocks vary. In an attempt to make sense of their relative contributions, the percentage contribution of rollover crashes is divided by the number of hours present in the specified bin. This is a remedial attempt at normalizing the rollover crashes. The hierarchy of crashes, in descending order, is lunch, morning, accumulated afternoon, and evening peak travel. Upon normalizing, the lunch peak is the highest owing to its single hour of representation; however, the relative importance of the evening peak overtakes the accumulated afternoon. The binning is noted to be flawed, as it is uneven and aggregation is dependent on cell sizes. Its motivation was devised to show the relative contribution of concentrated time blocks.

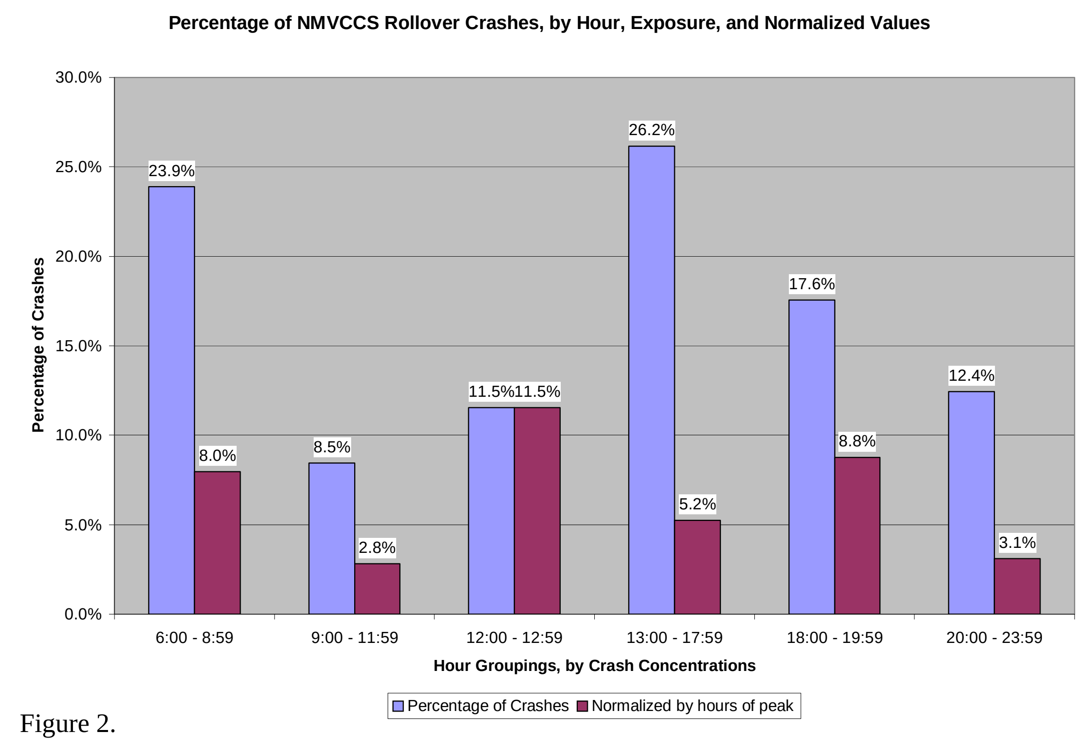


Figure 2.

By standardizing the normalization to uniform three hour blocks, the original peak hours were grouped. Further, the morning, midday, and evening peak hours accounted for nearly three-quarters of the rollover crash occurrence. This also avoided an artificial aggregation of mid-afternoon hours that suggested a smooth peak that did not exist.

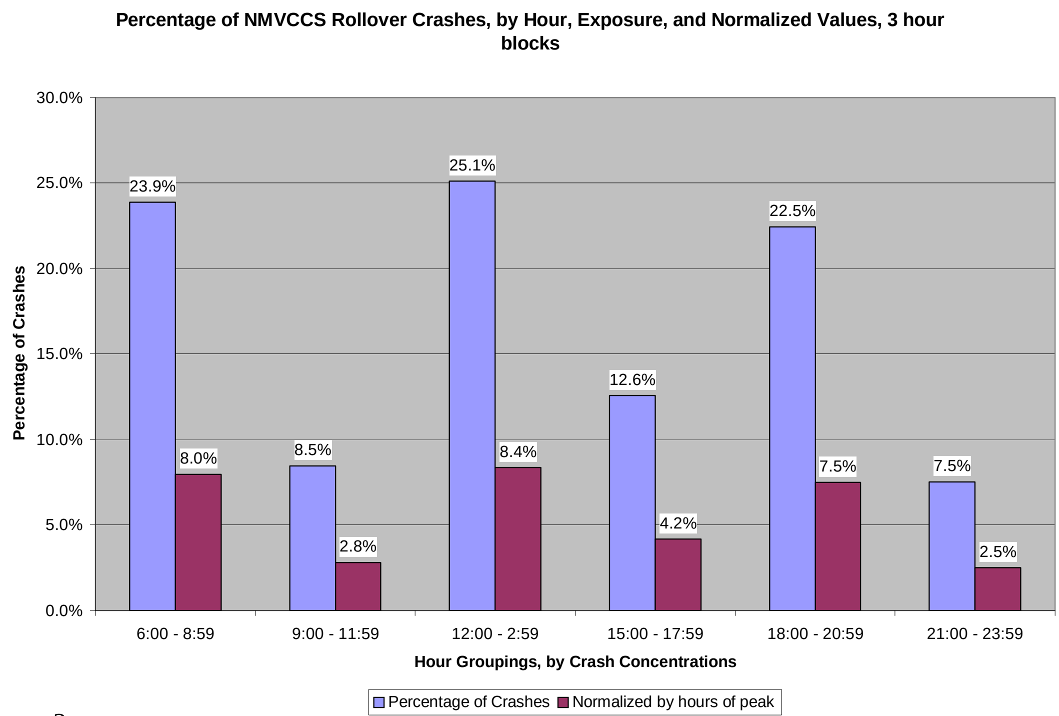


Figure 3.

Vehicle Counting

The following summary shows the intersection of total number vehicles reported in a crash and the incidence of case vehicles. Of the nearly 450,000 vehicles sustaining rollover, 2.1 percent occurred with more than one case vehicle qualified for NMVCCS reporting. Nearly 98 percent of rollover crashes involved one case vehicle. This is supported by the higher incidence of single vehicle rollover crashes seen historically in NASS CDS. Finally, nearly 70 percent of all NMVCCS vehicle rollovers are single vehicle crashes.

Table 3.
Number of NMVCCS Vehicles, by Total Number Reported for Crash and Total Number of Case Vehicles, Weighted

Total number of vehicles in the crash	Number of case vehicles in the crash			
	1	2	3	Total
1	308,747	0	0	308,747
2	6,509	118,073	0	124,582
3	591	782	16,319	17,692
4	122	1,191	378	1,691
5	0	0	144	144
Total	315,968	120,046	16,841	452,856

In multiple vehicle rollover crashes, the majority of vehicles were retained as case vehicles. In the case of five vehicles present in a crash, the percentage is 0.03 for three case vehicles but is reported as zero owing to rounding.

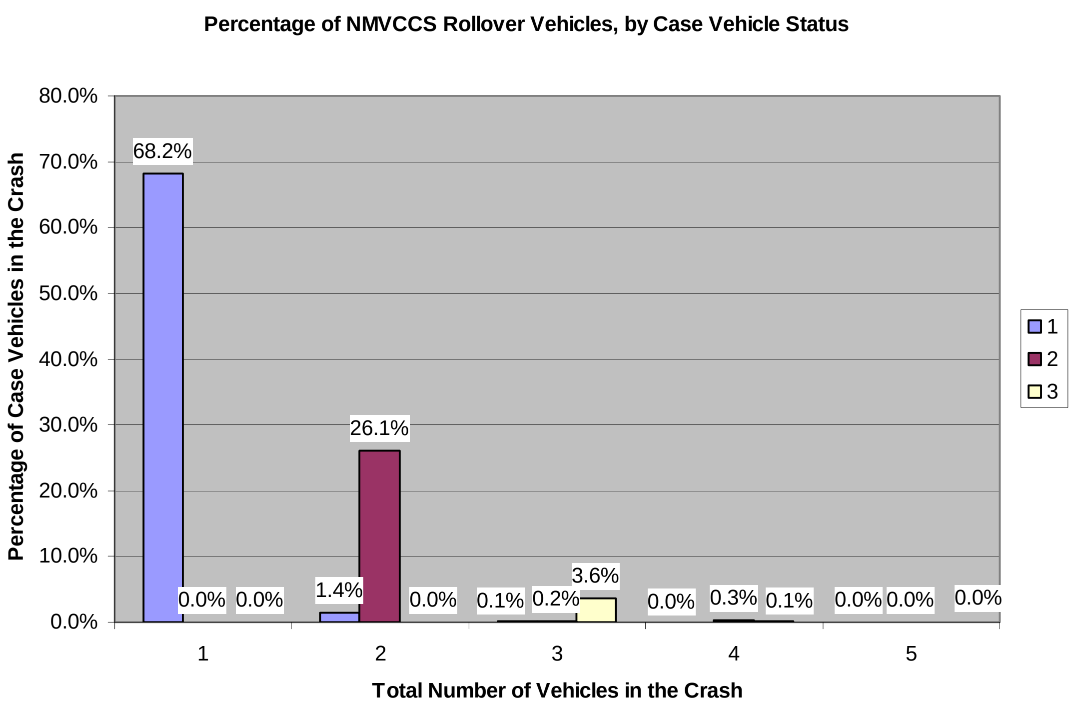


Figure 4.

Fire Occurrence and Inspection

Fire occurrence can hamper many forensic crash investigations. With NMVCCS, however, the researcher has opportunity to see at least some component of the crash wreckage on scene. Of the rollover crashes nearly 97 percent involve no fire incidence. Two percent of NMVCCS have a known fire incidence with 100 percent vehicle inspection rate. It should be noted that this is an exterior study of the vehicle unlike NASS CDS interior and exterior data acquisition. As an anecdotal observation of NASS CDS rollover reporting and fire incidence, this is usually a multiple event with accompanying planar impact.

The vehicle inspection type categories have been compressed. Although varying intentions exist for certain categorizations, the outcome is the same. For categorization purposes, completion can occur either on scene or after the fact, lack of completion can occur on scene or later, and no inspection subsumes refusal and inaccessibility

Table 4. Number of NMVCCS Vehicles, by Fire Incidence and Vehicle Inspection Type, Weighed				
	Vehicle Inspection Type			
Fire Incidence	Completed	Incomplete	None	Total
No	371,277	68,450	4,400	444,127
Yes	9,406	0	0	9,406
Unknown	2,756	0	0	2,756
Total	383,439	68,450	4,400	456,289

Although not valid for statistical analysis, unweighted values are reported to give the scope of a subsequent case review. Of the raw case counts, approximately 99 percent have no reported fire.

Table 5. Number of NMVCCS Vehicles, by Fire Incidence and Vehicle Inspection Type, Raw				
	Vehicle Inspection Type			
Fire Incidence	Completed	Incomplete	None	Total
No	939	119	18	1,076
Yes	12	0	0	12
Unknown	1	0	0	1
Total	952	119	18	1,089

Rollover Incidence and Number of Vehicle Roof Contacts

Nearly half of the rollover crashes sustain one roof impact and are inspected. This is noteworthy because of this very prevalent rollover type for which on scene information has been absent, in support of emerging technologies.

Table 6. Number of NMVCCS Vehicles, by Number of Roof Contacts and Vehicle Inspection Type, Weighted				
	Vehicle Inspection Type			
Number of Roof Contacts	Completed	Incomplete	None	Total
Zero (1 Quarter Turn)	93,026	11,507	2,271	106,804
One (2,3,4, or 5 Quarter Turns)	234,103	51,952	1,385	287,440
Two Plus (6+ Quarter Turns)	48,214	3,792	0	52,006
End over end	4,672	292	0	4,964
Unknown	3,424	907	744	5,075
Total	383,439	68,450	4,400	456,290

As noted in the graph, more than 80 percent of rollover crashes are subject to a complete vehicle inspection, as dictated by the protocols of the NMVCCS. Complete is an aggregation of on-scene and subsequent completion. Less than one percent failed to be inspected. The on-scene nature allow for vehicles to be easily assessable to the researcher.

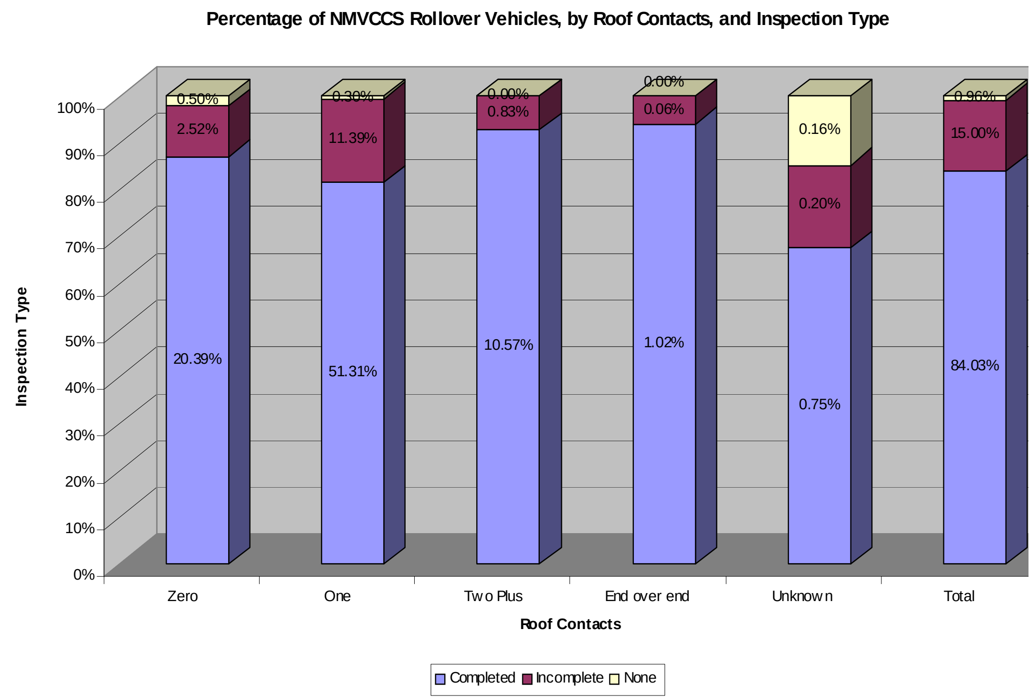


Figure 5.

Location on Vehicle where Initial Tripping Force is Applied and Location of Rollover Initiation

In an attempt to harmonize rollover incidence with that in NASS CDS, the following table was prepared. The table and figure use variables available in NASS CDS but benefiting from the freshness of the NMVCCS crash scene. Nearly 30 percent of rollover crashes have initial force applied to the wheels with the rollover crash occurring on the roadside. The wheels as initial tripping force comprise 37 percent of the rollover crashes. Followed by the tire forces, from which nearly 28 percent of the rollover crashes are produced. Finally, nearly one quarter of the rollover crashes result on the roadway and nearly 66 percent occurring on the roadside. Per the NMVCCS coding manual definition, tripping location at the wheels is reserved for those impacts involving wheel impacts to potholes and curbs, wheels that gouge the pavement or dig into the earth. Further, tripping location at the tires describes tire impacts to potholes and curbs.

Table 7. Number of NMVCCS Vehicles sustaining Rollover, by Location where Initial Tripping Force is Applied and Location of Rollover Initiation, Weighted						
	Location of rollover initiation					
Location on vehicle where initial tripping force is applied	On roadway	On shoulder -paved	On shoulder - unpaved	On roadside or divided traffic way median	Rollover - end-over-end	Total
Wheels	22,270	3,851	4,824	138,418	0	169,363
Tires	22,911	4,257	25,080	73,777	0	126,026
Side plane	44,093	3,016	521	18,944	0	66,573
End plane	9,360	0	0	17,133	0	26,493
Undercarriage	0	435	0	35,643	0	36,078
Non-contact rollover forces	9,087	0	1,193	16,343	0	26,622
Rollover - end-over-end	0	0	0	0	4,964	4,964
Unknown	0	0	0	169	0	169
Total	107,720	11,560	31,617	300,428	4,964	456,289

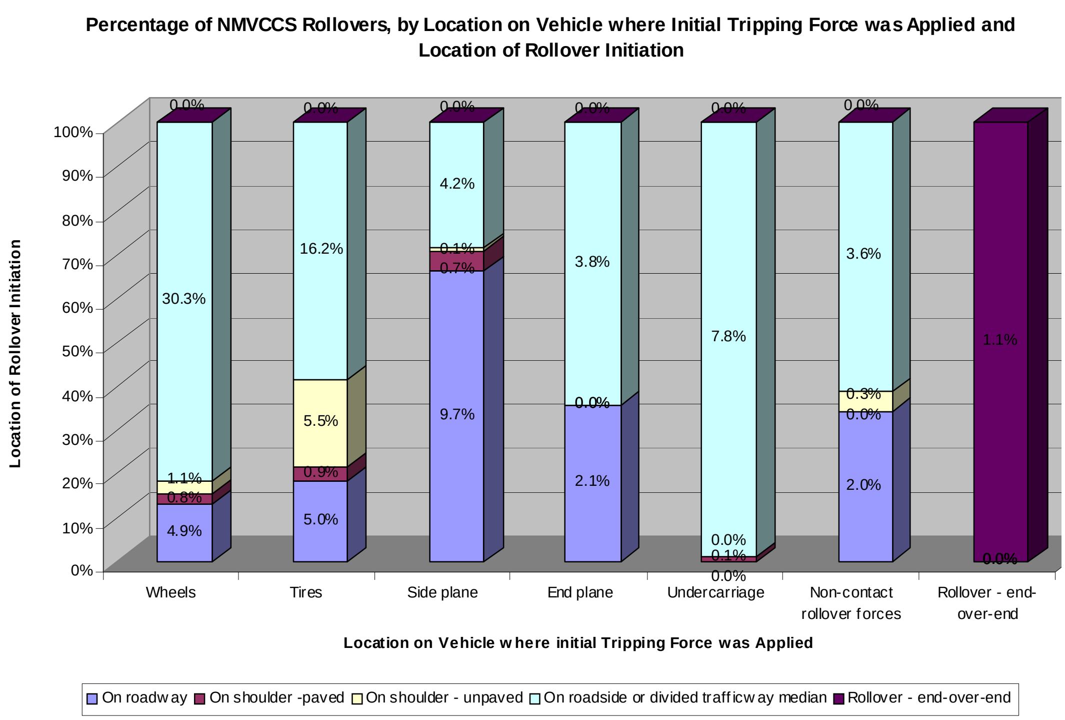


Figure 6.

With further consideration of the reporting for location of rollover, rollover initiation type, and rollover object type, additional insight is provided for more recent years of data collection.

Nearly 10 percent of rollover crashes are classified as trip over crashes resulting on the roadway. Nearly half of the rollover crashes are classified as trip over occurring on the roadside. Approximately 12 percent of rollover crashes occur as a result of contact with another vehicle. In terms of occurrence and roadway classification, nearly one quarter of rollover crashes occur on the roadway and approximately 66 percent occur on the roadside.

Table 8.
Number of NMVCCS Vehicles, by Location of Rollover Initiation and Type of Rollover Initiation, Weighted

Location of rollover initiation	Type of rollover initiation									Total
	Trip-over	Flip-over	Turn-over	Climb-over	Fall-over	Bounce-over	Collision with another vehicle	Other rollover initiation type	Roll-end-over-end (about the lateral axis)	
On roadway	45,044	0	9,087	0	0	0	52,782	808	0	107,720
On shoulder – paved	8,109	435	0	0	0	0	2,982	33	0	11,560
On shoulder - unpaved	29,904	0	220	0	973	0	521	0	0	31,617
On roadside or divided traffic way median	212,196	22,973	3,576	12,670	12,766	24,933	10,528	786	0	300,428
Rollover - end-over-end	0	0	0	0	0	0	0	0	4,964	4,964
Total	295,252	23,409	12,883	12,670	13,740	24,933	66,813	1,627	4,964	456,289

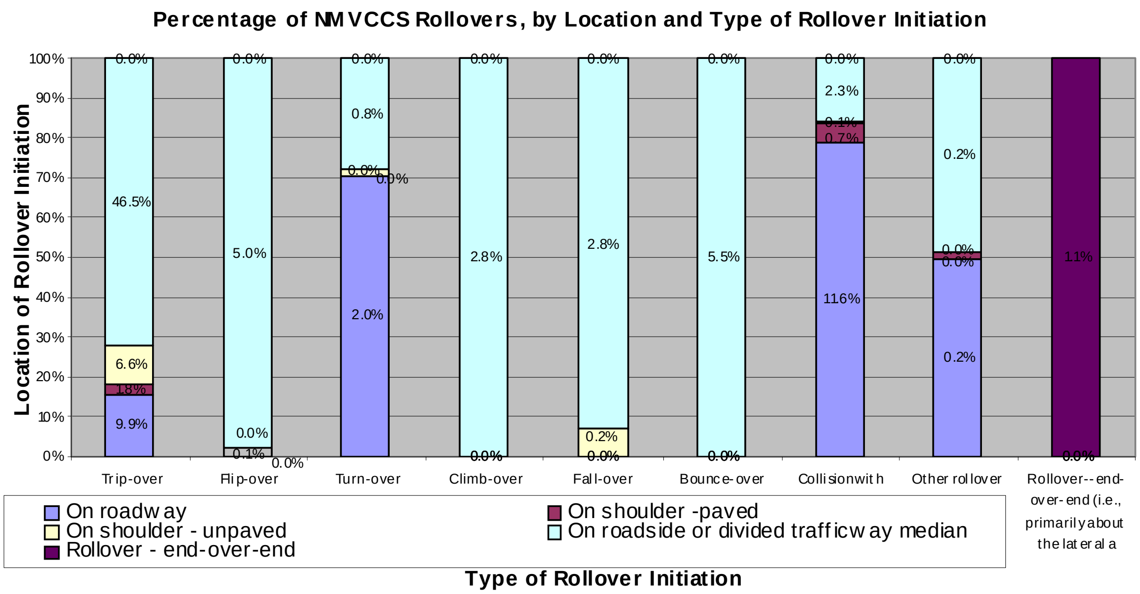


Figure 7.

As noted previously, multiple vehicle rollover crashes are less prevalent than single vehicle rollover crashes. Nearly 15 percent of rollover crashes might be attributed to vehicle contact and 12.5 percent of rollover crashes initiated by another vehicle result from a force application to the side plane. More than three-quarters of rollover crashes result pursuant to collision with a fixed object. Collisions with wheels and tires, classified as fixed objects, account for 37 and 38 percent of the rollover crashes, respectively. When considering rollover crashes, the most prevalent locations for tripping force to be applied are the wheels, tires, and side plane, in diminishing order.

Table 9. Number of NMVCCS Vehicles, by Type of Rollover Initiation and Location on Vehicle where Initial Tripping is Applied, Weighted									
Rollover initiation type of object contacted	Location on vehicle where initial tripping force is applied								Total
	Wheels	Tires	Side plane	End plane	Undercarriage	Non-contact rollover forces	Rollover - end-over-end	Unknown	
Vehicle	0	0	57,123	9,690	0	0	0	0	66,813
Non-collision	0	0	0	905	0	26,622	4,964	0	32,492
Collision with Fixed Object	169,226	126,026	8,799	15,898	36,004	0	0	169	356,121
Collision with Nonfixed Object	137	0	618	0	74	0	0	0	829
Other event	0	0	33	0	0	0	0	0	33
Total	169,363	126,026	66,573	26,493	36,078	26,622	4,964	169	456,289

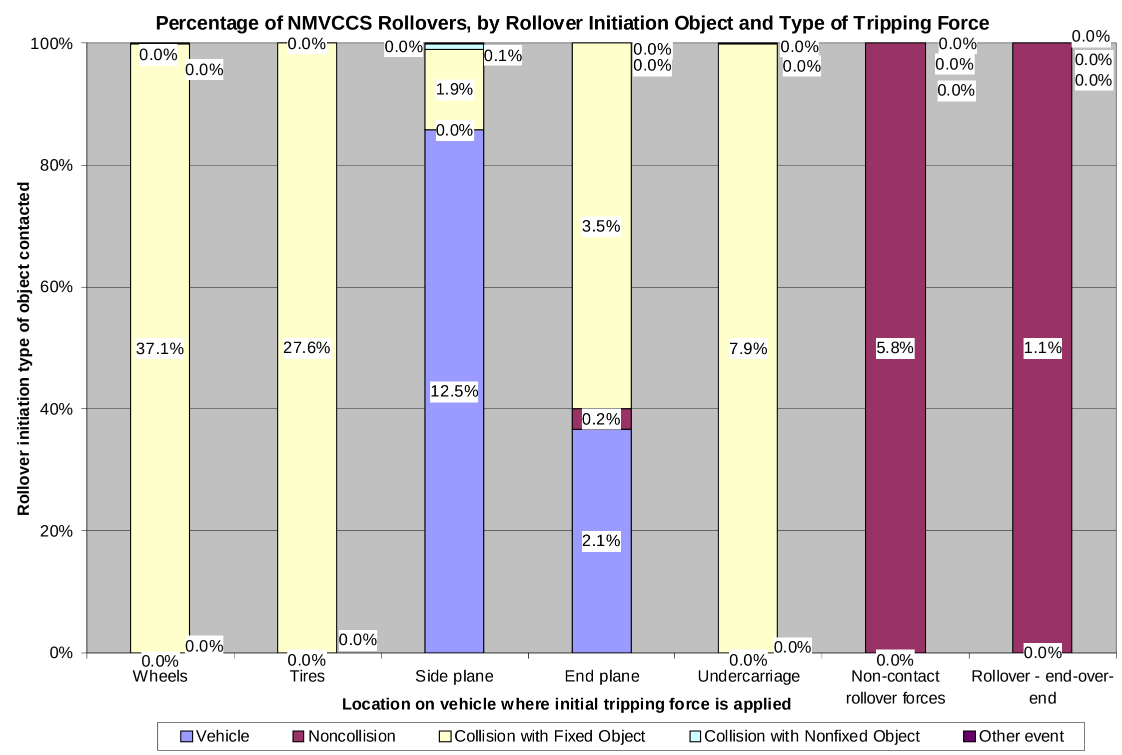


Figure 8.

In an attempt to increase the cell size without sacrificing resolution of the data, the following table and figure summarize the previous findings. It is noted that the use of the rollover initiation type object contacted might be used in lieu of the rollover object contact, if fine resolution can be avoided. This practice is advocated for smaller cell sizes as the results might not be significant.

Table 10.
Number of NMVCCS Rollover Crashes, by Rollover Initiation Type of Object and Location of Rollover Initiation

Rollover initiation type of object contacted	Location of rollover initiation					Total
	On roadway	On shoulder -paved	On shoulder - unpaved	On roadside or divided traffic way median	Rollover - end-over-end	
Vehicle	52,782	2,982	521	10,528	0	66,813
Noncollision	9,757	0	1,193	16,578	4,964	32,492
Collision with Fixed Object	45,044	8,544	29,904	272,630	0	356,121
Collision with Nonfixed Object	137	0	0	692	0	829
Other event	0	33	0	0	0	33
Total	107,720	11,560	31,617	300,428	4,964	456,289

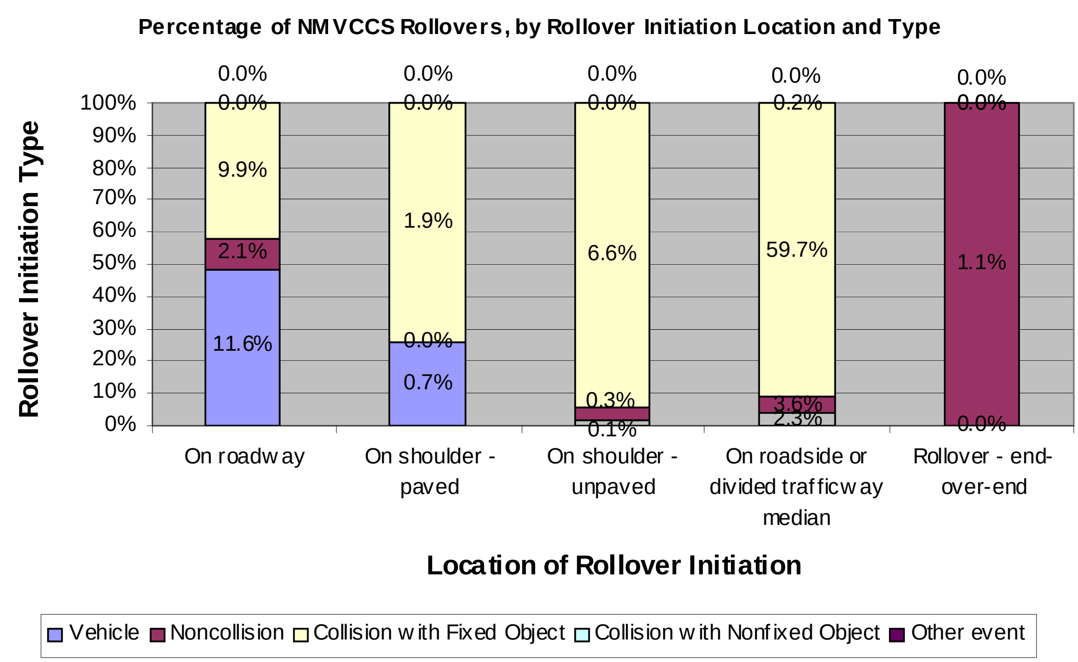


Figure 9.

Rollover Distance and Vehicle Quarter Turns

One of the most significant advances in rollover reporting has been the introduction of the rollover distance variable. With this the NASS CDS researchers started to measure the point of rollover initiation to termination point. Being on-scene, the NMVCCS measurement is considered more reliable owing to the less disturbed nature and the emergency workers and onlookers potentially able to indicate subtleties lost in the NASS CDS, such as a vehicle that rolls back onto a previously rolled side, a drop that might have occurred accentuating the force to which the occupant compartment was subjected.

In NMVCCS, nearly half of rollover crashes take place within 10 meters, as measured from the point of rollover initiation to the point of final vehicle rest. For crashes with ten meters or less of roll distance, 89 percent sustain less than two roof contacts. Approximately nine percent account for rotation about the lateral axis or have unknown rollover details. The distance has been disaggregated into ten meter increments however; distance rolled is reported in increments of 1 meter in NMVCCS. Note that the table starts with two meters rather than one because two meters was the shortest distance estimate reported for this variable.

Table 11.
Number of NMVCCS Rollover Crashes, by Estimated Roll Distance and Roof Contacts

	Roof Contacts					
Estimated Distance (in meters)	Zero (1 Quarter Turn)	One (2,3,4, or 5 Quarter Turns)	Two Plus (6+ Quarter Turns)	End over End	Unknown	Total
2-10	84,294	133,466	3,720	0	235	221,715
11-20	13,042	76,985	13,138	0	2,256	105,421
21-30	1,125	35,807	11,573	0	0	48,506
31-40	336	9,374	12,060	0	0	21,769
41-50	944	1,748	4,854	0	0	7,546
51-60	364	3,312	4,231	0	0	7,907
61-70	0	2,588	602	0	867	4,057
End-over-end rollover	1,922	7,509	675	4,350	0	14,455
Unknown	4,778	16,651	1,154	615	1,717	24,914
Total	106,804	287,439	52,007	4,964	5,075	456,289

Without benefit of significance testing, an increase to the higher distance range is noted for rollover of two roof contacts or greater. This is not surprising, as it is reasonable that dissipation of the energy with subsequent quarter turns would require a greater distance. For ease of graphic representation, the distance has been subsumed into two categories: 2 to 34 meters and 35 to 70 meters. The end-over-end and unknown categories were reported separately.

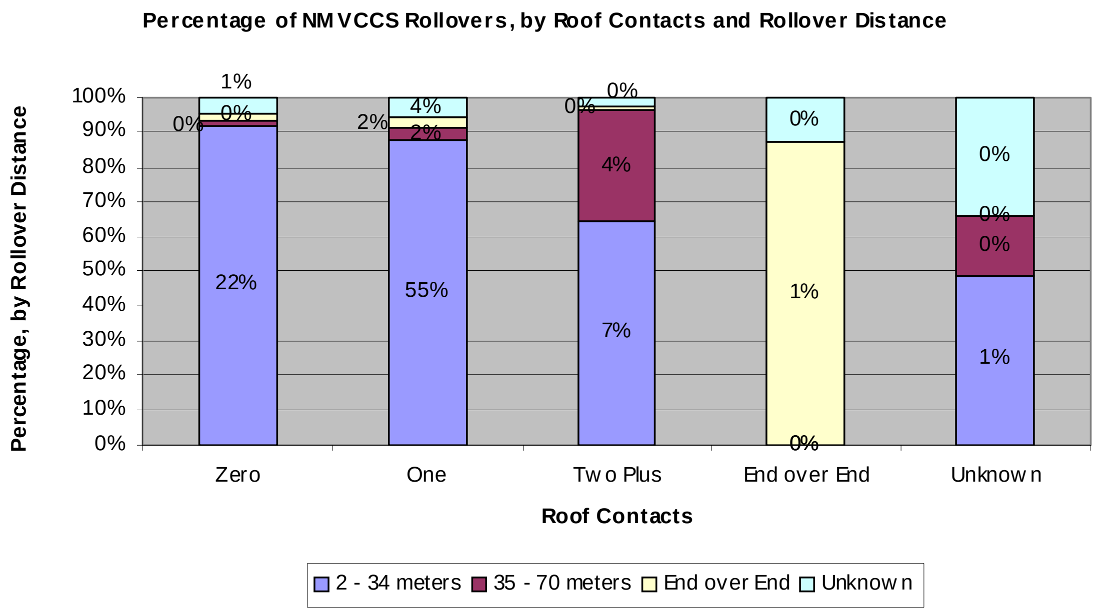


Figure 10.

When plotting the raw data, similar representation is seen for roof contacts disaggregated by distance rolled. This finding may prove useful in supporting case reviews performed without weighting factors but purporting relevance.

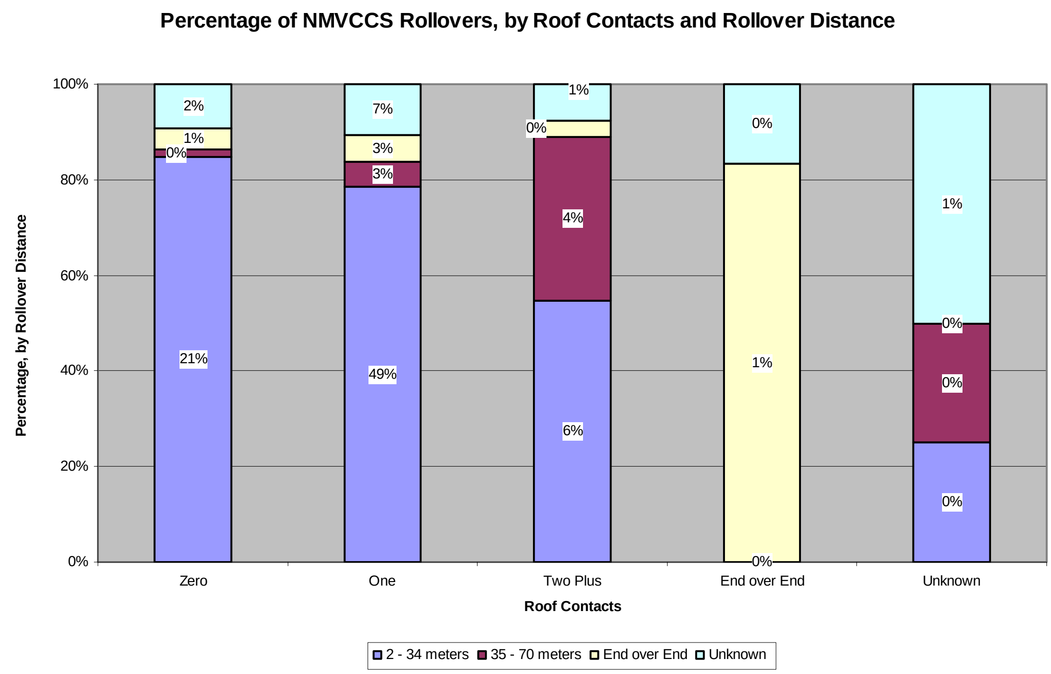


Figure 11.

Presence of Collision Deformation Classification and Data Recorder Information

Although EDRs have been introduced into the vehicle fleet and the cooperation amongst manufacturers has slowly led to Ford and General Motors products ability to be read, a limited representation of EDR data exists in the crash data bases. Less than ten percent EDR information has been obtained from on-scene data during the NMVCCS study of rollover crashes. For the majority of the fleet with EDR, it should be noted that information relevant to newer types of supplemental restraint technologies may not be output. The EDR reporting is constrained by the output structure imposed by the manufacturers, as well as the equipment resident in the vehicle.

Table 12. Number of NMVCCS Vehicles sustaining Rollover, by Presence of Collision Deformation Classification and Electronic Data Recorder Information, Weighted					
	EDR information obtained				
CDC/TDC information available		EDR information obtained	EDR information not obtained	Unknown	Total
No	0	0	4,620	0	4,620
Yes	1,279	44,025	406,126	239	451,669
Total	1,279	44,025	410,746	239	456,289

For those vehicles with accessed EDR information, no CDC information was collected. For unattainable EDR, almost 90 percent of CDC measurements were taken and reported in the data set.

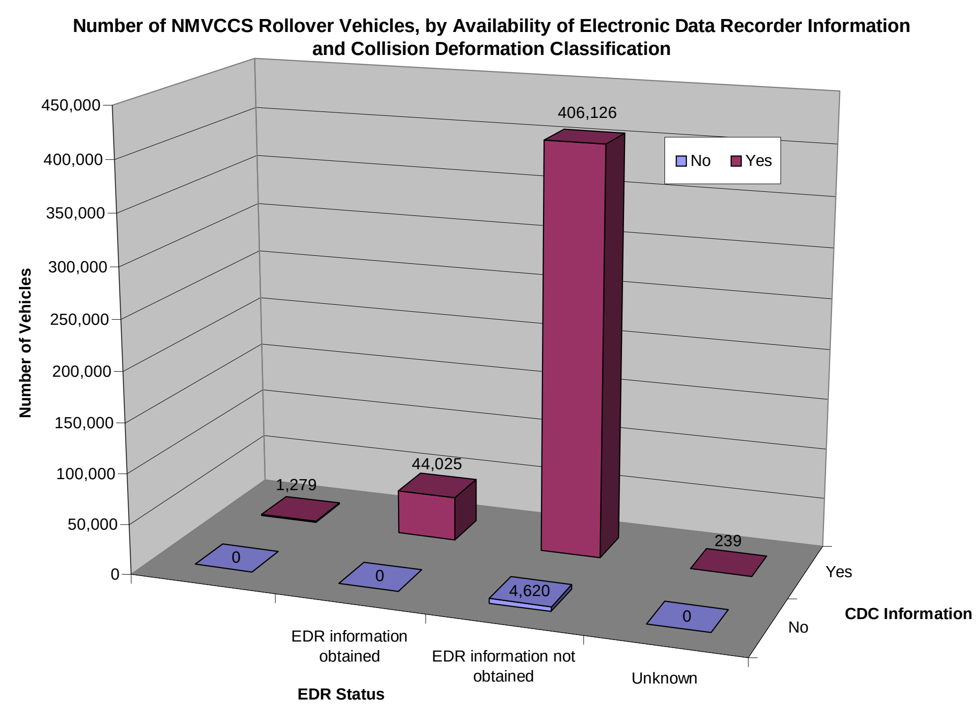


Figure 12.

The raw values are reported below. The 103 cases for which EDR data was obtained may form the basis of a subsequent clinical review in support of rollover research activities.

Table 13. Number of NMVCCS Vehicles sustaining Rollover, by Presence of Collision Deformation Classification and Electronic Data Recorder Information, Raw					
	EDR information obtained				
CDC/TDC information available	Missing	EDR information obtained	EDR information not obtained	Unknown	Total
No	0	0	19	0	19
Yes	4	103	962	1	1,070
Total	4	103	981	1	1,089

Rollover Population Vehicle Fleet

Vehicle Body Type Summarization, by Disposition and Model Year Grouping

For NMVCCS reporting, vehicles are described by vehicle body types. In the subsequent tables, the descriptors have been aggregated into six categories. The categories are: passenger car, Sport Utility Vehicle (SUV), Van (minivan and utility vans), light pick up trucks, heavy vehicles (subsuming large trucks and other heavy equipment), and other (vehicles failing to conform to the prior classifications).

Of the vehicles reported in NMVCCS that rolled over, less than two percent were removed from the crash scene by their own power. Another two percent of vehicle rollovers reported in NMVCCS were attributable to heavy trucks. Nearly 97 percent of NMVCCS vehicles that rolled over were towed passenger vehicles.

Table 14.
Number of NMVCCS Vehicles sustaining Rollover, by Vehicle Body Type and Vehicle Disposition, Weighted

	Disposition		
Body Type	Not Towed	Towed	Total
Passenger Car	2,878	181,394	184,272
SUV	1,134	172,322	173,456
Van	629	24,634	25,263
Pickup Truck	1,647	62,019	63,666
Heavy Vehicle	549	8,865	9,414
Other Vehicle	220	0	220
Total	7,056	449,233	456,290

Without regard for vehicle case status, the majority of passenger vehicles were towed from the crash scene due to disabling damage. Of the non-passenger vehicles, inclusive of heavy and other vehicles, the majority of these were also towed from the crash scene.

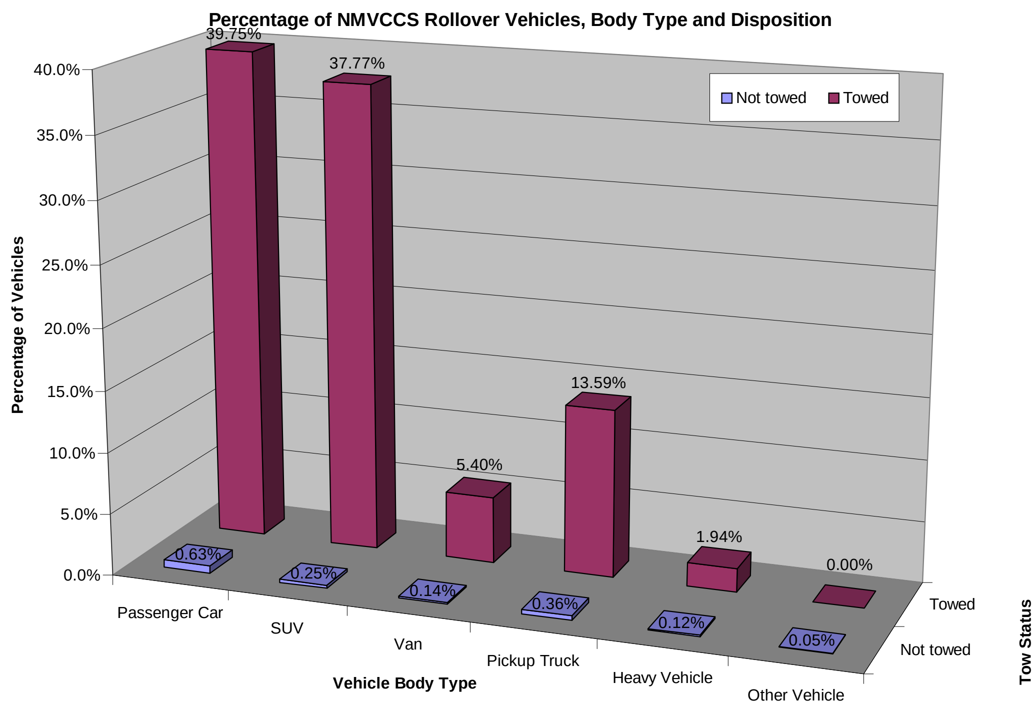


Figure 13.

Nearly 50 percent of vehicles sustaining rollover were produced in the model year 2000 or later. These vehicles will be useful for study for subsequent advances in rollover technology to establish thresholds of vehicle damage and injury. Slightly more than 13 percent were produced during the threshold model years of 1998 and 1999 and could conceivably be introduced into any study using NMVCCS data. This comment is made owing to the absence of extensive safety system equipment information. Safety equipment, by vehicle model and model year might provide valuable clues as to the potential performance of the later fleet. The remaining vehicles were produced prior to pervasive safety technologies and might not be deemed useful for subsequent rollover studies.

Table 15.
Number of NMVCCS Vehicles sustaining Rollover, by Model Year Grouping and Vehicle Body Type, Weighted

Model Year Grouping	Passenger Car	SUV	Van	Pick up Truck	Heavy Vehicle	Other Vehicle	Total
Pre-1998	84,661	52,613	10,298	23,212	1,991	0	172,775
1998 - 1999	11,587	27,208	7,455	8,807	4,511	220	59,786
2000-onward	88,023	93,635	7,510	31,647	2,913	0	223,728
Total	184,271	173,456	25,263	63,666	9,414	220	456,289

The later model years provides a representation of newer technologies relevant in rollover research. Further, the presence of nearly twice as many later model SUVs, as compared to pre-1998 SUV models also enhances the understanding of the rollover crash problem. Vans, however, have a smaller margin, both in overall representation, as well as newer model years.

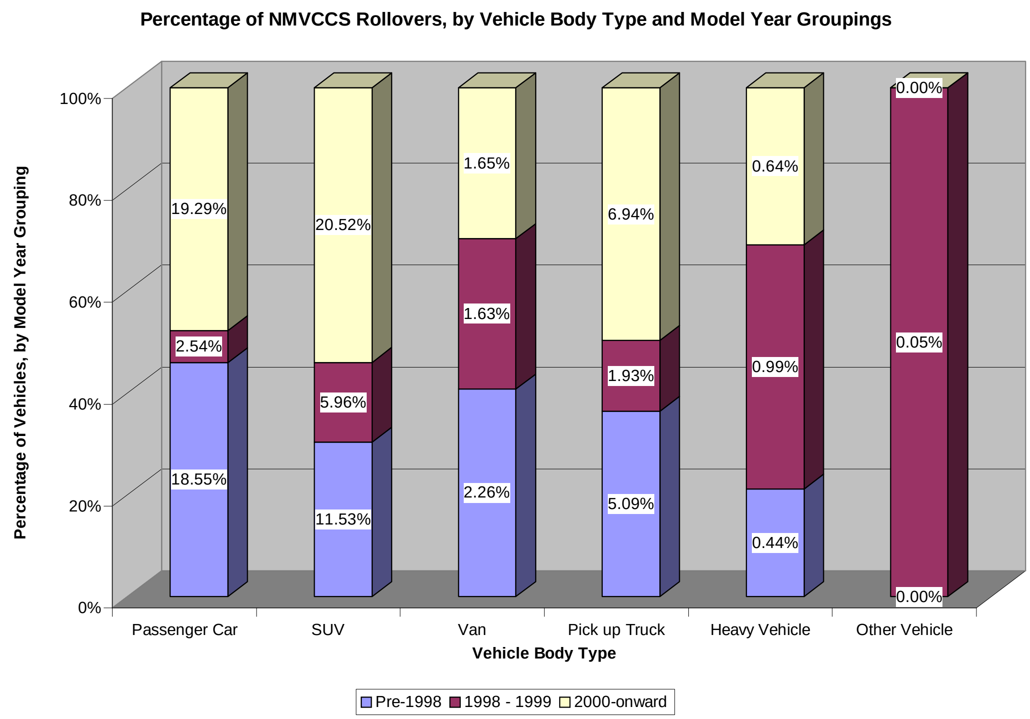


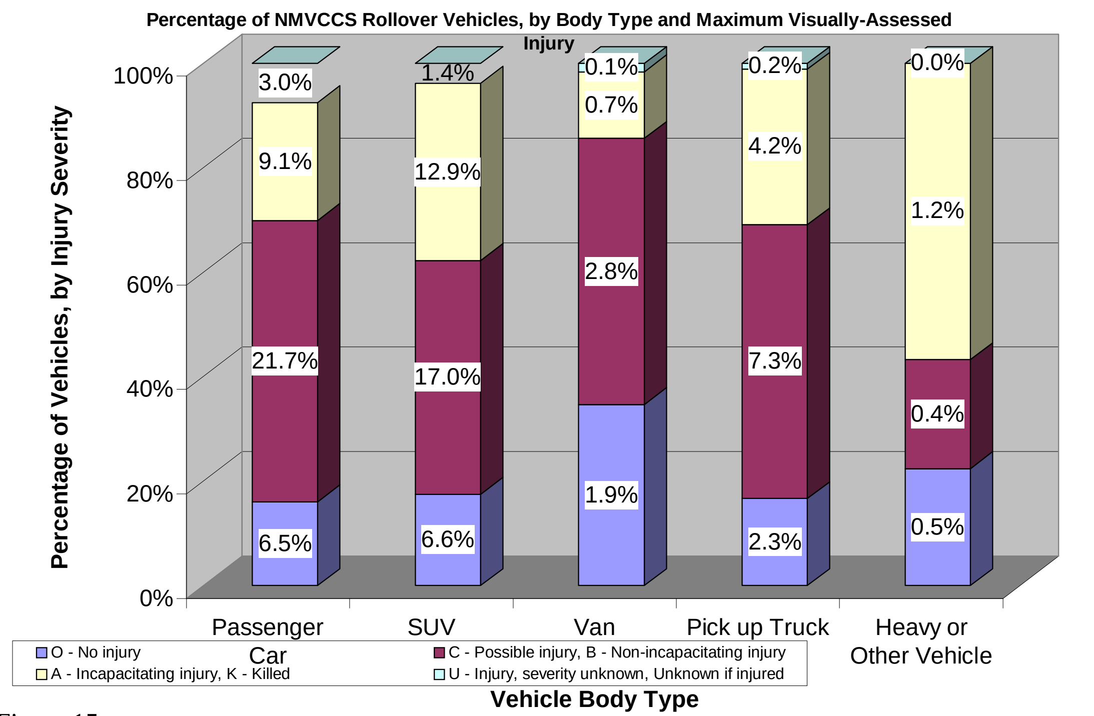
Figure 14.

Maximum Visually Assessed Injury Severity and Vehicle Body Type

A comparison of maximum visually assessed injury severity per rollover crash vehicle and vehicle body type was undertaken. Less than 18 percent of NMVCCS rollover vehicles transported uninjured occupants. Nearly a quarter of NMVCCS rollover vehicles had at least one occupant sustaining an incapacitating injury. Nearly 4 percent of NMVCCS rollover vehicles had at least one fatality. Nearly 80 percent of NMVCCS vehicles were split nearly evenly among passenger cars and SUVs. Nearly 20 percent of NMVCCS vehicles were passenger cars and SUVs transporting at least one incapacitated occupant. Of the 3.6 percent of NMVCCS vehicles transporting fatally injured occupants, 3.2 percent were transported in passenger cars and SUVs, with slightly over 2 percent traveling in passenger cars.

Table 16. Number of NMVCCS Vehicles sustaining Rollover, by Highest Injury Severity Reported in the Vehicle and Body Type, Weighted							
Injury Severity Reported in Vehicle	Passenger Car	SUV	Van	Pick up Truck	Heavy Vehicle	Other Vehicle	Total
O - No injury	29,607	30,269	8,757	10,604	2,110	220	81,566
C - Possible injury	51,103	37,176	5,731	13,076	1,689	0	108,776
B - Non-incapacitating injury	48,138	40,556	7,147	20,333	274	0	116,448
A - Incapacitating injury	31,045	54,791	3,107	17,311	5,341	0	111,595
K - Killed	10,531	4,106	119	1,634	0	0	16,389
U - Injury, severity unknown	4,516	4,295	56	658	0	0	9,526
Unknown if injured	9,332	2,263	345	51	0	0	11,990
Total	184,271	173,456	25,263	63,666	9,414	220	456,289

The weighted representation of passenger cars and SUV is nearly equivalent. Without benefit of significance testing, a slightly greater proportion of higher severity, incapacitating or fatal, injuries is noted for the SUV population when compared to passenger cars. With respect to uniquely heavy vehicles, however, seriously injured occupants are the most prevalent.



Percentage of NMVCCS Rollover Vehicles, by Body Type and Maximum Visually-Assessed Injury
Percentage of Vehicles, by Injury Severity
100%
80%
60%
40%
20%
0%
3.0%
9.1%
21.7%
6.5%
1.4%
12.9%
17.0%
6.6%
0.1%
0.7%
2.8%
1.9%
0.2%
4.2%
7.3%
2.3%
0.0%
1.2%
0.4%
0.5%
Passenger Car
SUV
Van
Pick up Truck
Heavy or Other Vehicle
O - No injury
C - Possible injury, B - Non-incapacitating injury
A - Incapacitating injury, K - Killed
U - Injury, severity unknown, Unknown if injured
Vehicle Body Type

Figure 15.

Rollover Roadway Geometry Generalizations

Speed Limit and Roof Contacts

The determination of travel speed prior to rollover or any crash is generally a mystery to those reconstructing the event. In the absence of EDR data, reliance must be given to police officer acumen and motorist assertions, while consideration is given to using a surrogate value. The surrogate value has been the travel speed owing to its standard on the roadway. The speed limits have been extended to roadway classification, as the first step of adding a roadside geometry back drop to the rollover crash occurrence.

Nearly 58 percent of NMVCCS vehicles that sustained a rollover ended in one or two quarter turns. Approximately 40 percent of vehicle rollovers occurred on roadway segments with posted speeds between 56 kph (35 mph) and 89 kph (55 mph). Slightly more than two percent of the vehicles reported to sustain rollover conditions were subject to rotation about the lateral axis. Just over one quarter of rollover crashes occur on moderate main arterial speeds, from 48 kph (30 mph) to 80 kph (50 mph). Slightly less than one quarter of rollovers occurred pursuant to one roof impact at moderate highway speeds, 89 kph (55 mph) to 105 kph (65 mph).

Table 17.
Number of NMVCCS Vehicles sustaining Rollover, by Speed Limit Range and Roof Contacts

Speed Limit Ranges (in kph)	Roof Contacts				Total
	Zero (1 Quarter Turn)	One (2,3,4, or 5 Quarter Turns)	Two Plus (6+ Quarter Turns)	End over End and Other	
24 - 40 Neighborhood Speeds	7,944	15,451	19	2,327	25,740
48 - 80 Main Arterial Speeds	67,995	130,659	20,529	2,467	221,651
89 - 105 Moderate highway speeds	28,378	108,280	20,133	4,769	161,561
113 + Higher highway speeds	2,312	30,265	10,564	476	43,616
Other Unknown	174	2,786	761	0	3,722
Total	106,803	287,441	52,007	10,039	456,290

The roadway speed limits associated with the roadway on which the crash occurred were extracted from NMVCCS. Based upon suggested AASHTO design characteristics, the speed limits were disaggregated into five roadway classifications. These included neighborhood streets, main arterials, two highway speeds, and other unknown. The moderate and higher speed demarcations were qualitative assessments. It is noted that as speed limit increases, a weak surrogate for travel speed, the number of roof contacts also increases. The previous assertion is made in the absence of significance testing.

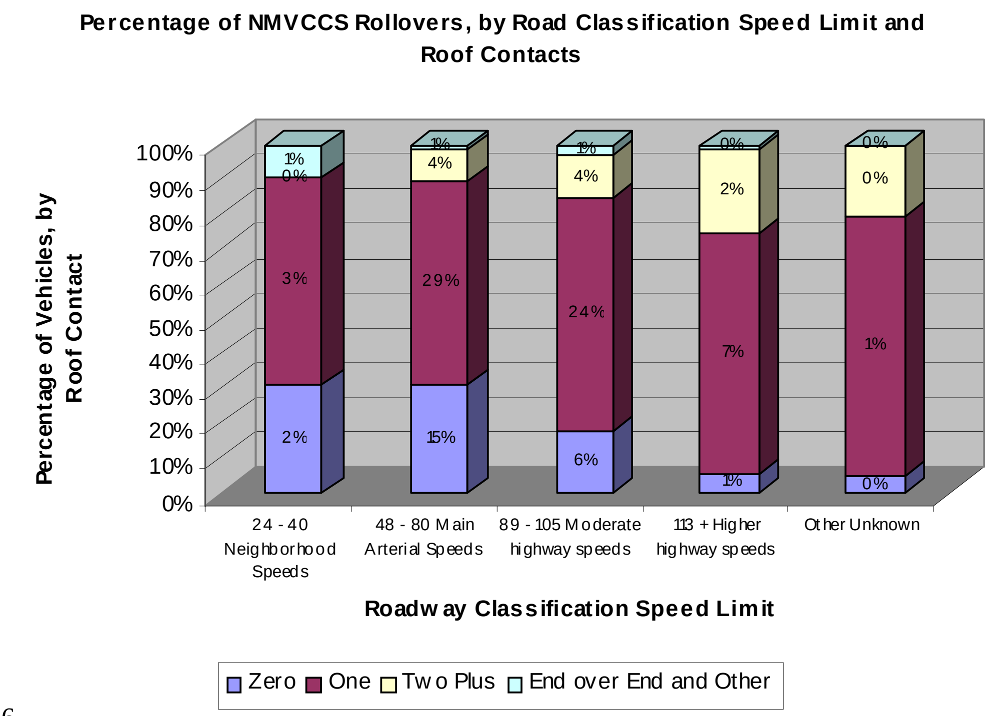


Figure 16.

Roadway Surface Condition and Roof Contacts

Approximately 80 percent of NMVCCS vehicles sustaining rollover were traveling on a dry surface. About 19 percent were subjected to some water-based conditions. The remaining rollovers were attributable to loose ground or unknown conditions.

Table 18.
Number of NMVCCS Vehicles sustaining Rollover Crashes, Surface Condition and Roof Contacts

Surface Condition	Roof Contacts: Zero (1 Quarter Turn)	One (2,3,4, or 5 Quarter Turns)	Two Plus (6+ Quarter Turns)	End over End and Other	Total
Dry	92,305	228,846	39,772	6,577	367,500
Wet	10,222	36,008	10,662	3,308	60,201
Standing water (1/4 inch or deeper)	453	2,097	0	153	2,704
Snow covered	220	892	89	0	1,201
Slush	174	1,075	0	0	1,249
Ice	3,365	18,115	437	0	21,917
Sand, dirt	0	0	1,047	0	1,047
Other/Unknown	65	406	0	0	471
Total	106,804	287,439	52,007	10,039	456,289

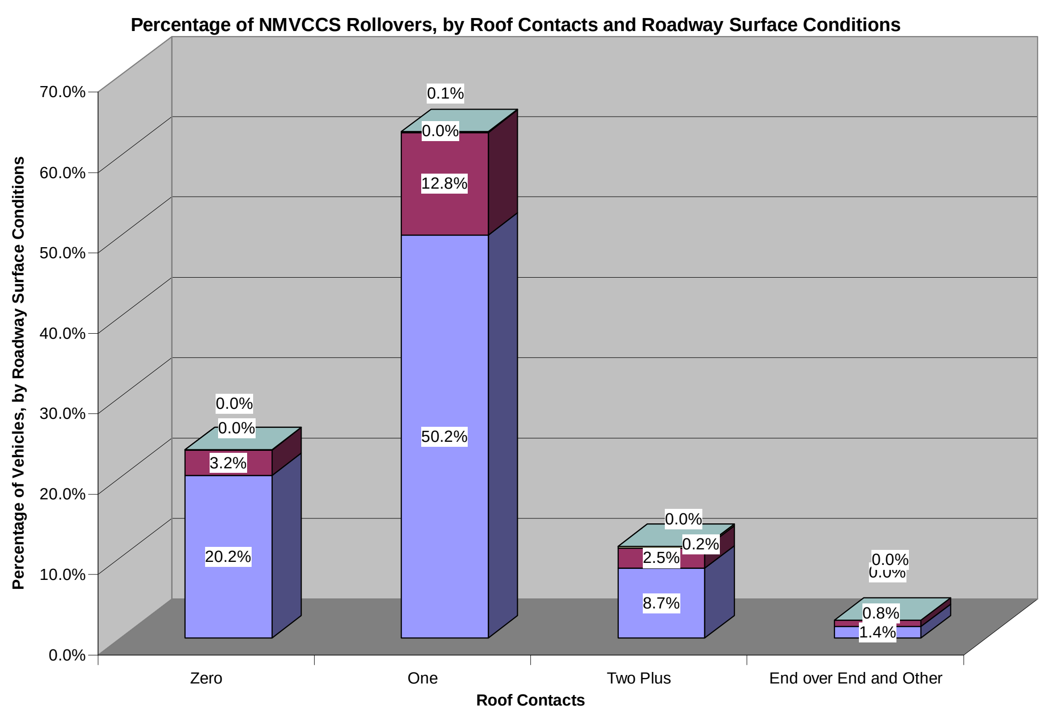


Figure 17.

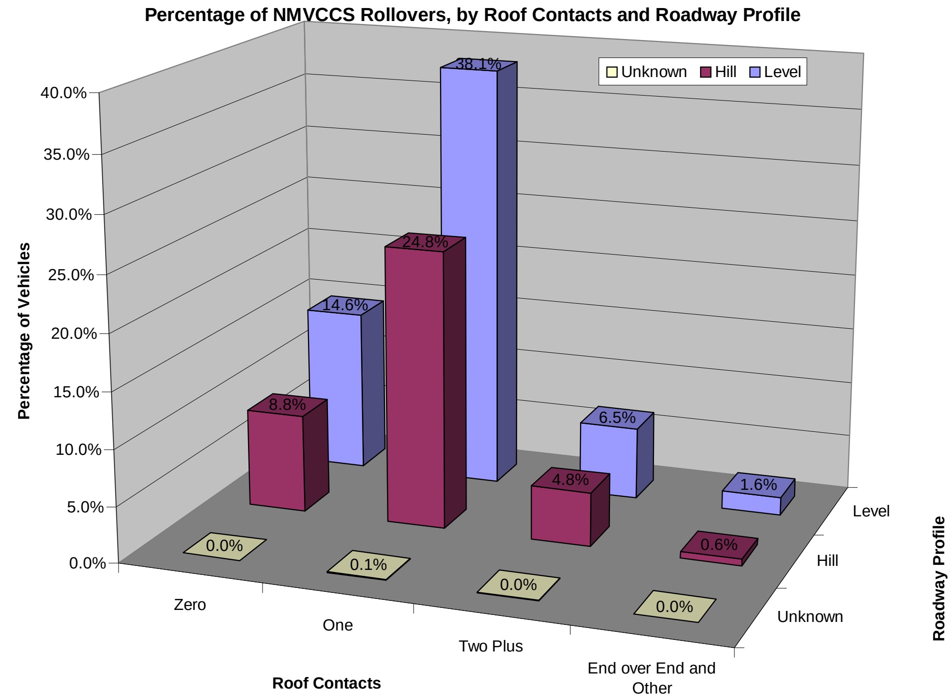
Roadway Vertical Profile and Roof Contacts

For further sense of the roadway geometry role in vehicle rollover crashes, NMVCCS collects roadway profile information, which has been summarized for purposes of this table.

Table 19.
Number of NMVCCS Vehicles sustaining Rollover, by Roadway Vertical Profile and Roof Contacts

Profile	Zero (1 Quarter Turn)	One (2,3,4, or 5 Quarter Turns)	Two Plus (6+ Quarter Turns)	End over End and Other	Total
Level	66,607	173,846	29,712	7,432	277,597
Hill	40,061	113,336	22,082	2,607	178,086
Unknown	136	258	213	0	607
Total	106,803	287,440	52,007	10,039	456,290

Nearly one quarter of NMVCCS rollover crashes occur on hills pursuant to one roof contact. Nearly 40 percent of NMVCCS rollover crashes terminate with one roof contact on level roadways. The percentage of rollover crashes occurring on hills suggests more external forces due to roadway geometry acting upon the vehicle and potentially, inducing rollover or worsening crash conditions. The incidence of rollover crashes occurring on hills is lower than rollover crashes occurring on a level roadway, which potentially experience less external forces due to roadway geometry.



Percentage of NMVCCS Rollovers, by Roof Contacts and Roadway Profile
Unknown
Hill
Level
Percentage of Vehicles
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
38.1%
24.8%
14.6%
8.8%
6.5%
4.8%
1.6%
0.6%
0.0%
0.1%
0.0%
0.0%
Zero
One
Two Plus
End over End and Other
Roof Contacts
Level
Hill
Unknown
Roadway Profile

Figure 18.

Radius of Roadway Curvature and Roof Contacts

Influential on vehicle handling, as well as sight distances, the radius of curvature is another element of roadway design that might aid in determining vehicle tolerance to certain inputs. Again, relationship is drawn for radius of curve and the various speeds. These put into perspective the interrelated design constraint upon which roadway geometry is developed.

The following table was developed using AASHTO approximations for roadway speeds for specified radii of curvature, a general equivalence was made for the speeds, roadway classifications, and recommended radii of curvature.

Approximately 60 percent of NMVCCS rollover crashes are listed classified as other or unknown. Nearly 30 percent of NMVCCS rollover crashes sustain rollover on roadways recommended radius of curvature for travel speeds of 48 kph (30 mph) - 80 kph (50 mph). Further, this recommendation is considered for main arterials. Among NMVCCS rollover crashes, 20 percent occurred at these main arterial speeds pursuant to one roof contact.

Table 20.
Number of NMVCCS Vehicles sustaining Rollover, by Radius of Curvature and Roof Contacts, Weighted

Radius of Curve, as a function of Design Speed and Classification	Zero (1 Quarter Turn)	One (2,3,4, or 5 Quarter Turns)	Two Plus (6+ Quarter Turns)	End over End and Other	Total
24 - 40 Neighborhood Speeds	7,029	2,199	509	537	10,273
48 - 80 Main Arterial Speeds	21,295	92,152	13,336	2,906	129,689
89 - 105 Moderate highway speeds	1,469	10,983	2,690	0	15,143
113 + Higher highway speeds	8,480	12,303	3,254	2,033	26,071
Other Unknown	68,531	169,803	32,218	4,563	275,115
Total	106,804	287,441	52,007	10,039	456,290

When considering only known crash radii of curvature, nearly three quarters of the vehicles fall into the main arterial classification, with over half of the rollover crashes sustained pursuant to the first roof contact. The radius of curvature reported in the NMVCCS was compared to the design radii of curvature to determine an idealized disaggregation by roof contacts.

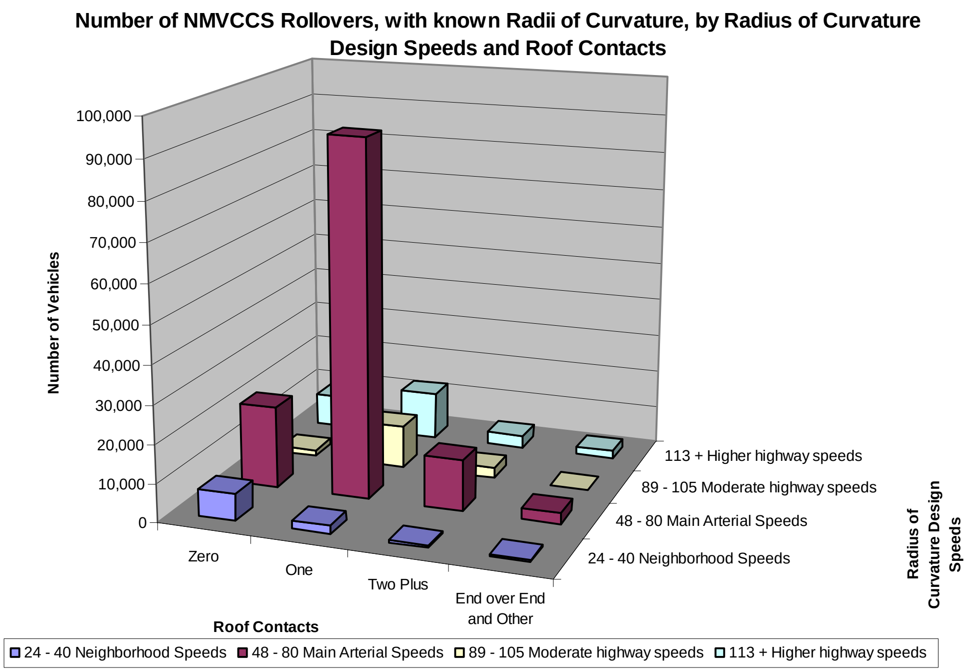


Figure 19.

Roadway Superelevation and Roof Contacts

Another component of roadway design is the superelevation, measured in relation to the crown of the road. Nearly 65 percent of NMVCCS rollover crashes are reported without superelevation parameters.

Table 21. Number of NMVCCS Vehicles sustaining Rollover, by Superelevation and Roof Contacts					
Superelevation	Zero (1 Quarter Turn)	One (2,3,4, or 5 Quarter Turns)	Two Plus (6+ Quarter Turns)	End over End and Other	Total
-8 - -7	361	1,467	0	0	1,828
-6 - -5	0	526	0	0	526
-4 - -3	0	541	552	0	1,093
-2 - -1	0	356	0	0	356
0	5,341	13,217	418	0	18,976
1 - 2	13,904	25,089	1,961	1,890	42,843
3 - 4	8,592	19,628	2,359	571	31,150
5 - 6	4,182	14,268	2,623	1,670	22,742
7 - 8	4,810	29,120	4,738	487	39,154
9 - 10	142	1,577	187	537	2,443
11 - 12	0	297	824	0	1,121
Other/Unknown	69,473	181,355	38,345	4,885	294,058
Total	106,804	287,441	52,007	10,039	456,291

Among known superelevations, more than one quarter of the NMVCCS rollover crashes occur at a superelevation of 1 - 2 percent. Further, approximately one quarter of the NMVCCS rollover crashes occur at a superelevation of 7 - 8 percent. Nearly 84 percent of rollover crashes occur at superelevations between 1 and 8 percent. It should be noted that the superelevation should be tempered by cross slope and varies by location in the country, owing to climatological conditions. As a frame of reference, a maximum superelevation is ten percent and the minimum cross slope 1 – 1.5%, which is generally employed in areas of benign roadway conditions induced by climate.

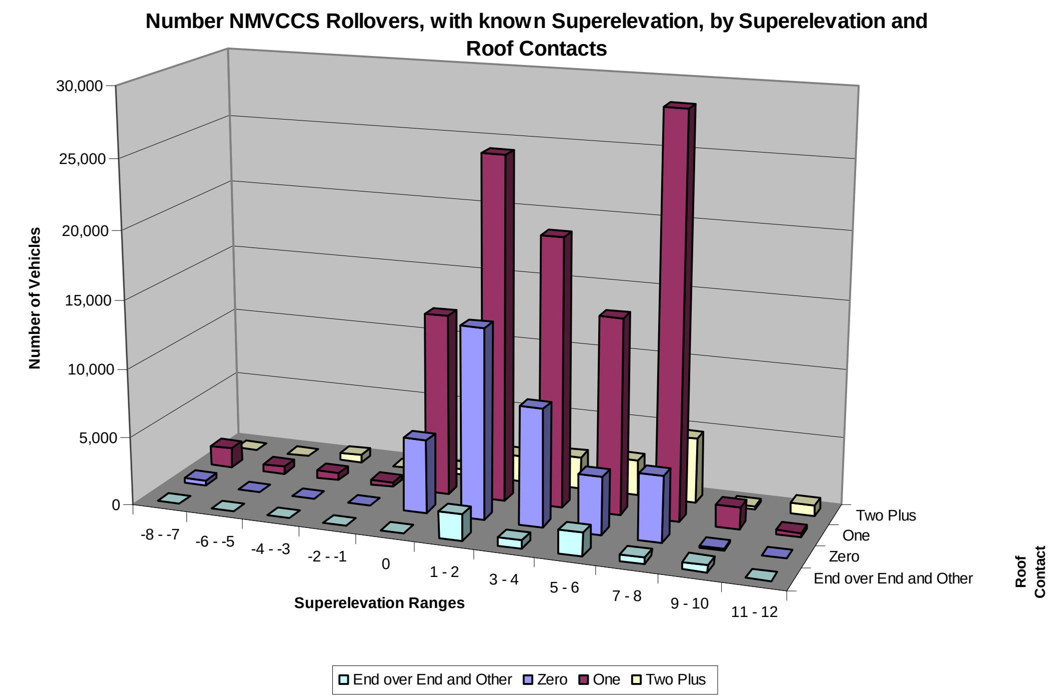

Number NMVCCS Rollovers, with known Superelevation, by Superelevation and Roof Contacts
Number of Vehicles
30,000
25,000
20,000
15,000
10,000
5,000
0
-8 - -7
-6 - -5
-4 - -3
-2 - -1
0
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11 - 12
Superelevation Ranges
Two Plus
One
Zero
End over End and Other
Roof Contact
End over End and Other
Zero
One
Two Plus

Figure 20.

Rollover Occupant Demography

Occupant Age and Role

Although fewer elements of occupant descriptors are reported in NMVCCS, as compared to the NASS CDS, a general demography of case vehicle occupants might be drawn. The following table disaggregates occupants into gross age bins corresponding very roughly to small child, moderate child, tween, adolescent, young driver, maturing driving, advancing age, and elderly. These are not terms supported in demography literature.

Table 22.
Number of NMVCCS Occupants, subjected to Vehicle Rollover, by Age and Role

Age Variable		Role		Total
Bin Size	Age Range	Driver	Passenger	
4	<3	0	27,482	27,482
6	4-9	0	43,737	43,737
2	10-11	0	3,325	3,325
4	12-15	90	17,716	17,805
9	16-24	157,162	68,442	225,604
31	25-55	227,772	69,075	296,847
14	56-69	36,992	13,476	50,468
19	70+	13,728	3,317	17,045
1	Unknown	20,545	13,738	34,283
90	Total	456,289	260,306	716,595

Nearly 30 percent of transported occupants subjected to rollover crashes are less than ten years old. Although gross age ranges more than a quarter of passengers are 16 - 24 years, with another quarter falling between 25 - 55 years. Older drivers account for less than ten percent of NMVCCS rollover occupants, potentially owing to lessened risk taking or hours of data collected, or self-regulation minimizing hours driven. Aging drivers exceed ten percent. None of these suppositions can be confirmed by NMVCCS. Instead these are generalities inherent to the demographic composition emerging over the past decade.

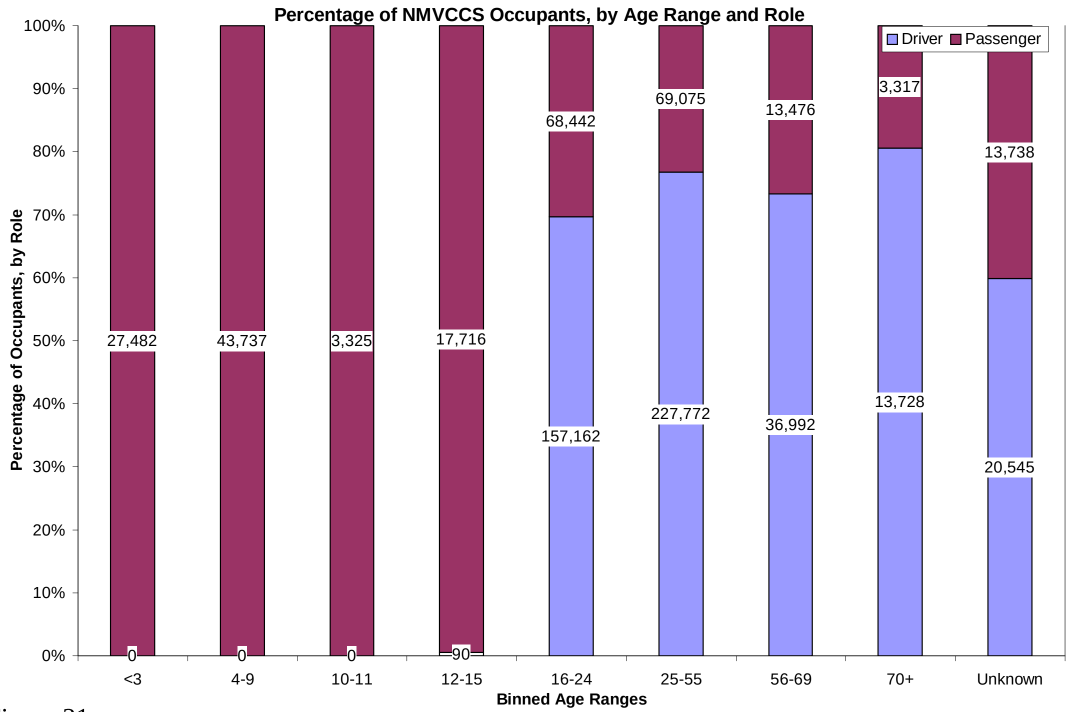


Figure 21.

Occupant Weight and Height

To make sense of various weight and height parameters, each variable was examined by gender. Further an equivalence of dummy size to Body Mass Index (BMI), based on tables compiled by The National Institutes of Health, with dummy-to-BMI equivalences suggested by NHTSA engineers specialized in biomechanics. BMI was applied to each height and weight table, respectively. From this, the following tables disaggregate the NMVCCS occupants by dummy corresponding BMI measurements. Please note that only known gender readings are noted in the figures below, as there is no dummy correspondence for unknown gender.

Table 23. Number of NMVCCS Occupants, subjected to Rollover Crash, by BMI based upon Weight alone and Gender					
Gross Weight Groupings		Gender			Total
Imperial (lbs)	Metric (kg)	Male	Female	Unknown	
<80 lbs	<36.4 kg	16,119	24,620	0	40,739
80-149 lbs	36.4 - 67.7	46,673	139,391	0	186,064
150-219	68.2 - 99.5	151,211	65,347	0	216,558
>220 lbs	100+	63,615	9,703	0	73,318
Unknown		112,401	76,488	11,028	199,917
Total		390,019	315,549	11,028	716,596

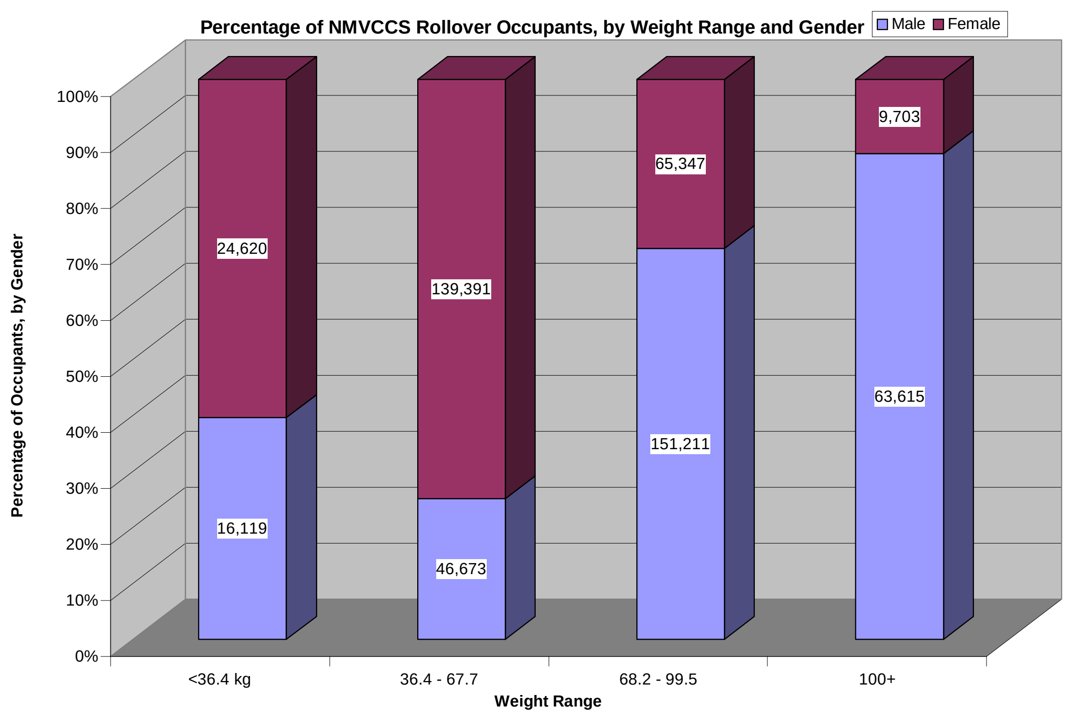


Figure 22.

In a very coarse look at generally accepted weight ranges for given age groups, slightly over a quarter of occupants register between 36 and 68 kilograms. One third of the occupants compose the 68 to 100 kilogram range. Approximately ten percent have a weight of 100 kilograms or greater.

Nearly half of the occupants register within the body dimensions covered by a 5th percentile dummy. An occupant between 147.3 and 172.7 centimeters falls within this range. Please recall that the weight is treated separately and for an accurate BMI reading the weight would also be considered. Of the remaining 50 percent, 14 percent of the occupants fell within the 50^{th} percentile range, 7 percent in the 95^{th} percentile range, and 28 percent were of unknown BMI composition, as reported by height.

Table 24.
Number of NMVCCS Occupants, subjected to Rollover Crash, by BMI based upon Height alone and Known Gender

	Gender	
BMI based upon Height	**Male**	**Female**
Off BMI Scale, <147.3 cm (58 inches)	7	1,130
5th Percentile, 58 cm (147.3 in) - 68 cm (172.7 in)	130,687	227,577
50th Percentile, 69 cm (175.26) - 73 cm (185.42)	90,837	6,490
95th Percentile, >74 cm (187.96 in)	50,972	0
Unknown	117,516	80,351
Total	390,019	315,548

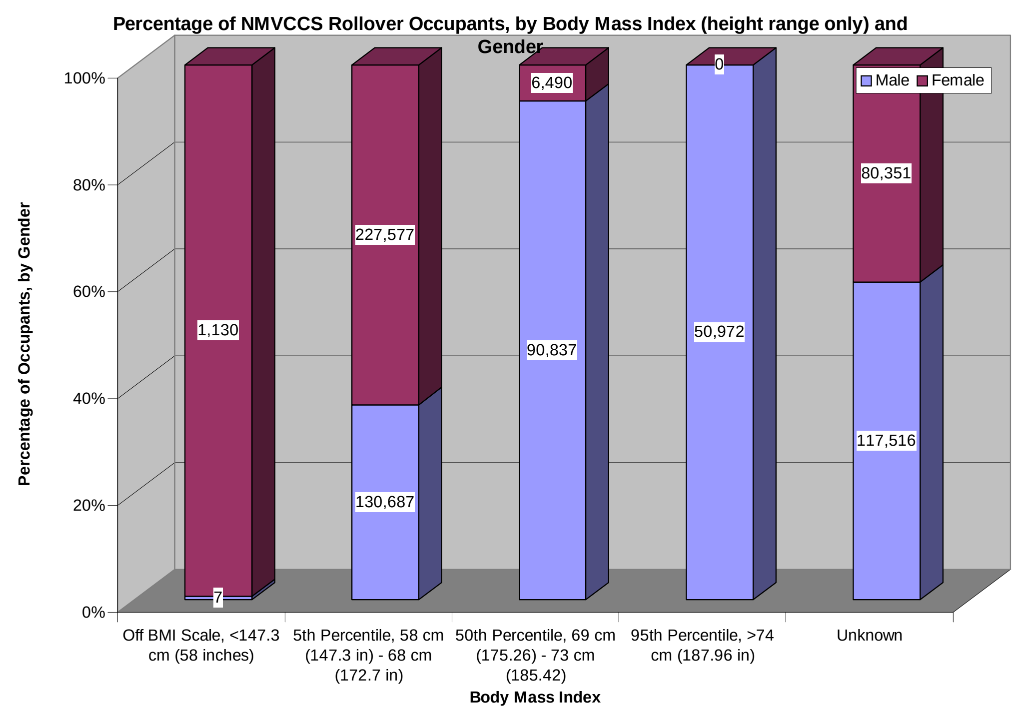


Figure 23.

Seating Position

Over 64 percent of NMVCCS rollover crash occupants are drivers. Drivers sustain over 15 percent of serious and fatal injuries, as a consequence of their magnitude. The next highest occupancy is for the front row right passenger seat, with over 16 percent. Nearly 18 percent of occupants were seated in a rear seating position. Nearly 30 percent of occupants were uninjured. Nearly 45 percent of NMVCCS rollover occupants sustained some injury of consequence. Nearly 70 percent of NMVCCS rollover occupants sustained some form of injury.

Table 25.
Number of NMVCCS Occupants, Subjected to Rollover Crash, by Seating Position and Injury Severity

Occupant Seating Role or Row	Occupant Injury Severity (KABCOU rating)				
	O - No injury	C - Possible injury, B - Non-incapacitating injury	A - Incapacitating injury, K - Killed	U - Injury, severity unknown, Unknown if injured	Total
Driver	111,564	215,258	110,766	22,298	459,886
Front, Nondriver	35,455	48,850	28,720	2,879	115,904
Second	51,765	43,389	9,447	2,726	107,328
Third	1,607	1,682	1,096	0	4,385
Fourth	0	0	0	0	0
Fifth	0	173	0	0	173
Other or Unknown	5,368	10,928	4,272	8,353	28,921
Total	205,759	320,280	154,302	36,256	716,597

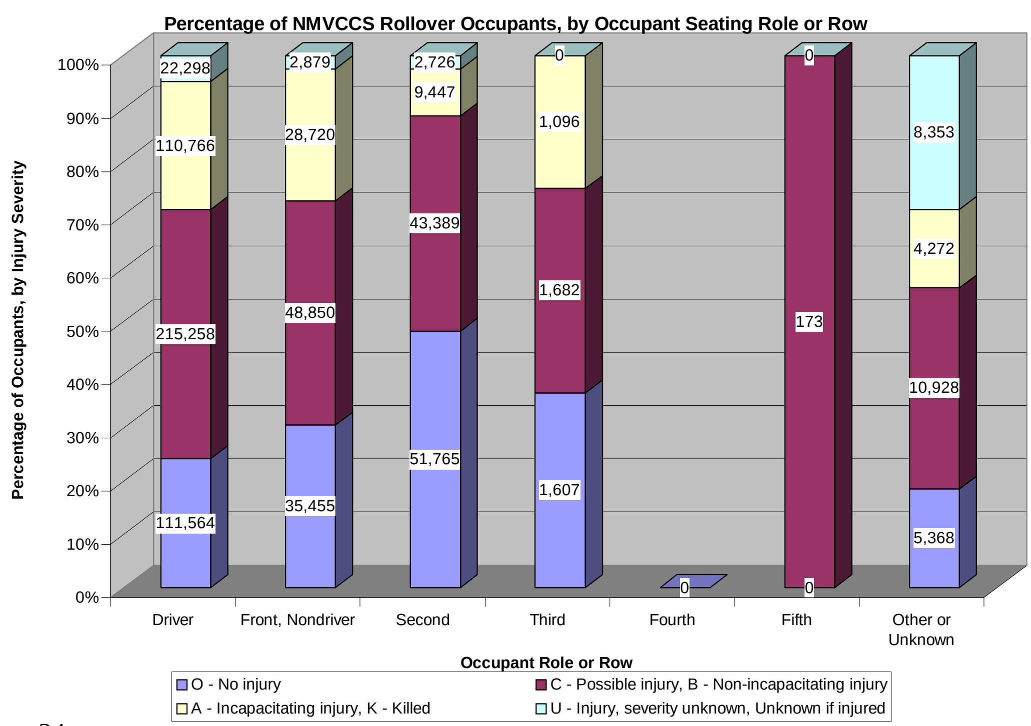


Figure 24.

Visually Assessed Injury Severity and Occupant Outcome

Nearly 60 percent of NMVCCS rollover occupants were transported from the scene to receive medical treatment. Approximately two percent of the decedents were transported to receive medical treatment. Over half of the NMVCCS rollover occupants were injured in some form and were transported to receive medical attention. Nearly 40 percent of the NMVCCS rollover occupants received an injury of consequence and were transported. Nearly 30 percent of NMVCCS rollover occupants received no visually identifiable injury and were not transported.

Table 26.
Number of NMVCCS Occupants, subjected to Rollover Crash, by Transport Status and Injury Severity

Is occupant transported to a treatment facility from the scene?	Occupant Injury Severity (KABCOU rating)							Total
	O - No injury	C - Possible injury	B - Non-incapacitating injury	A - Incapacitating injury	K - Killed	U - Injury, severity unknown	Unknown if injured	
Yes	15,322	122,490	127,522	130,288	13,658	11,937	5,590	426,808
No	190,437	45,382	23,661	1,845	8,511	1,013	15,845	286,694
Unknown	0	778	445	0	0	144	1,727	3,095
Total	205,759	168,651	151,628	132,133	22,169	13,094	23,162	716,596

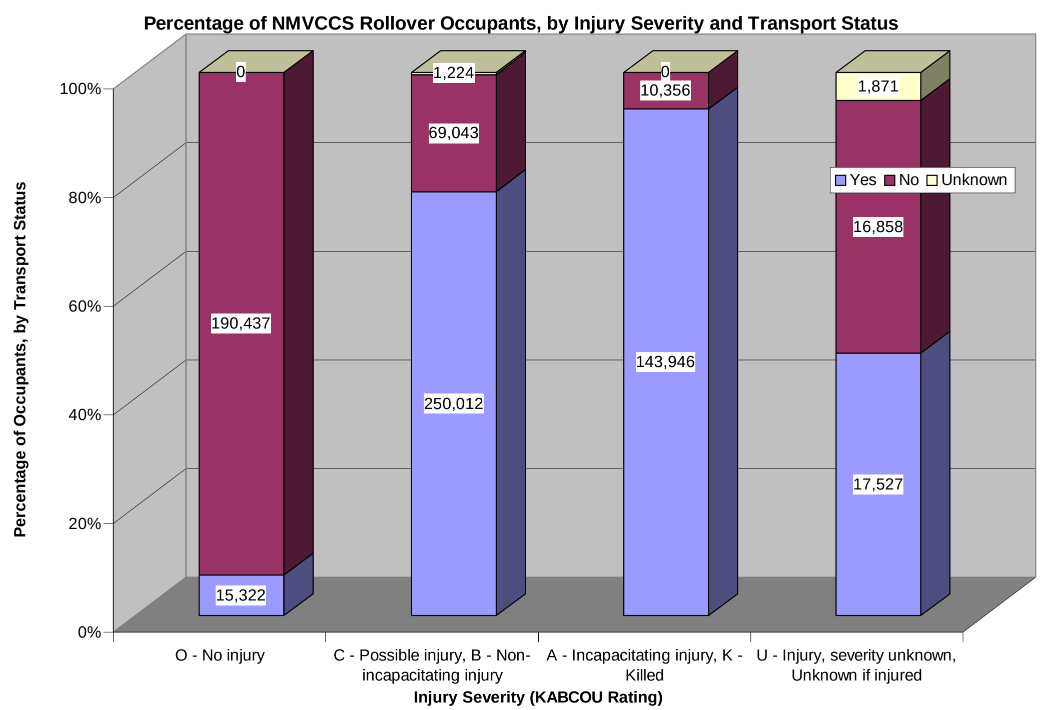


Figure 25.

Table 27. Number of NMVCCS Occupants, subjected to Rollover Crash, by Transport Status and Injury Severity					
Age Variable		Transport			Total
Bin Size	Age Range	Yes	No	Unknown	
4	<3	11,475	16,007	0	27,482
6	4-9	22,813	20,925	0	43,738
2	10-11	1,937	1,388	0	3,325
4	12-15	10,016	7,789	0	17,805
9	16-24	135,801	88,812	991	225,604
31	25-55	189,919	106,694	233	296,846
14	56-69	40,174	10,294	0	50,468
19	70+	13,366	3,679	0	17,045
1	Unknown	1,305	31,107	1,871	34,283
90	Total	426,807	286,694	3,094	716,596

When studying each age range, the transport status becomes more pronounced. With the advance of age, those transported increases. This is noted without benefit of a significance test.

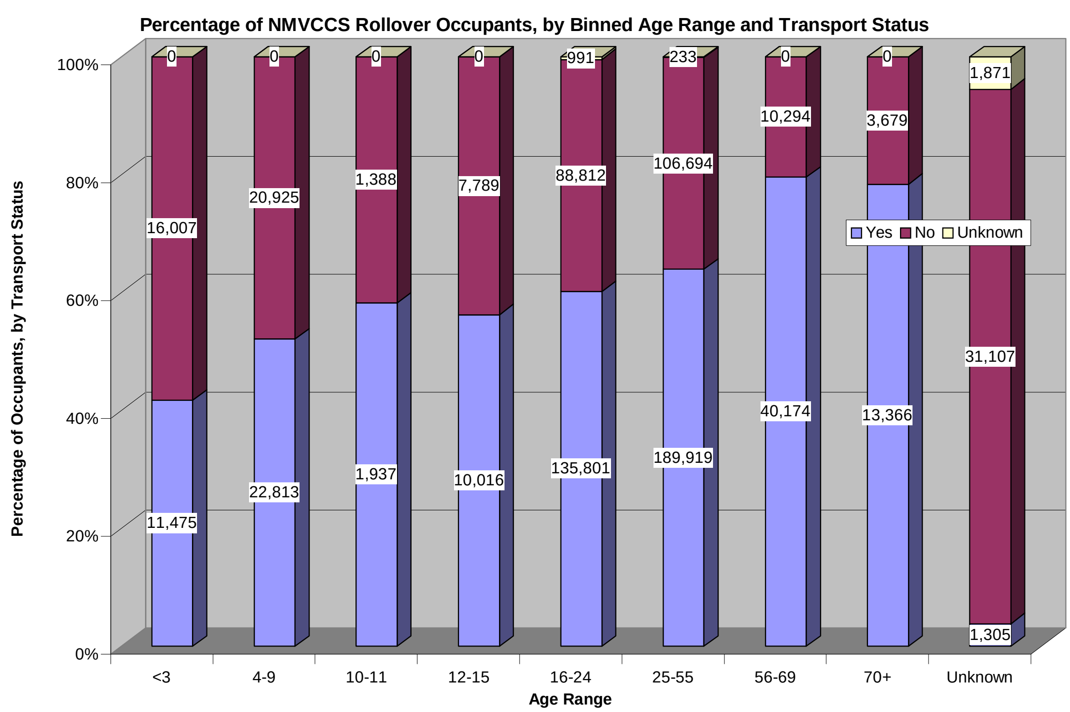


Figure 26.

Conclusions

From an initial review of NMVCCS, many important elements are being collected to advance the understanding of rollover crashes. In the absence of on-board cameras, occupant monitoring technologies, and limitless EDR output for all vehicle readings, the NMVCCS allows the NASS researcher to review a virtually unspoiled crash scene and attain behavioral information to understand the occupant inputs and responses to crash scene events.

In an attempt to use model year as a surrogate for vehicle protective equipment, three model groupings have been selected. Those vehicles produced before model year 1998, might be grouped as the older generations, have vehicles pervasively lacking advanced air bag protection and modern safety belt technologies. The model years 1998 through 1999 model years might be considered the threshold for modern technology introduction. The final grouping, model year 2000 onward, might be considered the time of pervasive introduction of safety technologies.

For the purposes of crashworthiness research support, NMVCCS information may provide a greater understanding of the rollover crash problem. First, a more modern crash fleet has been sampled with nearly 50 percent of the vehicles produced after 1999. Also, measures have been added, such as estimated rollover distance. With this, the EDR information has been obtained for ten percent of the vehicles. It is speculated that most, if not all, of the EDR readings will not contain the needed side rollover technology data. For the external reviewer, this is noted as a function of vehicle technology and manufacturer cooperation not a deficiency in NMVCCS data collection.

As a final note, the review of NMVCCS with the frame work of roadway design was meant to show the value added by the data collection protocols. This was not meant as an analysis of roadway design and rollover causation. This would not be possible based upon the need to know very specific information for the roadway segment on which the rollover occurred and a nearly meaningless attempt to try to aggregate the roadway segments by common elements, based upon sample size. Roadway segments are generally a careful mix of design parameters potentially unique to an area of the country, climatological elements, or roadway vehicle composition and local driving habits. To date, an exhaustive interrelationship has never been drawn from Federal Highway Administration and State roadway inventories, applicable injury data sources, vehicle composition and the geometry resident on those roadway segments. Upon collection, EDR data would be absent, as the acquisition of EDR data is strictly controlled. For this reason, the roadway geometry information is used to provide some external context for rollover crashes beyond the vehicle and occupant levels.

Next Steps

Of the 1,089 rollover crashes described in this paper, 103 crashes had successfully harvested EDR data from the case vehicle. This provides an opportunity to extend the understanding taken from NASS CDS by looking at a newer vehicle pool.

At present, three reviewers will undertake the review of cases with EDR data. These cases are deemed to have the most complete information approaching the goal of populating rollover crash reconstruction models. These results will be reported, as an extension to this report or possibly on their own, if the findings merit.

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