CAR-TRUCK CRASHES IN THE
NATIONAL MOTOR VEHICLE CRASH CAUSATION STUDY

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ABSTRACT

The National Motor Vehicle Crash Causation Survey (NMVCCS) provided in-depth investigative data on pre-crash factors and other characteristics of 5,470 crashes involving light passenger vehicles (“cars”). Within the dataset, 199 crashes, representing 79,721 crashes nationally, were collisions between cars and large trucks. Although only 3.6% of the NMVCCS, this data subset is a significant source of information about the genesis of car-truck crashes. This includes variables relating to crash configurations, critical reasons, associated factors, and conditions of occurrence. Findings supplement and generally corroborate those from the Large Truck Crash Causation Study. However, NMVCCS data are more recent and represent a wider range of crash severities. Cars were more likely than trucks to be the encroaching vehicle in car-truck collisions. Overall, 71.0% of assigned Critical Reasons (CRs) were to the car. Cars were more likely to be out-of-control prior to impact and to violate rights-of-way. Associated driver factors relating to impairment or aggressive acts were assigned more frequently to car drivers. Trucks were more likely to be assigned vehicle-related CRs and associated factors, however. Nationally, about 80% of truck-related fatalities occur in car-truck crashes. Understanding their genesis is essential for the development of effective countermeasures.

INTRODUCTION

In 2010, 76% of fatal crashes and 80% of injury-causing crashes involving large trucks were collisions with other vehicle in transport (1). Most were light passenger vehicles, including cars, SUVs, light trucks, and vans. In 2009, 80% of truck crash-related fatalities occurred in truck-light vehicle crashes; of these, 94% were occupants of the light vehicles. The motoring public pays a high toll from crashes involving large trucks, and the burden on the trucking industry is also high. Car-truck crashes create high liability exposure and business risk for trucking companies, even in crashes where the primary fault is not with the truck or its driver. For the people involved, experiencing a serious crash is a shattering, life-altering event, regardless of how the crash occurs or who is responsible.

Given the human and economic impact of these crashes, it is essential to understand how and why they happen. In 2001-2003, the National Highway Traffic Safety Administration (NHTSA) and the Federal Motor Carrier Safety Administration (FMCSA) collected data for the Large Truck Crash Causation Study (LTCCS), which remains the most extensive in-depth investigation into large truck crash genesis (2). Yet LTCCS data has its limitations. The LTCCS investigated only the most serious 11% of large truck crashes, those classified by the police as either K (person killed in the crash), A (incapacitating injury), or B (non-incapacitating) in the “KABCO” police-reported crash severity scale. It did not include C (possible injury) or O (no injury) crashes, which constitute the majority. In addition, LTCCS data collection ended on December 31, 2003, four days before the onset of new truck driver Hours-of-Service (HOS) rules which, among other changes, required two additional
off-duty hours daily. While the LTCCS crash sample of 967 crashes (492 of which were
two-vehicle) exceeds any other in-depth truck study, it still does not provide final answers to
many causation questions. Supplemental information sources are helpful.

The NMVCCS, conducted by NHTSA between 2005 and 2007, provides truck crash
causation information that is complementary to the LTCCS. The study reported in-depth
investigations of 5,471 crashes, all involving light passenger vehicles and 199 involving both
a light passenger vehicle and a large truck (3). The NMVCCS investigated no crashes
occurring between midnight and 6 a.m., but, importantly for trucks, it was conducted after the
major HOS changes implemented in early 2004. Most notably, the NMVCCS adds to our
knowledge of large truck crash causation because it included crashes of all “KABCO”
severity levels. This paper reviews 21 causation-related variables describing these 199 car-
truck crashes. It focuses on relative “fault” in car-truck crashes and on specific driver errors
and other failures precipitating the crashes. For simplicity, medium and heavy trucks,
including both single-unit and combination-unit trucks of greater than 10,000lb. Gross
Vehicle Weight Rating (GVWR), are simply called “trucks.” Light passenger vehicles,
including cars, SUVs, light trucks, and vans, are simply called “cars.”

REVIEW OF PAST STUDIES

Multi-Vehicle Crash Scenarios

The public and news media often refer to “truck accidents” in a monolithic way, with little
differentiation among types and causes, nor mention of other involved vehicles. Yet crash
statistics reveal that crashes develop through many different scenarios. Multi-vehicle crash
types of principal concern in truck safety include rear-end crashes (both truck-striking and
truck-struck), lane change/merge crashes, crossing path crashes (e.g., straight crossing paths,
left-turn across path), and head-on crashes (4, 5). Rear-end crashes are the most common
multi-vehicle crash scenarios, and include two distinct types based on location and causation:
lead vehicle stopped and lead vehicle moving. Lane change/merge crashes (often resulting in
same-direction sideswipes) are notable for trucks because limited side visibility leaves trucks
vulnerable to them. Compared to cars, trucks are most overrepresented in this crash type.
Crossing path crashes, usually occurring at intersections, are common and often result in
high-deceleration angle impacts. Head-on crashes are the highest-severity multi-vehicle
crash type but resemble single-vehicle crashes in their etiology.

Causes of Multi-Vehicle Truck Crashes

Although multi-vehicle crashes are themselves varied, as a class they differ from single-
vehicle crashes. LTCCS analyses (5, 6, 7, 8) have compared truck multi-vehicle and single-
vehicle crashes, finding sharp differences. Multi-vehicle crashes most often reflect errors
made by drivers in their interactions with other vehicles in traffic. Drivers fail to see other
vehicles, or respond incorrectly to their presence. In crash causation research, the Critical
Reason (CR) is “the immediate reason for [the] event and is often the last failure in the causal
chain” leading to the crash (9). Notable CRs in the LTCCS included driver inattention
(including distraction), inadequate surveillance, excessive speed, following too closely, and
illegal maneuvers. Frequent single-vehicle crash CRs included excessive speed (even more
commonly than in multi-vehicle crashes), asleep-at-the-wheel, vehicle failures, inattention, and response execution errors such as overcompensation. When the CR profiles of LTCCS multi-vehicle truck-CR, multi-vehicle car-CR, and truck single-vehicle crashes were compared, the two multi-vehicle types resembled each other far more than either resembled single-vehicle crashes (7). In other words, the same types of driver errors (and other failures) led to multi-vehicle crashes, regardless of the vehicle where the failure occurred. Single-vehicle crashes resulted from a different profile of errors, even though certain CRs were common in both.

Single-vehicle vehicle crashes most often involve loss of vehicle control resulting from driver misbehavior (e.g., speeding) and/or impairment (e.g., fatigue, illness). Truck driver involvements in single-vehicle crashes suggest higher future risk than involvement in multi-vehicle crashes, even those multi-vehicle crashes where the truck driver is deemed “at fault” (5, 7, 8).

Head-on crashes are an exception to the above generalizations; they resemble single-vehicle crashes more than other multi-vehicle crashes (5, 8). Few head-on crashes involve controlled maneuvers like passing; rather, they usually involve loss of vehicle control and unplanned lane departures (4, 5, 10). In many respects they differ from single-vehicle crashes only in the direction of the lane departure.

Oddly, perhaps, the CR profile for LTCCS truck single-vehicle crashes was more similar to the car-CR profile than to the truck-CR profile for multi-vehicle crashes (7). In other words, when car driver errors resulted in collisions with trucks, those errors sometimes resembled single-vehicle crash errors.

“Fault” Allocation in Car-Truck Crashes

The word “fault” is anathema to many traffic safety researchers, and most crash research datasets avoid its use or explicitly disavow it (9, 11, 12). Researchers prefer euphemisms such as “vehicle assigned the CR” or “vehicle with identified driver factors” to the blunt phrase “at-fault.” “At-fault” is considered simplistic and too easily confused with legal culpability. Nevertheless, nearly every crash results from a discrete precipitating error from one of the involved drivers, or from some other catastrophic failure originating in one vehicle. Understanding of relative “fault” in car-truck crashes is important and heuristic because it is a first step in determining where to direct resources toward reducing them.

Studies have consistently found principal “fault” to lie with the car driver in the majority of fatal car-truck crashes (5, 12, 13, 14, 15). The University of Michigan Transportation Institute (UMTRI) examined more than 8,000 fatal car-truck crashes occurring in the years 1994-1996 (12, 13). Crash records did not identify CRs, but they did identify driver factors such as “too fast for conditions” and “failure to keep in lane.” Driver factors were assigned to car drivers only in 71% of crashes, to truck drivers only in 16%, and to both drivers in 10%. Separately, the car driver total was 81%, versus 26% for truck drivers (13). FMCSA’s published statistics for recent years are nearly identical.

One interpretation of these fatal crash statistics is that they reflect the story of the driver surviving the crash (overwhelmingly the truck driver) and not true events. To address this possibility, UMTRI looked at 1,245 fatal crashes in which both drivers survived, but someone else was killed. In 73% the car driver was cited with a factor, versus 34% of the
truck drivers (13). Analysts also looked at crash trajectories and associated physical
evidence. Cars were the encroaching vehicles in 89% of head-on crashes, 88% of opposite
direction sideswipes, 80% of rear-end crashes, and 72% of same-direction sideswipes. A
more recent and even larger NHTSA analysis (15) had similar findings. An AAA Safety
Foundation study (16) of fatal car-truck crashes reported that 36% of car drivers were cited
for multiple driver factors, versus 11% of truck drivers.

Some studies have suggested that the proportion of cars “at-fault” in car-truck crashes
is lower for less severe crashes. In LTCCS car-truck crashes (which included K, A, and B
severity levels), 56% of CRs were assigned to the car. Among all LTCCS multi-vehicle
crashes (i.e., any crash with two or more vehicles), CR assignments varied with severity; the
other vehicle was assigned the CR in 77% of K, 63% of A, and 54% of B truck involvements
(10). A North Carolina study looked at 26 possible contributory factors cited in 16,264 PARs
of all KABCO severities. Based on these, the study classified “fault” as 40% car only, 48%
truck only, 9% both vehicles, and 3% neither vehicle (17). An almost even car-truck split of
41%-42% was reported for 2001-2005 Michigan PARs of all severities (18).

Comparison of Factors in Car-Truck Crashes

Two questions arise in considering CRs and other factors involved in the genesis of car-truck
crashes. First, are car- and truck-related causal profiles similar? Car and truck percentages
were similar for many factors cited in the LTCCS (6, 18). This included CRs such as
inattention (including distraction), excessive speed, illegal maneuvers, gap misjudgement,
and false assumption (6). Differences were notable, however. Contrasting CRs included the
following:

- Vehicle-related failure (all types): 7% of trucks, 4% of cars;
- Following too closely: 8% of truck drivers, 1% of car drivers;
- Asleep-at-the-wheel: 1% of truck drivers, 9% of car drivers;
- Heart attack or other physical impairment: 2% of truck drivers, 6% of car drivers.

Some associated factors differed for LTCCS car and truck drivers in their crashes;
these included (18):

- Brake problems: 27% of trucks, 2% of cars
- Driver unfamiliarity with roadway: 19% of truck drivers, 10% of car drivers
- Driver felt under work pressure: 10% of truck drivers, 3% of car drivers
- Driver fatigue: 7% of truck drivers, 15% of car drivers
- Aggressive driving: 5% of truck drivers, 9% of car drivers
- Driver illegal drugs: 0.4% of truck drivers, 7% of car drivers
- Driver alcohol use: 0.3% of truck drivers, 9% of car drivers.

A second question is whether car-truck crashes differ greatly from the larger body of
two-vehicle crashes. The AAA Safety Foundation study (16) analysed more than 45,000
1995-1998 fatal crashes to compare driver actions and factors in car-truck crashes to those in
car-car crashes. The study identified 94 different (though overlapping) driver actions and
factors. Examples included road departure, failure to yield, excessive speed, inattention,
reckless driving, specific illegal maneuvers, loss-of-control, and driver fatigue.

Overwhelmingly, factors were statistically equal in the two crash type distributions. Just 4 of
the 94 factors were found to be more frequent in car-truck crashes, and all were more likely
to be cited for the car than for the truck. They included:

- Following improperly
- Drowsy/fatigued driving
- Improper lane changing
- Vision obscured by weather conditions (e.g., rain, fog).

THE NATIONAL MOTOR VEHICLE CRASH CAUSATION STUDY (NMVCCS)

NMVCCS findings are based primarily on 5,471 crashes investigated between July 3, 2005
and December 31, 2007. To qualify, a crash had to involve at least one light passenger
vehicle which was towed due to collision damage. In addition, an emergency medical squad
had to be dispatched to the crash, even if there turned out to be no actual injury. This is a
higher severity threshold than regular police reporting, and thus the NMVCCS sample has
more high-severity crashes than are found in Police Accident Report (PAR) based datasets
such as the General Estimates System (GES). On the other hand, the severity threshold was
lower than that of the LTCCS, which required a serious K, A, or B occupant injury.

Because NMVCCS investigators were “on scene,” they had relatively undisturbed
access to crash evidence and were generally able to discuss the circumstances of the crash
there with drivers, passengers, and witnesses (3). The most important causation variable
discerned was the CR, which was assigned to just one vehicle (or its driver) in multi-vehicle
crashes. The CR taxonomy was very similar to that used in the LTCCS, thus permitting
comparisons between the datasets. Approximately 600 other variables captured crash
conditions of occurrence, other pre-crash events, and associated factors. Like the LTCCS,
the NMVCCS used causal variables similar to those originally used in the Indiana Tri-Level
Study (19). It used descriptive variables similar or identical to those in GES and FARS.

Both the LTCCS and NMVCCS coded factors associated with crashes, but they used
different criteria. LTCCS documentation (D, E) explicitly disclaims any necessary causative
role for associated factors: “No judgment is made as to whether the factors are related to the
crash. Investigators objectively record the presence or absence of the various items.” (17). In
the NMVCCS, a “crash-associated factor” was one that was “likely to add to the probability
of crash occurrence . . . “ (3). In other words, associated factors in the NMVCCS were
deemed to have contributed to the crash, whereas in the LTCCS they were merely present.

The need for on-scene investigations limited the NMVCCS sample to only those
-crashes occurring between 6 a.m. and midnight (3). In the LTCCS, 13% of multi-vehicle
-truck crashes occurred during these overnight hours (10), suggesting that the exclusion of
overnight crashes did not greatly reduce the number of car-truck crashes. Yet it did result in
an underrepresentation of factors associated with overnight driving, in particular driver
fatigue (for both car and truck drivers) and alcohol use (for car drivers). The exclusion might
have slightly reduced relative CR assignments to cars; in LTCCS multi-vehicle crashes,
trucks were assigned the CR 41% in of their 6 a.m. to midnight multi-vehicle involvements,
but in only 32% of their overnight involvements (10).

To generate nationally representative estimates, the NMVCCS used multi-stage
probability sampling similar to that in the Crashworthiness Data System (CDS) and the
LTCCS. Sampling locations were based on geography and urbanization. The 24 sampling locations were the same as those in the CDS and LTCCS. Random samples of specific crashes were based on their day and time of occurrence. Case weights permitting national estimates were inversely related to selection fractions. As with any sampling methodology, NMVCCS estimates are subject to sampling error, with errors relatively higher for lower-frequency events. The NMVCCS *Analytical Users Manual (10)* and other documentation (3) provide more information on crash selection criteria, sampling, and weighting.

**METHODOLOGY**

Out of 5,471 crashes documented in the NMVCCS, 3,230 involved two vehicles (3) and, of these, 199 crashes involved a car and a truck. The weighted estimate of 79,721 car-truck crashes represented 3.6% of all NMVCCS crashes and 6.4% of its two-vehicle crashes. These 199 car-truck crashes were the subject of this study. For some variables, related attributes are aggregated in the tables below. When attributes were aggregated, individual attribute numbers are shown; otherwise, they are omitted. For any given specification, two numbers are provided: the number of cases (out of 199) meeting the criteria and the weighted national number of crashes represented. Also provided is the weighted crash percentage based on a denominator of 79,721. All NMVCCS percentages provided in this report are based on *weighted* values only. Most tables provide the following values for each attribute:

- **C#** - Number of car (light passenger vehicle) cases
- **CW** - Estimated national car weight per NMVCCS sampling and weighting algorithms
- **CW%** - Above value divided by 79,721 and stated as a percentage.
- **T#** - Number of large truck cases
- **TW** - Estimated national truck weight
- **TW%** - Above value divided by 79,721 and stated as a percentage.

Consistent with NHTSA practice in other NMVCCS reports, and most traffic crash reporting, sampling errors are not provided. The reader should be aware that weighted national estimates and their percentages are subject to such errors. The analysis includes no statistical tests of observed differences because its goal is not to identify statistically significant differences, but rather more pronounced differences (or the lack thereof) having clear implications for crash countermeasures.

**RESULTS**

**Conditions of Occurrence**

Car-truck crash conditions of occurrence were compared to those of all two-vehicle crashes. Most NMVCCS car-truck crashes (80.8%) occurred during daylight, a proportion similar to that of all two-vehicle crashes. The pavement was dry in 83.2%, again similar to two-vehicle crashes in general. For about three-quarters of both crash categories no adverse weather condition was noted. More than half of car-truck crashes (52.1%) occurred on divided highways; for all two-vehicle crashes the percentage was 30.6%. Car-truck crashes were...
much more likely to occur in a non-junction section of roadway (62.5% vs. 21.7%) and much less likely to occur at an intersection or to be intersection-related (23.9% vs. 63.5%). A far greater percentage of car-truck crashes occurred in highway work zones (12.8%) than was the case for two-vehicle crashes in general (2.9%).

**Police-Reported Crash Severity**
Table 1 shows a breakdown of maximum police-reported crash injuries per the “KABCO” severity classification scale. Four datasets are shown:

- NMVCCS car-truck crashes
- All NMVCCS two-vehicle crashes
- Multi-vehicle crashes in the LTCCS
- All 2010 large truck multi-vehicle crashes per the Fatality Analysis Reporting System (for K) and the GES (for all other severity levels).

The NMVCCS car-truck crash severity profile does not differ dramatically from that of all NMVCCS two-vehicle crashes. Unlike the LTCCS, the NMVCCS car-truck dataset includes low-severity C and O crashes, about 43% of the total. Note, however, that the EMS response requirement for NMVCCS case selection meant that high-severity crashes were still overrepresented compared to all multi-vehicle truck crashes per FARS and GES.

<table>
<thead>
<tr>
<th>Severity Classification</th>
<th>NMVCCS Car-Truck</th>
<th>All NMVCCS 2-Vehicle</th>
<th>LTCCS Multi-Vehicle</th>
<th>All 2010 Trk Multi-Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>K - Killed</td>
<td>1.2%</td>
<td>1.6%</td>
<td>10.8%</td>
<td>1.3%</td>
</tr>
<tr>
<td>A - Incapacitating Injury</td>
<td>25.3%</td>
<td>18.6%</td>
<td>38.4%</td>
<td>3.5%</td>
</tr>
<tr>
<td>B - Non-Incapacitating Injury</td>
<td>26.4%</td>
<td>23.9%</td>
<td>50.8%</td>
<td>7.0%</td>
</tr>
<tr>
<td>C - Possible Injury</td>
<td>26.3%</td>
<td>35.7%</td>
<td>---</td>
<td>11.5%</td>
</tr>
<tr>
<td>O - No Injury</td>
<td>16.4%</td>
<td>19.9%</td>
<td>---</td>
<td>76.4%</td>
</tr>
<tr>
<td>U - Injury, Severity</td>
<td>4.4%</td>
<td>0.3%</td>
<td>---</td>
<td>0.2%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Selected Pre-Crash Variables**

*Movement Prior to Critical Crash Envelope*
This variable described the vehicle’s pre-crash movement pattern. While the overall car and truck distributions are similar, cars were more likely to be going straight whereas trucks were more likely to be stopped in a traffic lane or changing lanes/merging.
TABLE 2 Movement Prior to Critical Crash Envelope

<table>
<thead>
<tr>
<th>Pre-Crash Movement</th>
<th>C#</th>
<th>CW</th>
<th>CW %</th>
<th>T#</th>
<th>TW</th>
<th>TW %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Going straight</td>
<td>114</td>
<td>52,177</td>
<td>65.4%</td>
<td>98</td>
<td>42,199</td>
<td>52.9%</td>
</tr>
<tr>
<td>Decelerating in traffic lane</td>
<td>8</td>
<td>3,992</td>
<td>5.0%</td>
<td>14</td>
<td>5,247</td>
<td>6.6%</td>
</tr>
<tr>
<td>Accelerating or starting in traffic lane (3+4)</td>
<td>3</td>
<td>469</td>
<td>0.6%</td>
<td>2</td>
<td>32</td>
<td>0.0%</td>
</tr>
<tr>
<td>Stopped in traffic lane</td>
<td>17</td>
<td>6,188</td>
<td>7.8%</td>
<td>32</td>
<td>10,334</td>
<td>13.0%</td>
</tr>
<tr>
<td>Passing or overtaking another vehicle</td>
<td>6</td>
<td>644</td>
<td>0.8%</td>
<td>3</td>
<td>420</td>
<td>0.5%</td>
</tr>
<tr>
<td>Backing up (other than for parking position)</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
<td>2</td>
<td>620</td>
<td>0.8%</td>
</tr>
<tr>
<td>Negotiating a curve</td>
<td>28</td>
<td>11,010</td>
<td>13.8%</td>
<td>21</td>
<td>10,281</td>
<td>12.9%</td>
</tr>
<tr>
<td>Changing lanes or merging (15+16)</td>
<td>9</td>
<td>3,474</td>
<td>4.4%</td>
<td>9</td>
<td>5,965</td>
<td>7.5%</td>
</tr>
<tr>
<td>Successful avoidance maneuver to a previous critical event</td>
<td>10</td>
<td>1,679</td>
<td>2.1%</td>
<td>1</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Miscellaneous Others (7+8+10+11+12+18)</td>
<td>2</td>
<td>88</td>
<td>0.1%</td>
<td>7</td>
<td>950</td>
<td>1.2%</td>
</tr>
<tr>
<td>Unknown or no driver present</td>
<td>2</td>
<td>0</td>
<td>0.0%</td>
<td>10</td>
<td>3,673</td>
<td>4.6%</td>
</tr>
<tr>
<td>Total</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
</tr>
</tbody>
</table>

First Harmful Event Crash Type
This variable captures crash type or “role” by describing the action and/or relative position of each vehicle in the crash. Specific codes are grouped here based on their similarities in relation to cause, scenario, and/or potential countermeasures (5, 15). Rear-end crashes were the most frequent general category, representing 32.9% of the weighted total. Cars were more likely than trucks to be the striking vehicle in both lead vehicle stopped and lead vehicle moving rear-end crashes. In opposite direction crashes (i.e., head-on or opposite direction sideswipes), cars were far more likely than trucks to be the encroaching vehicle. Trucks were overinvolved in same direction scenarios (same direction sideswipe or turn across path) when they were moving toward the right. Figure 1 is a histogram illustrating marked car-truck differences for four crash roles. For most other crash roles, car and truck involvement patterns were similar.

TABLE 3 First Harmful Event Crash Type (ACCTYPE)

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>C#</th>
<th>CW</th>
<th>CW %</th>
<th>T#</th>
<th>TW</th>
<th>TW %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initially Departed Road or Struck Parked Vehicle (3+6+7+11)</td>
<td>11</td>
<td>8,958</td>
<td>11.2%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Rear-End, Lead Vehicle Stopped, Striking Vehicle (20)</td>
<td>20</td>
<td>8,692</td>
<td>10.9%</td>
<td>10</td>
<td>4,066</td>
<td>5.1%</td>
</tr>
<tr>
<td>Rear-End, Lead-Vehicle Stopped, Struck Vehicle (21+22)</td>
<td>10</td>
<td>4,066</td>
<td>5.1%</td>
<td>19</td>
<td>8,205</td>
<td>10.3%</td>
</tr>
<tr>
<td>Rear-End, Lead Vehicle Moving, Striking Vehicle (24+28)</td>
<td>13</td>
<td>10,701</td>
<td>13.4%</td>
<td>5</td>
<td>3,247</td>
<td>4.1%</td>
</tr>
<tr>
<td>Rear-End, Lead Vehicle Moving, Struck Vehicle (25+29)</td>
<td>5</td>
<td>3,247</td>
<td>4.1%</td>
<td>13</td>
<td>10,701</td>
<td>13.4%</td>
</tr>
<tr>
<td>Rear-End, Specifics Other (32)</td>
<td>1</td>
<td>519</td>
<td>0.7%</td>
<td>1</td>
<td>519</td>
<td>0.7%</td>
</tr>
<tr>
<td>Same Direction: Sideswipe or Turn Across Path, Vehicle Going Straight (44+45+71+73))</td>
<td>30</td>
<td>7,913</td>
<td>9.9%</td>
<td>22</td>
<td>4,481</td>
<td>5.6%</td>
</tr>
<tr>
<td>Same Direction: Sideswipe or Turn Across Path, Vehicle Moving Right (46+70)</td>
<td>10</td>
<td>1,644</td>
<td>2.1%</td>
<td>22</td>
<td>5,219</td>
<td>6.5%</td>
</tr>
<tr>
<td>Same Direction: Sideswipe or Turn Across Path, Vehicle Moving Left (47+72)</td>
<td>10</td>
<td>1,945</td>
<td>2.4%</td>
<td>6</td>
<td>1,801</td>
<td>2.3%</td>
</tr>
<tr>
<td>Same Direction: Sideswipe or Turn Across Path, Vehicle Going Straight (50+51+74)</td>
<td>12</td>
<td>3,479</td>
<td>4.4%</td>
<td>12</td>
<td>3,479</td>
<td>4.4%</td>
</tr>
<tr>
<td>Crash Type</td>
<td>C#</td>
<td>CW</td>
<td>CW%</td>
<td>T#</td>
<td>TW</td>
<td>TW%</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Specifics Other (48+49)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opposite Direction (e.g., Head-On), Encroaching Vehicle (50+64)</td>
<td>10</td>
<td>9,255</td>
<td>11.6%</td>
<td>1</td>
<td>236</td>
<td>0.3%</td>
</tr>
<tr>
<td>Opposite Direction (e.g., Head-On), Vehicle Going Straight (51+65)</td>
<td>1</td>
<td>236</td>
<td>0.3%</td>
<td>10</td>
<td>9,255</td>
<td>11.6%</td>
</tr>
<tr>
<td>Opposite Direction Impact, Specifics Other (62+66)</td>
<td>2</td>
<td>290</td>
<td>0.4%</td>
<td>2</td>
<td>290</td>
<td>0.4%</td>
</tr>
<tr>
<td>Turn Across Path (TAP) - Initial Opposite Directions (Left/Right) (68)</td>
<td>6</td>
<td>2,518</td>
<td>3.2%</td>
<td>6</td>
<td>163</td>
<td>0.2%</td>
</tr>
<tr>
<td>Turn Across Path - Initial Opposite Directions (Going Straight) (69)</td>
<td>6</td>
<td>163</td>
<td>0.2%</td>
<td>6</td>
<td>2,518</td>
<td>3.2%</td>
</tr>
<tr>
<td>Turn Into Same Direction, Various Roles (76+77+78+79)</td>
<td>8</td>
<td>2,459</td>
<td>3.1%</td>
<td>8</td>
<td>2,459</td>
<td>3.1%</td>
</tr>
<tr>
<td>Turn Into Opposite Direction, Various Roles (80+81+82+83)</td>
<td>15</td>
<td>5,241</td>
<td>6.6%</td>
<td>15</td>
<td>5,241</td>
<td>6.6%</td>
</tr>
<tr>
<td>Straight Crossing Paths, Various Roles (86+87+88+89+90)</td>
<td>18</td>
<td>2,959</td>
<td>3.7%</td>
<td>18</td>
<td>2,959</td>
<td>3.7%</td>
</tr>
<tr>
<td>Miscellaneous Other, or Uncoded (92+93+98+100+uncoded)</td>
<td>11</td>
<td>5,435</td>
<td>6.8%</td>
<td>23</td>
<td>14,881</td>
<td>18.7%</td>
</tr>
<tr>
<td>Total:</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
</tr>
</tbody>
</table>

**FIGURE 1 Selected Contrasting First Harmful Event Crash Types**

**Critical Reason**

The CR is “the immediate reason for this event and is often the last failure in the causal chain” leading to the crash (10). NHTSA specifically disclaims that the CR is the cause of the crash or that it implies assignment of fault (3, 10). Similar disclaimers were made in regard to the LTCCS (2, 11). Nevertheless, most CRs (e.g., as listed in Table 4 below) represent specific proximal driver errors or other failures triggering crash sequences. Table 4 shows that CRs were assigned to cars in 71.0% of the crashes, versus 29.0% for trucks. Cars were most overrepresented in the following: asleep-at-the-wheel, physical impairments, inattention and distraction, excessive speed, and unknown driver errors. Trucks were
overrepresented in false assumptions and vehicle-related factors. The CR percentages shown in Table 4 are based on all of the crashes; to find the factor percentage within each vehicle type, one should divide by the total weighted CR assignments for each; i.e., 56,629 for cars and 23,092 for trucks. Figure 2 is a histogram showing several contrasting CRs. Additional groupings in the figure include critical non-performance (sleep + heart attack or other physical impairment), inattention and distraction (both internal and external), and vehicle factors (component + vision obstruction + cargo shift).

### TABLE 4 Critical Reason Groupings

<table>
<thead>
<tr>
<th>Critical Reason</th>
<th>C#</th>
<th>CW</th>
<th>CW%</th>
<th>T#</th>
<th>TW</th>
<th>TW%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Reason Not Assigned to this Vehicle</td>
<td>71</td>
<td>23,092</td>
<td>29.0%</td>
<td>128</td>
<td>56,629</td>
<td>71.0%</td>
</tr>
<tr>
<td>Sleep, that is, actually asleep</td>
<td>9</td>
<td>4,361</td>
<td>5.5%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Heart Attack, Other Physical Impairment, Other Critical Non-Performance (101+102)</td>
<td>5</td>
<td>5,381</td>
<td>6.7%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Inattention (i.e. Daydreaming)</td>
<td>6</td>
<td>1,597</td>
<td>2.0%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Internal Distraction</td>
<td>20</td>
<td>5,285</td>
<td>6.6%</td>
<td>5</td>
<td>581</td>
<td>0.7%</td>
</tr>
<tr>
<td>External Distraction</td>
<td>4</td>
<td>1,196</td>
<td>1.5%</td>
<td>2</td>
<td>211</td>
<td>0.3%</td>
</tr>
<tr>
<td>Inadequate Surveillance (e.g. Failed to Look, Looked But Did Not See)</td>
<td>19</td>
<td>5,850</td>
<td>7.3%</td>
<td>17</td>
<td>4,859</td>
<td>6.1%</td>
</tr>
<tr>
<td>Other or Unknown Recognition Error (114+119)</td>
<td>4</td>
<td>1,752</td>
<td>2.2%</td>
<td>3</td>
<td>1,388</td>
<td>1.7%</td>
</tr>
<tr>
<td>Too Fast for Conditions, to be able to respond to unexpected actions, or for curve/turn (120+121+122)</td>
<td>8</td>
<td>8,684</td>
<td>10.9%</td>
<td>3</td>
<td>423</td>
<td>0.5%</td>
</tr>
<tr>
<td>Misjudgment of Gap or Other's Speed</td>
<td>6</td>
<td>775</td>
<td>1.0%</td>
<td>6</td>
<td>2,268</td>
<td>2.8%</td>
</tr>
<tr>
<td>Following too Closely to Respond to Unexpected Actions</td>
<td>1</td>
<td>138</td>
<td>0.2%</td>
<td>1</td>
<td>546</td>
<td>0.7%</td>
</tr>
<tr>
<td>False Assumptions of Other Road User's Actions</td>
<td>5</td>
<td>1,750</td>
<td>2.2%</td>
<td>8</td>
<td>3,392</td>
<td>4.3%</td>
</tr>
<tr>
<td>Illegal Maneuver</td>
<td>7</td>
<td>1,199</td>
<td>1.5%</td>
<td>6</td>
<td>589</td>
<td>0.7%</td>
</tr>
<tr>
<td>Inadequate or Incorrect Evasive Action, e.g. Braking Only, Not Braking and Steering (129+130)</td>
<td>6</td>
<td>2,382</td>
<td>3.0%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Aggressive Driving Behavior</td>
<td>4</td>
<td>1,028</td>
<td>1.3%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Turned with Obstructed View</td>
<td>1</td>
<td>56</td>
<td>0.1%</td>
<td>1</td>
<td>722</td>
<td>0.9%</td>
</tr>
<tr>
<td>Other or Unknown Decision Error (132+139)</td>
<td>3</td>
<td>902</td>
<td>1.1%</td>
<td>1</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Overcompensation</td>
<td>4</td>
<td>415</td>
<td>0.5%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Poor Directional Control e.g., Failing to Control Vehicle with Skill Ordinarily Expected</td>
<td>3</td>
<td>467</td>
<td>0.6%</td>
<td>4</td>
<td>537</td>
<td>0.7%</td>
</tr>
<tr>
<td>Unknown Performance Error</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
<td>1</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Type of Driver Error Unknown</td>
<td>10</td>
<td>13,194</td>
<td>16.6%</td>
<td>3</td>
<td>254</td>
<td>0.3%</td>
</tr>
<tr>
<td>Vehicle Component Failure (e.g., Brakes, Tires)</td>
<td>2</td>
<td>218</td>
<td>0.3%</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Vehicle-Related Vision Obstructions</td>
<td>2</td>
<td>0</td>
<td>0.0%</td>
<td>1</td>
<td>1,529</td>
<td>1.9%</td>
</tr>
<tr>
<td>Environmental (e.g., Slick Roads, Glare) (509+525)</td>
<td></td>
<td>0</td>
<td>0.0%</td>
<td>5</td>
<td>2,034</td>
<td>2.6%</td>
</tr>
<tr>
<td>Unknown Reason for Critical Event</td>
<td></td>
<td>0</td>
<td>0.0%</td>
<td>1</td>
<td>104</td>
<td>0.1%</td>
</tr>
<tr>
<td>Total, Critical Reason Assigned to this Vehicle</td>
<td>128</td>
<td>56,629</td>
<td>71.0%</td>
<td>71</td>
<td>23,092</td>
<td>29.0%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
</tr>
</tbody>
</table>
As noted earlier, research has suggested that car versus truck CR assignment varies as a function of crash severity, with cars more likely to be assigned primary responsibility for more severe crashes. The relatively small number of cases in the NMVCCS dataset did not permit a strong test of this hypothesis, but, overall, the NMVCCS findings were consistent with it. Based on the most severe police-reported injury in the car, cases could be split into 75 “KAB” cases and 101 “CO” cases. Cars were assigned the CR in a weighted 74.8% of KAB crashes, versus 65.2% of CO crashes.

**Attempted Avoidance Maneuvers**
About one-third of both car drivers (weighted 29.3%) and truck drivers (weighted 31.6%) were coded as having attempted one or more avoidance maneuvers in response to the critical precrash event. The variable did not specify maneuvers.

**Pre-Impact Stability of Vehicle**
Cars were about twice as likely as trucks to be out-of-control (i.e., skidding or otherwise not tracking) prior to their impacts; 36 were so coded, representing a weighted value of 15,089 (18.9%). This compares to 18 trucks with a weighted value of 6,139 (7.7%).

**Right-of-Way**
This variable established whether a vehicle had the right-of-way from a legal perspective. Cars were more likely to violate rights-of-way than were trucks. Of 136 cars with known right-of-way (i.e., coded yes or no), 74 were coded as not having the right-of-way. This was a weighted percentage of 30.0% of all cars; removing unknowns raised the percentage to 57.9%. This contrasts with 61 of 137 trucks, a weighted overall percentage of 20.1% or 39.3% of knowns.
Associated Factors

Driver Fatigue

This variable assessed whether the driver was fatigued, based on current and preceding sleep and work schedules, “and on a variety of other fatigue-related factors including recreational and non-work activities” (10). Fatigue was coded for 23 car drivers (weight = 13,234 or 16.6%) and 5 truck drivers (weight = 1,517 or 1.9%). As noted earlier, the NMVCCS exclusion of overnight crashes undoubtedly reduced driver fatigue coding for both cars and trucks.

<table>
<thead>
<tr>
<th>Fatigue?</th>
<th>C#</th>
<th>CW</th>
<th>CW %</th>
<th>T#</th>
<th>TW</th>
<th>TW %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Fatigued</td>
<td>23</td>
<td>13,234</td>
<td>16.6%</td>
<td>5</td>
<td>1,517</td>
<td>1.9%</td>
</tr>
<tr>
<td>Driver Not Fatigued</td>
<td>124</td>
<td>39,630</td>
<td>49.7%</td>
<td>143</td>
<td>60,347</td>
<td>75.7%</td>
</tr>
<tr>
<td>Unknown or No Driver Present</td>
<td>52</td>
<td>26,857</td>
<td>33.7%</td>
<td>51</td>
<td>17,788</td>
<td>22.3%</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
</tr>
</tbody>
</table>

Trip Duration

Few NMVCCS drivers had driven for long durations prior to their crash. Among 130 car drivers with known trip durations, the weighted mean trip duration was 34 minutes while the unweighted median was 20 minutes. Among 142 truck drivers with known trip durations, the weighted mean was 60 minutes while the unweighted median was 30 minutes. No car drivers, and only 10 of 142 truck drivers (weighted percentage = 4.2%), had driven for four hours or more prior to the crash.

Driver Illness

This associated factor documented whether “the driver experienced a medically verified illness during the precrash phase” (10). There were 7 car driver cases versus 3 truck driver cases. Weighted percentages were 3.4% and 1.7%, respectively.

Police-Reported Alcohol

Six (6) car drivers (weighted percentage = 1.0%) were reported to have used alcohol, versus one (1) truck driver (0.3%). The NMVCCS exclusion of crashes occurring between midnight and 6 a.m. greatly reduced alcohol citations.

Vehicle Condition-Related Factors

This variable documented “if any factors related to the vehicle’s conditions were present that may have been relevant to the crash.” Specific factors were not identified under this variable, though they may have been captured separately as CRs for some crashes. Salient vehicle conditions were more frequent for trucks than for cars. One or more vehicle condition-related factors were identified for 12 cars (weight = 2,608 or 3.3%) and for 20 trucks (weight = 9,570 or 12.0%).

TRB 2013 Annual Meeting
### TABLE 6 Vehicle Condition-Related Factor

<table>
<thead>
<tr>
<th>Vehicle Condition Factor?</th>
<th>C#</th>
<th>CW</th>
<th>CW%</th>
<th>T#</th>
<th>TW</th>
<th>TW%</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or more present</td>
<td>12</td>
<td>2,608</td>
<td>3.3%</td>
<td>20</td>
<td>9,570</td>
<td>12.0%</td>
</tr>
<tr>
<td>None present</td>
<td>176</td>
<td>71,715</td>
<td>90.0%</td>
<td>155</td>
<td>63,464</td>
<td>79.6%</td>
</tr>
<tr>
<td>Unknown or No Driver Present</td>
<td>11</td>
<td>5,398</td>
<td>6.8%</td>
<td>24</td>
<td>6,687</td>
<td>8.4%</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
<td>199</td>
<td>79,721</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Driver Aggressive Acts**
This variable established if the driver “performed any aggressive acts” (10), but did not identify them. Nine (9) car drivers performing one or more aggressive acts were identified, versus no truck drivers. The weighted value of the 9 car cases was 2,477 or 3.1%.

**Work-Related Stress/Pressure**
This variable identified work-related pressures experienced by the driver in the days leading up to the crash. Work pressures were identified for 9 car drivers (weight = 10,773 or 13.5%) versus 4 truck drivers (weight = 1,241 or 1.6%). Specific work pressures included:
- Required to work extended work shifts
- Learning new position
- Tight/unrealistic production/delivery schedule.

**Driver Hurry**
This variable identified whether the driver was in a hurry and provided the driver’s reason. Twelve (12) car drivers (weight = 2,269 or 2.8%) were determined to be in a hurry, versus 7 truck drivers (weight = 611 or 0.8%). Reasons included being late for scheduled activities (school, work, appointment) and being in a hurry due to a work-related delivery schedule. Truck drivers were more likely to state the latter.

**DISCUSSION**
NMVCCS car-truck crash statistics have corroborated previous studies (e.g., 6, 13, 14, 15, 16) finding car drivers to be principally responsible for a majority of car-truck crashes. The present car-CR percentage of 71.0% is similar to past studies of fatal crashes; what is different and unique is the fact that it is based on in-depth investigations of car-truck crashes of all KABCO levels. Cars were most likely to be the encroaching vehicle in rear-end crashes (both lead vehicle stopped and lead vehicle moving) and in opposite direction (e.g., head-on) crashes. Car drivers were more likely to be asleep, otherwise fatigued, impaired (by illness or alcohol), speeding, aggressive, and/or inattentive than were truck drivers. Cars were more likely to be out-of-control prior to impact and to violate rights-of-way. While most car-CR crash involvements with trucks fit the usual profiles for multi-vehicle crashes, a portion resembled single-vehicle crashes, except that here the errant car had the misfortune of striking a large truck instead of running off the road.

Driver fatigue dominates many discussions of truck safety, in large part due to the operational and economic importance of HOS rules. It may seem paradoxical that car drivers were far more likely to be asleep or fatigued in NMVCCS car-truck crashes, but the finding is
entirely consistent with LTCCS and other past reports (6, 16, 18). The NMVCCS excluded
overnight (midnight to 6 a.m.) crashes, but this exclusion likely affected car and truck drivers
similarly. What explains the high incidence of car driver fatigue and other scenarios where
car drivers relinquish vehicle control in these crashes? As professionals, truck drivers may
simply be more alert and in-control than car drivers. An alternative hypothesis is that the
difference is related to trucks’ relative inability to evade an errant car. For example, in a
head-on crash scenario where one vehicle is crossing the center line or median, trucks might
be less able to evade oncoming cars than cars can evade oncoming trucks. This would result
in the car-truck CR and encroachment splits seen, though the data do not provide positive
evidence for it. The “ability to evade” hypothesis merits future research.

In spite of sampling concerns inherent to small-sample studies, study findings affirm
the value of crash causation information for identifying and designing countermeasures. The
high incidence of truck-struck rear-end crashes (24.5% of the total) suggest the value of
enhanced conspicuity treatments or active warning systems on the rear of trucks and trailers.
Trucks were most likely to encroach other vehicles when moving from left to right, attesting
to their need for better right side visibility. Trucks were assigned vehicle-related CRs in
9.1% of the crashes. This supports the need for vehicle-related regulations and enforcement,
but it is also a reminder that most truck crashes are not primarily related to vehicle factors.

The three main causal categories of truck crashes appear to be different in regard to
etiology and implications for risk. Truck single-vehicle crashes were not in the current
dataset, but past studies indicate that they are most associated with driver impairment, overt
misbehavior, and vehicle maintenance failures (6, 7). Truck at-fault multi-vehicle crashes
may manifest some of these factors, but more often are due to less egregious traffic
interaction errors. Truck not-at-fault multi-vehicle crashes are due primarily to car driver
errors not directly related to truck driver or carrier actions. Safety evaluations of truck
drivers and carriers would be fairer, more diagnostic, and more predictive if they
differentiated among these three causal categories.

Leonard Evans noted that “A large portion of truck safety is rooted in the context of
overall traffic safety” (20). Study findings validate this view. Most truck crashes involve
cars. Car drivers precipitate most of these crashes and their causes are much like those of
motor vehicle crashes in general. Nationally and internationally, car-truck crashes may best
be reduced not by truck safety initiatives per se but rather by broader efforts to improve the
safety performance of roads, vehicles, and drivers.

ACKNOWLEDGEMENTS

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