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STUDY OF CAR/TRUCK CRASHES IN THE UNITED STATES

Arthur C. Wolfe
Oliver M. Carsten

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FINAL REPORT

THE UNIVERSITY OF MICHIGAN
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Project Final Report

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Sponsored by

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Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109

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16. Abstract

This report provides descriptive information about truck-car accidents in the United States using primarily data from the Fatal Accident Reporting System (FARS). In 1980 14 percent of all fatal accidents (37 percent of fatal multi-vehicle accidents) involved at least one car and one truck. Over half of these involved pickups and vans, while about one-seventh involved combination vehicles. Trucks, especially combination vehicles, are overinvolved in fatal accidents relative to FHWA estimates of miles traveled by different vehicle types. Truck-car involvement rates increased substantially from 1977 to 1979 but declined in 1980 (mainly for combination vehicles).

Other descriptive data are presented on fatality ratios in truck-car fatal crashes by type of truck and weight of car; on type of road; on road alignment; on road wetness; on light condition; on age of driver; on seat belt use; on vehicle rollover; on vehicle fire; on causative factors; on manner of collision; and on time of day and time of week.

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1.0 INTRODUCTION

Since the early 1950's the vehicle population and the road network of the U.S. have undergone major transformations. In 1950 the total estimated number of motor vehicles (excluding motorcycles) in the U.S. was 49.2 million, including 40.3 million automobiles and 8.6 million trucks. By 1980 the total number had increased to 155.9 million, including 121.7 million automobiles and 33.6 million trucks. While the number of automobiles has tripled in the past 30 years, the number of trucks of all types has almost quadrupled.[1]

In 1950 the Interstate Highway System was little more than a dream, with the vast majority of intercity travel taking place on roadways with unlimited access. Today, however, approximately 20 percent of all vehicle miles traveled in the country take place on divided limited access roads designed to modern interstate standards. Undoubtedly these kinds of improvements in the road network have been a major factor in the fact that the numbers of motor vehicle accidents have not increased as rapidly as the numbers of motor vehicles during the past 30 years.

The primary purpose of this study is to provide information about the extent and nature of car-truck crashes in the United States. Until 1975 national accident data were available only in aggregate form, and there was no satisfactory way to estimate the proportions of car-truck crashes. However, given the higher rate of increase in registered trucks as compared to registered passenger cars during the past 30 years, it would be expected that the proportions of car-truck crashes have been increasing somewhat for many years. In recent years there has also been a strong trend toward smaller cars, thus placing cars at an increasing disadvantage in these car-truck crashes. These facts have served as the major impetus for this special study of car-truck crashes.

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[1]U.S. Bureau of Public Roads, Highway Statistics: Summary to 1955, Washington, D.C., 1957, Table MV-200, p. 28; U.S. Federal Highway Administration, Highway Statistics 1980, Washington, D.C., 1981, Table MV-1, pp. 14-15.

Beginning in 1975 the National Highway Traffic Safety Administration developed the Fatal Accident Reporting System (FARS) to provide comprehensive national data on fatal motor vehicle crashes in the United States. These FARS data are available in computerized accident files, and it is now possible to obtain detailed national information on many aspects of interest concerning fatal crashes. The reader is cautioned to remember, however, that fatal crashes constitute less than one percent of all police-reported crashes, so one might expect some substantial differences between the circumstances of the fatal crashes reported in the national FARS data and the vastly larger number of non-fatal crashes which can not be analyzed on a national basis. Fortunately, many states have developed computerized data bases for all of their police-reported accidents, and it is possible to obtain useful supplementary information on non-fatal accidents in the United States from an analysis of some of these state accident files.

There is little detailed consideration of exposure data in this study, primarily because accurate detailed exposure data for various vehicle types by road class, time of day, etc. are not available. As background information, Federal Highway Administration (FHWA) estimates of miles traveled by passenger cars and trucks within four road classes are presented. In order to carefully evaluate possible countermeasures for car-truck accidents, it would be necessary to obtain much more detailed truck and car exposure data by road class and time of day. There are substantial differences in the time of day travel patterns of cars and heavy trucks on various roads, and a thorough analysis of truck-car accidents and accident propensities would have to take these differences into account.

Although various sources of data categorize trucks in different ways (by size, weight, purpose, number of trailers), this study has, for the most part, grouped them into four categories: pickup trucks, light vans, combination vehicles (primarily tractor-trailers), and all others (mostly medium or large straight trucks). Although more truck type detail is often available, there is so much variation in truck travel by road class that many displays are also divided on this dimension, and thus the numbers of cases would tend to be too small to permit meaningful consideration of more detailed truck types. Road classes are defined in somewhat more detail than usual, using combinations of variables (number of lanes and rural/urban, along with the more usual FHWA classification).

Since the intent of this study is to provide a national description of truck/car crashes, primary reliance is placed on NHTSA's FARS files. Most of the FARS presentations are based on data from the 1980 calendar year. For non-fatal crashes some data have been taken from the state files of Pennsylvania, Michigan, Texas, and Washington, although it has not always been possible to have consistent coding conventions among the various sources of data. The state data were sometimes available only for years earlier than 1980. These four states whose accident data are readily accessible in the HSRI computerized accident data archive represent the four major regions of the United States and together include about one-sixth of the U.S. population.

Report Contents

Section 2 provides some general background data on changes in exposure and accident frequency of cars and trucks in recent years, and it also shows how occupant fatalities are distributed in two-vehicle car-truck crashes. This section also looks briefly at the question of whether car-truck fatal accidents are more frequent than would be expected statistically (with more data on this subject included in Appendix A). Section 3 provides descriptive data on the circumstances of two-vehicle car-truck crashes--where they occur, how they occur, why they occur, when they occur, etc.--including some available driver and vehicle accident characteristics. Finally, Section 4 contains a brief summary of the findings and presents the study conclusions.

2.0 BACKGROUND DATA ON CAR-TRUCK EXPOSURE, ACCIDENTS, AND FATALITIES

Changes in the Vehicle Population

The FHWA estimates of the vehicle population at various points in time since 1950 are shown in Table 1. The passenger car count has tripled from 40.3 million in 1950 to an estimated 121.7 million in 1980. The total number of trucks has almost quadrupled from 8.6 million to 33.6 million over the same time period. While single-unit trucks (most of which are pickups) were not estimated separately in the 1950 data, they increased in number from under 13 million in 1963 to over 32 million in 1980. Considering only the population of cars and trucks, the proportion of all trucks has increased from 17.6 percent in 1950 to 21.6 percent in 1980, and the truck proportion of vehicle miles traveled has increased from 19.9 percent to 25.7 percent. From 1963 to 1980 the combination truck proportion of all vehicle miles traveled increased only from 3.7 percent to 3.9 percent, while single-unit truck mileage increased from 15.6 percent to 21.3 percent of the total.

A separate estimate of the increase in the truck population is available from the 1963, 1972, and 1977 National Truck Inventory and Use (TIU) surveys of the Census Bureau, excerpts from which are shown in Table 2. It should be noted that TIU vehicle estimates were benchmarked to FHWA estimates in 1972, but they were not so treated in 1977; so the figures for those two years may not be directly comparable. Still, the tremendous increases in both light and heavy-heavy trucks over a 16-year period are quite apparent, while medium trucks have apparently increased much less and light-heavy trucks have actually declined substantially in use on American highways. It is interesting to note that the percentage of trucks whose major use is for personal transportation increased from 24.5 percent in 1963 to 54.4 percent in 1977.

Another illustration of the great extent of light truck usage for personal transportation is available from the Nationwide Personal Transportation Study, conducted by the Bureau of the Census in 1977 and

Table 1

Growth in Use of Truck and Passenger Vehicles in the U.S.: FHWA Estimates*

Vehicle Type		1950		1963		1972		1977		1980	
		N	%	N	%	N	%	N	%	N	%
Passenger Cars	Registns	40,334	82.0	69,056	82.7	96,860	79.2	113,696	76.4	121,723	75.3
	Miles	363,613	79.3	641,344	79.6	986,407	77.8	1,118,649	75.8	1,111,887	73.1
	Mean	9.0	-	9.3	-	10.2	-	9.8	-	9.1	-
Motorcycles	Registns			786	0.9	3,798	3.1	5,015	3.4	5.725	3.5
	Miles			4,027	0.5	17,091	1.3	22,566	1.5	18,000	1.2
	Mean			5.1	-	4.5	-	4.5	-	3.1	-
Buses	Registns	224	0.5	298	0.4	407	0.3	492	0.3	529	0.3
	Miles	4,081	0.9	4,483	0.6	5,109	0.4	5,887	0.4	6,400	0.4
	Mean	18.2	-	15.0		12.6	-	12.0	-	12.1	-
Single-Unit Trucks	Registns			12,654	15.2	20,249	16.6	28,298	19.0	32,232	19.9
	Miles			125,753	15.6	213,122	16.8	266,000	18.0	324,570	21.3
	Mean			9.9	-	10.5	-	9.4	-	10.1	-
Combination Trucks	Registns			706	0.8	990	0.8	1,264	0.8	1,405	0.9
	Miles			29,816	3.7	46,613	3.7	63,465	3.9	60,000	4.3
	Mean			42.2	-	47.1	-	50.2	-	42.7	-
Total Trucks	Registns	8,604	17.5	13,360	16.0	21,239	17.4	29,562	19.8	33,637	20.8
	Miles	90,552	19.8	155,569	19.3	259,735	20.5	329,465	22.3	384,570	25.3
	Mean	10.5	-	11.6	-	12.2	-	11.1	-	11.4	-
Total Vehicles	Registns	49,162	100	83,500	100	122,304	100	148,765	100	161,614	100
	Miles	458,246	100	805,423	100	1,268,342	100	1,476,567	100	1,520,857	100
	Mean	9.3	-	9.6	-	10.4	-	9.9	-	9.4	-

*These statistics are taken from Table VM-1 in the annual FHWA reports <u>Highway Statistics</u> for 1965 (with revised 1963 data), 1972, 1977, and 1980. Registrations are in thousands, miles traveled are in millions, and mean miles are in thousands. For 1950 the data are from Tables MV-200 and VM-201 in <u>Highway Statistics: Summary to 1955</u>. Motorcycles are not included in the 1950 totals.

Table 2

Growth in Use of Registered Private and
Commercial Truck-Type Vehicles in the U.S.:
Census of Transportation Estimates From TIU Surveys*

Truck Type		1963		1972		1977	
		N	%	N	%	N	%
Light (<10K GVW)	Registns	8,853	73.3	14,598	74.0	22,395	85.4
	Miles	-	58.1	154,451	63.2	238,443	76.3
	Mean Miles	-	-	10.6	-	10.6	-
Medium (10-19.5K GVW)	Registns	1,128	9.3	2,822	14.3	1,583	6.0
	Miles	-	8.5	29,316	12.0	16,150	5.2
	Mean Miles	-	-	10.4	-	10.2	-
Light-heavy (19.5-26K GVW)	Registns	1,320	10.9	828	4.2	803	3.1
	Miles	-	11.1	8,755	3.6	8,245	2.6
	Mean Miles	-	-	10.6	-	10.3	-
Heavy-heavy (>26K GVW)	Registns	774	6.4	1,500	7.6	1,433	5.5
	Miles	-	22.3	52,019	21.3	49,683	15.9
	Mean Miles	-	-	34.7	-	34.7	-
All Trucks	Registns	12,075	100	19,745	100	26,213	100
	Miles	-	100	244,492	100	312,520	100
	Mean Miles	-	-	12.4	-	11.9	-

*Bureau of the Census, 1963 Census of Transportation, Volume II, Truck Inventory and Use Survey, (1965); 1972 Census of Transportation, Volume II, Truck Inventory and Use Survey, March 1974; 1977 Census of Transportation, Volume II, Truck Inventory and Use Survey, October 1980. Registrations are in thousands, miles traveled are in millions, and mean miles are in thousands.

1978 (Table 3). The proportion of households for which the only vehicle was a pickup truck in that year was 5.1 percent, and another 1.3 percent had a van as the sole vehicle. For multi-vehicle households, however, the pickup proportion of all household vehicles increased to 13.8

percent (plus 3.2 percent for vans). Taken all together, 14.8 percent of all household vehicles were pickup trucks or vans, and these vehicles accounted for 16.1 percent of all household miles. This estimate does not include commercial light truck mileage, which (according to the FHWA estimates) would increase the total to about 19 percent of all vehicle miles. Unfortunately, there is no way to distinguish trucks used for personal transportation from trucks used for commercial purposes in any of the available accident data files.

Tractor-trailer (or combination vehicle) travel has also increased markedly over this period. Figure 1 shows the proportional increases[2] in FHWA estimates of combination vehicle, straight truck, and passenger vehicle mileage from 1970 to 1980. Combination vehicle travel increased by about 67 percent from 1970 to 1978 compared to a less than 40 percent increase for passenger cars, but both combination truck and passenger car mileage have declined in 1979 and 1980. However, single-unit truck travel (mostly pickup) has continued to increase at a substantially faster pace than passenger vehicles, according to FHWA estimates.

Thus trucks (of all sizes) have been accounting for an increasing proportion of total vehicle miles traveled on American roads. At the same time cars have been growing smaller in line with national fuel conservation efforts. This fact, coupled with information on the increasing numbers of truck-car collisions in both national and state data, has prompted the study reported here.

Trends in Car-Truck Fatal Crashes

About 38 percent of all fatal accidents involve two or more motor vehicles, as is shown for 1980 in Table 4. In 1980 these multi-vehicle accidents accounted for 41 percent of the fatalities, an overrepresentation that might be expected considering the additional numbers of involved vehicles and their occupants.

Table 5 presents basic data on the trends in multi-vehicle fatal crashes in the United States for different types of trucks and for

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[2] Highway Statistics, U.S. Federal Highway Administration, Washington, D.C., various years, Table VM-1.

Table 3

1977-78 Household Motor Vehicle Ownership/Availability and Utilization: NPTS Data

Type of Motor Vehicle	Single-Vehicle Households Percent*	Multi-Vehicle Households Percent*	All Households %*	Total Household Miles %	Average Annual Vehicle Miles
Standard Auto	85.9	67.3	71.4	71.2	10,127
Station Wagon	6.9	8.6	8.2	9.1	11,271
Motorcycle Moped	0.2	3.6	2.9	0.9	3,288
Pickup	5.1	13.8	12.0	12.6	10,648
Vanbus/Minibus/ Other Van	1.3	3.2	2.8	3.5	12,657
Pickup w/Camper or Camper Coach	0.4	1.5	1.2	1.1	9,628
Other truck	0.1	1.7	1.3	1.4	11,244
Other	0.1	0.3	0.2	0.2	8,696
Total	100.0	100.0	100.0	100.0	10,188

*Percent of all vehicles.
NOTE: Ownership data are from Table 21 of Household Vehicle Ownership, Report No. 2 of the 1977 Nationwide Personal Transportation Study. Mileage data are interpolated from this table and from Table 9 of Household Vehicle Utilization, Report No. 5, of the Nationwide Personal Transportation Study, Washington, D.C., FHWA, 1980/1981. Household members owned 93.7% of the reported vehicles, while 3.6% were company-owned, 0.6% were leased, 0.1% were rented, 2.0% were "other."

passenger cars and other types of vehicles (motorcycles, buses, utility vehicles, ambulances, fire trucks, snowmobiles, campers, etc.). The data presented are just for 1977-1980 because the 1975 and 1976 FARS data contain some coding inconsistencies for vehicle type in some states which result in an undercounting of heavy trucks in those years. Thus

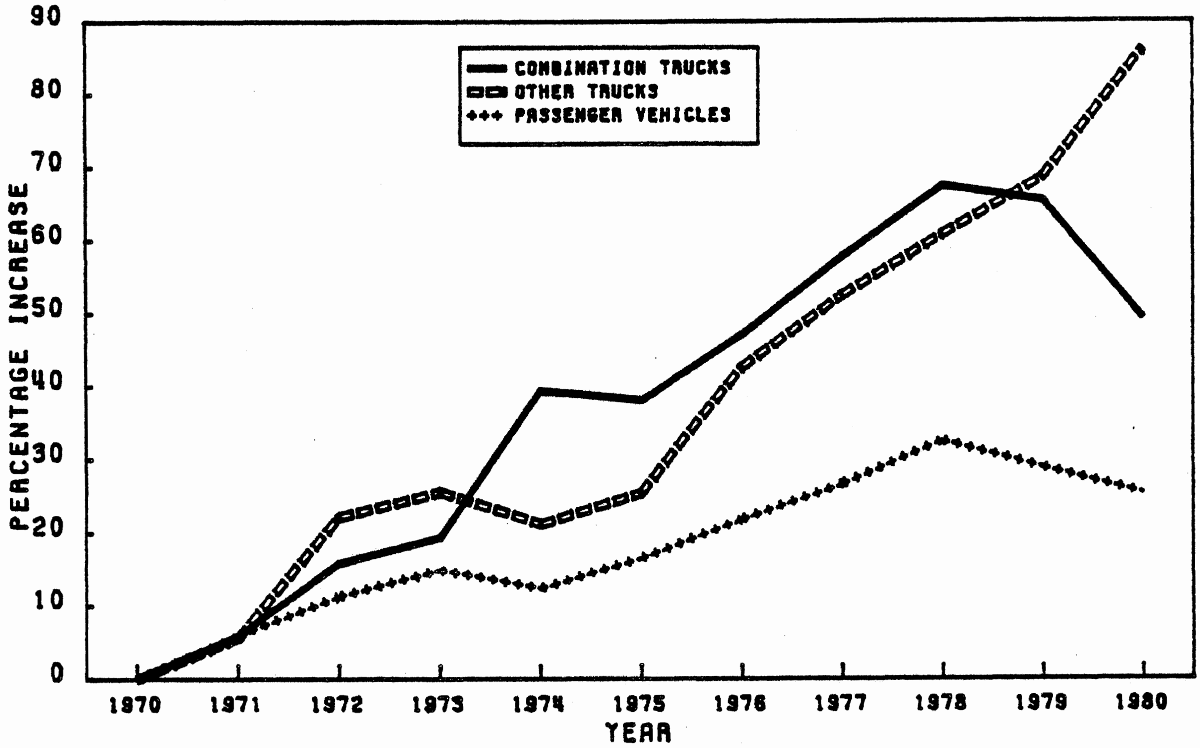

Figure 1
Percentage Increase in Vehicle Miles Traveled for Three Vehicle Types, 1970-1980 (FHWA Estimates)

the 1975-1976 FARS data are not directly comparable with 1977-1980 FARS data for heavy truck involvements.

Table 5 contains five types of basic accident information for each of the four years analyzed for seven truck types, all trucks, all passenger cars, and other vehicles. First is the number and percentage of vehicles of each type involved in multi-vehicle fatal crashes. These data show, as would be expected from the earlier data on changes in the registration estimates, that the proportion of truck involvement in multi-vehicle fatal crashes has been increasing while passenger car involvement has been decreasing. From 1977 to 1979 total truck involvement in multi-vehicle fatal crashes increased from 25.9 percent to 29.1 percent, while passenger car involvement declined from 63.7 percent to 60.5 percent. Other types of vehicles (many of which are motorcycles) also substantially increased their proportion of fatal

Table 4
1980 Fatal Accidents by Number of Vehicles Involved

Number of Vehicles	Distribution of Accidents		Distribution of Fatalities	
	N	%	N	%
1	28,144	62.2	30,184	59.1
2	15,414	34.0	18,714	36.6
3	1,419	3.1	1,798	3.5
4	221	0.5	280	0.5
5 or more	70	0.2	98	0.2
Unknown	3	0.0	3	0.0
Total	45,271	100.0	51,077	99.9

accident involvement in those years. Large involvement increases took place both for light trucks and for combination tractor trailers, but there was not much change for medium and light-heavy straight trucks. In 1980, however, as might be expected from the FHWA estimate of a sharp decline in annual miles driven for combination vehicles, the accident involvement of multi-unit vehicles declined substantially. In fact, overall accident involvements declined in 1980 for all types of vehicles except motorcycles, but the greatest rate of decline was for the heavy trucks--presumably a reflection of the economic recession in that year. Preliminary data for 1981 show another overall decline in fatal accidents, again led by heavy trucks. However, in 1981 it appears that fatal accident involvements declined more for light trucks and for motorcycles than for passenger cars, a reversal of the 1977-80 trends.[3]

[3]U.S. National Highway Traffic Safety Administration, Highway Safety Facts: Annual Trends - 1981, Washington, D.C. (1982).

Table 5
Fatal Accident Trends for Multi-Vehicle Accidents by Vehicle Type, 1977-1980*

Truck or Other Vehicle Type	Year	Vehicles: Number	Vehicles: % of All Vehicles in Fatal Accidents	Accidents	Fatalities in Vehicle Type (Listed at Left)	Other Fatalities in the Accidents	Total Fatalities in the Accidents
Pickups	1977	4,275	11.9	3,917	1,831	2,946	4,777
	1978	4,893	12.6	4,441	2,036	3,436	5,472
	1979	5,237	13.6	4,784	2,196	3,605	5,801
	1980	4,929	13.7	4,485	2,076	3,427	5,503
Vans and Truck-Based Station Wagons	1977	848	2.4	829	363	647	1,010
	1978	1,126	2.9	1,107	458	925	1,383
	1979	1,260	3.3	1,232	520	965	1,485
	1980	1,221	3.4	1,185	488	940	1,428
Other Single-unit Trucks	1977	974	2.7	945	114	1,021	1,135
	1978	1,059	2.7	1,022	130	1,087	1,217
	1979	1,110	2.9	1,072	144	1,113	1,257
	1980	1,017	2.8	982	119	1,054	1,173
Two-Unit Trucks	1977	2,781	7.7	2,595	259	2,914	3,173
	1978	3,103	8.0	2,891	314	3,252	3,566
	1979	3,265	8.4	3,039	292	3,440	3,732
	1980	2,735	7.6	2,541	256	2,906	3,162
Three or Four Unit Trucks	1977	112	0.3	105	26	119	145
	1978	114	0.3	108	9	128	137
	1979	148	0.4	136	14	160	174
	1980	105	0.3	100	14	126	140
Bobtail Tractors**	1977	35	0.1	35	4	35	39
	1978	76	0.2	75	13	71	84
	1979	102	0.3	100	17	100	117
	1980	108	0.3	107	11	124	135
Unknown Type Trucks	1977	296	0.8	287	41	312	353
	1978	313	0.8	292	45	308	353
	1979	132	0.3	126	24	119	143
	1980	50	0.1	48	13	46	59
Total Trucks (Sum of above)	1977	9,321	25.9	8,713	2,638	7,994	10,632
	1978	10,684	27.6	9,936	3,005	9,207	12,212
	1979	11,274	29.1	10,489	3,207	9,502	12,709
	1980	10,165	28.3	9,448	2,977	8,623	11,600

Table 5 (Continued)

Truck or Other Vehicle Type		Vehicles: Number	Vehicles: % of All Vehicles in Fatal Accidents	Accidents	Fatalities in Vehicle Type (Listed at Left)	Other Fatalities in the Accidents	Total Fatalities in the Accidents
Total Passenger Cars	1977	22,893	63.7	14,519	14,436	3,435	17,871
	1978	24,079	62.1	15,526	15,355	3,691	19,046
	1979	23,424	60.5	15,317	14,952	3,712	18,664
	1980	21,572	60.1	14,252	13,882	3,699	17,581
Other Types of Vehicles	1977	3,351	9.3	3,193	2,837	671	3,508
	1978	3,755	9.7	3,484	3,151	714	3,865
	1979	3,859	10.0	3,690	3,277	791	4,068
	1980	3,927	10.9	3,780	3,377	817	4,194
Unknown Types of Vehicles	1977	384	1.1	331	213	201	414
	1978	234	0.6	223	129	129	258
	1979	179	0.5	166	107	95	202
	1980	249	0.7	229	146	138	284
Grand Total	1977	35,949	100.0	26,756	20,124	12,301	32,425
	1978	38,752	100.0	29,169	21,640	13,741	35,381
	1979	38,736	100.0	29,662	21,543	14,100	35,643
	1980	35,913	100.0	27,709	20,382	13,277	33,659

*NOTE: The grand totals for the accident and fatalities data represent a double counting for accidents involving two different vehicle types. They are about 60 percent larger than the actual grand totals of vehicle accidents and fatalities.

**The FARS coding for bobtail tractors is clearly not very accurate, particularly for Pennsylvania. In 1977 no bobtail tractors were reported from Pennsylvania. However, for 1978, 1979, and 1980 Pennsylvania had 56 percent, 49 percent, and 42 percent, respectively, of the total bobtail tractors reported in FARS, while in those same years no single unit trucks over 19,500 pounds GVW were reported.

The third column of Table 5 shows the total number of multi-vehicle fatal accidents involving vehicles of each type. It should be noted that this presentation double counts many accidents. An accident involving just two pickup trucks is counted just once, but an accident involving a pickup and a van is counted twice, once in each row for each vehicle type. An accident involving a pickup, a passenger car, and a motorcycle is counted three times, once for each vehicle type. Thus the totals at the bottom of this column are about 60 percent larger than the actual number of multi-vehicle fatal accidents each year.

The final three columns show the numbers of fatalities to occupants of each type of vehicle during that year, the numbers of fatalities of other persons not in the designated vehicle type in accidents in which it was involved, and the numbers of total fatalities in accidents in which it was involved. Again this involves a double counting of some fatalities. If in a pickup-passenger car crash there was one fatality in each vehicle, this would be counted as one occupant fatality and one other fatality for pickups and would again be counted as one occupant fatality and one other fatality for passenger cars. It should be noted that "other fatalities" includes not only occupants of other types of vehicles but also pedestrians and bicyclists--although only about four percent of pedestrian and bicyclist fatalities occur in multi-vehicle accidents.

The most interesting aspect of these final three columns is the large differences among vehicle types in the ratio of occupant fatalities to other fatalities. For all types of trucks, and particularly for combination vehicles, there are many fewer fatalities to the truck's occupants than to other persons involved in the crash.

Fatality Ratios in 1980 by Vehicle Type

In Table 6 and Figure 2 these disparities in the number and distribution of fatalities among different vehicle types are shown graphically for 1980. The data are for two-vehicle accidents only, and they are for vehicle occupants only--thus excluding any pedestrians or bicyclists who were killed in two-vehicle accidents.

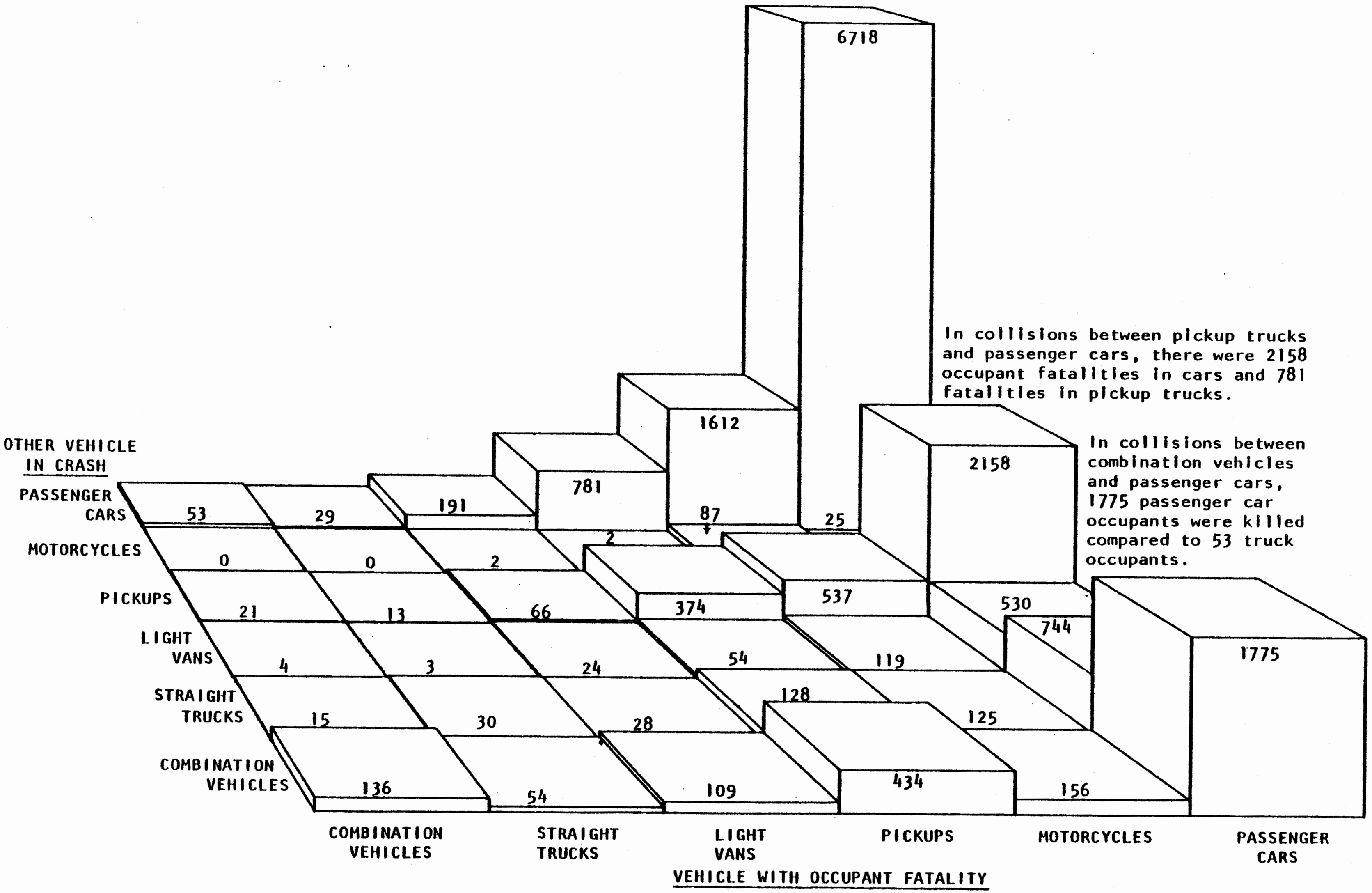

Figure 2
Occupant Fatality Distribution by Mix of Vehicles, U.S. Two-Vehicle Fatal Crashes
1980 N=17,137

Table 6

Fatalities in Two-Vehicle Accidents Involving Different Types of Vehicles, 1980

	Fatalities in First Vehicle Type	Fatalities in Second Vehicle Type	Ratio of Fatalities in First Vehicle Type to Fatalities in Second Vehicle Type
Passenger Car/Motorcycle	25	1612	0.016:1
Passenger Car/Pickup	2158	781	2.76:1
Passenger Car/Light Van	530	191	2.77:1
Passenger Car/Straight Truck	744	29	25.7:1
Passenger Car/ Combination Truck	1775	53	33.5:1
Motorcycle/Pickup	537	1	537:1
Motorcycle/Light Van	119	2	59.5:1
Motorcycle/Straight Truck	125	0	-
Motorcycle/ Combination Truck	156	0	-
Pickup/Light Van	54	66	0.82:1
Pickup/Straight Truck	128	13	9.8:1
Pickup/ Combination Truck	434	21	20.7:1
Light Van/Straight Truck	28	3	9.3:1
Light Van/ Combination Truck	109	4	27.3:1
Straight Truck/ Combination Truck	54	15	3.6:1

While FARS has available somewhat more detail than is shown here (for example, eight different kinds of passenger cars), the vehicles have been grouped into just six categories for display. These are (1) all passenger cars (including car-pickups), (2) all motorcycles, (3) all pickup trucks, (4) all light vans (including truck-based station wagens), (5) all straight trucks other than the above (including bobtail tractors and a few unknown truck types), and (6) all combination vehicles (including those with more than one trailer). The height of each bar is proportional to the number of occupants killed who were in the vehicle labeled along the front of the diagram. The diagonal represents collisions between like vehicles, the most notable being the collision between two cars which accounts for 6718 occupant fatalities--almost two-fifths of the 17,137 occupant fatalities in these two-vehicle crashes. Other than the diagonal, the bars should be considered in pairs--the car/pickup pair indicating 2158 fatalities in cars and 781 in pickups for all crashes (totaling 2939 fatalities) between those two vehicles. Other prominent entries are the car/van (530 car, 191 van, 621 total), and the car/combination vehicle (1775 car, 53 truck, 1828 total).

The Table 6 ratios of the number of occupants killed in vehicles of different size reflect both the mass ratio and the relative protectiveness of the two vehicles. For pickup/car crashes the ratio of car-to-pickup occupant fatalities is 2.76:1; for vans this is 2.77:1; for straight trucks it is 25.7:1; and for combination vehicles it is 33.5:1. Although pickups and vans have quite favorable fatality ratios in collisions with passenger cars, they still fare almost as poorly as cars in collisions with combination vehicles--the fatality ratios are 20.7:1 and 27.3:1, respectively.

Table 7 provides a more detailed look at occupant fatality ratios for 1980 truck-car crashes by both truck type and passenger car size. The data show the percentages of occupants killed and the resulting ratios for 4981 truck-car crashes in which the numbers of occupants in both the truck and the car were known (97.4 percent of the 5,115 two-vehicle truck-car crashes). Ratios of percentages of occupants killed are more meaningful than ratios of absolute numbers killed because the involved cars averaged larger numbers of occupants than the involved trucks (1.87 to 1.50). As might be expected, among the truck types, vans and truck-based station wagons had the largest average number of occupants (2.0), while combination trucks had the lowest average (1.15). Among the involved passenger cars there was less variation among weight classes, but the heavier vehicles did on average contain more occupants than the lighter ones.

Figure 3 shows graphically the basic results from the row totals of Table 7. What is most striking is the vulnerability of small car occupants in truck-car crashes. Whereas 61.3 percent of the occupants

Table 7

Occupant Fatalities in Truck-Car Fatal Accidents by Truck Type and Car Weight, 1980[a]

Truck Type	Occupant Fatalities[b]	Passenger Car Curb Weight in Pounds					Total
		1400-2499	2500-3499	3500-4499	4500+	Not Known	
Foreign Nameplate Pickups	Accident N	29	45	59	7	26	166
	Car Fatal %	52.6	36.0	17.6	44.4	46.8	34.0
	Truck Fatal %	22.5	37.7	50.5	55.5	23.8	38.9
	Car/Truck Ratio[d]	2.34	0.95	0.35	0.80	1.97	0.87
American Nameplate Pickups	Accident N	473	693	589	86	318	2159
	Car Fatal %	55.4	49.7	40.8	32.4	52.0	48.0
	Truck Fatal %	7.3	16.9	29.3	34.8	16.4	19.1
	Car/Truck Ratio[d]	7.61	2.95	1.39	0.93	3.16	2.52
Vans and Truck-Based Station Wagons	Accident N	124	193	167	24	95	603
	Car Fatal %	55.3	52.5	34.8	26.8	46.2	46.0
	Truck Fatal %	7.0	12.8	22.5	20.7	16.6	15.6
	Car/Truck Ratio[d]	7.85	4.10	1.55	1.30	2.78	2.96
Small Single-Unit Trucks	Accident N	48	62	57	4	38	209
	Car Fatal %	71.4	58.5	57.3	63.6	59.4	61.2
	Truck Fatal %	2.9	7.7	5.2	0.0	6.5	5.5
	Car/Truck Ratio[d]	24.29	7.60	11.03	-	9.20	11.05
Medium and Large Single-Unit Trucks	Accident N	34	72	49	3	34	192
	Car Fatal %	66.0	66.9	56.7	75.0	74.5	65.2
	Truck Fatal %	2.4	1.2	0.0	0.0	2.4	1.3
	Car/Truck Ratio[d]	27.74	56.89	-	-	31.31	48.88
Combination Trucks	Accident N	239	483	438	57	217	1434
	Car Fatal %	75.2	70.4	65.5	57.4	70.6	68.9
	Truck Fatal %	2.2	3.2	3.9	4.5	2.1	3.1
	Car/Truck Ratio[d]	33.97	23.32	16.83	12.81	34.20	22.23
Misc. Trucks[c]	Accident N	39	76	60	6	37	218
	Car Fatal %	76.5	66.7	62.1	61.5	64.3	66.3
	Truck Fatal %	3.3	2.9	3.7	14.3	1.8	3.2
	Car/Truck Ratio[d]	22.94	23.11	16.97	4.30	35.36	20.4

Table 7 (Continued)

Truck Type	Occupant Fatalities[b]	Passenger Car Curb Weight in Pounds					Total
		1400-2499	2500-3499	3500-4499	4500+	Not Known	
Total	Accident N	986	1624	1419	187	765	4981
	Car Fatal %	61.3	57.3	48.5	42.7	57.9	54.9
	Truck Fatal %	6.2	12.1	20.7	24.1	11.8	13.9
	Car/Truck Ratio[d]	9.89	4.72	2.34	1.77	4.91	3.94

[a]For two-vehicle accidents in which the number of occupants in each vehicle is known.

[b]Percentage of occupants in each vehicle type who were killed.

[c]Includes bobtail tractors, single-unit trucks of unknown size, and unknown truck types.

[d]The car/truck ratios may not fit the percentages exactly because the percentages have been rounded to one decimal place.

of cars under 2500 pounds were killed in these crashes, this was reduced to 42.7 percent for occupants of cars over 4500 pounds. At the same time the larger the car the larger the percentage of truck occupants who were killed. Almost one-quarter of the truck occupants were killed when involved with a car over 4500 pounds, while only 6.2 percent were killed when involved with a car under 2500 pounds. All the fatality ratios in Figure 3 are quite favorable to trucks, but they are much more favorable when the truck is involved with a small car than when it is involved with a large car. Overall, car occupants are almost four times as likely as truck occupants to be killed in truck-car crashes.

Figure 4 shows similar total percentages and ratios for the seven truck types of Table 7. Not surprisingly, crashes involving combination trucks had the largest percentage of car occupant deaths (68.9 percent), but medium and large single-unit trucks had an even smaller percentage of their occupants killed (1.3 percent) than did combination trucks (3.1 percent), so the highest fatality ratio (48.88:1) belongs to medium and large single-unit trucks. At the other end of the truck spectrum the foreign nameplate pickups (Datsun, Toyota, Mazda, Subaru, and

Volkswagen--Chevrolet Luv, Ford Courier, etc. could not be distinguished in the FARS data from other American pickups) had a larger percentage of their own occupants killed (38.9 percent) than of the car occupants (34.0 percent) in foreign pickup/car crashes, for a less-than-one ratio of 0.87:1. Vans and American nameplate pickups fall in between with respective ratios of 2.96:1[4] and 2.52:1.

It is obvious that differences in mass have a great deal to do with who gets killed in truck/car fatal crashes. For each of the seven truck types in Table 7 one can see the trend of increasing truck occupant fatalities and decreasing car occupant fatalities with increases in the car weight. Even for combination trucks there is an increase from 2.2 percent killed truck occupants when involved with a car under 2500 pounds to 4.5 percent killed truck occupants when involved with a car over 4500 pounds.

However, there seems to be an additional factor in the design of pickups and vans which is in their favor in crashes with cars. Most American pickups and vans fall in the 3500-4499 pound weight class. Yet in crashes with passenger cars in this weight class the fatality ratios are substantially favorable to the pickups (1.39:1) and the vans (1.55:1). Even in crashes with large passenger cars over 4500 pounds the pickups come out almost even (0.93:1), while the vans are still ahead (1.30:1). This is true despite the fact that there are fewer mandatory safety standards for light trucks than for passenger cars and that almost no pickup truck occupants could have been located in relatively safe rear seats (while at least some were probably in the very unsafe outside cargo areas). It is not clear just what this special design factor is (perhaps greater stiffness), but it appears that it is also important in addition to the larger mass in explaining the very high car-to-truck fatality ratios in crashes involving medium and large trucks.

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[4]When the 35 Volkswagon bus/car crashes are excluded from the van category, the ratio climbs to 3.42:1. The VW van fatality rates are rather similar to those for foreign pickups with 39.7 percent of the van occupants killed, but only 14.7 percent of the car occupants were killed in these 35 crashes for a total fatality ratio of only 0.37:1.

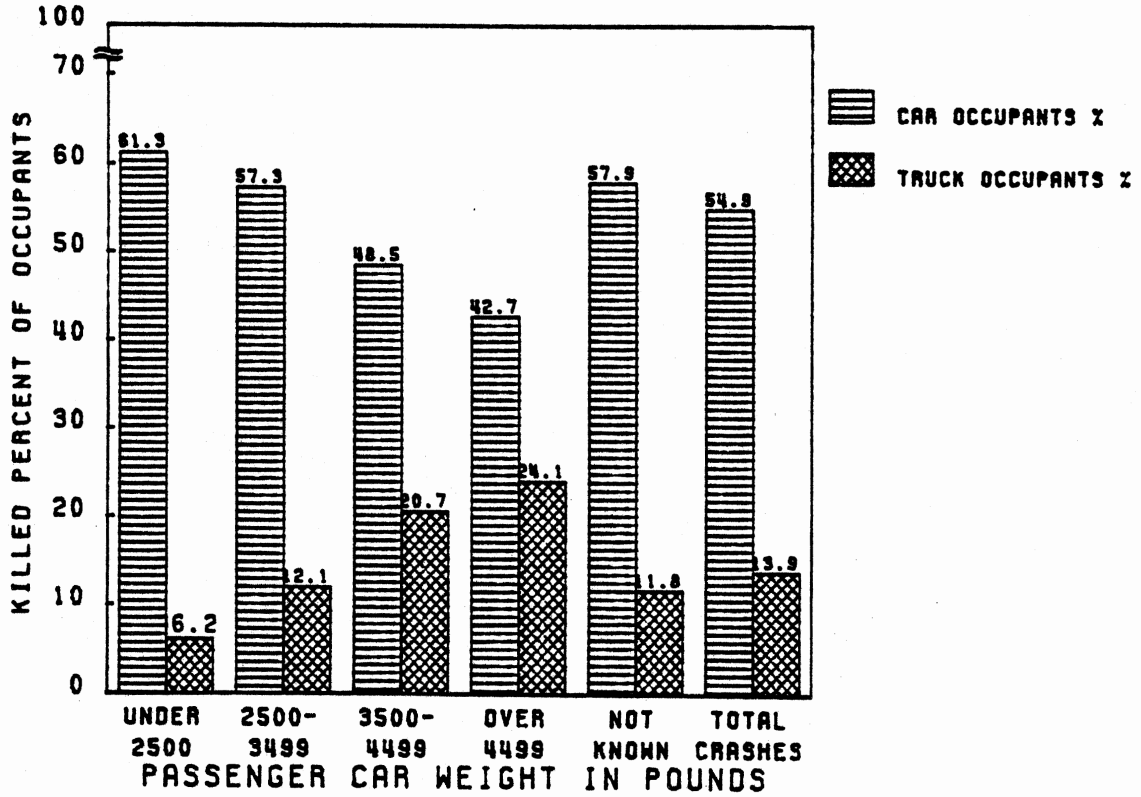

Figure 3

Occupant Fatalities in Car/Truck Crashes by Passenger Car Weight, 1980 FARS Data

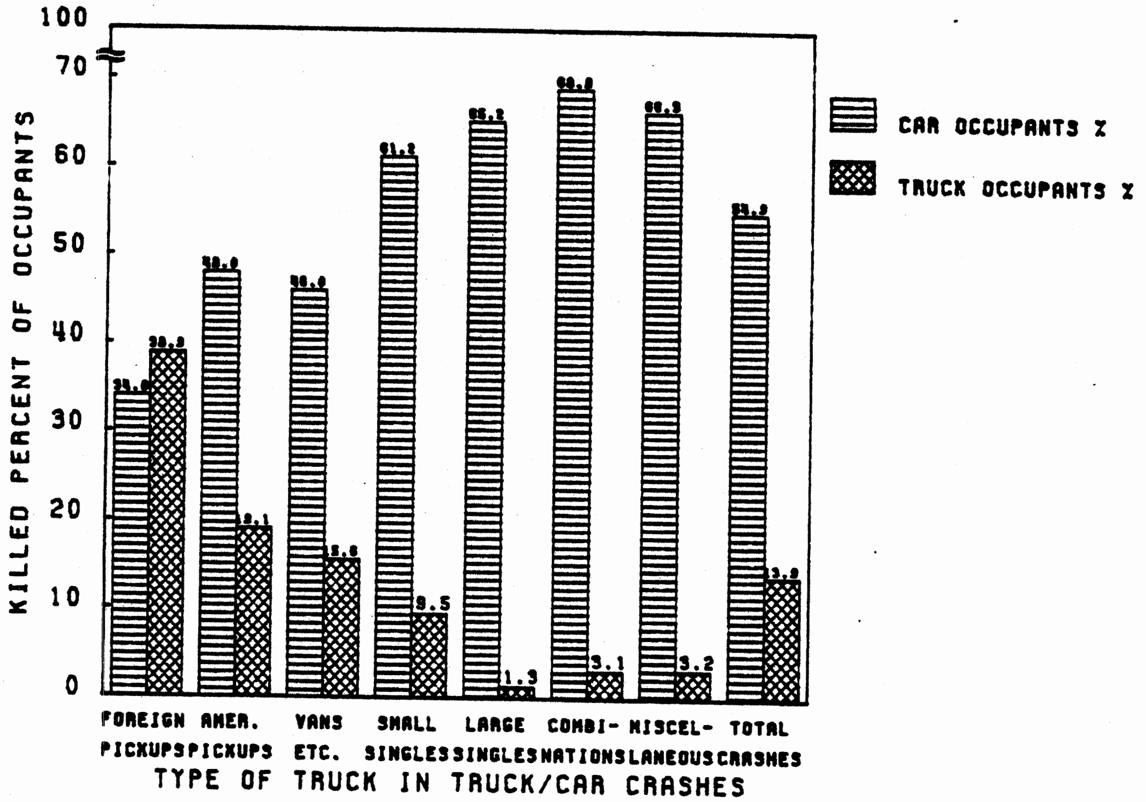

Figure 4

Occupant Fatalities in Car/Truck Crashes by Type of Truck, 1980 FARS Data

A similar analysis of fatality ratios in truck/car crashes was carried out for drivers and other occupants separately. This showed that truck drivers were slightly more likely to be killed than other truck occupants (14.2 percent compared to 13.3 percent), especially in vans and foreign pickups. This difference was greatly accentuated among car occupants. The percentage of car drivers killed was 66.4 percent compared to 41.7 percent of the other car occupants in truck/car crashes. Looking at only the drivers in these car/truck crashes, the car-to-truck fatality ratio was 4.66:1, while for other occupants it was 3.13:1.

Overrepresentation of Trucks in Multi-vehicle Accidents

An interesting question for this study concerns whether trucks are overrepresented in multi-vehicle accidents in relation to their exposure on American roads. To look at this question statistically, a binomial model has been applied to the FHWA estimates of miles driven in 1980 by passenger cars and trucks. These exposure estimates are far from perfect, but they are the best national estimates available. For the two-vehicle case, one would expect (on the basis of the total exposure estimates) that about 55 percent of the fatal accidents involving only cars or trucks would involve two cars, 38 percent would involve a car and a truck, and seven percent would involve two trucks. In actuality, only 46 percent of these fatal accidents involve two cars, 43 percent involve a car and a truck, and almost 11 percent involve two trucks. Thus trucks seem to be considerably over-involved both in fatal accidents with passenger cars and in fatal accidents with each other, as compared to what would have been expected on the basis of their estimated miles driven. This over-involvement is even higher for combination trucks specifically.

The full details of this statistical procedure are shown in Appendix A, including its application to the three-vehicle and four-vehicle cases. These applications find a much smaller overrepresentation of trucks in more than two-vehicle fatal crashes.

One is still left with the question as to whether trucks are overrepresented in all (i.e., mostly non-fatal) multi-vehicle accidents.

It may be that their overrepresentation in fatal accidents is largely a function of their greater mass or stiffness compared to cars, so that when an accident occurs involving a truck there may be a greater probability that someone will be killed than when two cars collide. Or it may be that trucks are more likely than cars to be involved in non-fatal as well as fatal accidents. This issue should be addressed by looking at state exposure and state accident data (fatal and non-fatal). Unfortunately, adequate exposure estimates for cars and trucks are not available at a state level. However, a preliminary look at this question in Texas and Washington accident files is included in Appendix A. It suggests that trucks are not overrepresented in all types of multi-vehicle accidents as they are in fatal multi-vehicle accidents.

3.0 DESCRIPTIVE STATISTICS OF CAR/TRUCK CRASHES

Introduction

This section presents detailed descriptive statistics about two-vehicle truck/car collisions, beginning with the distribution of the 5,115 fatal truck/car crashes across road types and vehicle types in 1980. Following that, a number of tabulations describing these accidents with respect to geometric configuration (how did they happen?), cause (why?), and time (when?) are presented.

For much of the following analysis of the FARS data, trucks have been separated into four groups--pickup trucks (including those with slide-in campers), 2-unit combination vehicles (truck or tractor and trailer), light vans, and all others. The "other" category consists mainly of medium and large straight trucks, but also contains small numbers of multi-unit combination vehicles (trucks or tractors with double or triple trailers) and tractors not pulling trailers, truck-based station wagons, and unknown truck types.

Road Class Definitions and Descriptions

Roadways are classified in most police-reported accident data sets in a variety of ways, no single one of which provides a fully useful picture of the road in question. One major categorization divides roads into Interstate Routes, U.S. and/or State Trunklines, other major arterials, county roads, and local streets. Other categorizations include divided versus undivided, rural versus urban,[5] and the number of traffic lanes. Combinations of these categories can serve to present a picture of various road types, but since the total number of combinations is large we have grouped these into twelve separate road types which tend to have different characteristics.

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[5]The FHWA convention, for example, considers roadways within incorporated jurisdictions of 5000 or more persons to be urban, all

For the FARS data presented herein interstate routes have been combined with "other limited access" roads, and further divided into rural and urban categories. They are best thought of as multi-lane divided roadways with full control of access--i.e., no at-grade intersections. Although the urban and rural design standards are similar, the urban category will typically carry higher traffic loads, and will often have more than two lanes in each direction. Conversely, the rural interstate routes will have relatively low traffic densities, and most often have only two lanes in each direction.

The next major category is the two-lane undivided state or U.S. trunkline highway. In most states these are the two-lane state-maintained roads which carry relatively heavy and high speed traffic. They may be thought of as generally well-maintained and designed roads, with reasonably good shoulders, and a minimum of objects (trees, poles, etc.) close to the road. These are characterized in this report as "2-lane undivided U.S. and State Trunklines", and are further separated into rural and urban designations.

A third category may be defined from a combination of U.S. and State trunklines with more than two lanes and divided (by some median) but not with limited access. Maintenance of these roadways is generally a state responsibility. They do, however, have many intersections and thus the potential for accidents of different types than the controlled access interstates. Again, these have been split into rural and urban segments which would typically exhibit different traffic densities and perhaps different travel speeds.

The fourth category is the two-lane other major "arterial" --i.e., not a state trunkline, but a locally-maintained road which carries substantial traffic. These might often be characterized as "collectors" leading to major roads of a higher quality. Because of their place in the road hierarchy, they often have fewer maintenance dollars available, more potential conflicts (driveways, shopping centers), and heavy but slower traffic. They are divided in this study into rural and urban,

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others rural. While other definitions of rural/urban may also be used, this seems to be common for police accident reports.

the former characterized by higher speeds, fewer street lights, and longer distances between intersections than the latter.

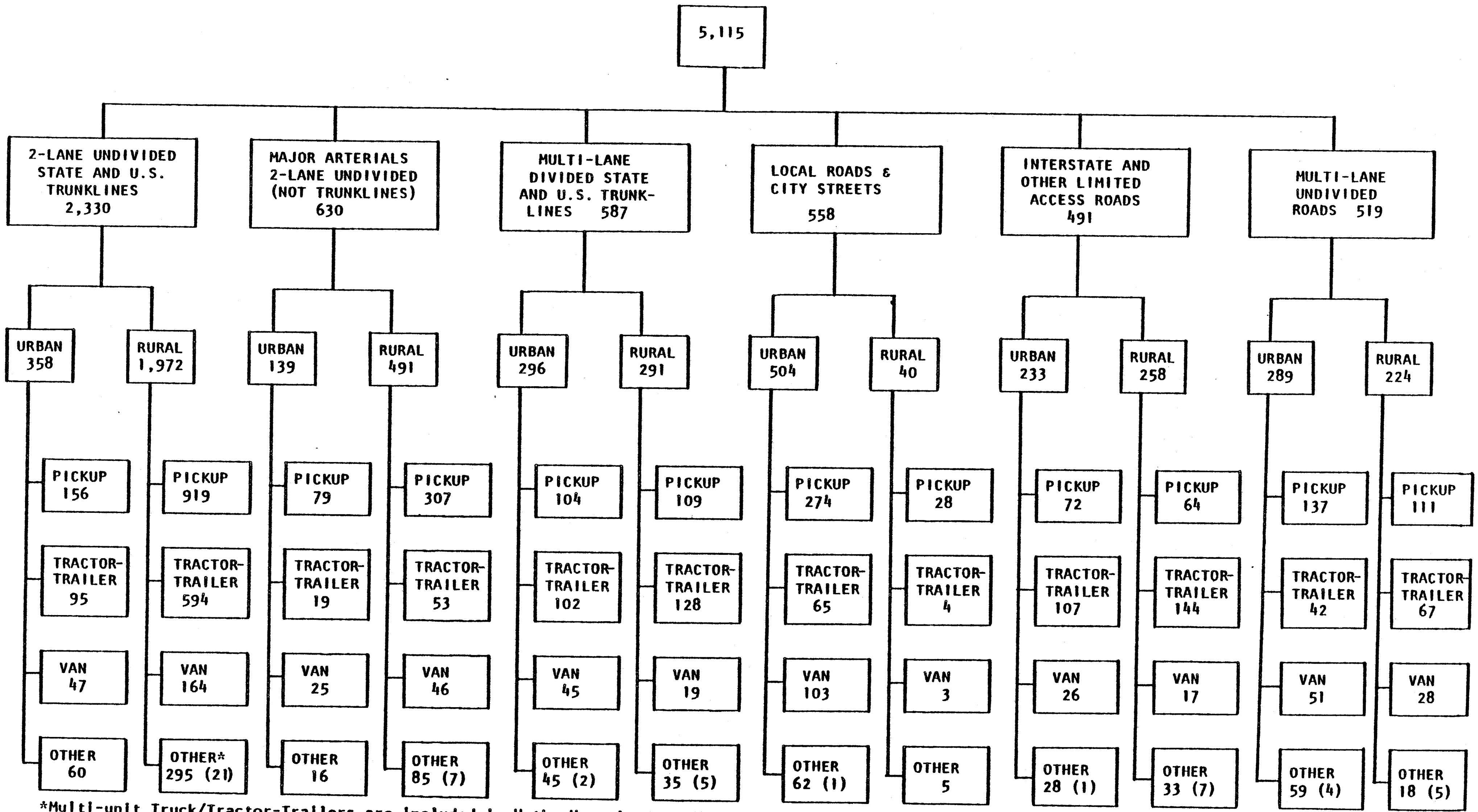
In the fifth category, local roads and streets are combined. These may be thought of as non- or minor arterials, locally maintained, and with relatively light traffic. These are then subdivided into rural and urban classes--with the rural category most often being considered a road and the urban category a street.

The sixth category contains all of the roads which do not fall under one of the above categories. Most of these are undivided more-than-two-lane roads. Again this category is split into rural and urban groups. The rural group may be thought of as mostly three- and four-lane locally-maintained roads, carrying moderate traffic at somewhat lower speeds than the other rural categories. In the urban case, these will be city-maintained multi-lane streets, frequently with curbs and parking.

There may be other combinations of road descriptors which would be of interest, of course, and the present selection represents some compromises. While the coding of the underlying variables in the FARS is intended to be consistent, there are some peculiarities in reporting which lead to some uncertainties even with the present selection. For example, some states designate roadways as state routes (for maintenance support purposes) which are functionally more like a county road in another part of the country. Within the limits of this kind of problem, we have attempted to divide road classes into meaningful categories as described above.

Truck Type and Road Location in Truck-Car Crashes

Figure 5 presents the distribution of 1980 two-vehicle truck/car fatal crashes in relation to road type, urbanization, and truck type. These 5,115 crashes resulted in 6161 occupant fatalities--slightly over one-third of the 18,178 occupant fatalities resulting from all types of two-vehicle crashes in 1980. These include 2369 car/pickup crashes (46 percent); 576 car/light van crashes (11 percent); 1427 car/two-unit tractor trailer crashes (28 percent); and 743 car/other truck crashes (15 percent). Because there is some missing data on the rural-urban



*Multi-unit Truck/Tractor-Trailers are included in "other" estimate. The number of these is shown in parentheses.

Figure 5
Distribution of Truck-Car Fatal Accidents by Truck Type and Road Class

dimension the numbers presented in the lower blocks of this diagram do not always sum to the top numbers.

The top row of blocks in Figure 5 shows the distribution of truck/car fatal accidents by the six major road classes used in this analysis. The first block shows that 2,330 fatal accidents took place on two-lane state and U.S. trunklines, and the two numbers below show that most of these were in rural areas (1,972). The 45.6 percent of the accidents which took place on two-lane trunklines contrasts sharply with the 491 accidents (9.6 percent) which took place on divided limited access highways. Looking down to the tractor-trailer row, one can see that 689 (95 urban plus 594 rural) accidents took place on two-lane trunklines (48.5 percent of the 1,420 tractor-trailer accidents), and 251 (107 urban plus 144 rural) accidents took place on limited access highways (17.7 percent), almost a three to one ratio. For all accidents 3,276 (64.3 percent) took place in rural areas, while for tractor-trailers 69.7 percent took place in rural areas. Only van accidents occurred more frequently in urban areas than in rural areas (51.7 - 48.3 percent).

These same data for the 48 road type and truck type cells are shown graphically in Figure 6. Each bar represents the accidents on one of the 12 urban or rural road classes, and within each bar the four different shadings represent the numbers of accidents involving the four truck types. The two-lane rural trunkline stands out in this graph with almost two-fifths of the total accidents. Within-bar vehicle comparisons show that pickup accidents are the most frequent type except on rural and urban interstates and on rural divided trunklines. On these roads, tractor-trailer accidents predominate, and pickup accidents are second in frequency. Tractor-trailers rank second on the rural and urban two-lane trunklines, on urban divided trunklines, and on rural multi-lane undivided roads. Vans rank second on urban two-lane arterials and urban city streets, while other trucks rank second on rural two-lane arterials, rural local roads, and urban multi-lane undivided roads.

The significance of the Figure 6 distribution of truck-car fatal accidents by truck type and road class is highlighted by a comparison

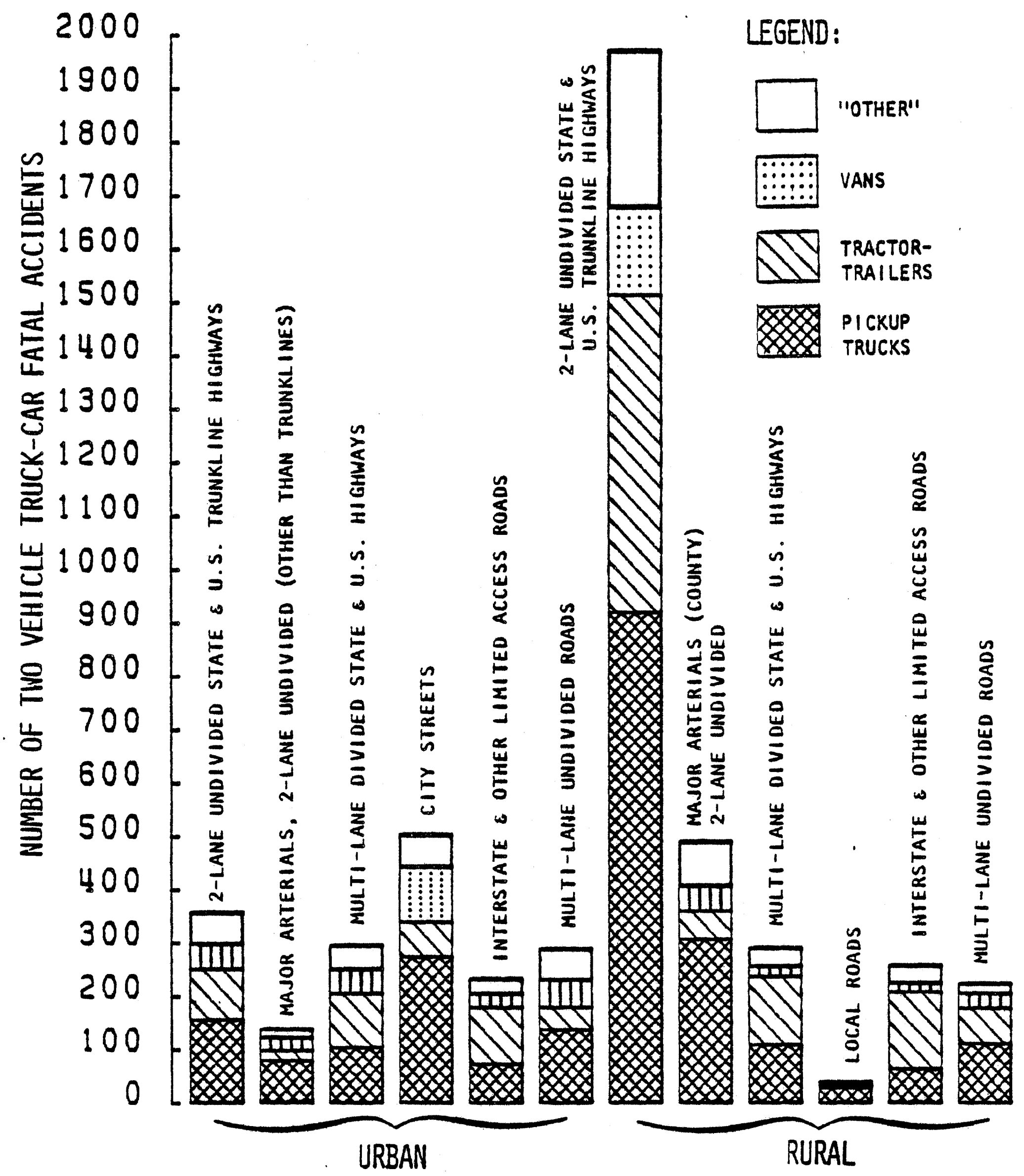


Figure 6

Two-Vehicle Car-Truck Fatal Accidents in the U.S. by Road Class and Type of Truck (FARS 1980) with available exposure data. Table 8 and Figure 7 compare percentages of fatal accidents with FHWA estimates of percentages of annual vehicle miles traveled (VMT) for two truck types and four road classes. This comparison is necessarily limited to the categories available in the VMT estimates published annually by the Federal Highway Administration.

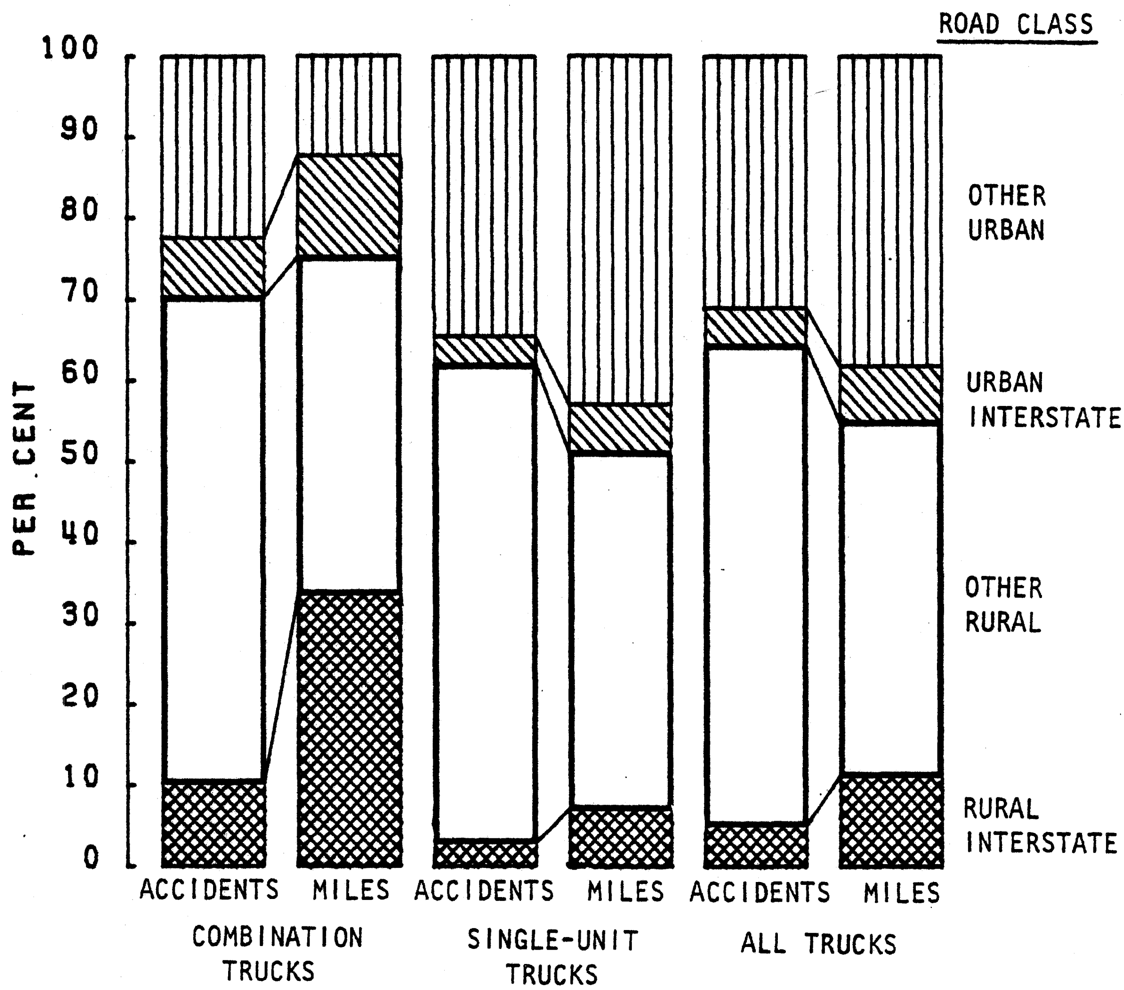


Figure 7
Road Class of 1980 Two-Vehicle Truck-Car Fatal Accidents and Miles Traveled for Two Truck Types

The data clearly demonstrate the relatively greater safety of truck travel on interstate highways, particularly for combination trucks. Whereas combination trucks have more than one-third of their mileage on

Table 8

1980 Car-Truck Fatal Accidents, Miles Traveled, and Accident Rates for Two Truck Types by Road Class on Which Accident Occurred (FARS 1980)* Accident Occurred (FARS 1980)*

Road Class		Combination Vehicles+			Pickups, Vans, Other			All Trucks		
		Fatal Accidents**	VMT	Ratio Accidents/ VMT	Fatal Accidents	VMT	Ratio Accidents/ VMT	Fatal Accidents	VMT	Ratio Accidents/ VMT
Interstate Rural	N	151	20.2	-	107	23.0	-	258	43.2	-
	%	10.3	33.7	0.31	3.0	7.1	0.42	5.1	11.2	0.46
Other Rural	N	883	24.95	-	2129	143.07	-	3012	168.02	-
	%	60.0	41.6	1.46	59.0	44.1	1.34	59.3	43.7	1.36
Interstate Urban	N	108	7.5	-	125	19.0	-	233	26.50	-
	%	7.3	12.5	0.58	3.5	5.9	0.59	4.6	6.9	0.67
Other Urban	N	330	7.35	-	1245	139.5	-	1575	146.85	-
	%	22.4	12.3	1.82	34.5	43.0	0.80	31.0	54.9	1.17
All Rural	N	1034	45.15	-	2236	166.07	-	3270	211.22	-
	%	70.2	75.3	0.93	62.0	51.2	1.21	64.4	54.9	1.17
All Urban	N	438	14.85	-	1370	158.5	-	1808	173.35	-
	%	29.2	24.8	1.18	38.0	48.8	0.79	35.6	45.1	0.79
Total	N	1472	60.0	-	3606	324.57	-	5078	384.57	-
	%	100.0	100.0	-	100.0	100.0	-	100.0	100.0	-

*VMT estimates in billions of miles traveled are from FHWA's Highway Statistics 1980, Table VM-1. In this presentation of the FARS accident data, all limited access roads are included in the interstate categories. This definition may not agree precisely with the FHWA interstate categories.

**As the numbers in this table represent two-vehicle truck/car crashes, the numbers of trucks involved is equal to the number of accidents.

+Combination vehicles include two-unit, three-unit, and four-unit tractor-trailer combinations.

rural interstate highways, they have only about one-tenth of their fatal accidents on such highways. On the other hand, while a little over two-fifths of their mileage is on other rural roads, three-fifths of their fatal accidents are on such roads--much more than would be expected on the basis of truck usage of these roads. Similarly, combination vehicle fatal accidents per mile traveled are substantially less on urban interstates than on other urban roads.

As one would expect due to the safer design features of interstate highways, single-unit trucks also have fewer fatal accidents per mile traveled on rural and urban interstates than on other rural and urban roads, although the differences are much less than for combination vehicles. It is interesting to note that combination vehicles have substantially more fatal accidents per mile traveled on urban roads, while the opposite is true for other single-unit trucks (as it is for passenger cars). The accuracy of the FHWA exposure estimates is open to considerable question, but it appears that combination vehicles are particularly liable to be in serious traffic accidents in dense urban traffic. It is fortunate that only about one-eighth of their mileage is acquired on non-interstate urban roads (compared to three-sevenths of the mileage for single-unit trucks).

Comparison of Truck/Car Accident and Vehicle Characteristics

Each of the cells in the bottom four rows of Figure 5 indicates the number of fatal two-vehicle truck-car crashes which occurred during 1980 involving that particular type of truck on the indicated road class. For each of these cells, many characteristics of the accident or of either vehicle/driver may be determined from the data. Tables 9, 10, and 11--each consisting of four parts (A, B, C, and D for the four types of trucks) present information about the accident (Table 9), the truck and its driver (Table 10), and the car and its driver (Table 11). Each table corresponds to a particular vehicle type, and comparisons of that vehicle's characteristics across road classes can be made by scanning the columns in that table. Comparisons between vehicle types can be made by looking at parallel entries in different tables.

Since the data presented in these tables come from the census of fatal crashes for the year 1980, the numbers may be regarded as true values rather than estimates. In that sense, then, any differences observed are real. For example, in Table 9-A, the mean number of fatalities for car/pickup truck crashes on urban trunklines is 1.25, and on rural trunklines it is 1.35. On city streets, the same type of crash leads to only 1.15 fatalities per crash.

Whether these differences are significant in a statistical sense--viewing the 1980 year as a sample of a longer time period--depends on both the observed difference and the number of crashes in each cell. While the significance may be computed using standard statistical methods (the t-test for means, or a chi-square for proportions), there are so many cells that it is not reasonable to present all those statistics. Some guidance in interpretation is offered, however. For those table entries shown as percentages, the confidence interval at a 95 percent level of significance would be about 14 percent for differences in percentages in the mid range based on 100 cases in each cell. With 500 cases the same interval would be about six percent. Thus, looking at Table 9-A, one can infer that the percent of pickup/car accidents on curves was significantly different for urban versus rural trunklines, but perhaps not so for the urban trunklines versus city streets. In general differences between cells containing much fewer than 100 cases should be viewed with caution.

There are a vast number of possible comparisons among truck types and road classes in these twelve tables. Some of the main differences are discussed below, but the reader is invited to use these data to study other comparisons of possible interest.

Looking at the mean number of fatalities in Tables 9-A to 9-D, there are almost always more fatalities per accident on rural roads than on urban roads, except for the comparison of city streets with minor rural roads. This is in line with previous findings that rural accidents tend to be more severe than urban accidents. The highest mean number of fatalities for cells with 50 accidents or more in the four tables is the 1.38 for pickup/car accidents on rural limited access highways, followed by the 1.35 for pickup/car accidents on rural two-

Table 9-A

Accident Factors in Two-Vehicle Car/Truck Fatal Crashes
PICKUP TRUCKS

Road Class/ Land Use	Number of Fatal Accidents	Mean Number of Fatalities in Accidents	Percent of Accidents on Curve	Percent Wet, Icy, Etc. Roadway Surface Conditions	Percent of Accidents During Dark
2-Lane Undivided (Urban) Trunklines	156	1.25	15.5	23.7	60.9
2-Lane Undivided (Rural) Trunklines	919	1.35	28.3	22.4	47.7
2-lane Undivided Major Arterials (Urban)	79	1.11	19.0	26.6	53.2
2-Lane Undivided Major Arterials (Rural)	307	1.26	22.8	18.6	39.4
Multi-Lane Divided Trunklines (Urban)	104	1.19	4.8	22.1	60.6
Multi-Lane Divided Trunklines (Rural)	109	1.25	8.3	10.1	47.7
City Streets (Urban)	274	1.15	11.0	14.2	54.4
Local Roads (Rural)	28	1.11	10.7	17.9	46.4
Interstate Quality Roads (Urban)	137	1.16	11.0	15.3	59.8
Interstate Quality Roads (Rural)	111	1.25	16.0	22.7	53.2
Multi-Lane Undivided Roads (Urban)	72	1.19	8.3	13.9	67.6
Multi-Lane Undivided Roads (Rural)	64	1.38	20.3	10.9	57.8

Table 9-B

Accident Factors in Two-Vehicle Car/Truck Fatal Crashes
TRACTOR-TRAILERS

Road Class/Land Use	Number of Fatal Accidents	Mean Number of Fatalities in Accidents	Percent of Accidents on Curve	Percent of Wet, Icy, Etc. Roadway Surface Conditions	Percent of Accidents During Dark
2-Lane Undivided (Urban) Trunklines	95	1.25	13.7	23.2	47.4
2-Lane Undivided (Rural) Trunklines	594	1.28	21.4	22.2	43.9
2-lane Undivided Major Arterials (Urban)	19	1.11	36.8	5.3	42.1
2-Lane Undivided Major Arterials (Rural)	53	1.34	20.8	9.4	26.4
Multi-Lane Divided Trunklines (Urban)	102	1.25	6.9	12.8	59.8
Multi-Lane Divided Trunklines (Rural)	128	1.25	6.2	18.0	54.7
City Streets (Urban)	65	1.09	6.2	24.6	47.7
Local Roads (Rural)	4	1.00	0	0	50.0
Interstate Quality Roads (Urban)	42	1.14	14.3	14.3	59.5
Interstate Quality Roads (Rural)	67	1.21	13.6	27.3	41.8
Multi-Lane Undivided Roads (Urban)	107	1.18	13.1	23.4	61.7
Multi-Lane Undivided Roads (Rural)	144	1.28	11.8	28.5	51.4

Table 9-C

Accident Factors in Two-Vehicle Car/Truck Fatal Crashes
VANS

Road Class/Land Use	Number of Fatal Accidents	Mean Number of Fatalities in Accidents	Percent of Accidents on Curve	Percent of Wet,Icy,Etc. Roadway Surface Conditions	Percent of Accidents During Dark
2-Lane Undivided (Urban) Trunklines	47	1.21	17.0	29.8	63.8
2-Lane Undivided (Rural) Trunklines	164	1.32	24.4	21.5	50.6
2-lane Undivided Major Arterials (Urban)	25	1.08	28.0	40.0	60.0
2-Lane Undivided Major Arterials (Rural)	46	1.33	13.0	8.7	39.1
Multi-Lane Divided Trunklines (Urban)	45	1.07	11.1	13.3	60.0
Multi-Lane Divided Trunklines (Rural)	19	1.21	0	5.6	57.9
City Streets (Urban)	103	1.09	7.8	22.6	58.2
Local Roads (Rural)	3	1.00	33.3	0	66.7
Interstate Quality Roads (Urban)	51	1.12	7.8	24.0	58.8
Interstate Quality Roads (Rural)	28	1.39	14.3	28.6	57.1
Multi-Lane Undivided Roads (Urban)	26	1.12	7.7	23.1	65.4
Multi-Lane Undivided Roads (Rural)	17	1.18	5.9	17.6	70.6

Table 9-D

Accident Factors in Two-Vehicle Car/Truck Fatal Crashes
OTHER TRUCKS

Road Class/Land Use	Number of Fatal Accidents	Mean Number of Fatalities in Accidents	Percent of Accidents on Curve	Percent of Wet,Icy,Etc. Roadway Surface Conditions	Percent of Accidents During Dark
2-Lane Undivided (Urban) Trunklines	60	1.05	20.0	27.1	47.5
2-Lane Undivided (Rural) Trunklines	295	1.28	22.7	26.1	30.8
2-lane Undivided Major Arterials (Urban)	16	1.12	31.2	31.2	25.0
2-Lane Undivided Major Arterials (Rural)	85	1.24	24.7	16.5	22.4
Multi-Lane Divided Trunklines (Urban)	45	1.29	11.1	11.1	40.0
Multi-Lane Divided Trunklines (Rural)	35	1.20	11.4	5.7	40.0
City Streets (Urban)	61	1.11	16.4	19.4	37.1
Local Roads (Rural)	5	1.00	20.0	40.0	40.0
Interstate Quality Roads (Urban)	59	1.20	15.2	17.0	45.8
Interstate Quality Roads (Rural)	18	1.28	27.8	16.7	33.3
Multi-Lane Undivided Roads (Urban)	28	1.04	17.9	32.1	35.7
Multi-Lane Undivided Roads (Rural)	33	1.39	15.2	9.1	51.5

lane trunklines. For tractor-trailer/car accidents, the highest mean is 1.34 on rural two-lane arterials, followed by 1.28 on both rural two-lane trunklines and rural interstates.

The next column in Tables 9-A to 9-D shows the percentages of accidents which took place on a curve. The outstanding figure here is the 28.3 percent of pickup/car accidents on rural two-lane trunklines. For each truck type the rural two-lane trunkline accidents took place on a curve more than one-fifth of the time, although it seems quite unlikely that curves constitute 20 percent of such roadways. Similar high rates of curve accidents are found on both urban and rural two-lane arterials. Curve accidents are less frequent on rural and urban interstates, but they are still probably disproportionate to the amount of curvature on these roads. Pickup/car accidents on curves seem particularly likely on rural interstates at 20.3 percent.

Similar large percentages of truck/car accidents took place when the road surface was wet, snowy, icy, etc. The outstanding number here is the 28.5 percent of tractor-trailer car accidents on rural interstates which took place in such wet conditions. Other wet accident rates greater than 25 percent are shown for tractor-trailers and vans on rural multi-lane undivided roads; for pickups,vans, and other trucks on urban two-lane arterials; for vans and other trucks on urban two-lane trunklines; and other trucks on rural two-lane trunklines. Accurate exposure data on wet road surfaces are not available, but these accident percentages seem much higher than reasonable estimates of the percentages of miles driven in such unfavorable road surface conditions.

The final columns of Tables 9-A to 9-D concern the percentage of truck/car accidents taking place after dark. The highest figure here is for pickup/car accidents on urban interstates at 67.6 percent. Over 60 percent of pickup/car accidents also took place after dark on rural two-lane trunklines and on urban multi-lane divided trunklines. In general, well over half of pickup and van accidents occurred during darkness, while almost half of the tractor-trailer accidents were in darkness, and somewhat less than half of the other truck accidents occurred after dark. For each road class the percentage of darkness accidents was greater in rural areas than in urban areas, probably reflecting the safety benefits of much more extensive street lighting on urban roads. Again it seems likely that these percentages of accidents during darkness are much larger than the percentages of driving during darkness performed by these vehicle types on these road classes.

Tables 10-A to 10-D and 11-A to 11-D provide data on five driver or vehicle variables for both vehicles in the truck/car accidents. These variables are mean driver age, seat belt use, vehicle rollover, driver ejection, and vehicle fire. Some of the highlights of these tables are indicated below.

In regard to driver age few significant differences are apparent. However, it is interesting that the truck drivers are generally somewhat older than the car drivers. Also tractor-trailer and other truck drivers tend to be older than pickup and van drivers, and among pickup drivers those with accidents on rural roads tend to be older than those with accidents on urban roads--while the opposite is true for van drivers. Reported safety belt use was quite infrequent for both truck and car drivers, although tractor-trailer drivers were reported to have been using safety belts much more than other truck drivers or car drivers, while pickup drivers were least likely to have been wearing belts. For all drivers belt use was reported more frequently for accidents on interstates than on other roads.

Rollover of one or both vehicles was fairly common in these accidents, particularly in accidents on interstate highways. All four types of trucks were much more likely to roll over than the cars they collided with, particularly the vans and pickups. Tractor-trailers were slightly less likely to roll over than the other types of trucks, while the cars they hit were somewhat more likely to roll over than were the other cars.

Ejection of the driver was somewhat less frequent than rollover for trucks, but it tended to be more frequent for cars. Drivers of other straight trucks and tractor-trailers were much less likely to be ejected than were drivers of vans and pickups, while drivers of the cars involved with tractor-trailers and other trucks were much more likely to be ejected than the drivers of cars involved with vans and pickups.

Table 10-A

Truck and Truck Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
PICKUP TRUCKS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Trucks With Rollover	Percent of Drivers Ejected	Percent of Trucks With Fire
2-Lane Undivided (Urban) Trunklines	156	32.4	99.2	11.5	9.1	1.3
2-Lane Undivided (Rural) Trunklines	919	35.7	98.4	9.6	7.1	2.6
2-lane Undivided Major Arterials (Urban)	79	32.4	100.0	7.6	3.8	1.3
2-Lane Undivided Major Arterials (Rural)	307	33.7	97.1	11.1	6.9	3.3
Multi-Lane Divided Trunklines (Urban)	104	34.7	97.7	15.4	7.9	1.0
Multi-Lane Divided Trunklines (Rural)	109	38.9	100.0	16.5	16.0	2.8
City Streets (Urban)	274	33.6	98.7	8.4	7.4	1.5
Local Roads (Rural)	28	39.6	100.0	7.1	7.1	0
Interstate Quality Roads (Urban)	137	32.5	97.3	11.0	7.5	3.6
Interstate Quality Roads (Rural)	111	35.1	98.7	12.6	7.3	0.9
Multi-Lane Undivided Roads (Urban)	72	36.0	91.9	19.4	16.2	0
Multi-Lane Undivided Roads (Rural)	64	37.0	92.7	20.3	8.1	4.7

Table 10-B

Truck and Truck Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
TRACTOR TRAILERS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Trucks With Rollover	Percent of Drivers Ejected	Percent of Trucks With Fire
2-Lane Undivided (Urban) Trunklines	95	38.7	89.9	7.4	3.2	1.0
2-Lane Undivided (Rural) Trunklines	594	36.6	92.4	8.1	1.2	4.9
2-lane Undivided Major Arterials (Urban)	19	37.1	89.5	0	0	0
2-Lane Undivided Major Arterials (Rural)	53	36.5	97.2	9.4	0	0
Multi-Lane Divided Trunklines (Urban)	102	38.5	97.1	5.9	2.0	2.0
Multi-Lane Divided Trunklines (Rural)	128	37.6	93.2	7.0	1.6	6.2
City Streets (Urban)	65	38.1	89.8	1.5	0	0
Local Roads (Rural)	4	47.0	0	0	0	0
Interstate Quality Roads (Urban)	42	36.9	97.2	2.4	2.4	0
Interstate Quality Roads (Rural)	67	37.7	90.6	9.0	1.5	1.5
Multi-Lane Undivided Roads (Urban)	107	38.4	86.2	15.9	2.0	4.7
Multi-Lane Undivided Roads (Rural)	144	39.3	83.5	16.0	3.5	2.1

Table 10-C

Truck and Truck Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
VANS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Trucks With Rollover	Percent of Drivers Ejected	Percent of Trucks With Fire
2-Lane Undivided (Urban) Trunklines	47	35.4	97.4	8.5	10.6	4.3
2-Lane Undivided (Rural) Trunklines	164	34.4	94.1	14.0	11.7	3.7
2-lane Undivided Major Arterials (Urban)	25	32.3	95.2	16.0	12.5	0
2-Lane Undivided Major Arterials (Rural)	46	31.2	89.7	17.4	8.7	2.2
Multi-Lane Divided Trunklines (Urban)	45	31.4	90.0	20.0	16.3	0
Multi-Lane Divided Trunklines (Rural)	19	28.2	100.0	15.8	11.8	0
City Streets (Urban)	103	36.1	96.8	11.6	12.0	0
Local Roads (Rural)	3	30.7	100.0	0	0	0
Interstate Quality Roads (Urban)	51	31.8	92.5	13.7	8.2	2.0
Interstate Quality Roads (Rural)	28	33.8	80.0	7.1	14.3	0
Multi-Lane Undivided Roads (Urban)	26	30.8	89.5	15.4	15.4	3.8
Multi-Lane Undivided Roads (Rural)	17	31.3	100.0	23.5	6.2	0

Table 10-D

Truck and Truck Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
OTHER TRUCKS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Trucks With Rollover	Percent of Drivers Ejected	Percent of Trucks With Fire
2-Lane Undivided (Urban) Trunklines	60	36.6	93.9	10.0	0	3.3
2-Lane Undivided (Rural) Trunklines	295	36.7	96.3	14.9	1.7	4.1
2-lane Undivided Major Arterials (Urban)	16	33.2	92.9	6.2	0	0
2-Lane Undivided Major Arterials (Rural)	85	35.6	98.0	9.4	2.4	1.2
Multi-Lane Divided Trunklines (Urban)	45	35.2	100.0	4.4	2.3	0
Multi-Lane Divided Trunklines (Rural)	35	42.1	89.3	8.6	0	2.9
City Streets (Urban)	62	33.6	94.4	0	3.5	3.2
Local Roads (Rural)	5	27.5	100.0	0	0	0
Interstate Quality Roads (Urban)	59	36.5	97.9	5.1	1.7	0
Interstate Quality Roads (Rural)	18	41.2	92.9	22.2	11.1	5.6
Multi-Lane Undivided Roads (Urban)	28	31.8	77.8	0	4.0	3.6
Multi-Lane Undivided Roads (Rural)	33	38.2	95.8	9.1	3.0	0

Table 11-A

Car and Car Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
PICKUP TRUCKS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Cars With Rollover	Percent of Drivers Ejected	Percent of Cars With Fire
2-Lane Undivided (Urban) Trunklines	156	35.1	96.8	4.5	8.4	2.6
2-Lane Undivided (Rural) Trunklines	919	36.4	96.6	4.6	6.1	2.8
2-lane Undivided Major Arterials (Urban)	79	33.6	94.7	6.3	2.5	1.3
2-Lane Undivided Major Arterials (Rural)	307	36.2	96.2	8.5	7.6	2.0
Multi-Lane Divided Trunklines (Urban)	104	39.6	95.3	3.8	5.9	1.0
Multi-Lane Divided Trunklines (Rural)	109	42.8	100.0	3.7	4.7	3.7
City Streets (Urban)	274	37.0	99.4	4.0	6.3	1.1
Local Roads (Rural)	28	29.3	100.0	3.6	7.1	10.7
Interstate Quality Roads (Urban)	137	37.8	95.0	3.6	5.8	2.2
Interstate Quality Roads (Rural)	111	34.5	94.9	5.4	9.4	3.6
Multi-Lane Undivided Roads (Urban)	72	30.8	96.7	8.3	7.2	0
Multi-Lane Undivided Roads (Rural)	64	38.2	89.3	12.5	9.4	7.8

Table 11-B

Car and Car Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
TRACTOR-TRAILERS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Cars With Rollover	Percent of Drivers Ejected	Percent of Cars With Fire
2-Lane Undivided (Urban) Trunklines	95	37.1	94.9	1.0	12.8	3.2
2-Lane Undivided (Rural) Trunklines	594	40.0	96.8	4.2	12.7	4.9
2-lane Undivided Major Arterials (Urban)	19	35.0	100.0	0	5.3	15.8
2-Lane Undivided Major Arterials (Rural)	53	38.4	100.0	1.9	11.5	0
Multi-Lane Divided Trunklines (Urban)	102	42.1	96.3	2.0	2.0	4.9
Multi-Lane Divided Trunklines (Rural)	128	43.1	93.5	7.0	12.0	6.2
City Streets (Urban)	65	41.4	94.0	1.5	0	3.1
Local Roads (Rural)	4	45.8	100.0	0	0	0
Interstate Quality Roads (Urban)	42	40.1	94.7	7.1	7.1	0
Interstate Quality Roads (Rural)	67	36.6	94.6	1.5	3.0	6.0
Multi-Lane Undivided Roads (Urban)	107	38.0	92.2	10.3	9.8	7.5
Multi-Lane Undivided Roads (Rural)	144	40.4	89.1	9.7	14.2	9.0

Table 11-C

Car and Car Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
VANS

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Cars With Rollover	Percent of Drivers Ejected	Percent of Cars With Fire
2-Lane Undivided (Urban) Trunklines	47	36.8	94.3	4.3	8.5	2.1
2-Lane Undivided (Rural) Trunklines	164	36.5	94.0	3.7	8.6	1.2
2-lane Undivided Major Arterials (Urban)	25	27.8	95.4	0	4.0	0
2-Lane Undivided Major Arterials (Rural)	46	39.9	96.0	4.4	9.3	0
Multi-Lane Divided Trunklines (Urban)	45	38.4	100.0	11.1	4.4	0
Multi-Lane Divided Trunklines (Rural)	19	48.1	93.3	5.3	0	0
City Streets (Urban)	103	35.9	93.6	0	5.8	1.0
Local Roads (Rural)	3	62.0	0	33.3	0	0
Interstate Quality Roads (Urban)	51	34.9	90.0	3.9	3.9	2.0
Interstate Quality Roads (Rural)	28	37.4	100.0	73.6	3.8	3.6
Multi-Lane Undivided Roads (Urban)	26	33.3	84.2	0	0	7.7
Multi-Lane Undivided Roads (Rural)	17	36.5	91.7	5.9	6.2	5.9

Table 11-D

Car and Car Driver Factors in Two-Vehicle Car/Truck Fatal Crashes
OTHER TRUCKS (Except Tractor-Trailers)

Road Class/ Land Use	Number of Fatal Accidents	Mean Driver Age	Percent of Drivers With No Restraint	Percent of Cars With Rollover	Percent of Drivers Ejected	Percent of Cars With Fire
2-Lane Undivided (Urban) Trunklines	60	38.7	91.7	0	3.4	1.7
2-Lane Undivided (Rural) Trunklines	295	40.3	98.0	6.1	11.6	3.0
2-lane Undivided Major Arterials (Urban)	16	31.2	100.0	0	6.7	0
2-Lane Undivided Major Arterials (Rural)	85	38.3	96.8	4.7	12.9	2.4
Multi-Lane Divided Trunklines (Urban)	45	41.1	100.0	4.4	4.6	2.2
Multi-Lane Divided Trunklines (Rural)	35	40.0	100.0	5.7	5.7	0
City Streets (Urban)	62	42.9	100.0	6.4	8.5	3.2
Local Roads (Rural)	5	42.2	100.0	0	20.0	0
Interstate Quality Roads (Urban)	59	37.6	93.9	1.7	3.4	0
Interstate Quality Roads (Rural)	18	40.6	100.0	22.2	33.3	0
Multi-Lane Undivided Roads (Urban)	28	38.8	94.7	7.1	3.8	3.6
Multi-Lane Undivided Roads (Rural)	33	37.3	100.0	0	6.1	0

Again driver ejection tended to be somewhat more frequent in interstate accidents.

Fire broke out in only a small percentage of these vehicles involved in car-truck accidents. Among the truck types fire was most frequent in cars which collided with tractor-trailers. The largest fire percentage for vehicle type/road class cells containing more than 50 accidents was the 9.0 percent of cars involved with tractor-trailers on rural interstates.

Accident Causation Factors--Why Do These Accidents Happen?

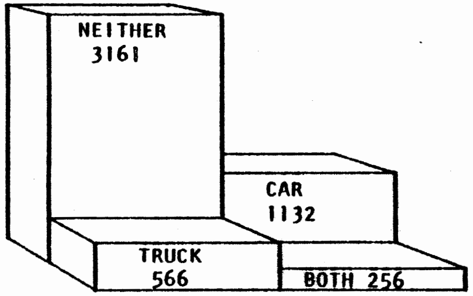
Alcohol as a Factor in Truck/Car Crashes

Alcohol usage is reported as a likely contributing factor in more than half of all fatal accidents. The Fatal Accident Reporting System records the blood alcohol reading where available, but a more complete indication is available in a "yes-no" variable for each driver in the FARS file. This has been tabulated for two-vehicle truck/car crashes, and the results are displayed in Figure 8.

Taking all 5,115 car/truck fatal crashes together, drinking on the part of at least one driver was reported in 1,954 (or 38.2 percent) of the cases. In 1,132 cases only the car driver was reported drinking versus 566 for only the truck driver--a ratio of two to one. In five percent of the crashes both the truck and car driver were reported drinking. The data aggregated over all truck types are shown in the upper left of Figure 8.

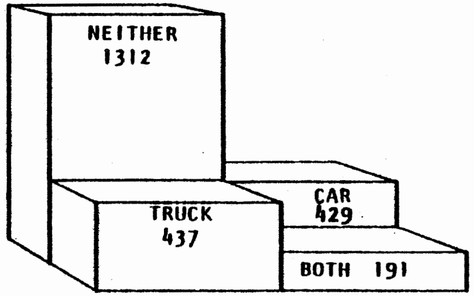
Interestingly both car and truck drivers were more likely to be reported as having been drinking in accidents in which they were killed. Of the 720 truck drivers killed 33.8 percent had been drinking, while only 13.2 percent of the truck drivers who survived were reported to have been drinking. Similarly, whereas 30.2 percent of the car drivers who died had been drinking, only 19.9 percent of the car drivers who survived were reported to have been drinking.

Not surprisingly, pickup drivers at 26.5 percent were the most likely to have been drinking among the four types of truck drivers.



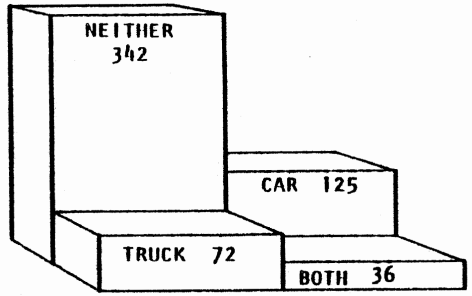
ALL TRUCKS

Alcohol Involvement for Truck and Car Drivers by Truck Type



PICKUPS

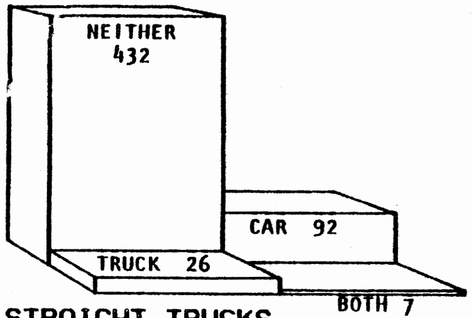
Alcohol Involvement for Truck and Car Drivers by Truck Type



VANS

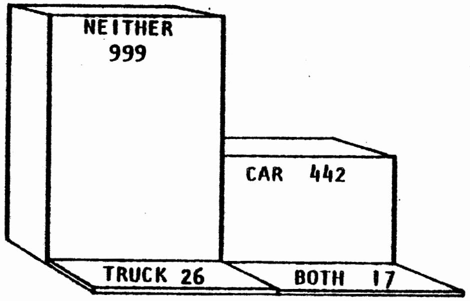
Alcohol Involvement for Truck and Car Drivers by Truck Type

These graphs depict the proportions of drinking drivers in car/truck fatal collisions in the U.S. in 1980. The bar heights represent the numbers of accidents in which neither driver, the car driver, the truck driver, or both drivers were reported to be drinking. Numbers for the individual trucks do not sum to the total for all trucks because of some missing data on truck type.



STRAIGHT TRUCKS

Alcohol Involvement for Truck and Car Drivers by Truck Type



COMBINATION VEHICLES

Alcohol Involvement for Truck and Car Drivers by Truck Type

Figure 8

Alcohol Involvement for Truck and Car Drivers by Truck Type in Two-Vehicle Car-Truck Crashes (FARS 1980)

Pickup truck and car drivers were almost equally often reported drinking in pickup-car crashes, and in eight percent of these crashes both drivers had been drinking (shown in upper-middle of Figure 8). For vans the car/truck drinking ratio was 1.5:1, with both drivers drinking in 6.3 percent of the cases. For straight trucks the car/truck (drinking) ratio was 3:1 with both drivers drinking in only 7 of the 557 crashes (1.3 percent). For combination vehicles the car/truck ratio was 10.7:1 with both drivers drinking in only 17 of the 1,484 crashes (1.1 percent).

Other Driver Contributing Factors in Car/Truck Accidents

Identification of causative or contributing factors in accidents is accomplished in different ways in different states. In the FARS data, a variable entitled "driver related factors" is encoded from information available in the state reports. Up to three such factors can be identified for each driver, and there are 54 separately defined factors available. Many of these are rarely reported (e.g., "driver depression" or "making an unlawful noise"). The ten most commonly reported factors are shown in Figure 9. The height of each bar represents the total number of reports of this item for both drivers, and the shading within the bar shows the ratio of car driver reports to truck driver reports. In the FARS data, truck drivers in general are less frequently cited for such items by a factor of about two to one.

The fault ratios (defined here as the number of car driver citations divided by the number of truck driver citations) are shown for these same ten factors by the type of truck involved in Table 12. As might be expected, the more professional operators are cited for all such faults less frequently, and vice versa--pickups being closest to a ratio of 1:1. For "careless" driving, pickups were in fact cited more often than their corresponding passenger cars.

It is interesting to note that another variable, Violations Charged, was also analyzed for these truck-car crashes. Initially this seemed to provide contradictory information on "fault" in these fatal accidents, for it showed the truck driver charged in 22 percent of the accidents while the car driver was charged in only 16 percent of the

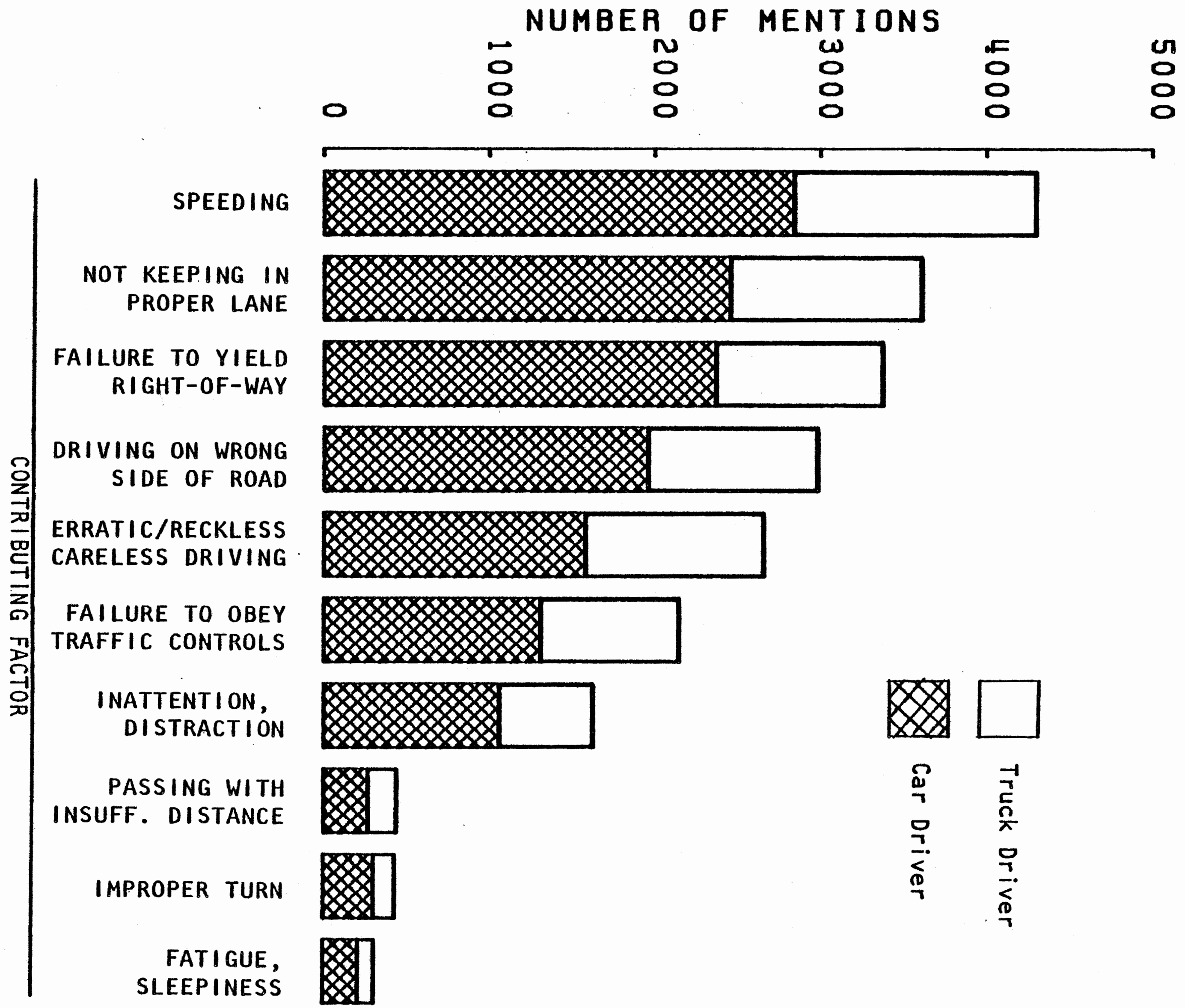


Figure 9
Driver-Related Contributing Factors in 1980
FARS Two-Vehicle Truck-Car Crashes

Table 12
Odds for Car Driver "Fault" in Car-Truck Accidents
by Driver Factor and Type of Truck in Accidents
(FARS 1980)

	Pickup Trucks	Vans	Straight Trucks	Tractor-Trailers
Speeding	1.42	1.70	5.18	2.39
Improper Lane	1.33	2.06	4.11	5.38
Fail to Yield	1.69	1.76	3.35	3.83
Wrong Side	1.28	1.46	3.2	4.52
Careless	0.82	1.36	1.95	3.59
Fail to Obey	1.07	1.11	1.83	3.45
Inattentive	1.18	1.88	2.62	3.53
Pass (insuf. distance)	1.13	2.0	2.0	1.94
Improper Turn	1.52	1.71	3.33	3.58
Asleep/Drowsy	1.33	3.00	3.00	3.75

accidents. However, further analysis revealed that violations are seldom charged against dead drivers (only about six percent of either dead truck drivers or dead car drivers were so charged). Among surviving car drivers 36.2 percent were charged with a violation, while among surviving truck drivers only 24.4 percent were charged with a violation. Among surviving tractor-trailer drivers only 17.2 percent were charged.

Fault Assessment in State Files

The lower assessment of fault for truck drivers than car drivers in truck/car fatal accidents is not reflected in the several files of state accident data analyzed which include all police-reported crashes. Data from the states of Michigan, Washington, Texas, and Pennsylvania were analyzed with respect to such factors, and in general the truck drivers were more often found at fault or were close to even with the car drivers.

Table 13 shows the distribution of citations in two-vehicle truck car crashes in Michigan during 1978. Car drivers were cited in 25 percent of the cases, pickup and panel truck drivers in 29.9 percent, and large straight truck drivers in 36.4 percent. Tractor-trailer drivers were about even with the passenger car operators.

Table 13

Issuance of Citations in Car/Truck Accidents
(Source: Michigan 1978)

Condition	Car Drivers	Pickup Panel Drivers	Straight Truck Drivers	Tractor Trailer Drivers
No Citation	1936 (75%)	1376 (70.1%)	173 (63.6%)	187 (73.6%)
Hazardous Violation	645 (25.0%)	585 (29.8%)	99 (36.4%)	65 (25.6%)
Other Violation . .	1 (0.0%)	2 (0.1%)	0 (0.0%)	2 (0.8%)

Although not shown in tabular form, Michigan cited car drivers more frequently (than truck drivers) for speeding, but truck drivers for being left of center, improper turning, and improper backing or starting up in traffic. For other categories (failure to yield, following too close) the results were about even.

<u>Contributing Circumstances in Washington Car/Truck Collisions</u>

Contributing circumstances are reported for each driver in 1979 Washington (State) accidents in considerable detail--28 distinct code values. The five most commonly reported factors are shown in Table 14. Truck drivers (large straight trucks and tractor-trailers are combined in this data set) are much underrepresented in the drinking category, but truck drivers are more often cited for improper turning and inattention. For the most part the other categories are about evenly distributed.

Table 14

Main Contributing Circumstances in 1979 Washington Car/Truck Collisions by Vehicle Type, in Percent

Contributing Circumstance	Car Driver	Pickup Driver	Van Driver	Large Truck Driver
Under Influence of Alcohol . .	4.4	5.3	3.9	0.8
Speeding . . .	9.6	8.7	7.3	8.4
Failure to Yield	15.5	17.2	18.7	15.1
Following Too Close . . .	5.2	6.7	7.2	7.6
Inattention . .	5.0	6.4	6.9	9.1
Other	17.0	15.5	14.7	18.4
None	43.3	40.2	41.3	40.6

Contributing Factors in Texas Truck/Car Crashes

Police in Texas use yet another list of categories in assigning accident (driver) contributing factors. Table 15 is taken from Texas data for 1977, and indicates how some contributing factors are distributed there in police-reported car/truck crashes. Column percentages for the factors are shown next to the numbers which are derived from a five percent sample of Texas accidents for that year. Again there is an underrepresentation of tractor-trailer drivers in drinking, but an excess in turning errors. Passenger car drivers are more often cited for speeding (not shown in the table) than are truck drivers. Overall in these crashes truck drivers were more often assigned one of these contributing factors than were car drivers.

Table 15

Contributing Factors in Car/Truck Crashes
Texas 1977 (by Vehicle/Driver Type)

Contributing Factor	Car Driver	Truck Driver	Tractor Trailer Driver
Failure to Yield	718 (43.3)	787 (39.8)	20 (14.4)
Disregard Sign/Signal . .	145 (8.7)	119 (6.0)	10 (7.2)
Improper Turn	201 (12.1)	181 (9.1)	45 (32.4)
Follow Too Close . . .	240 (14.5)	298 (15.1)	33 (23.7)
Passing Error	30 (1.8)	79 (4.0)	7 (5.0)
Failed to Signal	120 (7.2)	27 (1.4)	3 (2.2)
Improper Parking/Starting	100 (6.0)	391 (19.8)	20 (14.4)
Drugs/ Alcohol	106 (6.4)	97 (4.9)	1 (0.7)
Total	1660 (100.0)	1979 (100.0)	139 (100.0)

Contributing Factors in Pennsylvania Truck-Car Collisions

The first contributing factors coded for 1979 Pennsylvania truck-car crashes are shown in Figure 10. The leading five factors in these accidents were all driver errors: tailgating, improper turning, driving on the wrong side, failure to follow a traffic control device, and driving with insufficient clearance. Next was slippery roadway, followed by two more driver errors: speeding and improper entrance or exit. Tenth in importance was alcohol consumption.

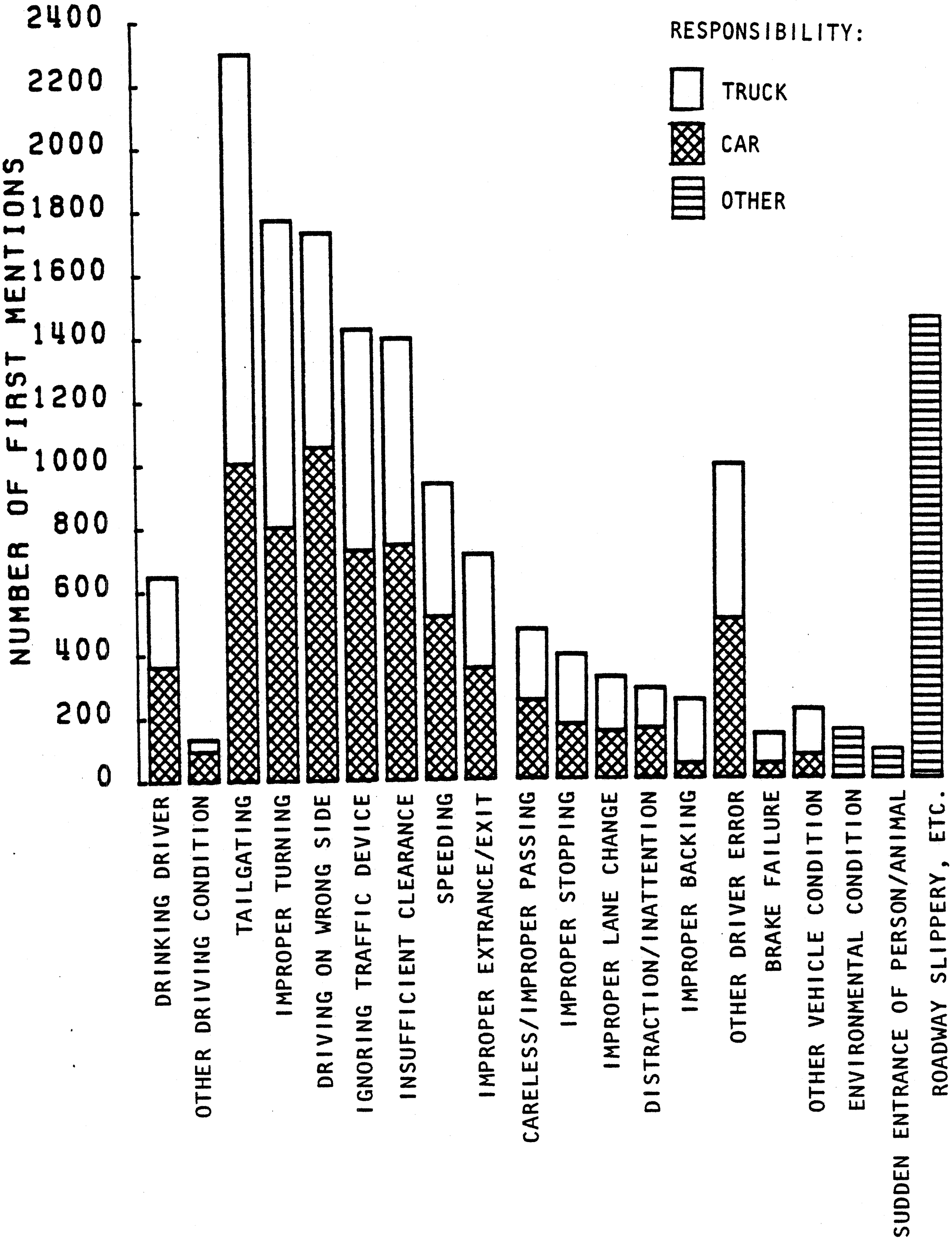


Figure 10
Responsible First Contributing Factors in 1979 Two-Vehicle Truck-Car Crashes in Pennsylvania

For most of these factors, responsibility was fairly evenly distributed between the truck and car drivers, as in other state data analyses. However, improper backing, brake failure, and other vehicle conditions were predominantly attributed to trucks, while drinking, other driver condition, and driving on the wrong side were disproportionately car factors.

In Table 16 the responsibility attributions are shown in relation to the severity of the accident and also for four truck types. Looking at the three severity rows, substantial differences are seen. For Pennsylvania fatal accidents, as in the FARS analyses reported above, the car driver or vehicle was twice as likely to be considered responsible for the accident as was the truck driver or vehicle. However, for other personal injury accidents, the truck was slightly more likely to be considered responsible. Interestingly, this ratio reverses again for property-damage-only accidents, with cars somewhat more likely to be considered responsible.

Among the four vehicle types responsibility was fairly evenly distributed between trucks and cars, except for combination vehicles. For the latter, the truck or its driver was considered responsible 38.5 percent of the time, while the car or its driver was considered responsible 47.1 percent of the time, and other conditions (environment, roadway, etc.) were considered responsible 14.3 percent of the time.

<u>Accident Configurations--How do these accidents happen?</u>

Two-vehicle accidents are coded in FARS as one of several possible configurations. The variable is called "manner of collision," but includes a code value "non-collision" which is occasionally reported (even though the accident involves two vehicles). There are six valid codes which are shown as column headings in Table 17. Data are tabulated here only for cells (taken from Figure 7) with at least 100 crashes. The table may be scanned in either direction. For example, scanning across the top line indicates that the majority (60.1 percent) of pickup/car fatal collisions on the two-lane rural trunkline road class are classified as "head-on." Scanning vertically reveals that light vans have nearly the same value on the same road class. Same-

Table 16
Responsibility for 1979 Two-Vehicle Truck-Car Crashes in Pennsylvania by Severity of Accident and by Four Truck Types

	Truck Driver or Vehicle Responsible		Car Driver or Vehicle Responsible		Other Conditions (Environment, Roadway, etc.)		Total
	N	%	N	%	N	%	
Fatal Accidents	132	30.4	258	57.4	44	10.1	434
Other Personal Injury	5718	45.4	5310	42.1	1580	12.5	12,608
Property Damage Only	3376	39.7	3881	45.6	1253	14.7	8510
<u>All Accidents</u>							
Pickups	4673	44.2	4571	43.1	1348	12.7	10,612
Vans	1615	42.9	1660	44.1	491	13.0	3766
Other Single Units	166	42.5	1679	43.0	564	14.4	3904
Combination Trucks	1260	38.5	1541	47.1	469	14.3	3270
Total	9226	42.8	9449	43.8	2877	13.3	21,552

NOTE: These data are based on up to three factors per crash. There were a total of 21,552 factors coded for 15,836 crashes.

direction sideswipe crashes are most likely by tractor-trailers on urban and rural interstates.

An alternative presentation of accident configuration is available in the relative distribution of damage location on the car and truck which collided. Figure 11 tabulates the number of combinations of damage for four cases: pickups or tractor-trailers crossed with two-

Table 17
Manner of Collision for Two-Vehicle Car-Truck Fatal Accidents For Main Road Types (FARS 1980)
(in percent)

Truck Type Road Class/ Land Use	Number of Fatal Accidents	Non-Collision	Rear-End	Head-On	Rear to Rear	Angle	Sideswipe Same Direction	Sideswipe Opposite Direction
PICKUP TRUCKS								
2-Lane Undivided U.S./State (Rural)	919	2.1	4.7	60.1	0	28.9	1.2	3.1
2-Lane Undivided Major Arterials (Rural)	307	1.6	3.3	49.2	0	43.6	0.7	1.6
City Streets	274	4.0	7.7	24.1	0	61.3	1.1	1.8
2-Lane U.S./State (Urban)	156	1.9	3.8	53.2	0	38.5	1.9	1.6
Multi-Lane/Undivided (Urban)	137	2.2	11.7	34.3	0	47.4	2.9	1.5
Multi-Lane Undivided (Rural)	111	9.0	9.0	42.3	0	38.7	0	0.9
Multi-Lane Divided (Rural)	109	0	21.3	24.1	0	53.7	0.9	0
Multi-Lane Divided (Urban)	104	3.8	13.5	17.3	0	60.6	3.8	1.0
TRACTOR-TRAILERS								
2-Lane U.S./State (Rural)	594	0.7	7.3	43.9	0.3	41.7	0.5	5.6
Interstate/Limited (Rural)	144	9.2	41.1	26.2	0	14.2	7.8	1.4
Multi-Lane/Divided (Rural)	128	1.6	19.5	5.5	0	70.3	3.1	0
Interstate/Limited (Urban)	107	9.3	45.8	15.9	0	17.8	9.3	1.9
Multi-Lane Divided (Urban)	102	1.0	29.7	7.9	0	59.4	1.0	1.0
VANS								
2-Lane Undivided U.S./State (Rural)	164	3.0	2.4	60.4	0	31.1	0.6	2.4
City Streets	103	6.8	8.7	17.5	0	65.0	0	1.9
OTHER TRUCKS								
2-Lane U.S./State (Rural)	295	3.4	7.5	43.4	0	40.7	1.0	4.1

lane-rural trunkline roads and rural interstates. The upper left display shows the dominance of head-on collisions for pickups on two-lane roads, with 510 (of a total of 867) cases in that category. Also of interest is the larger number of side impacts to the passenger car than to the truck in these fatal collisions.

Tractor trailers have a lower proportion (210 out of 521) of front-to-front fatal collisions than pickup trucks on the same highway type, and they have larger proportions of truck-front to car-left-side collisions and of front-to-rear collisions. On rural limited access highways front-to-front collisions are still relatively frequent for both types of trucks, but again they are a somewhat larger proportion for car/pickup collisions than for car/tractor-trailer collisions. On rural limited access roads tractor-trailer-front-into-car-back accidents are more frequent than car-front-into-tractor-trailer-back accidents, but the opposite is true on rural two-lane trunklines.

Time--When Do These Accidents Happen?

Accidents between cars and trucks clearly require the presence of both types of vehicles. In addition, fatal accidents are more likely to occur at certain times and places--related to the traffic capabilities of the roadway, the characteristics of the drivers, the speeds of travel, lighting conditions, etc. The major time distributions of truck/car fatal accidents are presented in this section.

Figure 12 shows the distribution of car/truck fatal accidents by month over the 1980 year. There is little remarkable about this except for the flatness of the curves. The slight upward slope perhaps suggests an increase in the health of the commercial trucking activity toward the end of 1980.

Figure 13 displays the distribution of fatal car/truck accidents by four-hour periods throughout the week, averaged over the year 1980. The data are not normalized, so that the area under each curve indicates the total number of accidents by truck type. Most conspicuous are the Friday and Saturday night periods, particularly for the pickup trucks.

Car/Pickup Collisions
U.S. and State Undivided 2-Lane Roads
(Rural) (867 Cases)

Truck Impacted Area	Passenger Car Impacted Area			
	Front	Right	Back	Left
Front	510	114	21	101
Right	40	6	0	2
Back	9	3	0	2
Left	31	7	0	21

Car/Pickup Collisions
Interstate and Other Limited Access Roads
(Rural) (57 Cases)

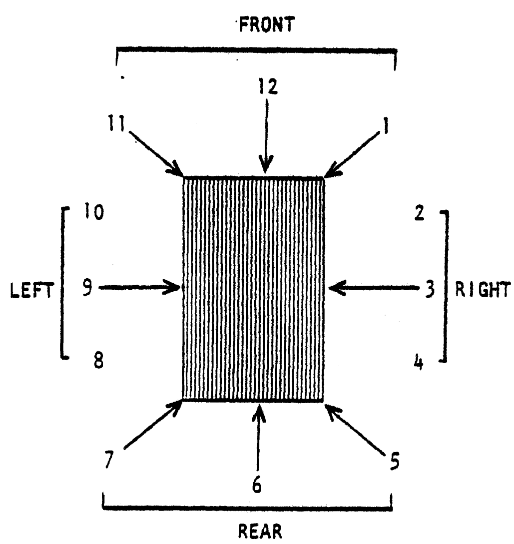
Truck Impacted Area	Passenger Car Impacted Area			
	Front	Right	Back	Left
Front	26	6	9	6
Right	0	0	0	0
Back	7	0	0	0
Left	1	0	0	2

Car/Tractor-Trailer Collisions
U.S. and State Undivided 2-Lane Highways
(Rural) (521 Cases)

Truck Impacted Area	Passenger Car Impacted Area			
	Front	Right	Back	Left
Front	210	60	22	91
Right	17	4	0	6
Back	35	0	0	3
Left	36	1	1	35

Car/Tractor-Trailer Collisions
Interstate and Other Limited Access Roads
(Rural) (125 Cases)

Truck Impacted Area	Passenger Car Impacted Area			
	Front	Right	Back	Left
Front	37	1	32	12
Right	2	1	0	7
Back	20	1	0	0
Left	7	3	0	2



Principal impact damage is coded for each vehicle in FARS by a numeral representing a clock face as shown at the left. These have been grouped for tabular comparison into four categories, and the relationship shown for 1980 fatal accidents.

Figure 11

Principal Impact Damage Distribution, 1980 Car-Truck Fatal Collisions

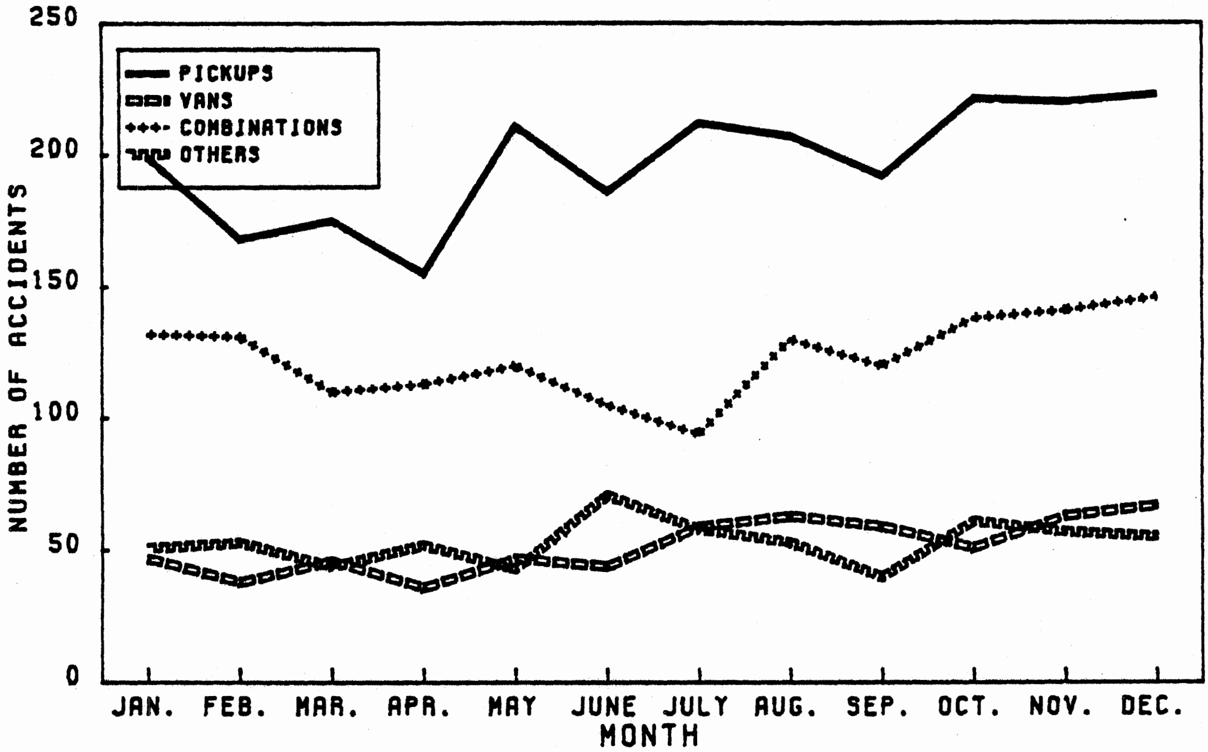


Figure 12

1980 Fatal 2-Vehicle Truck-Car Accidents by Month for Four Types of Trucks

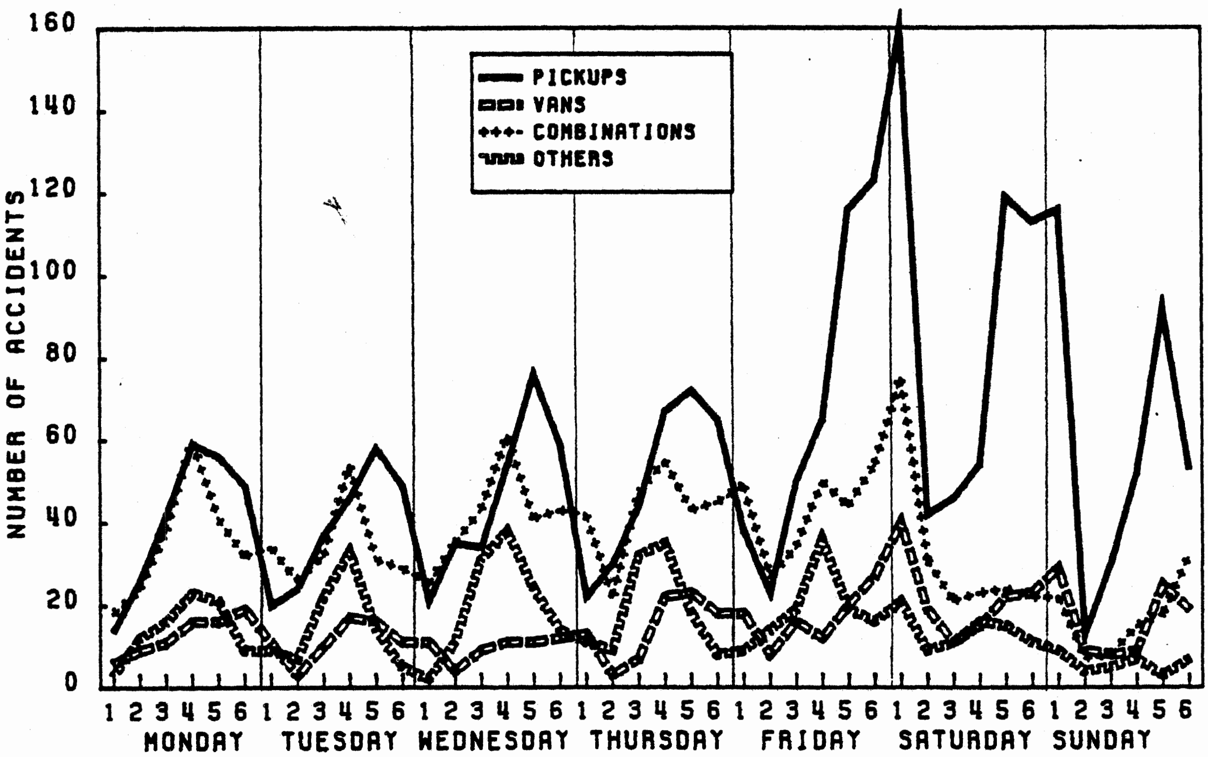


Figure 13

1980 Fatal 2-Vehicle Truck-Car Accidents by Four-Hour Time Periods and Day of the Week for Four Types of Trucks

On both Friday and Saturday nights the high values extend over the midnight period, and on Sunday the peak occurs earlier in the evening. The ratio of the average pickup truck involvements per four-hour period to the peak is of the order of one to four, with the first four hours of Saturday showing the highest value. Combination vehicles are relatively dormant on weekends, and the diurnal variation is relatively small for them. Medium and large straight trucks ("others" in the diagram) are evidently mostly daytime vehicles, their numbers falling essentially to zero for the second time period (4:00 a.m. to 8:00 a.m.). Vans, although a smaller population, show a cycle similar to that of pickups, but without the exceedingly strong weekend peaks.

4.0 SUMMARY AND CONCLUSIONS

Summary

There has been a tremendous increase in motor vehicles operating on American roads during the past 30 years. Today there are almost as many motor vehicles in the U.S. as there are persons old enough to drive. Since 1950 the numbers of cars in the U.S. has about tripled, while the number of trucks has almost quadrupled. These increases reflect both a great increase in the use of heavy trucks for commercial purposes and a tremendous increase in the use of light trucks (pickups and vans) primarily for personal transportation. The 1977-78 Nationwide Personal Transportation Study found that 14.8 percent of household vehicles were pickups and vans. In 1980 FHWA estimated that 73.1 percent of vehicle miles traveled in the U.S. were by passenger cars, 21.3 percent by single-unit trucks, and 3.9 percent by combination trucks. For combination trucks this was only a small increase from the 3.7 percent estimated in 1963 (the first year of such FHWA estimates), while for single-unit trucks this was a substantial increase from the 15.6 percent 1963 estimate.

In 1980 34 percent of the U.S. fatal accidents involved two vehicles. Among the two-vehicle accidents involving two cars, a car and a truck, or two trucks, 43 percent were car-truck accidents, somewhat more than the 38 percent which would be expected from the 1980 FHWA mileage estimates for passenger cars and trucks. Whether trucks are over-involved in all accidents, or only in fatal accidents, is not clear because adequate mileage data for the analysis of state all-accident files are lacking.

Reliable national data on truck involvements in multi-vehicle fatal crashes are only available since 1977. The trends show increases in involvement rates for all kinds of trucks in 1978 and again in 1979, but in 1980 there was little change for pickups and vans and a substantial decline for combination trucks. Presumably this was related to the downturn in the economy and in commercial truck activity in 1980. In 1980 truck-car fatal crashes, almost half (46.3 percent) involved pickups, 28.9 percent involved combination trucks, 12.1 percent involved vans and truck-based station wagons, and 12.6 percent involved other single-unit or unknown type trucks.

Data on fatality rates in these truck-car fatal accidents show that car occupants are much more likely to be killed than are truck occupants. Overall in 1980 54.9 percent of the car occupants in these crashes died, compared to only 13.9 percent of the truck occupants. As might be expected, the larger the truck and the smaller, the car the greater was the car-to-truck fatality ratio. However, even when light trucks crashed with large cars of about the same weight, the fatality ratios were favorable to the trucks--suggesting that there is something else in truck designs besides their mass which makes them more dangerous to the other vehicle, more protective to their own occupants, or both. Drivers were more likely to be killed than other occupants in both types of vehicles in these crashes, but this difference was greater for passenger cars.

Almost half (46 percent) of the fatal car-truck crashes in 1980 took place on two-lane undivided state and U.S. trunklines, mostly in rural areas. Only 9.6 percent took place on limited access highways, although the FHWA estimated that more than 18 percent of truck travel took place on such highways. For combination vehicles 17.3 percent of the fatal accidents took place on limited access highways, while the FHWA estimated that 46.2 percent of combination-vehicle travel took place on interstate highways in 1980. Combination vehicles had higher fatal accident rates on urban roads than on rural roads, while the opposite was true for single-unit trucks.

Looking at accident and driver characteristics, it appears that these 1980 truck-car fatal crashes took place disproportionately on curves, on wet roads, and after dark. Particularly noteworthy were the findings that 28 percent of pickup-car accidents on rural two-lane trunklines took place on a curve; that 28 percent of tractor-trailer/car accidents on rural interstates took place when the surface was wet, snowy, or icy; and that 68 percent of pickup-car accidents on urban interstates took place after dark. Well over half of all the pickup and van fatal accidents took place in darkness, while somewhat less than half of the large truck accidents occurred after dark. Among the involved drivers, the truck drivers and especially the tractor-trailer and straight truck drivers tended to be older than the car drivers. Reported safety belt use was quite low for all drivers but was highest for tractor-trailer drivers and lowest for pickup drivers.

In regard to responsibility for thes,e fatal crashes the car drivers were almost twice as likely as the truck drivers to be considered at fault. For tractor-trailer/car crashes the fault ratio was about 3:1 against the car drivers. The four most common driver contributing factors cited were speeding, improper lane changing, failure to yield the right of way, and driving on the wrong side. Alcohol use was analyzed as a separate variable, and for all accidents car drivers were almost twice as likely to have been drinking as truck drivers. However, there were great differences among types of truck drivers. Pickup truck drivers had been drinking about equally with the car drivers in pickup/car fatal accidents, while less than one tenth as many tractor-trailer drivers as car drivers had been drinking in tractor-trailer/car fatal crashes.

When one looks at responsibility data for all police-reported truck-car accidents in state files (Michigan, Washington, Texas, and Pennsylvania), a different picture emerges. For all types of accidents responsibility was fairly evenly distributed between the truck drivers and car drivers, but again tractor-trailer drivers were somewhat less likely to be considered responsible than other truck drivers.

In regard to accident configuration in the 1980 car-truck fatal crashes, head-on collisions were the most frequent type. Over 60 percent of the pickup and van fatal accidents on rural two-lane trunklines involved a head-on collision, compared to 44 percent of larger truck fatal accidents on these roads. For tractor-trailers on limited access divided highways, rear-end accidents were most frequent, while on other divided (non-limited access) highways angle accidents were most frequent. Even on limited-access divided highways, however, more than one-quarter (37 of 125) of the tractor-trailer fatal accidents were head-on collisions.

Analysis of time of day and day of week data for these 1980 car-truck fatal crashes show the highest peak for pickups and vans on Friday night after midnight. The periods between 4:00 p.m. and 12:00 a.m. on Friday, between 4:00 p.m. and 4:00 a.m. on Saturday-Sunday, and between 4:00 p.m. and 8:00 p.m. on Sunday also have very high numbers of pickup and van fatal accidents. These peak times are probably related to heavy drinking by the car drivers, the truck drivers, or both. For combination trucks and other large trucks there are daily peaks each weekday from 12:00 p.m. to 4:00 p.m., but again the highest peak is early Saturday morning--presumably due primarily to the many drinking car drivers at that time. For the rest of Saturday and Sunday these large trucks have many fewer fatal accidents than on weekdays.

Conclusions

Crashes between cars and trucks are a very serious problem on American highways, accounting for about 14 percent of motor vehicle fatalities in 1980. All trucks are somewhat over-represented in fatal crashes, compared to what would be expected from their amount of travel, and combination trucks are greatly over-represented. In two-vehicle car-truck fatal crashes, car occupants are almost four times as likely to be killed as truck occupants. The larger the truck and the smaller the car, the more this fatality ratio is favorable to the truck occupants. As American cars become smaller and if both light truck travel and heavy truck travel continue to increase faster than passenger car travel, as they did from 1970 to 1979, the number of Americans killed in truck-car crashes is likely to continue to increase.

Descriptive data on 1980 car-truck fatal crashes show that they are disproportionately likely on rural non-interstate roads, on curves, on wet surfaces, and after dark. Drinking was a factor in 38 percent of these accidents, and the peak accident times were late afternoons and nights on weekends--although only pickup drivers had been drinking as much as the car drivers in these accidents. Car drivers were about twice as likely as truck drivers to be considered at fault in all these fatal accidents, and in tractor-trailer/car accidents specifically the car drivers were three times as likely to be at fault.

Without fuller consideration of the relationships between accidents and exposure it is difficult to discuss countermeasures that might be introduced by either government or industry to reduce the extent of truck/car fatal accident involvement. Any measure that reduces the exposure of cars to trucks (such as disparate vehicles traveling on different roads or at different times) should lead to a reduction in the number of such crashes. The need to further improve the American road network for safer travel is indicated by the large proportion of truck-car accidents on curves of rural roads and by the large proportion of head-on collisions. The reduction in fatal accidents involving cars and large commercial vehicles in the most recent years seems to be explaned by the recession.

The limited consideration of exposure information presented in this report suggests that roads designed to interstate standards are much safer (per vehicle mile traveled) than other roadways, and to the extent that truck travel can be shifted or restricted to these roads there should be some improvement. The political and social ramifications of such regulation are clearly beyond the scope of the present study.

APPENDIX A

Data on the Accident Experience of Cars and Trucks Relative to Exposure

Two-Vehicle Fatal Accidents

If accidents occurred in proportion to exposure (i.e., if the chance of an accident was constant per mile traveled for any vehicle), then one should be able to estimate the chance of certain types of multiple-vehicle accidents from the relative exposure of the various types of vehicles. The binomial theorem may be used to calculate the expected proportions of car-car, car-truck, and truck-truck collisions among two-vehicle accidents involving only cars and trucks. Here the expected proportion of car-car accidents is equal to the square of the proportion of car exposure to the sum of car and truck exposure; the expected proportion of truck-truck accidents is equal to the square of the proportion of truck exposure to the sum of car and truck exposure; and the expected proportion of car-truck accidents is equal to 1 minus the sum of the other two proportions.

Thus if the proportion of car exposure is p and that of truck exposure is q, then the proportion of car-car accidents should be p^2, the proportion of truck-truck accidents q^2, and the proportion of car-truck accidents $1 - (p^2 + q^2)$ or 2pq.

Variation from this predictive model would indicate that accidents are not random events, but are instead influenced by certain systematic features of the car or truck population or of their respective exposures. For example, if car drivers tended to be younger and more inexperienced than truck drivers, one might expect relatively fewer truck-truck collisions.

The Highway Statistics Division of the Federal Highway Administration (FHWA) publishes annual estimates of vehicle miles traveled. The FHWA estimates that, during calendar year 1980, cars traveled 1,111,887 million vehicle miles and trucks (including light trucks and vans) traveled 384,570 million miles. If we restrict analysis to these two vehicle types, then cars accumulated 74.3 percent of the total mileage and trucks accumulated 25.7 percent. Using the binomial model, the expected number of car-car collisions should equal 0.743^2 of all collisions involving cars and trucks, or 0.5520. Truck-truck collisions would constitute 0.257^2, or 0.0660. Car-truck collisions would be 1 - (0.5520 + 0.0660) or 0.3820 . These proportions are shown on the first column of Table 18.

Table 18
1980 Two-Vehicle Car or Truck Fatal Accidents: Actual Proportions by Vehicle Mix Compared to Predicted Proportions
(N=11,898)

Collision Type	Proportion Predicted From Exposure	Actual Proportion of Fatal Accidents	Actual/ Predicted	Actual/ Predicted Normalized
Car-Car	0.5520	0.4625	0.8405	1.0
Car-Truck	0.3820	0.4299	1.1254	1.3390
Truck-Truck	0.0660	0.1076	1.6303	1.9397

The second column of Table 18 shows the actual proportion of fatal accidents involving cars and trucks found in the 1980 FARS data. The car-car proportion is somewhat lower than expected, the car-truck proportion is somewhat higher than expected, and the truck-truck proportion substantially higher than expected. The extent of the differences from the expected outcomes is shown in the third column, where the ratio of the actual to the expected outcome is given. This ratio is given in normalized form in column four with the car-car ratio assigned a value of one and the other ratios changed accordingly. In comparison to the outcome for fatal car-car collisions, car-truck collisions are overrepresented by 34 percent and truck-truck collisions by 94 percent.

Table 19 shows the same kind of data restricted to two-vehicle fatal accidents involving two passenger cars, two combination vehicles, or one passenger car and one combination vehicle. This indicates that combination vehicles are overrepresented in fatal collisions with passenger cars by 149 percent. Also of interest in this table is the finding that combination vehicles are more than six times as likely to collide fatally with each other as would be expected on the basis of their total miles traveled.

Table 19

1980 Two-Vehicle Fatal Accidents for Cars and Combination Vehicles: Actual Proportions by Vehicle Mix Compared to Predicted Proportions (N=7100)

Collision Type	Proportion Predicted From Exposure	Actual Proportion of Fatal Accidents	Actual/ Predicted	Actual/ Predicted Normalized
Car-Car	0.9002	0.7750	0.8609	1.0
Car-Combination Vehicle	0.0972	0.2085	2.1451	2.4917
Combination-Combination	0.0026	0.0165	6.3462	7.3716

The "overrepresentation" of trucks in these accidents could well be attributed to the fact that the analysis is restricted to a fatal accident data set rather than a general accident data set. One possible explanation is that the probability of someone being killed is greater in a truck-truck collision or in a truck-car collision than in a car-car collision, although trucks may not be overrepresented in non-fatal collisions. Alternative explanations are that trucks are simply more likely than cars to be involved in all types of crashes (which might be expected considering their larger average size compared to cars), or that exposure is non-uniform--e.g., trucks might tend to travel together thus increasing the chance of truck-truck collisions.

Three-Vehicle Fatal Accidents

The binomial model can be applied equally to three-vehicle accidents. In this case there are four mixes of vehicles: car-car-car, car-car-truck, car-truck-truck, and truck-truck-truck. Using the same notation as before, the probabilities are:

car-car-car: p^3

car-car-truck: $3p^2q$

car-truck-truck: $3pq^2$

truck-truck-truck: q^3

The various proportions using the FHWA exposure estimates are given in column 1 of Table 20.

Table 20
1980 Three-Vehicle Car or Truck Fatal Accidents: Actual Proportions by Vehicle Mix Compared to Predicted Proportions (N=1089)

Collision Type	Proportion Predicted From Exposure	Actual Proportion of Fatal Accidents	Actual/ Predicted	Actual/ Predicted Normalized
Car-Car-Car	0.4102	0.4013	0.9783	1.0
Car-Car-Truck	0.4256	0.3701	0.8696	0.8889
Car-Truck-Truck	0.1471	0.1855	1.2610	1.2890
Truck-Truck-Truck	0.0170	0.0432	2.5412	2.5976

Once again the second column shows the actual distribution obtained from the 1980 FARS data. And once again, accidents involving cars alone are somewhat less frequent than predicted, while accidents involving trucks are slightly more frequent than predicted. The general pattern is that the more trucks involved the greater the overrepresentation compared to predicted proportions. The proportion of car-car-truck fatal accidents is actually lower than expected. The actual chance that three-vehicle accidents will involve at least one truck is about 60 percent compared with a predicted 59 percent, so the truck overrepresentation is not as significant in three-vehicle accidents as in two-vehicle accidents.

Four-Vehicle Fatal Accidents

Expanding the binomial model once again for four-vehicle accidents, the following probabilities obtain:

Car-Car-Car-Car: p^4

Car-Car-Car-Truck: $4p^3q$

Car-Car-Truck-Truck: $6p^2q^2$

Car-Truck-Truck-Truck: $4pq^3$

Truck-Truck-Truck-Truck: q^4

The results of applying the FHWA exposure estimates of 0.743 for cars and 0.257 for trucks are shown in column 1 of Table 21.

Table 21
1980 Four-Vehicle Car or Truck Fatal Accidents: Actual Proportions by Vehicle Mix Compared to Predicted Proportions (N=183)

Collision Type	Proportion Predicted From Exposure	Actual Proportion of Fatal Accidents	Actual/ Predicted	Actual/ Predicted Normalized
Car-Car-Car-Car	0.3048	0.3497	1.1473	1.0
Car-Car-Car-Truck	0.4217	0.3279	0.7776	0.6777
Car-Car-Truck-Truck	0.2186	0.2295	1.0499	0.9151
Car-Truck-Truck-Truck	0.0505	0.0820	1.6238	1.4153
Truck-Truck-Truck-Truck	0.0044	0.0109	2.4773	2.1592

Fatal accidents involving many trucks are generally more frequent than expected, although accidents involving only one or two trucks are less frequent than expected. Given the small number of four-vehicle accidents (183), one can not place much confidence in these exact numbers, but the overrepresentation of accidents involving three trucks and the larger overrepresentation of accidents involving four trucks is consistent with the prior tables. Again this could be explained by either a greater accident truck-truck probability or a greater chance of a fatality given a truck crash involvement. Overall among these 183 four-vehicle accidents the proportion involving at least one truck (65 percent) is somewhat less than the proportion predicted on the basis of exposure (69.5 percent).

Applying the Binomial Model to State Distributions of Two-Vehicle Accidents

The uncertainty as to whether this overrepresentation of trucks in fatal accidents is due to a greater propensity of trucks to be involved in accidents or is due to the greater severity of accidents involving trucks may be resolved in part by testing the binomial model with non-fatal accident data. There is no adequate national file of all types of police-reported accidents, but many state files exist.

In analyzing these state files a slightly different approach is used. Previously the estimated proportions of travel by vehicle type (p for cars, q for trucks) were used to predict rates of multiple-vehicle accidents. For two-vehicle accidents, p^2, 2pq, and q^2 were defined as the expected proportion of car-car, car-truck, and truck-truck accidents, respectively.

Conversely, if p^2 (the proportion of two-vehicle crashes which involve two cars) is known, then 2pq and q^2 (as well as p and q) may be computed by the same model. Thus the traffic mix can be estimated from accident data, and given a certain proportion of car-car accidents, the proportions of car-truck and truck-truck accidents can be tested to see whether they fit the binomial model.

Table 22 shows the application of this approach to Texas two-vehicle accidents. The first two columns show the actual frequency and proportions of the three types of two-vehicle accidents. Then using the 0.5585 proportion for car-car accidents (p^2), the predicted proportions of car-truck (2pq) and truck-truck (q^2) accidents were calculated. These are shown in column 3. The calculated proportions are very close to the actual proportions, indicating that the mix of accident types approximately fits a binomial distribution.

Table 22
Texas 1980 Two-Vehicle Accidents (5% Sample)
Actual and Binomial Distributions

Accident Type	Actual Distribution		Binomial Distribution Using Actual Car-Car Proportion
	N	Proportion	
Car-Car	8147	0.5585	0.5585
Car-Truck	5452	0.3738	0.3777
Truck-Truck	987	0.0677	0.0638

The car-car proportion (p^2) is the basis for estimating the proportion of vehicle mileage traveled by cars (p) and the proportion traveled by trucks (q). From the Texas figures in Table 22, we derive 75 percent as the proportion traveled by cars; 25 percent as the proportion traveled by trucks. This is almost exactly the same as the FHWA estimates of 74.3 percent for cars, 25.7 percent for cars which was used earlier to predict accident distributions. When the binomial model was used to predict the proportion of fatal accidents from exposure, car-truck and truck-truck accidents were indeed found to be overrepresented. However, if this overrepresentation can be attributed to the greater crash severity (i.e., a greater chance of a fatality, given an accident) then it should not be found in the distribution of all police-reported accidents. The Texas data seem to confirm this, as the fit obtained with the binomial model is very good.

Examination of data from the state of Washington supports the hypothesis that all police-reported accidents fit the model better than do fatal accidents. The Washington distributions are shown in Table 23.

Table 23
Washington 1979 Two-Vehicle Accidents:
Actual and Binomial Distributions

Accident Type	Actual Distribution		Binomial Distribution Using Actual Car-Car Proportion
	N	Proportion	
Car-Car	41,962	0.6054	0.6054
Car-Truck	23,544	0.3397	0.3453
Truck-Truck	3.809	0.0550	0.0493

Once again a binomial distribution has been calculated from the proportion of car-car accidents. And once again a fairly good fit is obtained with the binomial distribution, shown in column 3. The traffic mix estimated from this distribution is 78 percent for cars and 22 percent for trucks, again close to the FHWA exposure estimates.

Conclusion

There is, of course, a possibility of other explanations for the fit or non-fit to the model including many complex interactions. If trucks always traveled together on dangerous high-speed roads, but were well distributed otherwise in time and place, this might explain why truck-truck fatal accidents were more frequent than the binomial model predicts. Yet the majority of the truck miles considered in this development are accounted for by pickups and vans--vehicles which are apparently used much like passenger cars.

The fit obtained between predicted distributions using the binomial model and actual distributions of all accidents is generally fairly close. However, to test this fit properly one needs independent data on car and truck exposure in the relevant states, data which are not readily available. With fatal accidents some other factor appears to be operating to make the proportions of accidents involving trucks generally higher than expected. It seems likely, given the good fit with all police-reported accidents, that this factor is the greater likelihood of a fatality in accidents involving trucks.