Identifying Unsafe Driver Actions that Lead to Fatal Car-Truck Crashes

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Executive Summary

In 2000, 5,211 persons were killed and about 140,000 were injured in crashes involving large trucks. The purpose of this study is to explain the unsafe driver actions and conditions that are more likely in fatal crashes between cars and large trucks than in fatal crashes between cars and to identify strategies for educating motorists in safe driving practices that will help them avoid such crashes.

RESEARCH METHODS

The study analyzed two-vehicle crashes in the 1995–98 Fatality Analysis Reporting System (FARS) database to compare car-car crashes with car-truck crashes. A limitation of the study is that it did not address nonfatal crashes, single-vehicle crashes, or crashes involving more than two vehicles; this is important to keep in mind because fatal and injury crashes are not similar in their causes or in the numbers of people they affect.

The research was conducted in three stages. The first stage sought to identify driving maneuvers or actions of cars and large trucks that have a higher chance of resulting in fatal car-truck collisions than fatal collisions with a similar vehicle. The second stage involved discerning patterns associated with these driving actions through a detailed examination of actual crash reports. The third stage involved exploring ways that the risks associated with the identified driving actions can be effectively communicated to motorists, paying special attention to the fit between study findings and potential instructional approaches.

THE FIRST STAGE OF RESEARCH: IDENTIFYING UNSAFE DRIVER ACTIONS

The first stage of research involved an analysis of 94 driver-related factors. Using probability analysis techniques, the authors determined the likelihood of involvement for each factor based on the probability that the crash did or did not involve a truck.

Information about the precrash actions of drivers was sought in national crash databases such as FARS, a national database of all vehicle crashes in the United States that result in at least one fatality. These data are based on such sources as police observations of the postcrash scene and the unsworn testimony of surviving people and other witnesses. It was recognized that these sources have limitations. For instance, the physical evidence on which the police base their opinions may be conflicting or ambiguous, and people involved in a crash may be unable to remember information about the events before the crash.

Because of these uncertainties, it is not possible to directly assess precrash driver actions or to identify causal relationships between unsafe driving actions and crashes by simply tabulating crash data. It would be possible, however, to

use an indirect data-analysis approach that would address the inherent uncertainty. Accordingly, the authors chose an analytical method that allowed them to estimate conditional probabilities.

The data file for analysis was created from FARS data for 1995–98 and consisted of all fatal crashes involving passenger vehicles (cars, station wagons, minivans, sport utility vehicles, and pickup trucks) and trucks (straight trucks and tractor-trailers) of more than 10,000 pounds gross vehicle weight. The analysis was limited to two-vehicle crashes, which accounted for about 86% of all multi-vehicle crashes involving only passenger vehicles and 82% of multi-vehicle crashes involving passenger vehicles and trucks. In this report, crashes between passenger vehicles, regardless of type, are referred to as "car-car crashes" and crashes between passenger vehicles and large trucks are referred to as "car-truck crashes." The analysis file contained data on 35,244 fatal car-car crashes and 10,732 fatal car-truck crashes.

The results of the data analysis indicate that most driver factors are equally likely to be recorded for fatal car-truck crashes as for fatal car-car crashes. Moreover, drivers who get involved in fatal crashes probably drive in the same manner around trucks as they do around other cars. Indeed, in cases for which driver factors were recorded, five of the equally likely factors: failing to keep in lane, failing to yield right-of way, driving too fast for conditions or in excess of posted speed limit, failing to obey traffic control devices and laws, and inattentive comprised about 65% of reported unsafe car driver acts in both car-truck and car-car crashes. Four factors (out of 94) were found to be more likely to occur in fatal car-truck crashes than in fatal car-car crashes:

- *Following improperly*
- *Driving with vision obscured by rain, snow, fog, sand, or dust*
- *Drowsy or fatigued driving*
- *Improper lane changing*

However, these four factors were recorded for only about 5% of the car-truck crashes.

THE SECOND STAGE OF RESEARCH: DETAILED REVIEW OF CAR-TRUCK CRASH RECORDS

The second stage of the research involved closely examining a random sample of 529 crashes for the top four factors differentiating fatal car-car and fatal car-truck crashes. Hard-copy materials—including original police accident reports, crash diagrams, and other crash-related information from the 1995–98 Trucks in Fatal Accidents records maintained by the Center for National Truck Statistics—were reviewed. The results of this analysis corroborate earlier studies of car-truck crashes showing that there are many more unsafe actions by car drivers than truck drivers. Also as expected, the crashes were much more dangerous for car drivers than truck drivers; car drivers accounted for nearly 98% of driver fatalities.

The results of the analysis also indicate that more than half of the fatal car-truck crashes in which a driver fell asleep were head-on crashes, and more than one-quarter of these occurred between 3 and 6 a.m. The results point to the use of alcohol or drugs and speeding as unsafe behaviors among younger drivers for both cars and trucks involved in fatal car-truck crashes. Finally, the results are consistent with previous research; for instance:

- *Drowsy or fatigued driving and following improperly were more likely to be reported for male than female car drivers.*
- *Car drivers in crashes in which their vision was obstructed tended to be older than the other drivers.*
- *Car drivers who were drowsy/fatigued were likely to be younger than other drivers.*
- *Younger truck drivers were more likely than older truck drivers to follow improperly, speed, and use alcohol or drugs.*

The Third Stage of Research: Exploring the Development of Educational Materials

The third stage of the research explored instructional strategies that could be used to teach motorists about the risks associated with the four unsafe driving actions and conditions identified in the first stage of the research. Effective educational efforts could include:

Teaching motorists how to operate around large trucks, focusing on instruction on the four unsafe factors

Creating an interactive World Wide Web site that educates drivers about the dangers associated with driving near trucks and allows them to test their knowledge

Personal computer–based driving simulations, demonstrations, or computer games showing interactions between cars and large trucks

Discussion of Findings

It is important to note again that, because of data limitations, this study looked only at fatal crashes. Nevertheless, the findings from this study are consistent with the findings from a study of unsafe driving acts of car drivers in the vicinity of trucks that was not limited to fatal crashes. It also needs to be noted that three of the four driver factors that were found in this study to be more likely to be associated with fatal car-truck crashes than with fatal car-car crashes were among those considered by safety experts to be dangerous and frequent near trucks.

A key finding of this study is that most of the 94 unsafe driver acts were about as likely in fatal car-truck crashes as in fatal car-car crashes. Therefore general safe driving practices are also relevant around large trucks. However, programs to educate drivers in safe practices need to emphasize that driving mistakes around trucks can have much more severe consequences.

Introduction

In 2000, 5,211 persons were killed and about 140,000 were injured in crashes involving trucks with a gross vehicle weight of more than 10,000 pounds (NHTSA 2001). In collisions between passenger vehicles (which include various types of vehicles; hereafter, "cars") and large trucks, the structural properties and greater mass of large trucks put the occupants of the cars at a disadvantage—98% of the deaths in fatal two-vehicle crashes involving a car and a large truck were among occupants of the car (FMCSA 2001). Between 1990 and 2000, the number of trucks registered in the United States with gross vehicle weights above 10,000 pounds increased 30% and the number of miles traveled by such trucks increased 41%. Although the number of cars and miles traveled also rose, the rate of increase was lower. Between 1990 and 2000, registrations for passenger cars and light trucks in the United States increased by 18% and their miles traveled increased by 27% (NHTSA 2001). If these trends continue, car drivers will be more and more likely to encounter large trucks.

Many crashes between cars and large trucks occur because a maneuver performed by one of the vehicles is unanticipated by the other, leaving insufficient time to avoid the crash. In some cases, a maneuver performed by a car near a large truck may carry a higher crash risk than the same maneuver performed near another car. Similarly, a large truck may perform a maneuver that carries low risk of a crash near another truck in the traffic stream, but a higher risk when performed near a smaller vehicle. One reason why some car drivers perform unsafe maneuvers near large trucks may be that they simply do not know the risks associated with driving near trucks.

Most research aimed at understanding the causes of crashes between cars and trucks indicates that the actions of car drivers contribute more to car–large truck crashes than do the actions of truck drivers (e.g., Schwartz and Retting 1986; AAA Michigan 1986; Massie and Sullivan 1994; Braver et al. 1996; Blower 1998; and Stuster 1999). It has been argued that the average motorist assumes that the operation of cars and large trucks is virtually the same (Mason et al. 1992) and that motorists are poor judges of the speed, maneuverability, braking, and acceleration capabilities of large vehicles (Ogden and Wee 1988; Hanowski et al. 1998; Stuster 1999). It is probable that educating motorists about the risks of driving near trucks or training motorists how to drive near trucks would help promote safer driving practices.

There are public information and educational programs aimed at teaching motorists how to drive near trucks. Many employ materials such as brochures, pamphlets, and videos (e.g., Michigan Center for Truck Safety 2000), and there is a growing reliance on web sites (e.g., U.S. Department of Transportation, www.nozone.org; Crash Foundation, www.trucksafety.org/shared.html). In the age of increasing interactive computing technology and widespread use of home computers, it seems natural that such technology might be employed to help teach motorists to drive safely near trucks. However, regardless of the approach or technology used, the most successful educational programs are those that match instructional strategies with desired outcomes (Salas and Cannon-Bowers 2001).

The main objectives of this research were to explain driving actions that lead to crashes between cars and large trucks and to identify strategies for educating motorists about the risks of such actions. The research was conducted in three stages. The first stage sought to identify maneuvers and driving actions of cars and large trucks that have a higher chance of resulting in car-truck collisions than collisions between cars. The second stage involved discerning patterns associated with these maneuvers and actions through a detailed examination of actual crash reports. The third stage involved exploring ways to make motorists aware of the risks of the identified driving actions, paying special attention to the fit between study findings and potential educational strategies.

Methodology

Information about driver actions that contribute to crashes between passenger vehicles and large trucks can be found in national crash databases, such as the Fatality Analysis Reporting System (FARS) and the General Estimates System of National Sampling System (GES). These databases contain information about unsafe driving acts that occur before crashes and other relevant data for each involved traffic unit in a vehicular crash. These data come from a geographically diverse group of locations with similarly diverse driving environments and are representative of the United States as a whole.

However, there is an inherent uncertainty associated with information about driver actions, because such information is usually reported by police officers who arrive after the crash and rely on observations of the postcrash scene, their professional experiences, and the unsworn testimony of the surviving parties and other witnesses. The physical evidence found by the officers may be conflicting or ambiguous, individuals who were involved in the crash may not be fully forthcoming or may be unable to remember information about events before the crash, and witnesses generally did not pay attention to the precrash actions but are merely bystanders recalling actions they happened to see. In some cases, officers may record all the factors they believe were factors in the crash; in others, they may record only the factors they believe are most relevant; in still others, they may not record any factors at all.

The uncertainty associated with this information—which has been recognized by researchers (e.g., Wolfe and Carsten 1982; Braver et al. 1996)—makes direct assessment of the precrash maneuvers and actions by simple tabulations of these data insufficient to identify the causal relationships between unsafe driving actions and crashes.

Despite the inherent uncertainty, these national crash databases are still a useful source of information about the precrash actions that contribute to crashes between vehicles. This has been substantiated by Blower (1998) in a study of collisions between large trucks and passenger cars. Blower found that the coding of driver-related factors was relatively consistent with what one would expect from the physical configuration of the crash, especially crashes that involved fatalities. Thus, there is credible information about driver pre-crash actions in the data files, but the analysis methods employed must be able to account for the inherent uncertainty. An approach based on the application of Bayes' Theorem is well suited for analyzing data with the types of challenges identified above (Pollard 1986; Benjamin and Cornell 1970) and was therefore selected for this study.

Ideally, a Bayesian approach could be applied to crashes of all injury severities. However, it is better suited to fatal crashes because of limitations of the available national data set that includes nonfatal injuries. The FARS data set, which contains records for all fatal vehicle crashes in the United States, is based on police accident reports and more detailed investigations. The GES data set contains information about a nationally representative sample of police-reported crashes of all severities and is based on police accident reports alone. Because reports are more carefully prepared for crashes involving a fatality than for crashes of lower injury severity, the level of detail needed for the research approach presented here is more likely to be found in FARS than in GES. Moreover, unlike FARS, which has specific variables for driver-related factors, driver actions in GES have to be obtained from any violations charged. GES introduces more uncertainty about drivers' pre-crash actions because police officers issue citations based on many considerations including the seriousness of the offense, the existence of sufficient evidence to prove the charge, the intent of the violator, and whether other enforcement actions might be appropriate.

Another problem with using GES data for this analysis is that the data are drawn from a complex sample. Each crash in this data set represents from 2 to 3,000 crashes, resulting in standard errors that can be quite large. Collectively, these uncertainties render any findings from Bayesian analysis of driver precrash actions from the GES data meaningless. Therefore, this research only uses data from FARS, thus limiting the analysis to fatal crashes.

In the first stage of the research, a Bayesian approach was used to examine relationships between unsafe driving and crashes between passenger vehicles and large trucks (referred to as cars and trucks, respectively, throughout this report). Data from FARS were analyzed to estimate the conditional probability of a given unsafe driving action being reported, given that the crash was a car-truck crash, and to identify unsafe driving actions that occur with greater probability before car-truck crashes than before car-car collisions.

In the second stage of the research, the relationship between the identified actions and car-truck crashes was further scrutinized by examining selected hard-copy reports from the Trucks in Fatal Accidents records maintained by the Center for National Truck Statistics. These data files provide coverage of all fatal crashes involving trucks with gross vehicle weights of more than 10,000 pounds recorded in FARS. The hard copies included police reports, crash diagrams, interviews, and other relevant information about the crash. The purpose of these examinations was to identify patterns and behavioral sequences leading up to the car-truck collisions, and if possible, to identify characteristics of drivers associated with these actions. In the third stage of the research, potential behavior and knowledge interventions that could be used to change these unsafe driving actions were identified and appropriate instructional strategies to deliver these interventions were explored.

CHAPTER 1

The First Stage of Research: Identifying Unsafe Driver Actions

Bayesian Approach

In the first stage of this research, relationships between unsafe driving and car-truck crashes were examined by estimating the conditional probability that a specific unsafe driving action (UDA) would be reported, given that the crash was a car-truck crash. These conditional probabilities were estimated by applying Bayes' Theorem, using this relationship:

$$P(UDA/car\text{-}truck) = \frac{P(car\text{-}truck/UDA) * P(UDA)}{P(car\text{-}truck)}$$

The value of P(car-truck/UDA) is the probability that the crash was a car-truck crash, given that a specific UDA was also reported. This value is estimated from the data by considering the numbers of all cases and those cases in which a car-truck crash and the UDA were coded together. P(UDA) is the overall probability of the specific UDA being reported as a contributing factor, and it is estimated from the numbers of cases in which the UDA was reported in the data. P(car-truck) is the overall probability that a crash was a car-truck crash and was estimated from the data.

The probability of a specific UDA being associated with a car-car crash was similarly estimated from the data, using this relationship:

$$P(UDA/car\text{-}car) = \frac{P(car\text{-}car/UDA) * P(UDA)}{P(car\text{-}car)}$$

where P(car-car) is the overall probability that a car-car crash occurred, and P(car-car/UDA) is the probability that a car-car crash occurred, given that a specific UDA was reported.

The likelihood ratio of a given UDA being recorded in a car-truck crash as compared with a car-car crash was assessed from crash records. This likelihood ratio is the probability of a crash being a car-truck crash when the UDA was recorded, as compared with the probability of a crash being a car-car crash when the same UDA was recorded. The larger the likelihood ratio, the greater the association between the UDA and car-truck crashes relative to car-car crashes. The likelihood ratio was calculated using this relationship:

$$\textit{Likelihood ratio} = \frac{P(UDA/car\text{-}truck)}{P(UDA/car\text{-}car)}$$

DATA

The data file for analysis was created using data from the Fatality Analysis Reporting System (FARS) for the period 1995–98. The data file consisted of data for all fatal crashes involving passenger vehicles (passenger cars, station wagons, minivans, sport utility vehicles, and pickup trucks) and trucks (straight trucks and tractor trailers of more than 10,000 pounds gross vehicle weight). Our analysis file contained 35,244 fatal car-car crashes and 10,732 fatal car-truck crashes (table 1.1).

Table 1.1. Two-Vehicle Fatal Crashes, 1995–98

Year	Car-Car Crashes	Car–Large Truck Crashes
1995	8,719	2,527
1996	8,846	2,669
1997	8,962	2,821
1998	8,717	2,715
Total, 1995–98	35,244	10,732

Source: Fatality Analysis Reporting System data.

The analysis was limited to two-vehicle crashes for two reasons. First, most multi-vehicle fatal crashes are between two vehicles (about 86% of all fatal car-car crashes and about 82% of all fatal car-truck crashes from 1995 through 1998 involved only two vehicles).

Second, in crashes involving more than two vehicles, an initial collision between two vehicles often precipitates the involvement of other vehicles. Because we were investigating the actions that lead to a crash rather than the chain of events that follow it, we were concerned with the vehicles involved in the initial collision. If we had included crashes involving more than two vehicles, we would have had to sort through complicated sequences to determine which two vehicles were involved in the initial crash. By examining only two-vehicle crashes, we avoided this problem and still had a large number of cases to analyze.

In the 35,244 fatal car-car crashes, 42,192 people died—26,864 (63.67%) were drivers, 14,122 (33.47%) were passengers, 20 (0.05%) were occupants of a vehicle not in transport, 1,133 (2.68%) were non-occupants, and 53 (0.12%) were unknown occupants (it could not be determined if the person was the driver or a passenger). In the 10,732 fatal car-truck crashes, 12,554 people died—8,848 (70.47%) were car drivers, 3,442 (27.42%) were car passengers, 12 (0.10%) were unknown car occupants, 223 (1.78%) were truck drivers, and 29 (0.23%) were truck passengers.

In FARS, information about driver precrash actions can be found in a set of variables for "driver-level related factors." These variables are coded by FARS analysts from information provided by the investigating officer in the narrative of the police accident report and also from any other supporting materials (FHA 1996).

The 94 possible related factors that can be coded for a driver in FARS data are listed in appendix A. Some of the items given as driver-level related factors are not actually factors that contributed to the crash. For example, there are codes for nontraffic violations and for other nonmoving violations. However, items that do not directly cause a crash account for only about 5% of the items listed. In 1995 and 1996, up to three driver-level related-factor variables could be coded for a driver involved in a crash. In 1997 and 1998, this number was increased to four. In the rest of this report, driver-level related factors are referred to as "driver factors."

Table 1.2 shows the distribution of the number of driver factors recorded for drivers in fatal two-vehicle car-car and car-truck crashes in the analysis file. Driver factors were recorded for approximately 54% of drivers in both car-car and car-truck crashes. However, among drivers in fatal car-truck crashes, such factors were more likely to be recorded for drivers of cars than for trucks. For example, driver factors were coded for 80% of the involved car drivers but for only 27% of the involved truck drivers in car-truck crashes. Multiple driver factors were coded for about 25% of all drivers involved.

Table 1.2. Number of Unsafe Driver Actions Coded for Drivers in Fatal Car-Truck and Car-Car Crashes, 1995-1998.

Number of Driver Factors Coded	Car-Car Crashes (Number of Car Drivers; n = 70,488)	Car-Truck Crashes: Number of Car and Truck Drivers (n = 21,464)	Car-Truck Crashes: Number of Car Drivers (n = 10,732)	Car-Truck Crashes: Number of Truck Drivers (n = 10,732)
0	32,390 (45.9%)	9,952 (46.4%)	2,115 (19.7%)	7,837 (73.0%)
1	20,495 (29.1%)	6,541 (30.5%)	4,826 (45.0%)	1,715 (16.0%)
2	12,323 (17.5%)	3,700 (17.2%)	2,877 (26.85)	823 (7.7%)
3	4,795 (6.8%)	1,158 (5.4%)	843 (7.9%)	315 (2.9%)
4	485 (0.7%)	113 (0.5%)	71 (0.7%)	42 (0.4%)

Source: Fatality Analysis Reporting System data.

We examined the combinations of driver factors to determine if any appeared together often enough to be treated together in the study. There were 2,246 unique combinations of driver factors for drivers with multiple driver factors. An examination of these combinations showed that the number of drivers coded for any one of these combinations was quite small. We therefore decided to use the individual driver factors, whether they appeared alone or in combination with other factors in further analysis. Appendix B shows both the driver factors in the analysis data file and also how often each appeared as a multiple factor.

Table 1.3 shows the frequency of the most common driver factors for two-vehicle crashes in the analysis data file. Factors associated with nonmoving violations are not shown in this table.

It is interesting that the distributions of the driver factors recorded for car drivers in both car-car and car-truck crashes were similar, suggesting that precrash driving actions of car drivers involved in fatal crashes were not significantly affected by whether the crash involved another car or a truck. Indeed, in cases for which driver factors were recorded, five driver factors: failure to keep in lane, failure to yield right-of-way, driving too fast for conditions or exceeding posted speed limit, failing to obey traffic control devices and laws, and inattentive comprised about 65% of reported unsafe car driver acts in both car-truck and car-car crashes. In other words, drivers who get involved in fatal crashes probably drive in the same manner around trucks as they do around other cars.

Table 1.3. Frequency of Unsafe Driver Actions in Fatal Car-Truck and Car-Car Crashes, 1995-98.

Driver Factor	Number of Times Driver Factor was Coded for Drivers in:			
		Car-Truck Crashes		
	Car-Car Crashes (61,466 UDAs)	In Both Cars and Trucks (17,867 UDAs)	In Cars (13,393 UDAs)	In Trucks (4,474 UDAs)
Failure to keep in lane or running off road	11,077 (18%)	3,336 (19%)	2,806 (21%)	530 (12%)
Failure to yield right of way	10,853 (18%)	2,722 (15%)	2,123 (16%)	599 (14%)
Driving too fast for conditions or in excess of posted speed limit	7,781 (13%)	2,114 (12%)	1,665 (12%)	449 (11%)
Failure to obey actual traffic signs, traffic control devices or traffic officer; failure to obey safety zone traffic laws	6,356 (10%)	1,611 (9%)	1,246 (9%)	365 (8%)
Inattentive (talking, eating)	3,901 (6%)	1,372 (8%)	1,110 (9%)	262 (6%)
Operating the vehicle in an erratic, reckless, careless, or negligent manner; or operating at erratic or suddenly changing speeds	2,376 (4%)	753 (4%)	567 (4%)	186 (4%)
Driving on wrong side of road (intentionally or unintentionally)	2,371 (4%)	616 (3%)	536 (4%)	80 (2%)
Sliding due to ice, water, slush, sand, dirt, oil, or wet leaves on road	1,406 (2%)	408 (2%)	370 (3%)	38 (1%)
Making improper turn	1,252 (2%)	349 (2%)	263 (2%)	86 (2%)
Passing with insufficient distance or inadequate visibility; or failing to yield to overtaking vehicle	839 (1%)	213 (1%)	164 (1%)	49 (1%)
Drowsy, sleepy, asleep, or fatigued	670 (1%)	344 (2%)	300 (2%)	44 (1%)
Overcorrecting	643 (1%)	177 (1%)	149 (1%)	28 (1%)
Improper or erratic lane change	539 (1%)	245 (1%)	185 (1%)	60 (1%)
Following improperly	482 (1%)	374 (2%)	275 (2%)	99 (2%)
Vision obscured by rain, snow, fog, sand, or dust	401 (1%)	231(1%)	145 (1%)	86 (2%)

Source: Fatality Analysis Reporting System data.

ESTIMATING LIKELIHOOD RATIOS

The frequencies of driver factors from the analysis file provided the data needed to estimate the likelihood of a driver factor being recorded for car-truck crashes compared with car-car crashes. The details of the calculation are in appendix C; table 1.4 shows the results.

Table 1.4. Estimated Likelihood of Driver Factor in Fatal Car-Truck Crash Relative to Fatal Car-Car Crash

Driver Factor (DF)	Conditional Probability (*P*) *P*(DF/car-car)	*P*(DF/car-truck)	Likelihood Ratio
Failure to keep in lane or running off road	0.3136	0.3130	0.9980
Failure to yield right of way	0.3079	0.2537	0.8240
Driving too fast for conditions or in excess of posted speed	0.2197	0.2006	0.9130
Failure to obey actual traffic signs, traffic control devices or traffic officer; failure to obey safety zone traffic laws	0.1803	0.1502	0.8331
Inattentive (talking, eating)	0.1099	0.1304	1.1867
Operating the vehicle in an erratic, reckless, careless or negligent manner; or operating at erratic speed or suddenly changing speed	0.0673	0.0705	1.0472
Driving on wrong side of road (intentionally or unintentionally)	0.0673	0.0576	0.8561
Sliding due to ice, water, snow, slush, sand, dirt, oil, or wet leaves on road	0.0399	0.0433	1.0864
Making improper turn	0.0355	0.0327	0.9197
Passing with insufficient distance or inadequate visibility or failing to yield to overtaking vehicle	0.0238	0.0199	0.8358
Drowsy, sleepy, asleep, or fatigued	0.0190	0.0320	1.6815
Overcorrecting	0.0182	0.0166	0.9084
Improper or erratic lane change	0.0153	0.0227	1.4868
Following improperly	0.0137	0.0349	2.5417
Vision obscured by rain, snow, fog, sand, or dust	0.0111	0.0223	1.9998

Source: Calculations in table C.1.

A likelihood ratio of 1 indicates that the driver factor is equally likely to be recorded for a fatal car-truck crash as for a fatal car-car crash. The greater the likelihood ratio, the more likely it is that the driver factor was recorded for a car-truck crash rather than a car-car crash. As can be seen from table 1.4, the majority of the likelihood ratios were close to 1. Four of the driver factors had likelihood ratios equal to or greater than 1.5:

- *Drowsy, sleepy, asleep, or fatigued*
- *Following improperly*
- *Vision obscured by rain, snow, fog, smoke, sand, or dust*
- *Improper or erratic lane change*

These ratios indicate that these driver factors were more likely to be associated with fatal car-truck crashes than with fatal car-car crashes.

Table 1.5. Driver Factors More Likely to Occur in Fatal Car-Truck Crashes than in Fatal Car-Car Crashes by Driver

Driver Factors More Likely to Occur in Car-Truck than in Car-Car Crashes	Number and % of Crashes	Driver Factor Assigned to Driver of:		
		Car Only	Truck Only	Both Car and Truck
Drowsy, sleepy, asleep, or fatigued	344 100%	300 87%	44 13%	0 0%
Following improperly	373 100%	272 72.9%	98 26.3%	3 0.8%
Improper or erratic lane change	243 100%	183 75.3%	58 23.9%	2 0.8%
Vision obscured by rain, snow, fog, smoke, sand, or dust	165 100%	79 47.9%	20 12.1%	66 40.0%

Source: Data in table C.1.

Because FARS data contain information about the weight of the truck, body type, and number of trailers, we could also determine whether some driver factors were more likely to be present in fatal crashes between cars and certain types of trucks. It was not possible to compare the likelihood of car-truck crashes by the number of trailers because the number of tractor-trailer combinations with no trailers or with two or more trailers was very small. However, there were adequate data in the analysis file to calculate and compare the likelihood of driver factors in fatal crashes of cars with heavy trucks (with gross vehicle weights of more than 33,000 pounds) relative to fatal crashes of cars with medium-weight trucks (with gross vehicle weights of 10,000 to 33,000 pounds). The calculations can be found in appendix D.

The relative likelihood values for three of the driver factors were equal to or exceeded 1.5, indicating that these driver factors were more likely to be recorded in fatal crashes between cars and heavy trucks than in fatal crashes between cars and medium-weight trucks. These factors were:

- *Passing with insufficient distance or inadequate visibility or failing to yield to an overtaking vehicle*
- *Vision obscured by rain, snow, fog, smoke, sand, or dust*
- *Improper or erratic lane change*

All other driver factors were equally likely in fatal crashes of cars with heavy or medium-weight trucks.

Taken together, the results of all the likelihood analyses suggest (1) that improper or erratic lane changes and obscured vision were more likely to contribute to fatal car-truck crashes than to fatal car-car crashes, and (2) that among car-truck crashes, these factors had a greater effect on crashes involving heavy trucks than on crashes involving medium-weight trucks. Passing with insufficient distance or adequate visibility and failing to yield to an overtaking vehicle were as likely to contribute to fatal crashes between cars and trucks as to fatal crashes between cars. However, among car-truck crashes, these factors were more likely to contribute to a fatal crash between a car and a heavy truck than to a fatal crash between a car and a medium-weight truck. Driver sleep or fatigue and improper following—although more likely to contribute to fatal car-truck crashes than fatal car-car crashes—did not differentially affect heavy versus medium-weight trucks.

The preceding analysis did not identify which driver in each crash was coded with the driver factor. Table 1.5 above shows the numbers and percentages of car and truck drivers assigned the driver factor.

For crashes in which driver sleepiness or fatigue was a contributing factor, 87% of the time it was the car driver and 13% of the time it was the truck driver who was asleep or fatigued. When improper following and improper lane changes contributed to a fatal car-truck crash, the unsafe maneuver was performed by the car driver approximately three-quarters of the time and the truck driver one-quarter of the time. For crashes in which obscured vision contributed to the crash, the factor was recorded for both the driver of the car and the driver of the truck in 40% of the crashes.

Conclusions

An examination of the FARS records for two-vehicle fatal crashes from 1995 to 1998 showed that driver factors were much more likely to be recorded for car drivers than for truck drivers involved in fatal crashes The distributions of the driver factors for car drivers involved in fatal car-car crashes and in fatal car-truck crashes appeared to be similar. Because of the complexity and uncertainty of identifying contributing actions and conditions, and their coding in the crash record, a Bayesian approach was used to estimate the likelihood of specific driver factors being recorded in fatal car-truck crashes as compared with car-car crashes. The results indicate that most driver factors were equally likely to be recorded for fatal car-truck crashes as for fatal car-car crashes. In crashes for which driver factors were recorded, five of these equally likely factors (failing to keep in lane, driving too fast for conditions or in excess of posted speed limit, failing to yield right-of-way, speeding, failing to obey traffic control devices and laws, and inattentive) comprised about 65% of reported unsafe car driver acts in both car-truck and car-car crashes.

Four driver factors were found to be more likely in car-truck crashes than in car-car crashes:

- *Drowsy, sleepy, asleep, or fatigued*
- *Following improperly*
- *Vision obscured by rain, snow, fog, smoke, sand, or dust*
- *Improper or erratic lane change*

Two of these driver factors—following improperly, and improper or erratic lane change — are actions of the driver. The other two factors — drowsy, sleepy, asleep, or fatigued; and vision obscured by rain, snow, fog, smoke, sand, or dust — are conditions of the driver (the first one is an indication of the driver's physical condition; the second one is an external environmental condition that possibly interacts with the driver's physical condition, e.g., poor vision). These four driver factors, however, were found in only about 5% of the car-truck crashes.

These results imply that driver actions contributing to fatal car-truck crashes are similar to those contributing to fatal car-car crashes. However, the higher likelihood that the factors of improper lane changing, improper following, and driving while drowsy or fatigued or with obscured vision will be recorded in fatal car-truck crashes than in fatal car-car crashes indicates that the consequences of these actions are more severe for car drivers when they occur in the vicinity of trucks than in the vicinity of other cars.

CHAPTER 2

The Second Stage of Research: Detailed Review of Car-Truck Crash Records

The second stage of our research was to examine the set of car-truck crashes characterized by one or more of the four driver factors that disproportionately contributed to fatal car-truck crashes and to look for patterns in precrash events or in driver characteristics. For this, we turned to hard-copy materials from the Trucks in Fatal Accidents (TIFA) files of the Center for National Truck Statistics (CNTS).

These annual TIFA files contain detailed data on heavy and medium-weight trucks involved in fatal crashes in the United States. CNTS develops the TIFA files from Fatality Analysis Reporting System (FARS) data, police accident reports, and interviews both with truck owners or drivers and with police officers investigating the crashes. Because CNTS made the hard-copy materials used to develop the TIFA files available to our research team, we read the original police report, examined crash diagrams, and in some cases read through interviews with surviving vehicle occupants and witnesses to glean more information than was contained in the electronic record of the event.

Cases Involving the Four Driver Factors

Our analysis file obtained from FARS for the years 1995–98 contained records of 1,125 car-truck crashes, with at least one of the four driver-related factors identified above as more likely to contribute to car-truck crashes than to car-car crashes. From these 1,125 crashes, a sample of 532 cases (47%) was drawn randomly, and hard-copy TIFA crash records for these cases were requested from CNTS. The research team reviewed material for 529 of these cases (no information was available for 3 cases), reconstructing the behavioral sequences and identifying the unsafe driver actions and conditions that led to these car-truck crashes. In the 529 car-truck crashes, 626 people died — 403 (64.38%) were car drivers, 187 (29.87%) were car passengers, 33 (5.27%) were truck drivers, and 3 (0.48%) were truck passengers.

The unsafe driver actions and conditions that were obtained from the narrative description of the crash and used in this analysis included the original driver factor and other actions or conditions of the driver that appeared to have contributed to the crash — for example, driving under the influence of alcohol or drugs, cutting off another vehicle, running a red light, not stopping for a stop sign, and making an unsafe U-turn. A database was prepared that contained information about the crash (time and date, age and gender of drivers, type of crash, roadway, configuration and weight of the truck, type of passenger vehicle, unsafe actions or conditions of the drivers of both vehicles before the crash, and a short summary of the narrative). Information from this detailed review was grouped into four sets, based on the original driver factor. Example cases from the database are given in appendix E, which consists of summary tables of unsafe driver actions and conditions for each of the four sets of crashes.

Table 2.1 gives some of the characteristics of the fatal car-truck crashes for each of four sets of crashes defined by the original FARS driver factor. The table summarizes much of what is known about car-truck crashes in general. More than half of the fatal car-truck crashes in which a driver fell asleep were head-on crashes, and more than one-quarter of these occurred between 3 and 6 a.m. Most occurred on roads without physical barriers between opposing lanes (60% occurred on undivided two-way roads, and 30% on divided roads without median barriers). Almost all of the fatal crashes in which a driver was following improperly were rear-end crashes. Although a greater portion occurred on divided roadways, the split between divided and undivided roads was relatively close. Improper or erratic lane changes led to rear-end and sideswipe crashes. Most of these crashes occurred on divided roadways. Two-thirds of the fatal car-truck crashes that were a consequence of obstructed vision occurred on undivided roadways, about a quarter occurred in January, and nearly a third occurred between 6 and 9 a.m.

Table 2.1. Number and Features of Reviewed Cases by Driver Factor

Driver Factor	Number of Cases	Most Frequent Crash Type (percent)	Most Frequent Road Type (percent)	Month with Most Cases (percent)	Hours with Most Cases[a] (percent)
Drowsy, sleepy, asleep, or fatigued	158	Head-on (54.1)	Two-way, not divided (60) Divided with median, no barrier (30)	October (12.7)	0300–0600 (27.4)
Following improperly	172	Rear-end (91.3)	Two-way, not divided (42) Divided (56)	October (14.0)	1800–2100 (18.0)
Improper or erratic lane change	113	Rear-end (31.8) Sideswipe (27.4)	Two-way, not divided (15) Divided (85)	April (14.2)	1500–1800 (18.6)
Vision obstructed by rain, snow, fog, smoke, sand, or dust	86	Angle (44.2)	Two-way, not divided (66%) Divided (34%)	January (24.4)	0600–0900 (30.2)

[a]Hours are given in 24-hour style; e.g., 1300 = 1 pm.
Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

To explore patterns further, we grouped cases in each of the four sets according to whether the unsafe actions and conditions were associated with the driver of the car, with the driver of the truck, or with both (Table 2.2). Recall that unsafe driver actions and conditions were identified in the review of the hard-copy materials and included more information about the cause of the crash than just the original driver factor.

Table 2.2. Unsafe Driver Actions and Conditions by Vehicle for the Four Sets of Reviewed Cases

Driver Factor	Number of Cases (percent)	Number of Actions and Conditions Noted (percent) for Drivers of:		
		Cars Only	Trucks Only	Both Cars and Trucks
Drowsy, sleepy, asleep, or fatigued	158 (100)	137 (86.7)	20 (12.7)	1 (0.6)
Following improperly	172 (100)	124 (72.1)	37 (21.5)	11 (6.4)
Improper or erratic lane change	113 (100)	83 (73.5)	24 (21.2)	6 (5.3)
Vision obstructed by rain, snow, fog, smoke, sand, or dust	86 (100)	52 (60.5)	13 (15.1)	21 (24.4)

Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

Of the 158 cases from the set of crashes with the driver factor "drowsy, sleepy, asleep, fatigued," 137 were found to be a result of unsafe actions and conditions of the car driver alone. In all these cases, indications were that the car driver was not fully awake. In some cases, witnesses stated that the driver appeared asleep. In others, people who knew the driver stated that he or she had had very little sleep in the past few days. For about 60% of the cases, no other information was available other than that the car had crossed the center line or median.

In 20 cases from this set of crashes, the unsafe actions and conditions were found for the truck driver alone. Two of these cases involved alcohol, and 17 involved the truck crossing the center line or median. Of these 17 cases, the truck driver was ill in 1 case, and no other reason could be identified in 16 cases. For this set of crashes, there was only 1 case in which unsafe actions and conditions could be identified for both vehicles. It involved a car driving into the rear of a truck stopped in the traffic lane with the truck's emergency lights flashing and the driver asleep.

Of the 172 cases involving the driver factor "following improperly," unsafe driver actions and conditions were identified for the car driver alone in 124 cases, for the truck driver alone in 37 cases, and for both drivers in 11 cases. Of the 124 cases in which the unsafe actions were noted for the car driver alone, the actions and conditions accounting for the greatest proportions of crashes were following too closely and/or driving too fast to stop when the vehicle in front slowed or stopped (39%), inattention with no attempt to slow down or stop (21%), speeding (17%), and alcohol (16%). For the 37 cases in which the actions of the truck driver alone contributed to the crash, the largest proportions of crashes were attributed to following too closely (51%) and inattention with no attempt to slow down or stop (38%). Of the 11 cases in which actions of both drivers contributed to the crash, the pattern was that one vehicle was following too closely and the leading vehicle took some action. In 1 case, for example, the leading truck tested his brakes to make sure that they were working. In 3 of these cases, the car driver had been drinking; in 1 case, the truck driver had been drinking.

Of the 113 cases involving the driver factor "improper or erratic lane change," unsafe actions and conditions were found for the car driver alone in 83 cases, for the truck driver alone in 24 cases, and for both drivers in 6 cases. For the cases in which actions and conditions were found for the car driver alone, the actions and conditions accounting for the greatest proportions were that the driver had been drinking (23%), moved over laterally into a truck in the next lane (18%), cut off the truck by moving directly in front of it (11%), lost control during a lane change (11%), or made an unsafe turn (8%). Of the cases in which unsafe actions and conditions were identified for truck drivers alone, the largest proportions of actions and conditions were that the driver moved laterally into the car in the next lane (79%), lost control during a lane change (12%), or cut off the car (8%). For the 6 cases in which both drivers contributed to the crash, the drivers' actions were combinations of speeding, lateral moves into the occupied adjacent lane, and cutting off vehicles.

Finally, of the 86 cases involving "vision obstructed by rain, snow, fog, smoke, sand, or dust," unsafe actions and conditions were found for the car driver alone in 52 crashes, for the truck driver alone in 13 crashes, and for both drivers in 21 crashes. Of the cases in which unsafe actions and conditions were identified for car drivers alone, the largest proportions of actions and conditions were failing to yield the right of way (21%), losing control (19%), speed-related (17%), sleep and fatigue (6%), inattention (6%), and alcohol (4%). In the rest of these cases, no finer breakdown than obstructed vision could be identified. Of the 13 cases in which unsafe actions and conditions were identified for truck drivers alone, the largest proportions were failing to yield the right of way (29%) and speed-related (14%). The remaining cases involved obstructed vision, following too closely, and making unsafe turns. In almost 30% of the 21 cases with unsafe driver actions and conditions for both drivers, obstructed vision was noted for both. The remaining cases were combinations of obstructed vision and speed, failing to yield the right of way, unsafe lane changes, and inattention.

Age and Gender Effects

Tables 2.3 and 2.4 show age and gender distributions for cases in which unsafe driver actions and conditions were found, respectively, for car drivers only and for truck drivers only. The mean and 25th, 50th, and 75th percentile age categories are good indicators of the age distribution of the drivers whose actions and conditions contributed to the car-truck crash. From these values, it can be seen that car drivers involved in car-truck crashes in which obstructed vision was a contributing factor were likely to be relatively older, whereas car drivers involved in crashes in which the car driver was drowsy, asleep, or fatigued were likely to be relatively younger. For truck drivers, the mean and 25th, 50th, and 75th percentile ages show that younger truck drivers were more likely to be involved in car-truck crashes in which they followed improperly. For the other three sets of crashes, the age distributions are similar and reflect those of truck drivers in general.

Table 2.3. Age and Gender Distributions of Cases— Unsafe Driver Actions and Conditions Noted for Car Driver Only

Driver Factor	Age of Car Driver (years)				Male Car Drivers (percent)
	Mean	25th percentile	50th percentile	75th percentile	
Drowsy, sleepy, asleep, or fatigued	37	20	33	49	74
Following improperly	41	26	37	52	79
Improper or erratic lane change	40	23	36	50	62
Vision obstructed by rain, snow, fog, smoke, sand, or dust	47	28	48	67	61

Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

Table 2.4. Age and Gender Distributions of Cases — Unsafe Driver Actions or Conditions Noted for Truck Driver Only

Driver Factor	Age of Truck Driver (years)				Male Truck Drivers (percent)
	Mean	25th percentile	50th percentile	75th percentile	
Drowsy, sleepy, asleep, or fatigued	44	34	43	55	100
Following improperly	39	30	40	47	97
Improper or erratic lane change	46	33	47	62	96
Vision obstructed by rain, snow, fog, smoke, sand, or dust	45	32	45	55	94

Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

The proportion of male drivers in all four sets of crashes was found to be high. For truck drivers, this reflects the fact that at the time these data were collected, most truck drivers were male. However, for car drivers, this indicates either that males are more likely than females to engage in unsafe actions leading to fatal car-truck crashes or that males make up more of the driver population on the road when fatal car-truck crashes occur.

To test if male car drivers were more likely than females to engage in unsafe actions that led to fatal car-truck crashes, the gender of drivers in the crashes in which actions and conditions were noted only for car drivers was tabulated and compared against the gender of car drivers in crashes in which actions and conditions were noted only for truck drivers. In other words, the numbers of male and female car drivers whose actions contributed to fatal car-truck crashes were compared with the numbers of male and female car drivers who were in fatal car-truck crashes but did not cause them. Table 2.5 shows the number of male and female car drivers in fatal crashes in which driver actions and conditions of car drivers led to the crash for each of the four sets of crashes based on the original driver-related factors.

Table 2.5. Gender Distribution of Car Drivers in Fatal Car-Truck Crashes — Unsafe Driver Actions and Conditions Noted for Car Driver Only

Driver Factor	Males	Females	Unknown	Total
Drowsy, sleepy, asleep, or fatigued	100	34	3	137
Following improperly	98	26	0	124
Improper or erratic lane change	54	29	0	83
Vision obstructed by rain, snow, fog, smoke, sand, or dust	28	21	3	552
Total	280	110	6	396

Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

The gender distribution of car drivers for the fatal crashes in which the actions and conditions of the truck driver alone led to the crash was 56 males, 37 females, and 1 unknown. These car drivers were simply on the road at the time of the crash and reflect the gender distribution of car drivers. For this comparison, the specific driver factors of truck drivers were not important.

The hypothesis of independence between gender and contribution or non-contribution of car drivers to fatal car-truck crashes was tested with categorical analysis (appendix F). The results of the analysis indicated that there was a gender effect for fatal car-truck crashes in which the car driver was drowsy, asleep, or fatigued, and for fatal car-truck crashes in which the car driver was following improperly. No effects of gender were found for crashes in which the car driver made an improper or erratic lane change or for crashes in which the car driver's vision was obstructed.

We next examined unsafe driver actions and conditions in detail. We found that some were common to all four sets of crashes and accounted for a large portion of unsafe actions and conditions. These included driving under the influence of alcohol or drugs, driving while fatigued or asleep, inattention, failing to yield the right of way, moving over laterally into or cutting off another vehicle, following too closely, and driving at excessive speed or at speeds unsafe for conditions.

We combined the four separate sets of fatal crashes, tabulated the common unsafe actions and conditions, and looked at the age of the car and truck drivers for each action or condition category. Tables 2.6 and 2.7 show the number of cases in each category and the mean and 25th- and 75th-percentile age for, respectively, car drivers and truck drivers. Cases in which unsafe actions were noted for both drivers in the crash are included. The 10 unsafe driver actions and conditions in the tables accounted for 85% of the cases in which unsafe actions and conditions were noted for car drivers and 82% of the cases in which they were noted for truck drivers.

Table 2.6. Unsafe Actions and Conditions of Car Drivers in Fatal Car-Truck Crashes by Age

Major Action or Condition	Number of Car Drivers (percentage of 434 crashes)[a]	Age (years)		
		Mean	25th percentile	75th percentile
Alcohol or drugs	53 (12.2)	39	26	45
Fell asleep, fatigue	87 (20.0)	37	21	50
Inattention	34 (7.8)	42	25	59
Failed to yield right of way	13 (3.8)	51	34	70
Changed lanes into other vehicle or cut off other vehicle	30 (6.9)	42	26	52
Speed-related	49 (11.3)	37	22	47
Followed too closely	62 (14.3)	42	26	56
Lost control	29 (6.7)	43	23	64
Unsafe turn	8 (1.8)	61	46	81
Wrong way	6 (1.4)	44	30	64

[a]For the 529 cases reviewed, there were 434 crashes in which an unsafe action or condition was noted for the car driver (these included crashes for which unsafe action or conditions also were noted for the truck driver).

Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

Table 2.7. Unsafe Actions and Conditions of Truck Drivers in Fatal Car-Truck Crashes by Age

Major Action or Condition	Number of Truck Drivers (percentage of 134 crashes)[a]	Age (years)		
		Mean	25th percentile	75th percentile
Alcohol or drugs	5 (3.7)	37	33	40
Fell asleep, fatigue	16 (11.9)	42	30	48
Inattention	7 (5.2)	44	32	56
Fail to yield right of way	6 (4.5)	46	33	54
Changed lanes into other vehicle or cut off other vehicle	24 (17.9)	41	32	49
Speed	12 (9.0)	38	30	43
Followed too close	27 (20.1)	38	30	46
Lost control	8 (6.0)	41	26	51
Unsafe turn	5 (3.7)	46	31	57
Wrong way	0 (0)	—	—	—

[a]For the 529 cases reviewed, there were 134 crashes in which an unsafe action or condition was noted for the truck driver (these included crashes for which unsafe action or conditions also were noted for the car driver).

Sources: Authors' calculations using data from the Trucks in Fatal Accidents files of the Center for National Truck Statistics and from the Fatality Analysis Reporting System.

For car drivers, the oldest 25th-percentile age was for unsafe turning (age 46 years). Although the second highest 25th-percentile age was only 34 (for failing to yield the right-of-way), it was still notably higher than the 25th-percentile age for the other unsafe driver action and conditions. The youngest 75th-percentile age for car drivers was for alcohol or drugs (age 45) and for speed (age 47). For truck drivers, the 25th-percentile ages were similar across all actions and conditions. However, the youngest 75th-percentile ages for truck drivers were also for alcohol or drugs (age 40) and speed (age 43).

The results of these analyses point to the use of alcohol or drugs and speeding as unsafe behaviors among younger drivers for both cars and trucks involved in fatal car-truck crashes. Among older car drivers involved in fatal car-truck crashes, the predominant driver actions and conditions were unsafe turns and failure to yield the right of way.

Conclusions

Hard-copy materials—including original police accident reports, crash diagrams, and in some cases witness statements—were reviewed for a sample of more than 500 fatal car-truck crashes with at least one of the four driver factors identified above as more likely to contribute to car-truck crashes than to car-car crashes. Behavioral sequences leading to the crashes were reconstructed, and more detailed unsafe driver actions and conditions were identified. A database containing information about the drivers, vehicles, and actions and conditions of each driver was developed and analyzed.

Several gender and age effects were found for car drivers in this sample. Male car drivers were more likely than female car drivers to be involved in fatal car-truck crashes in which they were drowsy, asleep, fatigued, or following improperly. Males and females were equally likely to be involved in fatal car-truck crashes in which they made an improper or erratic lane change or had their vision obstructed. At the same time, car drivers involved in crashes in which their vision was obstructed were more likely to be older than car drivers exhibiting the other driver factors. The age of car drivers who fell asleep or were fatigued before a fatal car-truck crash was likely to be lower than that for other crash-involved car drivers. We also found that other driver actions and conditions—such as use of alcohol or drugs, speed-related actions, failure to yield the right of way, and inattention—were often associated with car drivers and exhibited age and gender effects consistent with crash risk in general.

This analysis also found age effects among the truck drivers involved in fatal car-truck crashes. Younger truck drivers were more likely to be involved in fatal car-truck crashes in which they followed improperly. Unsafe behaviors such as speeding and the use of alcohol or drugs were also more likely among younger truck drivers than older truck drivers. These results are consistent with those from a study of younger truck drivers by Blower (1996), but the number of cases involving older and younger truck drivers was relatively small, so these findings should be treated with caution.

CHAPTER 3

The Third Stage of Research: Exploring the Development of Educational Materials

In the third stage of the research, we sought to identify strategies for developing instructional materials that would provide a good fit with our findings on the driver factors associated with fatal car-truck crashes. Educational strategies are most effective when the nature and content of the instruction match the desired program outcomes. These outcomes—here termed "instructional targets"—are typified by changes in knowledge, behavior, and attitudes (Craig 1976; Salas and Cannon-Bowers 2001).

Instructional Targets

Changes in Knowledge

Knowledge outcomes are those whereby information is passed from the instructor to the student to improve the student's intellectual understanding of issues. In developing strategies to increase a person's knowledge of traffic safety issues, it is helpful to consider two subtypes of knowledge: static and dynamic (Salas and Cannon-Bowers 2001). Static knowledge represents information that does not change or remains relatively constant over time, or information about situations that do not require action by the student. Examples of static knowledge include vehicle identification, explanations of laws, the placement of control pedals, and the fact that trucks brake take longer to stop than cars. Dynamic knowledge reflects an understanding of information that describes systems in motion and potential responses to and effects of actions within these systems. Examples of dynamic knowledge include knowing how to estimate relative speed and distance between vehicles, knowing how to respond when a truck moves into your lane, and knowing how to merge into traffic near a truck. Another way to describe the difference between static and dynamic knowledge is that, in general, static knowledge involves simple relationships and dynamic knowledge involves complex relationships.

Changes in Behavior

Behavioral outcomes are those whereby one overtly acts in a physical, observable way to influence one's environment (Fiske and Taylor 1984). Though it is common to classify thought processes like estimating relative speeds and distances between vehicles as cognitive behavior, here these are described under dynamic knowledge. As was the case in the knowledge category, behavioral targets can be subdivided into two groups: simple and complex. Simple behaviors are those that do not occur in response to an external stimulus; they must be mastered so they can be chained with perceptions and other behaviors to create the complex behavior patterns that emerge in everyday driving. Examples of simple behaviors include pressing the brake or accelerator pedal, turning the steering wheel, and looking in the mirrors. Behaviors that involve a response to a perception, a perceptual-behavior feedback loop, or a chain of behaviors are categorized as complex (Salas and Cannon-Bowers 2001). Examples of complex behaviors include pressing the brake pedal in response to a cue, maintaining lane position, or accelerating and moving into an adjoining lane before passing a vehicle.

Changes in Attitudes

Attitudes represent a more challenging target for instructional efforts than do knowledge or behavior. Attitudes consist of three kinds of components: affective, cognitive, and behavioral (Fiske and Taylor 1984). Affective components of attitudes are related to one's subjective mood or to an objective physiological response. Subjective mood is generally expressed in verbal statements of affect (e.g., "I'm scared"). An objective physiological response is displayed in effects on the sympathetic nervous system (e.g., an increased heart rate under threat).

The cognitive components of attitudes are related to the beliefs and opinions through which attitudes are expressed. These expressions are made through perceptual responses and verbal statements of belief (Fiske and Taylor 1984). For example, a car driver with the attitude that truck drivers are rude and abusive might perceive a situation in which a car and truck interact negatively as being the fault of the truck driver. In this situation, the car driver's negative attitude toward truck drivers was expressed through the perception that the truck driver was at fault. Verbal statements of belief are more objective expressions of attitudes (e.g., "Truck drivers are not considerate of car drivers").

Behavioral components of attitudes include the physical and mental processes that prepare an individual to act in a certain manner (Fiske and Taylor 1984). For example, a person could have the attitude that truck drivers change lanes without caring whether there is a car in the adjoining lane. This person may sit up in the seat to make it easier to execute an emergency avoidance maneuver (physical preparation) or begin to consider options if the truck were to start changing its lane into the car's path (mental preparation).

Instructional Strategies

Instructional programs attempt to change knowledge, behavior, or attitudes. Accordingly, there are different instructional strategies that are most effective for creating each type of change. These strategies fall into a continuum from passive education to active participation, as is shown in figure 3.1. This framework is quite similar to that used by the U.S. military when developing training materials and exercises (e.g., Salas and Cannon-Bowers 2001).

The passive–active continuum describes a range from strategies that involve passively receiving information to strategies that engage the student more and more in activities that are targets of instruction. For example, listening to a lecture is a very passive strategy, whereas simulations using actual vehicle platforms or on-the-road practice are active strategies.

Matching Instructional Targets and Strategies

The key to successful instruction is to match the appropriate target with the appropriate strategy. Table 3.1 summarizes the extent to which various instructional strategies fit with instructional targets.

Table 3.1. Fit of Instructional Targets and Strategies

Strategy	Target: Knowledge Change		Target: Behavior Change		Target: Attitude Change		
	Static	Dynamic	Simple	Complex	Affective	Cognitive	Behavioral
Lectures, books, movies	+	0	–	–	–	0	0
Computer-based instruction (test)	+	0	–	–	–	0	0
Computer-based instruction (graphic)	+	+	0	0	–	0	0
Computer-based simulation (personal computer)	0	+	0	+	0	+	+
Computer-based simulation (vehicle platform)	–	+	+	+	0	+	+
Closed-track simulation (real vehicles)	–	+	+	+	+	–	+
On-the-road practice (real vehicles)	–	+	+	+	+	–	+

Note: The symbols represent the extent to which there is an apparent fit: "+" indicates a good or acceptable fit, "0" indicates a possible or weak fit, and "–" indicates a poor or no fit between the instructional strategy and the instructional target.

Table 3.1 shows that, in general, instructional targets that are complex or require interaction with the environment are best handled using active instructional strategies that reflect the nature and context of the task. As the instructional problem becomes more complex and more closely tied to individual driving and incident conditions, it becomes more and more necessary to conduct the instruction with activities that closely match the situation for which the student is being trained (Ford and Weissbein 1997; Anderson et al. 1995).

Matching Research Findings with Instructional Targets and Strategies

The analyses described above presented four unsafe driving behaviors engaged in by car divers, who then become involved in a fatal crash with a large truck. These behaviors are improper following, improper lane change, driving with vision obscured by rain, snow, or other airborne particles, and driving while drowsy, asleep, or fatigued. In this section, we discuss possible behavior, knowledge, and attitude changes that may be targeted to affect these unsafe driving behaviors and the instructional strategies that may be applied to create the changes. A summary table of the instructional strategies and educational targets for these behaviors is given in appendix G.

Knowledge Change

Passive strategies—lectures, brochures, films, and computer-aided instruction—are best suited to static knowledge (Salas and Cannon-Bowers 2001). In the case of instruction on following maneuvers, static knowledge involves specific linear measures that reflect appropriate following distances (e.g., 200 feet). For lane-changing maneuvers, static knowledge includes laws about appropriate lane use. For driving with vision obscured by rain, snow, fog, smoke, sand, or dust, static knowledge includes the general effects of these conditions on vision and driving (e.g., reduced sight distance). For driving while drowsy, asleep, or fatigued, static knowledge includes alertness cues and the effects of sleep, sleep deprivation, and fatigue on performance, as well as methods for mitigating the effects of drowsiness and fatigue.

Dynamic knowledge for following and lane-changing maneuvers includes assessing relative speeds and distances between vehicles and the effects of road conditions on vehicle stability. In addition, dynamic knowledge for lane-changing maneuvers includes the ability to assess the relative speeds and spacing in the lane that the vehicle is moving into and the sight distance at the point where the lane change is being made. Dynamic knowledge for driving with vision obscured by rain, snow, fog, smoke, sand, or dust involves assessing the extent to which the decrease in vision shortens sight distance and hence reduces the reaction time available for making decisions.

Collectively, these relationships involving dynamic knowledge are best taught with dynamic instructional technologies that present stimuli to students using the most realistic simulations possible (Oser et al. 1999; Jentsch and Bowers 1998: a life-size simulator with a vehicle platform, closed-course simulation (driving a real vehicle on a closed course or test track), or on-the-road practice (driving a real vehicle on a real road). For driving while drowsy, sleepy, or fatigued, dynamic knowledge includes the effects of drowsiness and fatigue on the time to perceive a stimulus, the time needed to develop a response, and the reaction time once a decision has been made. Personal computer–based simulators could be used to assess alertness and determine likely declines in performance.

Behavior Change

Simple behaviors for following and lane-changing maneuvers include the ability to manipulate the brake and accelerator pedals and the steering wheel. These are best taught with physical manipulations of these controls (either actual or simulated; Salas and Cannon-Bowers 2001). For driving with obscured vision, simple behaviors include the ability to manipulate windshield wipers and the defogger, along with the brake and accelerator pedals and the steering wheel. Again, the best instructional strategy is manipulation of real or simulated controls. This implies the use of a life-size simulator with a vehicle platform, closed-course simulation, or on-the-road practice. Few actual behaviors—either simple or complex—can reduce the detrimental effects of drowsiness or fatigue on driving, other than getting rest. However, the effects of these conditions can be demonstrated to the student with very controlled personal computer–based simulation.

Complex behaviors for following and lane-changing maneuvers include estimating relative speeds and distances and behavioral reactions to rapidly decreasing space between vehicles. Instructional strategies for these require fidelity to actual conditions using high-level motion-based simulation, closed-track simulation, or on-the road practice.

For driving with obscured vision, complex behaviors include estimating relative speed, relative spacing, and reactions to more and more complex, uncertain environments. Again, instructional strategies for these require fidelity to actual conditions using high-level motion-based simulation, closed-track simulation, or on-the road practice. As simulated driving conditions become more like actual conditions, so will the effects of training using the chosen technology (Oser et al. 1999). The loss of vision creates an additional condition for students engaged in complex behavior training: stress, which compounds difficulties caused by decreased vision by further reducing sight distance. One of the best methods for reducing stress is to expose students again and again to the stressor so that they gain experience successfully negotiating the hazard (Gulian et al. 1989).

Attitude Change

For people to make long-lasting attitude changes, they not only must be presented with information and arguments consistent with the desired changes, but—more important—they must experience situations that mirror and thus reinforce the desired attitudes (Fiske and Taylor 1984). In other words, an attitude change is more likely to occur among persons who experience situations consistent with the desired attitude than by those who are simply presented with the desired attitude. This requires instructional settings that mirror real-world conditions to the greatest extent possible. It also needs to be noted that attitude change is not necessarily related to actual behavioral change. For example, though most people have the attitude that safety belts are an effective safety device, many do not use them. This may be due in large part to competing attitudes (e.g., "The government has no place telling me what to do").

Reliable evidence suggests that participating in role-playing exercises (a highly active form of instruction) may be the best mechanism to modify attitudes (Fiske and Taylor 1984). This may be particularly true for car-truck interactions in which the car driver probably has no idea about the nature of the driving task from the truck driver's perspective. In all probability, the only way car drivers may change their attitudes about trucks and truck drivers is to experience the situation from the truck driver's perspective. This could be accomplished using a truck-driving simulator or closed-track simulation. Indeed, at the low end of the reality-cost spectrum, one can envision training in which car drivers simply sit inside of tractor-trailer rig to get a feel of what the driver can see.

Costs are an important factor in choosing instructional strategies and technologies. It is difficult to estimate the costs of simulation technologies in general because they can vary greatly. As technologies become more sophisticated or lifelike in controlled settings, their costs generally increase. However, costs can be controlled by using existing software or driving facilities. If a particular training technology requires developing new software or driving facilities, its costs can be expected to rise considerably.

Conclusions

The third stage of the research explored instructional strategies that could be used to convey to motorists the risks associated with the four unsafe driving actions and conditions identified in the earlier part of the research. Instructional strategies attempt to make changes in knowledge (static and dynamic), behavior (simple and complex), or attitudes (affective, cognitive, and behavioral). Such strategies form a continuum from passive instruction (e.g., listening to a lecture) to actively engaging the student in the activities that are the target of the instruction (e.g., on-the-road practice). Although the examples presented here were aimed at the four driver actions and conditions that are more likely in fatal car-truck crashes than in fatal car-car crashes, similar strategies can be developed to teach drivers about the risks associated with other driver actions. A key requirement for an effective instructional strategy is that it match the instructional target.

A review of instructional strategies and targets indicates that brochures and short films efficiently convey static knowledge, such as laws, rules, and conventions about driving. However, these methods are not particularly effective for conveying dynamic knowledge of relationships, such as how to assess the relative speeds and distances between vehicles, the effects of road conditions on vehicle stability, or the effects of drowsiness or fatigue on driving performance. More effective instructional strategies for such relationships call for the student to actively participate in simulated or real scenarios. Instructional strategies intended to change behavior, whether simple (e.g., manipulation of vehicle controls), or complex (e.g., how to react to excessive relative speed and rapidly decreasing space between vehicles) also call for the student to actively participate in simulated conditions or controlled conditions on the road.

Technologies that can provide such training include personal computer–based simulations and demonstrations, and motion-based simulators (e.g., driving simulators or computer games). These could be developed on the basis of real-world scenarios, in which drivers would need to make certain maneuvers around large trucks and would need to react to the actions of the trucks and other traffic. An effective way for motorists to learn about driving near trucks would be to experience the situation from the truck driver's perspective. This could be accomplished using personal computer–based simulators or computer games in which the motorist assumes the role of truck driver. Perhaps the best technology for behavioral change (although impractical in many situations) would involve closed-track or on-the-road driving experience with a tractor-trailer. At the low end of the reality-cost spectrum, one can envision training in which a car driver simply sits inside a tractor-trailer rig to get a feel for what the truck driver can see.

CHAPTER 4

Discussion of Findings

This study's examination of Fatality Analysis Reporting System records for two-vehicle fatal crashes from 1995 to 1998 showed that driver factors related to unsafe driver actions were much more likely to be recorded for car drivers than for truck drivers. Most of these driver factors were as likely to be recorded for car-car crashes as for car-truck crashes. In crashes for which factors were recorded, five driver factors (failing to keep in lane, driving too fast for conditions or in excess of posted speed limit, failing to yield right-of-way, failing to obey traffic control devices or laws, and inattentive) comprised about 65% of reported unsafe car driver acts in both car-truck and car-car crashes. However, using Bayesian analysis, four driver factors were found to be more likely in car-truck crashes than in car-car crashes:

- *Drowsy, sleepy, asleep, fatigued*
- *Following improperly*
- *Vision obscured by rain, snow, fog, smoke, sand, or dust*
- *Improper or erratic lane change*

These four driver factors were recorded in approximately 5% of the car-truck crashes. This finding indicates that although many driver actions and conditions are equally risky whether performed near cars or trucks, particular actions and conditions are riskier in car-truck than in car-car encounters.

Given the unequal distribution of deaths for car and truck occupants, there is a potential for survivor bias in this study. In both the first and second stages of research, the vast majority of fatalities were car occupants; only a small percentage were truck occupants. Therefore, truck drivers and occupants had more influence on the police reports than car drivers and occupants. Fortunately, in many cases other witnesses and additional evidence (e.g., skid marks, impact sites) were also available to the crash investigators who were writing the reports.

It is important to note that this study looked only at fatal crashes. The uncertainty associated with trying to identify drivers' actions in the national crash data set that contained nonfatal crashes was too large to make inclusion of nonfatal crashes feasible in this study. It is possible that the patterns of driver actions in nonfatal car-truck crashes are different than those for fatal car-truck crashes; a study by Blower (1998) tentatively concluded that this may be the case.

Nevertheless, our findings from this study are consistent with the findings from a study of unsafe driving acts of car drivers in the vicinity of trucks that was not limited to fatal crashes (Stuster 1999). Stuster's study included rating by truck drivers, crash investigators, and safety experts of the danger and frequency of various driving maneuvers performed by car drivers in the vicinity of trucks. His research found several unsafe driving acts performed in the vicinity of trucks to be among the most dangerous and frequent ones:

- *Changing lanes abruptly in front of a truck*
- *Driving left of center*
- *Following too closely*

"Following too closely" and "changing lanes abruptly in front of a truck" match two of the driver factors found in our study, and the detailed review of the car-truck crashes conducted in the second stage of our research showed that many of the crashes in which the driver factor was recorded as "drowsy, sleepy, asleep, or fatigued" resulted in the vehicle driving left of center. It is interesting to note that three of the four driver factors found in our study to more likely be associated with fatal car-truck crashes than with fatal car-car crashes were also among those considered by safety experts to be dangerous and frequent in the vicinity of trucks.

Programs to promote safe driving near large trucks could educate drivers about the risks of driving near large trucks by starting with the top five unsafe driver actions. Educational materials might include standard brochures and brief films. However, it could be argued on the basis of research and experience that brochures and films generally produce little behavioral change. More effective would be an interactive World Wide Web site that educates drivers about the dangers of driving near trucks and allows them to test their knowledge.

Perhaps the best technology to enable car drivers to change their behavior when they drive near trucks (although impractical in many situations) would be to enable them to get closed-track or on-the-road driving experience with a large truck to see what it is like. Personal computer–based driving simulations, demonstrations, or computer games based on real-world scenarios in which car drivers must accomplish particular maneuvers near trucks and at the same time react to various maneuvers from trucks appear to present a reasonable balance between potential for dissemination and behavior change. However, before such programs can be developed it is important to understand the conditions that will encourage drivers to use them.

A key finding from the first stage of this study is that the profile of causes and characteristics for fatal car-truck crashes are very similar to those for fatal car-car crashes. This finding is further supported by our second-stage review of original police accident reports, crash diagrams, and witness statements for a sample of more than 500 fatal car-truck crashes with at least one of the four driver factors that showed age and gender effects consistent with broader crash risks. These included alcohol and speeding among younger car drivers and problems with negotiating intersections (e.g., failure to yield the right of way) among older car drivers. This finding implies that effective programs to promote safe driving in general can also be used to promote safe driving near trucks. However, these programs need to emphasize that though the same safe-driving techniques generally apply to driving around both cars and trucks, making some mistakes around trucks can have much more severe consequences.

References

AAA Michigan. 1986. Cars and Trucks: Sharing the Road Safely. Dearborn: AAA Michigan.

Anderson J.R., A.T. Corbett, K.R. Koedinger, and R. Pelletier. 1995. Cognitive tutors: lessons learned. Journal of Learning Science 4: 167–207.

Benjamin, J.R. and C.A. Cornell. 1970. Probability, Statistics, and Decisions for Civil Engineers. New York: McGraw Hill.

Blower, D.F. 1996. The Accident Experience of Younger Truck Drivers. Technical Report GLCTTR-81-96/1. Ann Arbor, Mich.: Great Lakes Center for Truck and Transit Research.

———. 1998. The Relative Contribution of Truck Drivers and Passenger Vehicle Drivers to Truck-Passenger Vehicle Traffic Crashes. Report UMTRI 98-25. Ann Arbor: University of Michigan Transportation Research Institute.

Braver, E.R., D.F. Preusser, A.F. Williams, and H.B. Weinstein. 1996. Major Types of Fatal Crashes between Large Trucks and Cars. Arlington, Va.: Insurance Institute for Highway Safety.

Craig, R.L., ed. 1976. Training and Development Handbook. New York: McGraw-Hill.

FMCSA (Federal Motor Carrier Safety Administration). 2001. Large Truck Crash Profile: The 1999 National Picture. Washington, D.C.: U.S. Department of Transportation.

FHA (Federal Highway Administration). 1996. FARS Coding and Validation Manual, 1996. Washington, D.C.: U.S. Department of Transportation.

Fiske, S.T., and S.E. Taylor. 1984. Social Cognition. New York: Random House.

Ford, J.K., and D. Weissbein. 1997. Transfer of training: an updated review and analysis. Performance Improvement Quarterly 10: 22–41.

Gulian, E., L.M. Debny, A.I. Glendon, D.R. Davies, and G. Matthews. 1989. Coping with driver stress. In Stress and Tension Control, vol. 3, ed. M.G. McGuigan and W.E. Sime. New York: Plenum.

Hanowski, R.J., W.W. Wierwille, A.W. Gellatly, R.R. Knipling, and R. Carroll. 1998. Safety Issues in Local/Short Haul Trucking: The Drivers' Perspective. Proceedings of the Human Factor and Ergonomics Society, 42nd Annual Meeting, 1185–89.

Jentsch, F., and C. Bowers. 1998. Evidence for the validity of PC-based simulations in studying aircrew coordination. International Journal of Aviation Psychology 8: 243–60.

Mason, J.M., Jr., M. Patten, C.M. Plummer, Jr., and R.J. Micsky. 1992. Safer Truck Travel. University Park: Pennsylvania Transportation Institute.

Massie, D.L., and K.P. Sullivan. 1994. An Assessment of Truck Driver Training Issues Based on Precollision Events. Ann Arbor: University of Michigan Transportation Institute Center for National Truck Statistics.

Michigan Center for Truck Safety. 2000. Sharing the Road: Driving Safety Around Trucks Video. Lansing.

NHTSA (National Highway Traffic Safety Administration). 2001. Traffic Safety Facts 2000. DOT Report HS809337, Washington, D.C.: U.S. Department of Transportation.

Ogden, K.W., and T.H. Wee. 1988. Truck Involvement in Urban Road Accidents in Australia. Clayton, Australia: Monash University Department of Civil Engineering.

Oser, R.L., J.A. Cannon-Bowers, E. Salas, and D.J. Dwyer. 1999. Enhancing human performance in technology rich environments: Guidelines for scenario-based training. In Human–Technology Interaction in Complex Systems, ed. E. Salas, vol. 9, 175–202. Greenwich, Conn.: JAI Press.

Pollard, W.E. 1986. Bayesian Statistics for Evaluation Research, Beverly Hills, Calif.: Sage Publications.

Salas, E., and J.A. Cannon-Bowers. 2001. The science of training: A decade of progress. Annual Review of Psychology 52: 471–99.

Schwartz, S.I. and Retting, R.A. (1986). New York City Heavy Truck Crashes: 1983-1985 Findings. Indianapolis: Institute of Transportation Engineers.

Stuster, J. 1999. The Unsafe Driving Acts of Motorists in the Vicinity of Large Trucks. Final Report. Santa Barbara, Calif.: Anacapa Sciences.

Wolfe, A.C., and O.M. Carsten. 1982. Study of Car/Truck Crashes in the United States. Technical Report UM-HSRI-82-2. Ann Arbor: University of Michigan Transportation Research Institute.

Appendix A: Driver-Level Related Factors in FARS

Physical or Mental Condition

Drowsy, sleepy, asleep, or fatigued

Ill, passed out, or blacked out

Emotional (e.g., depressed, angry, or disturbed)

Drugs—medication

Other drugs (marijuana, cocaine, etc.)

Inattentive (talking, eating, etc,)

Restricted to wheelchair

Impaired due to previous injury

Deaf

Other physical impairment

Mother of dead fetus

Mentally challenged

Failure to take drugs or medication

Miscellaneous Factors

Traveling on prohibited trafficways

Illegally driving on suspended or revoked license

Leaving vehicle unattended with engine running, leaving vehicle unattended in roadway

Overloading or improper loading of vehicle with passengers or cargo

Towing or pushing vehicle improperly

Failure to dim lights or to have lights on when required

Operating without required equipment

Creating unlawful noise or using equipment prohibited by law

Following improperly

Improper or erratic lane changing

Failure to keep in proper lane or running off road

Illegal driving on road shoulder, in ditch, on sidewalk, or on median

Making improper entry to or exit from trafficway

Starting or backing up improperly

Opening vehicle door into moving traffic or when vehicle is in motion

Passing where prohibited by posted signs, pavement markings, hill or curve, or school buses displaying warning not to pass

Passing on wrong side

Passing with insufficient distance or inadequate visibility or failing to yield to overtaking vehicle

Operating the vehicle in an erratic, reckless, careless, or negligent manner or operating at erratic or suddenly changing speeds

High-speed chase with police in pursuit

Failure to yield right of way

Failure to obey actual traffic signs, traffic control devices, or traffic officers, failure to observe safety-zone traffic laws

Passing through or around barrier

Failure to observe warnings or instructions on vehicle displaying them

Failure to signal intention

Giving wrong signal

Driving too fast for conditions or in excess of posted speed limit

Driving less than posted maximum

Operating at erratic or suddenly changing speeds

Making right turn from left turn lane or making left turn from right-turn lane

Making improper turn

Failure to comply with physical restrictions of license

Driving wrong way on one-way trafficway

Driving on wrong side of road (intentionally or unintentionally)

Operator inexperience

Unfamiliar with roadway

Stopping in roadway (vehicle not abandoned)

Underriding a parked truck

Improper tire pressure

Locked wheel

Overcorrecting

Getting off/out of or on/in to moving vehicle

Getting off/out or on/in to non-moving vehicle

VISION OBSCURED BY:

Rain, snow, fog, smoke, sand, or dust

Reflected glare, bright sunlight, or headlights

Curve, hill, or other design features (including traffic signs, embankment)

Building, billboard

Trees, crops, vegetation

Motor vehicle (including load)

Parked vehicle

Splash or spray or passing vehicle

Inadequate defroster or defogging system

Inadequate lighting system

Obstructing angles on vehicle

Mirrors—rear-view

Mirrors—other

Head restraints

Broken or improperly cleaned windshield

Other obstruction

Avoiding, Swerving, or Sliding Due to:

Severe crosswinds

Wind from passing truck

Slippery or loose surface

Tire—blowout or flat

Debris or objects in road

Ruts, holes, bumps in road

Live animal in road

Vehicle in road

Phantom vehicle

Pedestrian, pedalcyclist, or other nonmotorist in road

Ice, water, snow, slush, sand, dirt, oil, or wet leaves on road

Other Miscellaneous Factors

Carrying hazardous cargo improperly

Hit-and-run vehicle drive

Non-traffic-related violation charged—manslaughter or other homicide offense

Other nonmoving traffic violation

Possible Distractions (Inside Vehicle)

Cellular telephone

Fax machine

Computer

Onboard navigation system

Two-way radio

Heads-up display

Unknown

Frequency of Driver Factors Recorded in Fatal Two-Vehicle Crashes

Table B.1. Frequency of Driver-Related Factors for Drivers of Cars in Fatal Car-Car Crashes, 1995–98

Driver Factor	As One Factor	With Other Factors	Overall Frequency	Percentage of Drivers with This Factor
Failure to keep in lane or running off road	4,091	6,986	11,977	29
Failure to yield right of way	6,174	4,679	10,853	28
Driving too fast for conditions or in excess of posted speed limit	1,522	6,259	7,781	20
Failure to obey actual traffic signs, traffic control devices, or traffic officer; failure to obey safety-zone traffic laws	2,504	3,852	6,356	17
Inattentive (talking, eating)	602	3,299	3,901	10
Operating vehicle in an erratic, reckless, careless, or negligent manner or operating at erratic or suddenly changing speeds	450	1,926	2,376	6
Driving on wrong side of road (intentionally or unintentionally)	997	1,374	2,371	6
Non-traffic-related violation charged—manslaughter or other homicide offense	79	2,278	2,357	6
Other nonmoving violation	680	1,244	2,371	6
Sliding due to ice, water, slush, sand, dirt, oil, or wet leaves on road	184	1,222	1,406	4
Making improper turn	345	907	1,252	3
Passing with insufficient distance or inadequate visibility; or failing to yield to overtaking vehicle	291	548	839	2
Hit-and-run vehicle driver	189	514	703	2
Drowsy, sleepy, asleep, or fatigued	68	602	670	2
Overcorrecting	21	622	643	2
Improper or erratic lane change	165	374	539	1
Following improperly	215	267	482	1
Vision obscured by rain, snow, fog, sand, or dust	133	268	401	1
Passing where prohibited	89	309	398	1
Vision obscured by curve, hill, or other design features	137	225	362	1
Ill, passed out, or blacked out	46	249	295	1
Vision obscured by motor vehicle	97	165	262	1
Stopping in roadway (vehicle not abandoned)	175	77	252	1
Leaving vehicle unattended with engine running on road	177	30	207	0.5

Source: Fatality Analysis Reporting System data.

Table B.2. Frequency of Driver Factors for Drivers of Cars in Fatal Car-Truck Crashes, 1995–98

Driver Factor	As One Factor	With Other Factors	Overall Frequency	Percentage of Drivers with This Factor
Failure to keep in lane or running off road	1,262	1,544	2,806	33
Failure to yield right of way	1,142	981	2,123	25
Driving too fast for conditions or in excess of posted speed limit	367	1,297	1,665	19
Failure to obey actual traffic signs, traffic control devices, or traffic officer; failure to obey safety-zone traffic laws	534	712	1,246	14
Inattentive (talking, eating)	253	857	1,110	13
Operating the vehicle in an erratic, reckless, careless, or negligent manner or operating at erratic or suddenly changing speeds	177	390	567	7
Driving on wrong side of road (intentionally or unintentionally)	261	275	536	6
Sliding due to ice, water, slush, sand, dirt, oil, or wet leaves on road	38	332	370	4
Drowsy, sleepy, asleep, or fatigued	22	278	300	3
Following improperly	168	107	275	3
Making improper turn	81	782	263	3
Other nonmoving violation	21	213	234	3
Improper or erratic lane change	69	116	185	2
Passing with insufficient distance or inadequate visibility; or failing to yield to overtaking vehicle	63	101	164	2
Overcorrecting	3	146	149	2
Vision obscured by rain, snow, fog, sand, or dust	35	110	145	2
Non-traffic-related violation charged—manslaughter or other homicide offense	7	113	120	1
Stopping in roadway	59	25	84	1
Vision obscured by reflected glare, bright sunlight, headlights	10	54	64	1
Operator inexperience	3	39	42	0.5

Source: Fatality Analysis Reporting System data.

Table B.3. Frequency of Driver Factors for Drivers of Trucks in Fatal Car-Truck Crashes, 1995–98

Driver Factor	As One Factor	With Other Factors	Overall Frequency	Percentage of Drivers with This Factor
Failure to yield right of way	305	294	599	21
Failure to keep in lane or running off road	177	353	530	18
Driving too fast for conditions or in excess of posted speed limit	119	330	449	16
Failure to obey actual traffic signs, traffic control devices, or traffic officer; failure to obey safety-zone traffic laws	135	230	365	13
Non-traffic-related violation charged—manslaughter or other homicide offense	9	258	267	9
Inattentive (talking, eating)	60	202	262	9
Other non-moving violation	126	97	223	7
Operating vehicle in an erratic, reckless, careless, or negligent manner or operating at erratic or suddenly changing speeds	50	136	186	6
Stopping in roadway	78	32	110	4
Following improperly	43	58	99	4
Leaving vehicle unattended with engine running in roadway	89	10	94	3
Sliding due to ice, water, snow, slush, sand, dirt, oil, or wet leaves on road	28	66	87	3
Making improper turn	43	44	86	3
Vision obscured by rain, snow, fog, sand, or dust	43	43	84	3
Starting or backing improperly	43	41	82	3
Driving on wrong side of road (intentionally or unintentionally)	18	64	80	3
Avoiding vehicle or swerving due to vehicle in road	34	46	73	3
Operating without required equipment	27	46	73	2
Improper or erratic lane change	23	37	60	2
Overloading or improper loading of vehicle with passengers or cargo	30	30	60	2
Other nonmoving violation	31	27	58	2
Passing with insufficient distance or inadequate visibility or failing to yield to overtaking vehicle	24	25	49	2
Drowsy, sleepy, asleep, or fatigued	7	37	44	2
Locked wheel	28	15	43	2
Overcorrecting	0	28	28	1
Vision obscured by hill, curve, or other design feature	18	9	27	1

Source: Fatality Analysis Reporting System data.

Appendix C:

Likelihood of Driver Factor in Fatal Car-Truck Crash Relative to Fatal Car-Car Crash

Table C.1. Estimation of Conditional Probabilities and Likelihood Ratio

Driver Factor	Number of Fatal Car-Car Crashes with This Driver Factor[a]	Number of Fatal Car-Truck Crashes with This Driver Factor[a]
Failure to keep in lane or running off road	10,867	3,302
Failure to yield right of way	10,770	2,702
Driving too fast for conditions or in excess of posted speed limit	7,504	2,086
Failure to obey actual traffic signs, traffic control devices or traffic officer; failure to obey safety-zone traffic laws	6,304	1,599
Inattentive (talking, eating)	3,753	1,356
Operating the vehicle in an erratic, reckless, careless, or negligent manner or operating at erratic or suddenly changing speeds	2,299	733
Driving on wrong side of road (intentionally or unintentionally)	2,349	612
Sliding due to ice, water, slush, sand, dirt, oil, or wet leaves on road	1,300	430
Making improper turn	1,250	350
Passing with insufficient distance or inadequate visibility; failing to yield to overtaking vehicle	837	213
Drowsy, sleepy, asleep, or fatigued	670	344
Overcorrecting	640	177
Improper or erratic lane change	532	243
Following improperly	482	373
Vision obscured by rain, snow, fog, sand, or dust	271	165

Conditional Probability of This Driver Factor, Given a Fatal Car-Car Crash[b]	Conditional Probability of This Driver Factor Given a Fatal Car-Truck Crash[c]	Likelihood Ratio of This Driver Factor in Fatal Car-Truck Crash Relative to Fatal Car-Car Crash[d]
0.3136	0.3102	0.9980
0.3079	0.3079	0.8240
0.2197	0.2006	0.9130
0.1803	0.1502	0.8331
0.1099	0.1304	1.1867
0.0673	0.0705	1.0472
0.0673	0.0576	0.8561
0.0399	0.0433	1.0864
0.0355	0.0327	0.9197
0.0238	0.0199	0.8358
0.0190	0.0320	1.6815
0.0182	0.0166	0.9084
0.0153	0.0227	1.4868
0.0137	0.0349	2.5417
0.0111	0.0223	1.9998

[a]Number of crashes with factor = number of drivers with factor – number of cases in which factor was coded for both drivers.

[b]Conditional probability of this driver factor (DF) given a fatal car-car crash: *P*(DF/car-car) = [*P*(car-car/DF) * *P*(DF)] / *P*(car-car), where *P*(car-car/DF) is estimated from the data by the ratio of the number of car-car crashes with the DF to car-car and car-truck crashes with this DF. *P*(DF) is estimated from the data by the number of times the DF is coded for the two-vehicle crashes considered. *P*(car-car) is estimated from the data with the ratio of the number of car-car crashes to the total number of two-vehicle crashes considered.

[c]Conditional probability of this driver factor given a fatal car-truck crash: *P* (DF/car-truck) = [*P*(car-truck/DF) * *P*(DF)] / *P*(car-truck), where *P*(car-truck/DF) is estimated from the data by the ratio of the number of car-truck crashes with the DF to the total of car-car and car-truck crashes with this DF. *P*(DF) is estimated from the data by the number of times the DF is coded for the two-vehicle crashes considered. *P*(car-truck) is estimated from the data by the ratio of the number of car-truck crashes to the total number of two-vehicle crashes considered.

[d]Likelihood ratio of this driver factor in fatal car-truck crash relative to fatal car-car crash: Likelihood ratio = *P*(DF/car-truck) / *P*(DF/car-car).

Source: Authors' calculations from Fatality Analysis Reporting System data.

Appendix D:

Likelihood of Driver Factor in Fatal Car–Heavy Truck Crash Relative to Fatal Car–Medium-Weight-Truck Crash

Table D.1. Estimation of Conditional Probabilities and Likelihood Ratio for Crashes between Cars and Heavy and Medium-Weight Trucks

Driver Factor	Number of Fatal Car–Heavy Truck Crashes with This Driver Factor[a]	Number of Fatal Car–Medium-Weight-Truck Crashes with This Driver Factor[a]
Failure to keep in lane or running off road	2,354	581
Failure to yield right-of-way	1,870	487
Driving too fast for conditions or in excess of posted speed limit	1,459	397
Failure to obey actual traffic signs, traffic control devices, or traffic officer; failure to obey safety-zone traffic laws	1,091	314
Inattentive (talking, eating)	961	228
Operating vehicle in an erratic, reckless, careless, or negligent manner or operating at erratic or suddenly changing speeds	544	106
Driving on wrong side of road (intentionally or unintentionally)	471	85
Sliding due to ice, water, slush, sand, dirt, oil, or wet leaves on road	318	74
Making improper turn	235	65
Passing with insufficient distance or inadequate visibility; or failing to yield to overtaking vehicle	156	23
Drowsy, sleepy, asleep, or fatigued	254	50
Overcorrecting	107	39
Improper or erratic lane change	187	31
Following improperly	268	57
Vision obscured by rain, snow, fog, sand, or dust	131	19

[a]Number of crashes with factor = number of drivers with factor – number of cases in which factor was coded for both drivers.

[b]Conditional probability of this driver factor (DF) given a fatal car-heavy truck crash: *P*(DF/car–heavy truck) = (*P*(car–heavy truck/DF) * *P*(DF)) / *P*(car–heavy truck), where *P*(car–heavy truck/DF) is estimated from the data by the ratio of the number of car–heavy truck crashes with the DF to two-vehicle crashes with this DF. *P*(DF) is estimated from the data by the number of times the DF is coded for the two-vehicle crashes considered. *P*(car–heavy truck) is estimated from the data with the ratio of the number of car–heavy truck crashes to the total number of two-vehicle crashes considered.

	Conditional Probability of This Driver Factor, Given a Fatal Car–Heavy Truck Crash[b]	Conditional Probability of This Driver Factor, Given a Fatal Car–Medium-Weight Truck Crash[c]	LikelihoodRatio of This Driver Factor in Fatal Car–Heavy Truck Crash Relative to Fatal Car–Medium-Weight-Truck Crash[d]
	0.3166	0.3169	0.9991
	0.2522	0.2701	0.9340
	0.1985	0.2218	0.8951
	0.1466	0.1716	0.8542
	0.1326	0.1298	1.0217
	0.0756	0.0595	1.2712
	0.0615	0.0447	1.3758
	0.0469	0.0460	1.0195
	0.0319	0.0360	0.8864
	0.0219	0.0130	1.6842
	0.0333	0.0267	1.2454
	0.0151	0.0225	0.6726
	0.0245	0.0164	1.4947
	0.0361	0.0311	1.1613
	0.0346	0.0204	1.6980

[c]Conditional probability of this driver factor given a fatal car–medium-weight-truck crash: *P*(DF/car–medium-weight truck) = [*P*(car–medium-weight truck /DF) * *P*(DF)] / *P*(car-medium-weight truck), where *P*(car–medium-weight truck/DF) is estimated from the data by the ratio of the number of car–medium-weight-truck crashes with the DF to the two-vehicle crashes with this DF. *P*(DF) is estimated from the data by the number of times the DF is coded for the two-vehicle crashes considered. *P*(car–medium-weight truck) is estimated from the data by the ratio of the number of car–medium-weight-truck crashes to the total number of two-vehicle crashes considered.

[d]Likelihood ratio of this driver factor in fatal car–heavy truck crash relative to fatal car–medium-weight-truck crash: Likelihood ratio = *P*(DF/car–heavy truck) / *P*(DF/car–medium-weight truck).

Source: Authors' calculations from Fatality Analysis Reporting System data.

APPENDIX E: Examples and Summary from Detailed Review

Table E.1. Example Cases from Study Database Developed from Review of Cases

Date	Time (24-hour system)	Truck				Car		
		Driver Age	Driver Sex	Vehicle Type	Weight	Driver Age (years)	Driver Sex	Vehicle Type
March 31	1300	52	Male	Tractor, 1 trailer	33,000+	32	Male	Passenger
May 18	1600	46	Male	Standard pickup, 1 trailer	14,000–16,000	38	Male	Pickup
Aug. 6	0800	61	Male	Tractor, 1 trailer	33,000+	70	Male	Passenger
May 6	0600	31	Male	Tractor, 1 trailer	33,000+	54	Male	Pickup
Oct. 15	1900	38	Female	Tractor, 1 trailer	33,000+	41	Male	Passenger

Crash		Roadway		Driver actions		Narrative Summary
Type	Configuration	Functional Class	Trafficway Flow	Truck	Car	
Angle	Same trafficway, same direction	Urban Interstate	Median, with barrier	None	Cut off other	Car tried to pass truck on right. Right front of truck hits left front of cat. Car goes out of control, hits left axle of truck.
Rear end	Same trafficway, same direction, forward impact	Urban Interstate	Median, no barrier	None	Cut off other	Pickup was weaving in and out of traffic, changed lanes into path of truck. Truck swerved, jackknifed, and hit pickup.
Angle	Change trafficway, vehicle turning left across path	Urban Interstate	Median, no barrier	None	Unsafe turn	Car in lane 1, truck in lane 2. Car crossed lane 2 in attempt to turn left into emergency vehicle crossover. Truck hit car.
Rear end	Same trafficway, same direction, rear-end slower vehicle	Urban Interstate	Median, no barrier	Unsafe merge	Speed, inattention	Truck pulled into lane from shoulder and was accelerating. Car did not slow down, hit truck.
Rear end	Same trafficway, same direction, rear-end slower vehicle	Urban Interstate	Median, no barrier	Speed, inattention	Avoidance maneuver	Car slowed and changed lanes to avoid pedestrians in right lane. Truck hit car from behind.

Source: Data from the Fatality Analysis Reporting System and from the Trucks in Fatal Accidents records maintained by the Center for National Truck Statistics.

Table E.2. Summary of Unsafe Driver Actions and Conditions for Cases with Driver Factor "Drowsy, Sleepy, Asleep, or Fatigued"

Unsafe Action or Condition in Addition to Drowsy, Sleepy, Asleep, or Fatigued	Unsafe Actions and Conditions Noted for:	
	Number of car drivers (percent); *n* = 138	Number of truck drivers (percent); *n* = 21
Alcohol and crossed center line or median, alcohol and speed, drugs and crossed center line	9 (6.5)	2 (9.5)
Crossed center (center line, median, or toll plaza), no other reason given	80 (58.0)	16 (76.2)
Ill and crossed center line	2 (1.5)	1 (4.8)
Drifted to shoulder, drifted to shoulder and overcorrected, drove in left lane or ran off road	10 (7.2)	0 (0.0)
Followed too closely	7 (5.1)	0 (0.0)
Inattention, failed to slow down or stop	13 (9.4)	0 (0.0)
Lost control, overcorrected and lost control	10 (7.2)	1 (4.8)
Driving wrong way	4 (2.9)	0 (0.0)
Unknown or other	3 (2.2)	1 (4.8)

Source: Trucks in Fatal Accident records maintained by the Center for National Truck Statistics.

Table E.3. Summary of Unsafe Driver Actions and Conditions for Cases with Driver Factor "Following Improperly"

Unsafe Action or Condition	Unsafe Actions and Conditions Noted for:	
	Number of Car Drivers (percent); *n* = 135	Number of Truck Drivers (percent); *n* = 47
Alcohol and failed to stop, alcohol and followed too closely, alcohol and lost control, alcohol and speed	23 (17.0)	1 (2.1)
Followed too closely, followed too closely and unable to stop, followed too closely and speed unsafe for conditions	52 (38.5)	18 (37.5)
Inattention, failed to slow down and stop	27 (20.0)	7 (14.6)
Speed, speed and followed too closely, speed and inattention, speed and unsafe lane change, speed unsafe for conditions	23 (17.0)	12 (25.0)
Unsafe and passed improperly	2 (1.5)	2 (4.2)
Lost control	1 (0.7)	2 (4.2)
Made unsafe turn	0 (0.0)	1 (2.1)
Unknown or other	7 (5.2)	5 (10.4)

Source: Trucks in Fatal Accident records maintained by the Center for National Truck Statistics.

Table E.4. Summary of Unsafe Driver Actions and Conditions for Cases with Driver-Related Factor "Improper or Erratic Lane Change"

Unsafe Action or Condition	Unsafe Actions and Conditions Noted for:	
	Number of Car Drivers (percent); *n* = 89	Number of Truck Drivers (percent);*n* = 30
Alcohol and improper lane change, alcohol and unsafe turn, alcohol and speed, alcohol and driving wrong way, alcohol and passing unsafely, alcohol and crossed center line, drugs	19 (21.3)	0 (0.0)
Changed lanes into other vehicle	18 (20.2)	20 (66.6)
Cut off other vehicle	9 (10.1)	2 (6.6)
Cross center line	3 (3.4)	0 (0.0)
Lost control, lost control during lane change	9 (10.1)	4 (13.3)
Made unsafe turn	7 (7.9)	2 (6.6)
Inattention, inattention and crossed center line, inattention and avoidance maneuver	4 (4.5)	0 (0.0)
Passed unsafely and lost control, passed unsafely and speed	3 (3.4)	1 (3.3)
Speed and changed lanes into other vehicle, unsafe speed for conditions, speed and avoidance maneuver	12 (13.5)	0 (0.0)
Driving wrong way	1 (1.1)	0 (0.0)
Avoidance maneuver	2 (2.2)	0 (0.0)
Failed to yield right of way	1 (1.2)	0 (0.0)
Unknown or other	1 (1.2)	1 (3.3)

Source: Trucks in Fatal Accident records maintained by the Center for National Truck Statistics.

Table E.5. Summary of Unsafe Driver Actions and Conditions for Cases with Driver-Related Factor "Vision Obstructed by Rain, Snow, Fog, Smoke, Sand, or Dust"

Unsafe Action or Condition	Unsafe Actions and Conditions Noted for:	
	Number of Car Drivers (percent); *n* = 73	Number of Truck Drivers (percent); *n* = 34
Alcohol and drugs and driving wrong way, alcohol and crossed center	2 (2.7)	1 (2.9)
Fatigue, asleep, inattention	12 (16.4)	2 (5.9)
Failed to yield right of way	11 (15.1)	6 (17.6)
Speed and failed to slow down and stop, speed and lost control, speed and reckless driving, speed unsafe for conditions	12 (16.4)	6 (17.6)
Vision obstructed, vision obstructed and fog, vision obstructed and white out	15 (20.5)	8 (23.5)
Lost control, lost control and crossed center line	12 (16.4)	0 (0.0)
Driving wrong way	2 (2.7)	2 (5.9)
Made unsafe turn	0 (0.0)	3 (8.8)
Followed too closely	2 (2.7)	1 (2.9)
Unknown or other	3 (4.1)	4 (11.8)

Source: Trucks in Fatal Accident records maintained by the Center for National Truck Statistics.

Appendix F: Test for Gender Effects

1. H_0 = gender of car driver is independent of active participation in fatal car-truck crash with driver factor = drowsy, sleepy, asleep, or fatigued:

Gender Effect	Males	Females	Total
Car driver actions contribute to crash, driver factor = drowsy, sleepy, asleep, or fatigued	100	34	134
Car driver actions do not contribute to crash	56	37	93
Total	156	71	227

$\chi^2 = 5.305$; $\chi^2_{(0.05,1)} = 3.841 < 5.305$. Therefore, reject H_0.

2. H_0 = gender of car drivers is independent of active participation in car-truck crash with driver factor = following improperly:

Gender Effect	Males	Females	Total
Car driver actions contribute to crash, driver factor = following improperly	98	26	124
Car driver actions do not contribute to crash	56	37	93
Total	154	63	217

$\chi^2 = 9.133$; $\chi^2_{(0.05,1)} = 3.841 < 9.133$. Therefore, reject H_0.

3. H_0 = gender of car drivers is independent of active participation in car-truck crash with driver factor = improper or erratic lane change:

Gender Effect	Males	Females	Total
Car driver actions contribute to crash, driver factor = improper or erratic lane change	54	29	83
Car driver actions do not contribute to crash	56	37	93
Total	110	66	176

$\chi^2 = 0.439$; $\chi^2_{(0.05,1)} = 3.841 > 0.439$. Therefore, do not reject H_0.

4. H_0 = gender of car drivers is independent of active participation in fatal car-truck crash with driver factor = vision obstructed by rain, snow, fog, smoke, or sand:

Gender Effect	Males	Females	Total
Car driver actions contribute to crash, driver factor = vision obstructed by rain, snow, fog, smoke, sand, or dust	28	21	49
Car driver actions do not contribute to crash	56	37	93
Total	84	58	14

$\chi^2 = 0.125$; $\chi^2_{(0.05,1)} = 3.841 > 0.125$. Therefore, do not reject H_0.

5. H_0 = gender of car driver is independent of active or passive participation in a fatal car-truck crash where one of the four driver-related factors (drowsy, sleepy, asleep, or fatigued; following improperly; improper or erratic lane change; vision obstructed by rain, snow, fog, smoke, sand, or dust) was noted for the crash:

Gender Effect	Males	Females	Total
Car driver actions contribute to crash	280	110	390
Car driver actions do not contribute to crash	56	37	93
Total	336	147	483

$\chi^2 = 4.756$; $\chi^2_{(.05,1)} = 3.841 < 4.756$. Therefore, reject H_0.

APPENDIX G: Instructional Strategies and Targets

Table G.1. Effective Instructional Strategies for Simple Knowledge Change

Effective Instructional Strategies	Examples of Simple Knowledge for:			
	Following maneuvers	Lane changing	Driving while drowsy, sleepy, asleep, or fatigued	Vision obscured by rain, snow, fog, smoke, sand, or dust
Lectures, books, brochures, movies, videos	Linear measures of appropriate following distance	Laws about appropriate lane use	Alertness cues; effects of sleep deprivation and fatigue on performance; methods for reducing drowsiness and fatigue	General effects of conditions on vision and driving

Table G.2. Effective Instructional Strategies for Dynamic Knowledge Change

Effective Instructional Strategies	Examples of Dynamic Knowledge for:			
	Following maneuvers	Lane changing	Driving while drowsy, sleepy, asleep, or fatigued	Vision obscured by rain, snow, fog, smoke, sand, or dust
Real size simulator; closed-course simulation; on-the-road practice	Assessment of distances, relative speeds, and relative speeds and distances between vehicles; effects of road conditions on vehicle stability	Assessment of distances, relative speeds, and relative speeds and distances between vehicles in own lane and in lane vehicle is moving into; assessment of sight distance at the point that the lane change is being made; effects of road conditions on vehicle stability		
Personal computer–based simulator technology			Effects of drowsiness and fatigue on the time to perceive a stimulus, develop a response, and the reaction time	

Table G.3. Instructional Strategies for Simple Behavior Change

Effective Instructional Strategies	Examples of Simple Behaviors for:			
	Following maneuvers	Lane changing	Driving while drowsy, sleepy, asleep, or fatigued	Vision obscured by rain, snow, fog, smoke, sand, or dust
Actual manipulations of these controls in life-size simulator or on-the-road practice	Ability to manipulate brake and accelerator pedals and steering wheel	Ability to manipulate brake and accelerator pedals and steering wheel		Ability to manipulate windshield wipers and defogger in addition to brake and accelerator pedals and steering wheel
Controlled personal computer–based simulation			Demonstrate detrimental effects of these conditions on performance	

Table G.4. Instructional Strategies for Complex Behavior Change

Effective Instructional Strategies	Examples of Complex Behaviors for:			
	Following maneuvers	Lane changing	Driving while drowsy, sleepy, asleep, or fatigued	Vision obscured by rain, snow, fog, smoke, sand, or dust
High-level motion-based simulation; closed-track simulation; on-the road practice	Estimation of relative speeds and distances between vehicles; behavioral reactions to excessive relative speed and rapidly decreasing space between vehicles	Estimation of relative speeds and distances between vehicles; behavioral reactions to excessive relative speed and rapidly decreasing space between vehicles		Estimation of relative speed, relative spacing; behavioral reactions to increasingly complex and uncertain environments
Controlled personal computer–based simulation			Demonstrate detrimental effects of these conditions on performance	

Identifying Unsafe Driver Actions
that Lead to Fatal Car-Truck Crashes
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