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U.S. Department
Transportation

National Highway Traffic Safety Administration

DOT/HS-808-802
DOT-VNTSC-NHTSA-98-2

Final Report
October 1998

Fatality Risks In Collisions Between Cars and Light Trucks

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035224

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE

October 1998

3. REPORT TYPE AND DATES COVERED

Final Report
12/23/96 - 12/19/97

4. TITLE AND SUBTITLE

FATALITY RISKS IN COLLISIONS BETWEEN CARS AND LIGHT TRUCKS

5. FUNDING NUMBERS

S8014/HS876

6. AUTHOR(S)

Hans Joksch

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

The University of Michigan
Transportation Research Institute
2901 Baxter Road
Ann Arbor, MI 48109-2150

8. PERFORMING ORGANIZATION REPORT NUMBER

DOT-VNTSC-NHTSA-98-2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Department of Transportation
National Highway Traffic Safety Administration
400 Seventh Street, SW
Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

DOT/HS-808-802

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

This report is available to the public through the National Technical Information Service, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Collisions between cars and light trucks (which include utility vehicles, pickup trucks, and vans) were studied, using data from the Fatal Accident Reporting System and the Fatality Analysis Reporting System. Tables show vehicle occupant deaths for the years 1982 through 1996, by the types of vehicles colliding. Tables further disaggregated by impact points on the vehicles are available from NHTSA in electronic form. Ratios of driver deaths in colliding vehicles were studied. In collisions between cars, the fatality ratio varies by 1:10 if the weight ratio of the cars varies by 1:2. If a car is struck in the left side by another car, the death ratio for its driver is five times higher than if it were struck in the front. If struck by a light truck, the fatality ratio for a car driver is roughly double if struck at the same side by a car of a similar weight as the truck. These figures must be interpreted with caution, because they could be influenced by confounding factors that could not be controlled.

14. SUBJECT TERMS

collision, car, light trucks, utility vehicles, pickup trucks, vans, fatalities, weight ratio, impact location.

15. NUMBER OF PAGES

62

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION

Inches	0	1	2	3	4	5							
Centimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13

QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

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

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures.

Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

Preface

This study assesses the aggressivity of light trucks and vans (LTVs) in traffic collisions with cars. It builds on the previous NHTSA-sponsored study: *Vehicle Aggressivity: Fleet Characterization Using Traffic Collision Data*, and focuses on LTV aggressivity identified in the previous study. LTVs include pickup trucks, sport utility vehicles, and vans. The work was performed by the University of Michigan Transportation Institute (UMTRI) for the U.S. Department of Transportation (DOT), National Highway Traffic Safety Administration (NHTSA) as part of its program on Vehicle Aggressivity and Fleet Compatibility. Mr. Clay Gabler of NHTSA was the Contracting Officer's Technical Representative (COTR) for this project. The work was performed by Hans Joksch of UMTRI and edited by Richard Tucker of Camber Corporation an on-site service contractor to the DOT's Volpe National Transportation Systems Center (Volpe Center).

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ABBREVIATIONS

FARS	Fatality Analysis Reporting System (formerly the Fatal Accident Reporting system)
GES	General Estimates System
GVWR	Gross Vehicle Weight Rating
NASS	Until 1995: National Accident Sampling System Since 1996: National Automotive Sampling System
NHTSA	National Highway Traffic Safety Administration
VIN	Vehicle Identification Number

EXECUTIVE SUMMARY

The objective of this study is to assess the aggressivity of light trucks and vans (LTVs) in traffic collisions with cars. It builds on the previous NHTSA-sponsored study: *Vehicle Aggressivity: Fleet Characterization Using Traffic Collision Data,* and focuses on LTV aggressivity identified in the previous study. LTVs include pickup trucks, sport utility vehicles, and vans.

Crashworthiness is the capability of a vehicle to protect its occupants in a collision, and vehicle aggressivity is its capability to cause injury to occupants of the other vehicle in a collision. Both crashworthiness and aggressivity have to be considered because to separate these effects in data from traffic collisions is not straightforward. In this study, however, crashworthiness could be only implicitly considered.

The data for the analysis were taken from NHTSA's Fatality Analysis Reporting System (FARS). A historical description of trends in collisions between different classes of vehicles was developed, using FARS data for the years 1982 through 1996.

A detailed analysis of LTV-to-car collisions was conducted using FARS data for the calendar years 1991 through 1995. Collisions considered were between two cars, or a car and an LTV, where at least one driver was killed. Because curb weight for LTVs was available only for the model years 1985-93, only LTV models of these years could be included in this more detailed analysis. Both airbag and non-airbag equipped vehicles were included in the analysis, but the scope of the study did not allow to distinguish them.

Driver age affects the evaluation of crashworthiness and aggressivity of vehicles. Older drivers are much more likely to die in comparable crashes than younger drivers. However, crashes involving younger drivers are likely to be more severe than those involving older drivers. To control for the greater vulnerability of older drivers, and greater aggressivity of younger drivers, parallel analyses were done: for all collisions, and for collisions involving only "middle age" drivers of 26 to 49 years.

The major findings of the study are summarized below. The fatality risk ratio, discussed below, is the ratio of driver deaths in the collision partner to driver deaths in the subject vehicle.

- Weight Incompatibility. The weight ratio of the two vehicles affects the relative fatality risks in a collision. In collisions between two cars with a weight ratio of 2:1, not rare in actual collisions, about 10 drivers die in the lighter car for every driver death in the heavier car. These differences are mainly due to the effect of the weight ratio on the velocity changes.

- Impact Location. Nearly as strong an effect as the impact location. If a car is being struck on the left side by another car of the same weight with middle age drivers, five are killed in the struck car for each driver killed in the striking car. For collisions involving all drivers, the ratio is as high as 10 to 1. These differences result mainly from the lower crashworthiness of cars when being struck in the side compared with cars being struck in the front.

- LTV Aggressivity. Besides these large effects that are already present in car-to-car collisions, being struck by an LTV is worse than by a car of the same weight, whether in a frontal or a left side impact. In addition, to the effects of weight ratios, and of impact location, approximately twice as many car drivers are killed than in similar collisions with cars of the same weight as the LTV. This is the "pure" aggressivity effect of light trucks.

- Consequence of LTV Aggressivity. One consequence of the increased risk ratio in collisions between LTVs and cars is that, in 1996, at least 2,000 car occupants would not have been killed, had their cars collided with other cars instead of light trucks of the same weight. This estimate is based on plausible assumptions.

All findings should be interpreted with caution, because other possibly confounding factors could not be studied and effects of aggressivity and crashworthiness could not be unambiguously separated without analyzing nonfatal collisions.

1. INTRODUCTION

Consider collisions between vehicles of an arbitrary type A and of an arbitrary type C, and those between type B and type C. If, in otherwise comparable collisions, the fatality (or injury) risk for occupants of vehicle C is greater in collisions with vehicle A than in collisions with vehicle B, then vehicle type A is considered more aggressive than vehicle type B. Conceptually, this is a satisfactory definition; however, its use has practical limitations. A database is needed that includes all collisions, fatal and nonfatal. Now, only FARS, the Fatality Analysis Reporting System, contains enough records of fatal collisions to disaggregate vehicle classes to the degree required. (The FARS database was formerly named the Fatal Accident Reporting System.) It contains data from 1975 on all motor vehicle crashes; however, it does not contain nonfatal crashes.

One approach to estimate aggressivity from fatal collisions alone, without using nonfatal collisions, is to compare the number of occupants of other vehicles killed, per registered vehicle of the type studied. This assumes implicitly that the number of all fatal and nonfatal collision involvements of a vehicle type is proportional to its numbers registered. This is not so, at least not generally, and often not even approximately.

Another approach using only data on fatal collisions is to compare the number of deaths in vehicles of type A, and type C in collisions between vehicles of types A and C with the number of deaths in collisions between vehicles of types B and C. This approach was used in this study. However, it does not allow direct separation of the effects of crashworthiness from those of aggressivity.

If injury risks are studied, certain states have accident data files that can be used. The data files contain a large number of injury collisions and all police-reported noninjury collisions. Injury risk data, however, is much less precise than fatality risk information, and does not distinguish among a wide range of more-or-less-severe injuries. Also, in studies of other questions, injury risk differences have been found to be different from fatality risk differences. Therefore, preference should be given to studying fatality risks.

Weight plays an important role in collisions between vehicles. The heavier vehicle experiences a lower velocity change (delta v) than the lighter vehicle. Consequently, the occupants of the lighter vehicle face a greater fatality risk. This effect can result in much greater fatality risk differences than those resulting from other vehicle characteristics. Therefore, to recognize the effect of other vehicle characteristics better, *net* aggressivity is the effect on fatality risk that remains after controlling for vehicle weight, whereas *gross* aggressivity is the effect without controlling vehicle weight.

Besides vehicle weight, nonvehicle factors that influence the fatality risks in collisions must be considered; for example, the victims age, restraint use, closing speeds, collision configurations and possibly others. Controlled factors were vehicle weight, collision configuration (four configurations were distinguished, in some analyses 12 impact points), and the victim's age.

The scope of the present work was limited. Fatal collisions involving a passenger car and a light truck (which include sports utility vehicles, pickup trucks, and vans) using data from the FARS file were studied. Only fatality risks for drivers were compared. Sometimes only the three classes of light trucks were distinguished, sometimes each was subdivided into two classes, as coded in the FARS file. (See the Appendix.)

2. DATA PREPARATION

All analyses in this report are based on data from the Fatal Accident Reporting System (since 1997 called the Fatality Analysis Reporting System), FARS. Two different databases were prepared: one for the creation of the tables in Section 3, covering the years 1982-96, the other for the analyses in Section 4, covering the years 1991-95 (1996 data were not yet available when these analyses were done).

For the tabulations in Section 3, all FARS cases were used. For the other analyses, collisions between two cars and collisions between a car and a light truck where at least one driver was killed were selected. Cases where only vehicle occupants other than the driver were killed were excluded; such cases could not be studied without additional information from other sources. Light trucks are defined to include utility vehicles, pickup trucks, and vans.

Variables extracted from the files were driver injuries, driver age, impact points (initial and principal) on the vehicle, underride (since 1994), the vehicle identification number (VIN), and, for cars, the weight NHTSA derived by decoding the VIN. For light trucks, the VIN is very often missing; usually only the gross vehicle weight rating (GVWR) is given. It can be very different from the empty weight of the vehicle, or its weight with few occupants.

To control for the greater vulnerability of older drivers and greater aggressivity of younger drivers, many comparisons were also made for the collisions involving only *middle age* drivers defined to be of ages 26 to 49 years.

Weights of light trucks of the model years 1985-1993 were obtained from another source.[1] Kahane had obtained actual weights for light trucks, which were provided in electronic form. Trucks were identified by a proprietary code, which could be not obtained in electronic form. However, Kahane's report listed the VIN characteristics of light truck models and their proprietary code. A BASIC program was written that wrote a SAS program, which decoded VINs into the proprietary code. Then, the actual weights were attached to the records of light trucks of the model years 1985-93. Therefore, light trucks in this study are restricted to the model years 1985-93, except in section 3, where all model years were used. Table 2-1 shows the number of suitable cases.

Table 2-1. Number of Cases Suitable for Analysis in the FARS Files 1991-95.

Type of Collision	Number of cases
Car-car	12,819
Car-compact utility vehicle	1,617
Car-large utility vehicle	571
Car-compact pickup truck	3,496
Car-standard pickup truck	5,612
Car-minivan	1,180
Car-large van	1,465

[1]C.J. Kahane, *Relationship between Vehicle Size and Fatality Risk in Model Year 1985-93 Passenger Cars and Light Trucks*. NHTSA Technical Report DOT HS 808 570, January 1997.

3. DEATHS BY VEHICLE TYPE OVER TIME

To study how the type of vehicle in collisions in which people died changes over time, many tables were produced and are shown in the Appendix. A taxonomy of collisions and collision involvements was developed. They are categorized based on the following FARS vehicle-body-type classifications:

- Car, further distinguish by:

- unknown weight	(code 0)
- weight under 2,450 lbs.	(code 1)
- weight between 2,450 and 3,449 lbs., and	(code 2)
- weight 3,450 lbs. or more	(code 3)

- Utility Vehicle, further distinguish by:

- compact utility vehicle	(code 1)
- large utility vehicle	(code 2)

- Van, further distinguish by:

- minivan	(code 1)
- large van	(code 2)

- Pickup Truck, further distinguish by:

- compact pickup truck	(code 1)
- standard pickup truck	(code 2)

- Truck, including all single unit and combination trucks, except pickup trucks
- Bus
- Motorcycle and Moped
- Other

For calendar years 1982 to 1990, the FARS vehicle-body-type codes do not allow disaggregation of pickup trucks into compact and standard, nor of vans into minivans and large vans. Therefore, for those years, all pickup trucks and vans appear under code 1; code 2 shows counts of zero. Utility vehicles are disaggregated differently from calendar years 91 - 96 into "Truck-Based Utility" and "Utility, Base Body Unknown"; therefore, for the utility vehicles for codes 1 and 2 are not comparable with those with the same codes for calendar years 91 - 96.

Data in the Appendix for collisions between two vehicles were organized in a bivariate table with the vehicle classes matrixed as rows and columns. The entry in a cell shows how many people died in a vehicle (showed by the column) colliding with a vehicle (showed by the row). To include all vehicle occupant deaths, a row *none* was added for single-vehicle collisions or rollovers, and a row *over 1* for collisions involving more than two vehicles.

Appendix tables A.1-A to O show the figures for the years 1982 through 1996 disaggregated for light trucks, and tables A.2-A to O present the same information, but not disaggregated for light trucks.

The cells in tables A.1-A through O were further disaggregated by impact types. (The disaggregated tables from which the Appendix tables are derived are available from NHTSA in electronic form.) Table 3-1 and 3-2 show examples of these tables. Table 3-1 disaggregates a cell for single-vehicle accidents. (The same format also applies to collisions with more than one other vehicle.) The columns show the impact location and the number of deaths.

Table 3-2 shows the disaggregation of a cell for collisions between two vehicles. The columns show the impact on the vehicles in which the deaths occurred, and the rows show impact on the other vehicle in the collision.

All tables in the file are in the same format, so they can be read by a simple computer program, if the data are to be analyzed further.

Table 3-1. Sample of the Detailed Tabulations by Impact for Single-Vehicle Crashes, Calendar Year 1996. Tabulations for Collisions with More Than One Other Vehicle use the Same Format.

Vehicle in which death occurred = car 2
Other vehicle = none

Front	Right	Rear	Left	Other
2654	701	153	703	1191

Table 3-2. Sample of the Detailed Tabulations by Impact for Collisions between Two Vehicles, Calendar Year 1996.

Vehicle in which death occurred = car 2
Other vehicle = utility vehicle 1

	Front	Right	Rear	Left	Other
Front	127	97	10	118	0
Right	9	0	0	2	0
Rear	5	0	0	0	0
Left	5	3	0	2	0
Other	1	0	0	0	0

4. COLLISIONS BETWEEN CARS AND LIGHT TRUCKS

4.1 Planning the Analyses

Since the scope of this study was limited, the focus of the analysis is on what is considered the most important question: How do collisions between cars and light trucks compare with collisions between two cars? Since only the FARS database would be used, crashworthiness and aggressivity could not be separated. Thus, if light trucks should be more crashworthy than comparable cars (at least in terms of weight), our results would overestimate the aggressivity of light trucks.

Many factors influence the injury and fatality risk in a collision; therefore, only those considered most important are used. The collision configuration is the most obvious one, and it was always included. Vehicle weight, and more specifically, the ratio of the weight of the two vehicles, plays a strong role. Vehicle geometry can be expected to have an influence, but no relevant data are available. To explore this question, over-and underride information was considered.

Restraint systems substantially reduce injury risk in certain collision configurations; however, seat-belt-use information in most motor vehicle accident data files, including FARS, is generally considered exaggerated, and its inclusion could seriously distort the results. FARS does provide information on airbag deployment, but it seems incomplete. The presence of an airbag can be determined from the VIN, using a computer program developed by NHTSA named AOPVIN.SAS. However, including the presence of an airbag in the analysis would have considerably complicated it. Therefore, the results apply only to a vehicle population with the mix of cars with and without airbags represented in the database.

Occupants in different seating positions are affected differently by a collision. Most vehicles in the FARS cases have only one occupant: the driver. Some have a right-front seat occupant, and few have more than two occupants. Not all states report uninjured occupants other than the driver; therefore, consideration of occupants other than the driver would have complicated the analysis, and added uncertainty to the findings.

An important driver factor is age. Age has two effects in a crash: Crashes involving young drivers tend to be more severe than those involving older drivers. However, older drivers are much more likely to die in comparable crashes than younger drivers. The latter effect may be much stronger than the first. Therefore, the age of the victim (always the driver who died, without regard to fault or responsibility for the collision) is included into some analyses.

4.2 Risk Ratios by Weight and Collision Configuration

Since injury mechanisms in different collision configurations differ, collision configurations were always distinguished. The simplest configurations are front-front (impacts on both vehicles 11, 12, or 1, on the clock scale used by FARS), front-left side (clock positions 8, 9, or 10), front-right side (clock positions 2, 3, or 4), and front-rear. Because in the latter case deaths are relatively rare, it was not studied. Comparing vehicle classes only within each collision configuration is a simple way to control it. To control for the large differences in weight in the vehicle population, ideally only collisions between vehicles of nearly equal weight should be studied, but this would reduce the number of usable cases too much. Therefore, a function of the weight ratio is fitted to the fatality ratio as a dependent variable, and from it the ratio of fatalities or fatality risks, for vehicles of the same weight is estimated.

Frequently, a logistic function is used to model the 0/1 variable death in one vehicle or in the other vehicle. It has the advantage that the resulting probability of death will always be a value between 0 and 1, as it should be, and that it uses implicitly the correct variance for a binomial variable. One of its disadvantages is that cases where both drivers are killed are difficult to deal with. More serious is that there is no reason to assume that the true relation can be approximated by a logistic function, the shape of which is fairly limited even if higher powers of the independent variable are added.

Therefore, a different approach that requires fewer assumptions was selected. In the first step, deaths in one vehicle and those in the other vehicle were dealt with separately. Death in one vehicle is a 0/1 variable, represented as a function of the weight ratio of the two vehicles; the weight ratio is known to be a good predictor of relative fatality risks. Assuming that the fatality risk does not decrease when the ratio of the other vehicle's weight to that of the case vehicle increases is plausible. With this very weak, but plausible, assumption, an isotonic regression model was fit to the data.[2] With a 0/1 dependent variable, it also uses implicitly the correct variance. Fitting an isotonic regression amounts to developing intervals (usually of unequal lengths) of the independent variable and averaging the observed values in each interval so that the resulting step-function is monotone nondecreasing. What distinguishes this procedure from simply *binning* the data and averaging them within each bin is the relatively complex procedure for stepwise developing the *bins* so that a true maximum likelihood estimate results. An interesting property of isotonic regression is that the fit is invariant against any monotone transformation of the independent variable. For instance, if the regression has been fitted to the weight ratio, it will still be the maximum likelihood fit if it is transformed into a function of the logarithm of the weight ratio.

In the first step, separate isotonic regressions were fit to the deaths in each vehicle nondecreasing with the weight ratio for one vehicle and nonincreasing with the weight ratio for the other vehicle. Then, in the next step the ratio of the probabilities that represent the ratio of expected deaths in the two vehicles was calculated for each weight ratio. The resulting functions were qualitatively similar to those shown in figure 4.2-1, but did not show the simple, approximately linear relation appearing there. Some experimenting showed that such a simple pattern appeared when logarithmic scales were used for the weight ratio and for the fatality ratio.

One disadvantage of isotonic regression is apparent in the figure: the resulting function is a step function, when in reality a smooth function is to be expected. This becomes more critical when the case numbers are smaller (e.g., refer to figure 4.2.-13), and in extreme cases the function can consist of a single step.

Figure 4.2-1 shows, as baseline, the fatality ratio for collisions between two cars. The heavy line combines collisions irrespective of an impact site on the case vehicle. The line for front-front collisions is very close, because front-front collisions account for most deaths. Over the range of weight ratios for 0.6 to 1.8, the step function for the fatality ratio can be well approximated by a straight line. This line corresponds to a relation fatality ratio = $(\text{weight ratio})^{2.7}$. From previous work,[3] a relation close to fatality ratio = $(\text{weight ratio})^{4}$ is expected; however, outside the range of the weight ratio from 0.6 to 1.8, where one of the vehicles experiences a much greater delta v than the other, the relation appears steeper.

Because of the symmetry of the situation, it can be expected that the function is antisymmetric relative to a weight ratio 1. Though approximately so, this is not strictly the case because assigning numbers 1 and 2 to the vehicles in a symmetric collision is arbitrary. Police officers sometimes assign the number 1 to the vehicle with the most severely injured occupant, or the driver deemed at fault. To avoid potential biases resulting from such patterns, the vehicles were assigned numbers 1 or 2 randomly. To achieve perfect antisymmetry, the data set would have to be combined with a duplicate set where the vehicle numbers are

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[2]R.E. Bartholomew, J.M. Brenner, H.D. Brunk, **Statistical Inference Under Order Restrictions.** Wiley, 1972.

[3]H.C. Joksch, *Velocity Change and Fatality Risk in a Crash - A rule of Thumb.* Accident Analysis and Prevention, 25, 1993, pp. 103-103.

exchanged, but since this is not done, the fatality ratio for front-front collisions between cars is 1.1, not 1 as it should be.

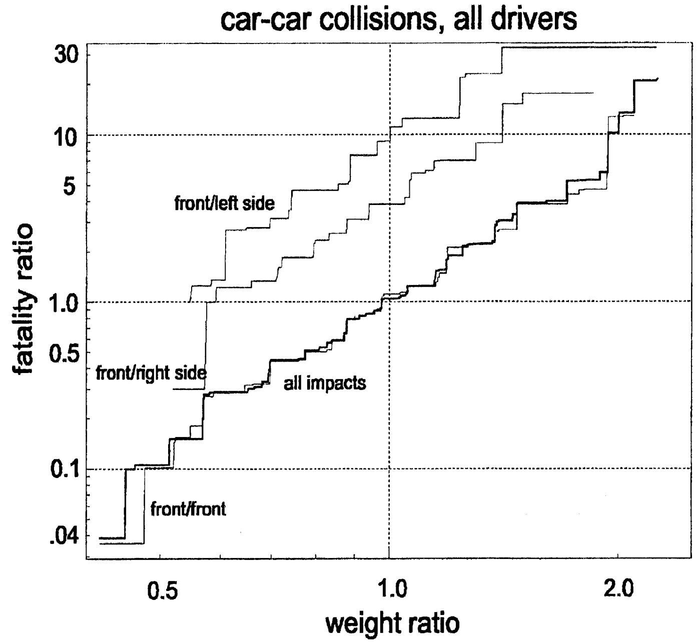

Figure 4.2-1. Ratio of Driver Fatalities in Collisions Between Two Cars, by Weight Ratio of the Cars, and Collision Configuration.

Also shown are the risk ratios (deaths in car-struck divided by deaths in striking cars) for front-left-side (clock positions 8, 9, or 10), and front-right-side (clock positions 2, 3, or 4) collisions. Both relations are practically parallel to that for front-front collisions. However, the risk for the driver of the struck car is much higher. In a front-right-side impact, it is 3.8 times higher than in a front-front impact. For front-left-side impacts, where the driver is near the struck side, the risk ratio is much higher: 9.2. However for a weight ratio only a little greater than 1, the ratio is already 11.1. This reflects a weakness of the isotonic regression approach: It gives a step function, where in reality it can be expected to be a continuous function.

If it is assumed, at least as an approximation, that the absolute risk for the driver of the car striking with the front is independent of where it strikes the other car (this is probably not quite true, because different types of impacts are likely to have different closing speeds), these factors reflect the lower crashworthiness of the side of a car, compared with its front. This has to be considered when looking at the fatality ratio in side impacts by light trucks into cars: Some part of the large fatality ratio is due not to aggressivity of light trucks, but due to the lower crashworthiness of the sides of cars, compared with the front.

Figure 4.2-1 represents collisions involving all drivers. If more vulnerable older drivers were more likely to drive heavier cars, or more likely to be struck at the side, the apparent effects of weight ratio and impact type would be distorted. To reduce this effect, the analysis was repeated using only cases where both drivers were from 26 to 49 years old; in this range, the probability of death per crash involvement changes relatively little.

Figure 4.2-2 shows for all car collisions the relation between fatality ratio and weight ratio for the selected middle-age drivers. To allow comparisons, the ratio for all drivers, as already shown in figure 4.2-1, is also shown. Overall, the relations are very close, but that for middle-age drivers is slightly steeper. In the range of weight ratios between 0.6 and 1.8, the exponent describing the slope is about 3.3, comparing with 2.7 for all drivers.

Figure 4.2-3 shows the relations for the different impact types in collisions involving only middle-age drivers. One obvious difference is that the widths of the steps of the isotonic regression are wider than in figure 4.2-1. This is a consequence of the much lower number of collisions involving only middle-age drivers. Another difference is that the three relations are no longer closely parallel. Though they are roughly parallel, the slopes for side impacts appear slightly lower.

The most striking difference, when comparing with figure 4.2-1 is that now the relation for left- and right-side impacts are roughly the same. For left-side impacts, the risk ratio for cars of equal weight is 4.4; for a slightly higher weight ratio it is 5.7. For right-side impacts, the risk ratio for cars of equal weight is 3.1, for slightly higher weight ratios it is already 3.4, and for only little higher weight ratios it jumps to 8.5. Simplifying the matter, it might be said that after controlling for weight, the risk of a driver being killed by a side impact is roughly four to five times as high as that of being killed in a front impact.

For front-left impacts, control for age remarkably reduced the risk ratio from about 9 to 11 to about 4 to 6, by a factor of two, whereas it practically did not change it for front-right-side impacts. This could have several reasons. Driver age has an influence on the driving environment, collision configuration, and accident severity. To determine the reasons, would have required an analysis beyond the scope of this study.

Figure 4.2-4 shows fatality ratios versus weight ratios for collisions between pickup trucks and cars for all drivers. Figure 4.2-5 shows these ratios for cases where both drivers were between 26 and 49 years of age.

The overall patterns of the two graphs are very similar. Here, contrary to the case of collisions between cars, age control does not reduce the ratio of 9:1 for left-side-to-front impacts for vehicles of the same weight. However, for weight ratios slightly larger than 1, the relation changes from 17:1 to 12:1. This reveals a disadvantage of isotonic regression: if due to sparse data the steps of the fitted functions become high, reliable ratios between two approximating functions are unobtainable.

Figure 4.2-6 compares front-front collisions of two cars with front-front collisions between a car and a pickup truck. The slope of the relation for collisions between a car and a pickup truck is steeper than for collisions between two cars. In figure 4.2-7, controlled for driver age, this may not be the case.

Figure 4.2-8 shows corresponding relations for collisions when a pickup truck, or another car impacts a car on the left side. The slopes of the two relations appear very similar. In Figure 4.2-9, including only cases with both drivers between 26 and 49 years, the steps are so high that slopes cannot really be compared.

Figures 4.2-10 and 4.2-11 show the corresponding relations for collisions between utility vehicles and cars, and figures 4.2-12 and 4.2-13 show these relations between vans and cars. Because of the small case numbers, the relations have large steps and are therefore not precisely defined. Those for middle-age drivers are even coarser and should be interpreted with great caution.

Figures 4.2-14 to 16 summarize the findings. The numbers in these following figures and the corresponding discussion differ somewhat from the more detailed discussions in the text that discusses figures 4.2-1 - 4.1-13. The reason was already mentioned. If the case numbers are small, especially when only collisions between middle-age drivers are studied, the steps of the isotonic regression function can be high. Comparing the fatality ratios for weight ratios exactly equal to 1 can be misleading, if for values

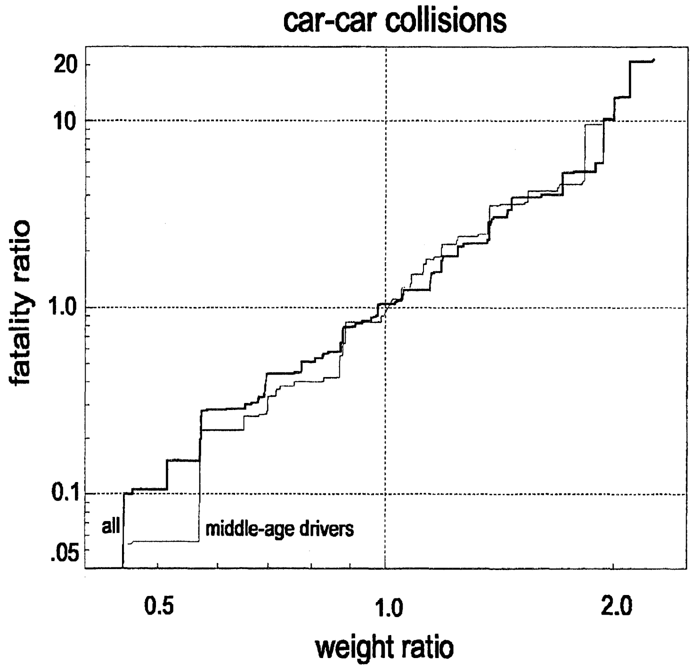

Figure 4.2-2. Ratio of Driver Fatalities in Collisions Between Two Cars, by Weight Ratio of the Cars, for All Drivers, and Drivers 26 to 49 Years Old. All Collision Configurations.

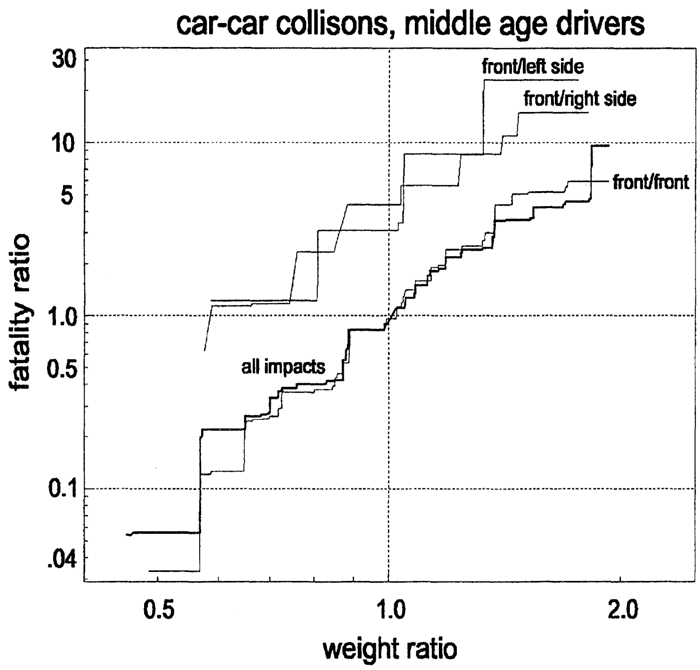

Figure 4.2-3. Ratio of Driver Fatalities in Collisions Between Two Cars, by Weight Ratio and Collision Configuration. Drivers 26 to 49 Years Old.

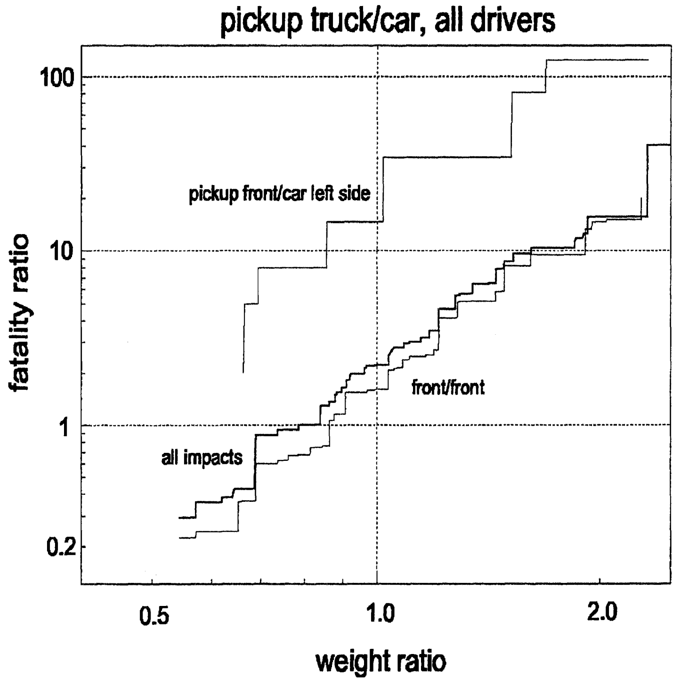

Figure 4.2-4. Ratio of Car Driver Fatalities to Pickup Truck Driver Fatalities in Collisions Between a Car and a Pickup Truck, by Ratio of the Weight of the Pickup Truck and the Car, and Collision Configuration.

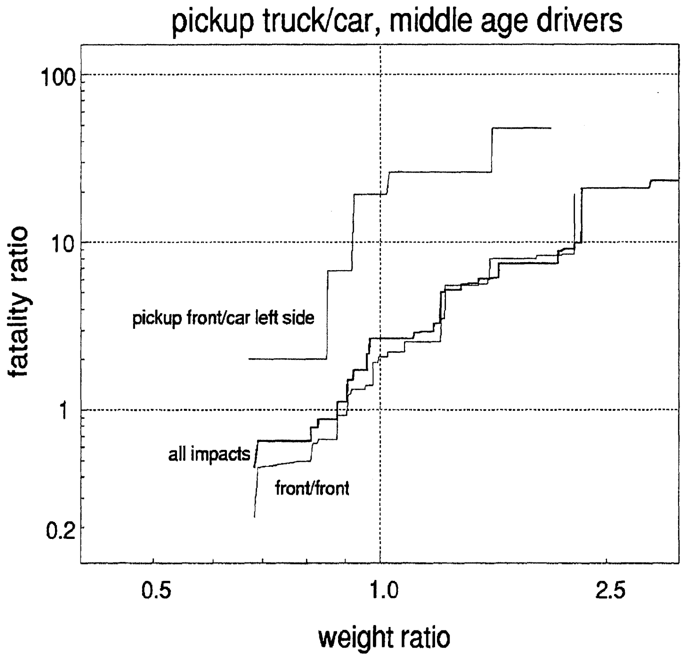

Figure 4.2-5. Ratio of Car Driver Fatalities to Pickup Truck Driver Fatalities in Collisions Between a Car and a Pickup Truck, by Ratio of the Weights of Pickup Truck and the Car, and Collision Configuration. Drivers 26 to 49 Years Old.

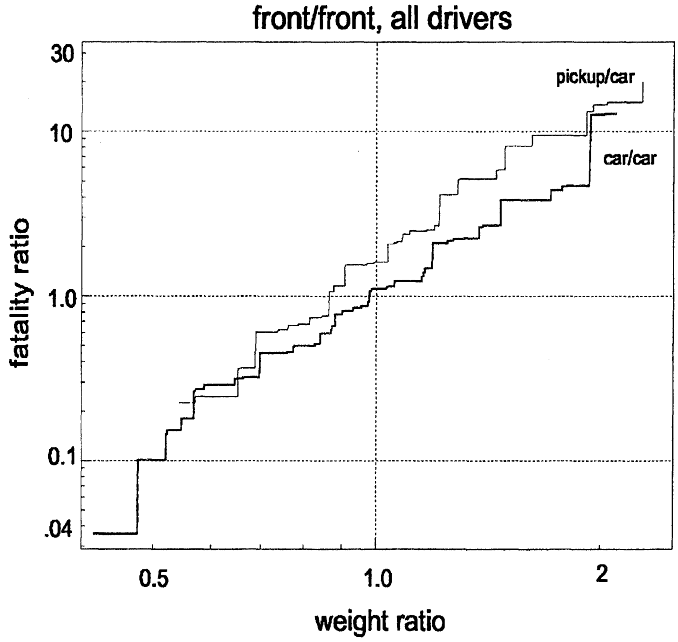

Figure 4.2-6. Ratio of Car Driver Fatalities to Pickup Driver Fatalities in Collisions Between a Car and a Pickup Truck, by Ratio of the Weights of the Pickup Truck and the Car, in Frontal Collisions.

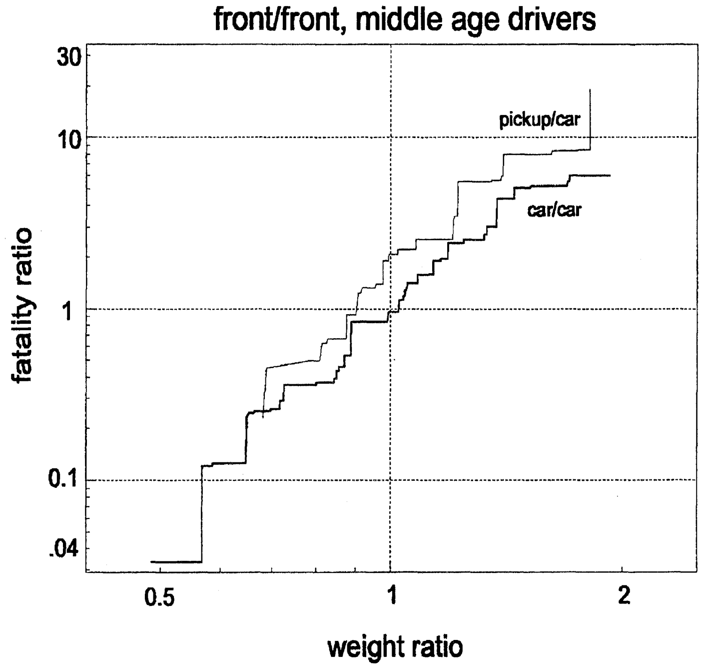

Figure 4.2-7. Ratio of Driver Fatalities in Front-front Collisions Between a Pickup Truck and a Car, and Collisions Between Two Cars, by Ratio of the Weights of the Vehicles. Drivers 26 to 49 Years Old.

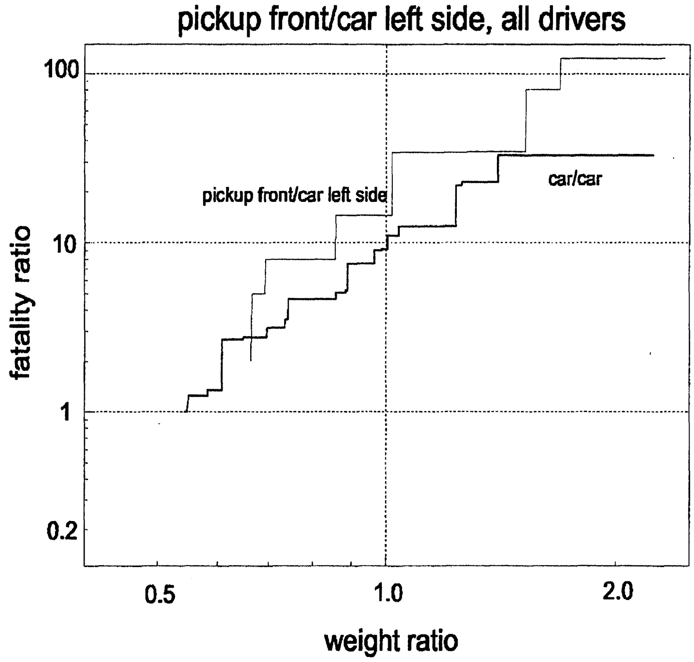

Figure 4.2-8. Ratio of Driver Fatalities in Front-left Side Collisions Between Pickup Trucks and Cars, and Collisions Between Two Cars, by Ratio of the Weights of the Pickup Truck and the Car.

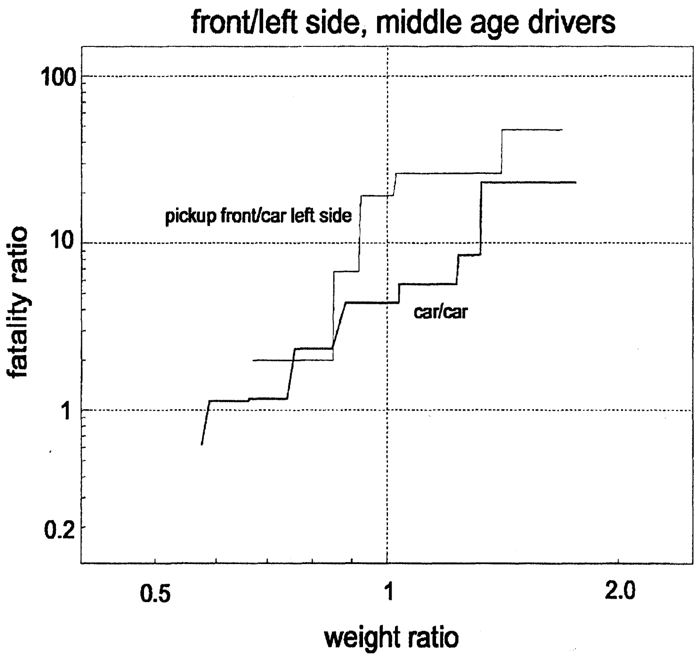

Figure 4.2-9. Ratio of Driver Fatalities in Front-left Side Collisions Between Pickup Trucks and Cars, and Collisions Between Two Cars, for Middle Age Drivers, by Ratio of Weight of the Pickup Truck and the Car.

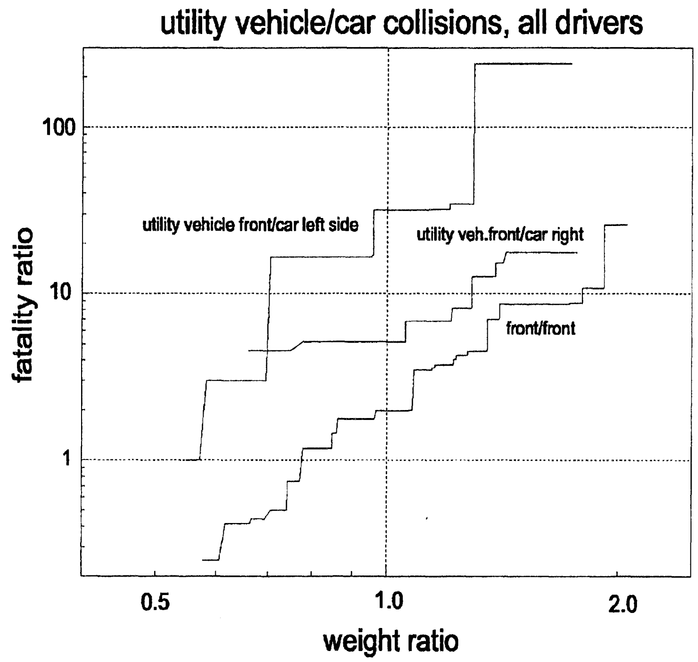

Figure 4.2-10. Ratio of Driver Fatalities in Collisions Between Utility Vehicle and Car, by Vehicle Weight Ratio and Collision Configuration.

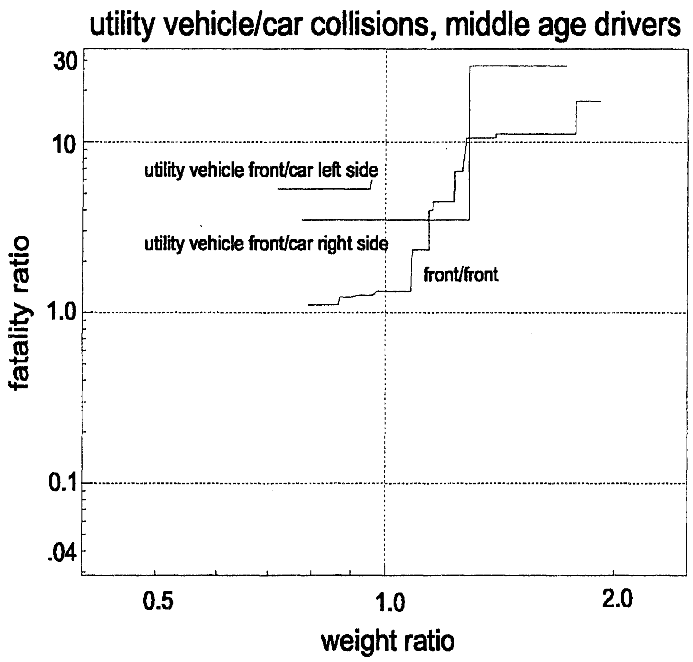

Figure 4.2-11. Ratio of Driver Fatalities in Collisions Between Utility Vehicle and Car, by Vehicle Weight Ratio and Collision Configuration, Middle Age Driver.

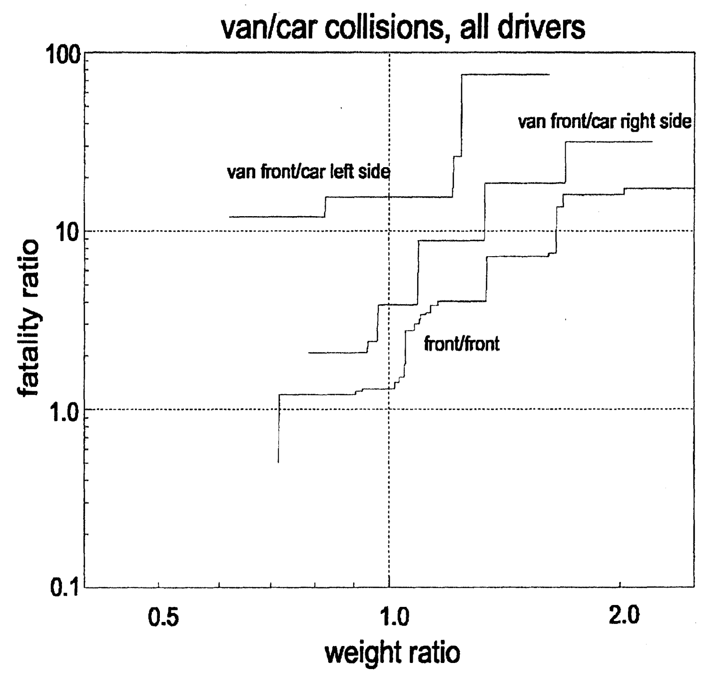

Figure 4.2-12. Ratio of Driver Fatalities in Collisions Between Vans and Car, by Vehicle Weight Ratio and Collision Configuration.

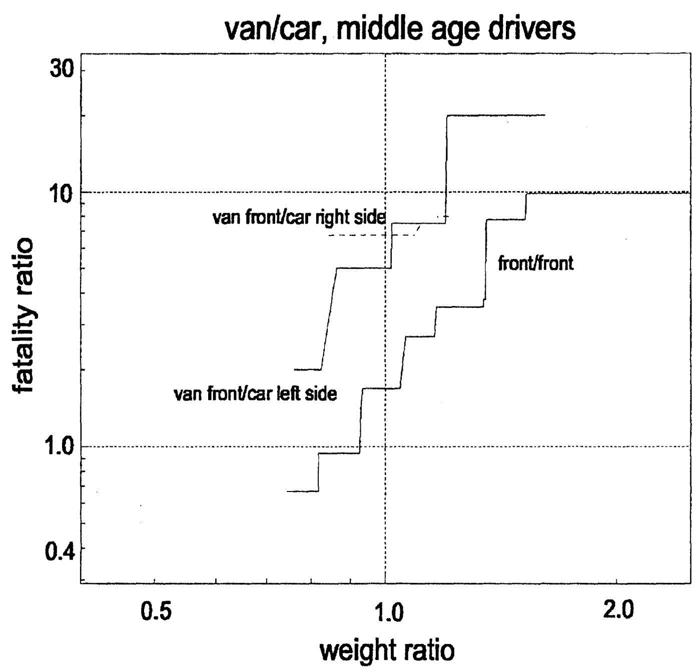

Figure 4.2-13. Ratio of Driver Fatalities in Collisions Between Vans and Cars, by Vehicle Weight Ratio and Collision Configuration, Middle Age Driver.

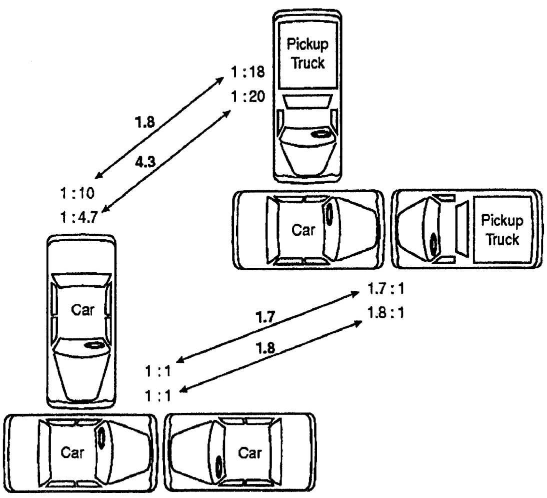

Figure 4.2-14. Comparing Collisions Between Pickup Trucks and Cars of the Same Weight, with Collisions Between Cars of the Same Weight.

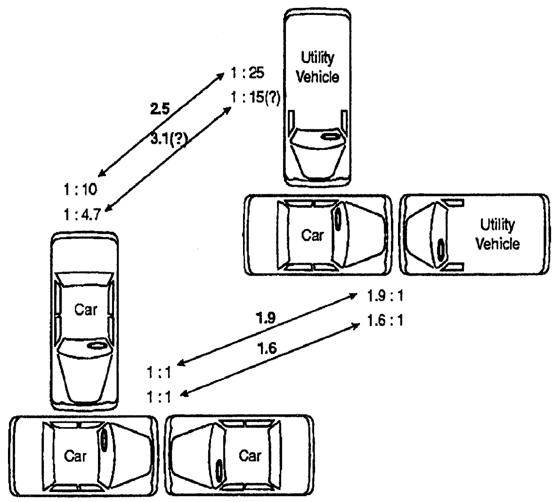

Figure 4.2-15. Comparing Collisions Between Utility Vehicles and Cars of the Same Weight, with Collisions Between Cars of the Same Weights.

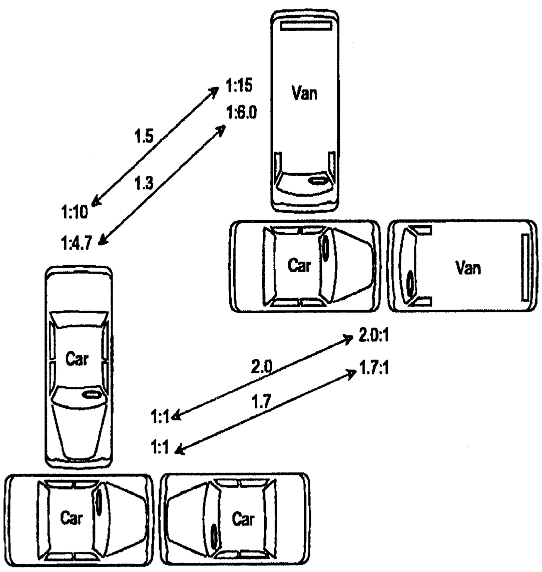

Figure 4.2-16. Comparing Collisions Between Vans and Cars of the Same Weight, with Collisions Between Cars of the Same Weights.

NOTE: The ratios are those of driver deaths in the struck car to driver deaths in the striking vehicle. The bold figures are the double ratios of the ratios shown by the arrows. The upper figures are for all collisions. The lower figures are for collisions involving only drivers of ages 26 to 49.

Figures with question marks are based on very few cases, requiring extrapolation to collisions between vehicles of the same weight.

slightly different from 1 the fatality ratios are different. Therefore, the step function was replaced by a linear function approximating the step function near the weight ratio 1. Because this procedure is not completely objective and the relatively great uncertainty of a line fitted to a high-step function, no formal procedure was used; it was "eye balled."

Collisions between two cars are shown in the lower left on all three figures as a basis for comparison. (To reduce the number of figures, two types of collisions are combined into one diagram, but the numerical results are presented separately.) In the upper right, collisions between one type of light truck and a car are shown, where the light truck is impacting the car. Again, two types of collisions are shown in one diagram, but the numerical results are presented separately.

In frontal collisions between two cars, the expected ratio of deaths must be 1, deviations from 1 being random variations. In side impacts by a car, the ratio of deaths in the struck car to those in the striking car is 10:1 for all drivers, and 4.7:1 for middle-age drivers. These values compare with 6.6:1 found in a previous study[4] for drivers of ages 26 to 55 years old. However, the fact that in the previous study weight was not controlled for must be considered. It could be that vehicles of different weights, because of different driver populations, play different roles in collisions. On the other hand, cars with airbags were excluded. Since no effect of airbags is expected in side impacts, relatively more drivers would be killed in the striking car when airbag vehicles are excluded. This is not so. The ratio 1:6.6 when excluding airbag cars reflects a lower risk than the ratio 1:4.7 when cars with airbags are included in the population.

Figure 4.2-14 compares these collisions with those of a pickup truck and a car. The ratios of drivers killed in the cars to those killed in the pickup trucks are 1.7:1 and 1.8:1, for all drivers and middle-age drivers, respectively. This is much less than the ratio 3.0:1 found in the previous study.

One factor increasing the ratio is the lack of control for vehicle weight in the previous study. Also, the exclusion of airbags increases the relative risk for car occupants.

Comparing the findings for the truck-car, and car-car collisions, the "pure" increase in the fatality ratio by being struck by a pickup truck instead of a car appear to be only 1.7 to 1.8, except in collisions between middle-age drivers. Why this is so would require a much more extensive study.

Comparing collisions between utility vehicles and cars (figure 4.2-15) with those of the previous study, shows that the ratios of 1.9:1 and 1.6:1 are again much smaller than in the previous study: 5.6:1. The reasons are likely the same.

In side impacts by utility vehicles, the ratios of 25:1 and 15:1 (the latter being very uncertain) are again smaller than the ratio of 30:1 in the previous study.

Comparing collisions between utility vehicles and cars with those between two cars shows "pure" utility vehicle effects of 1.6 to 2.5 to be roughly comparable to the "pure" pickup effect. As in side impacts by pickup trucks, the age-controlled double ratio of 3.1 is higher than the other double ratios. However, not too much weight should be placed on this observation, because this ratio is based on an extrapolation from very low case numbers.

Looking at collisions between vans and cars (figure 4.2-16) shows again a similar pattern. In frontal impacts, the fatality ratios are 2.0:1 and 1.7:1, and in side impacts 15:1 and 6:1. In our previous study, the corresponding figures, controlling for age 5.4:1 and 13:1.

Comparing the van-car collisions with car-car collisions, the double ratios range from 1.5 to 2.0. Contrary to the situation for other truck types, the age-controlled double ratio for side impacts is lower, not higher.

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[4]H. C. Joksch, D. Massie, R. Pichler, *Vehicle Aggressivity: Fleet Characterization Using Traffic Collision Data*, Final Report, DOT HS 808 679, DOT-VNTSC-NHTSA-98-1, February 1998.

To summarize: after controlling for vehicle weight, the fatality risk for a car driver when colliding with a light truck is very roughly doubled compared with a collision with a car of the same weight. This figure includes the effects of airbags in the population during the years 1991 to 1995. The effect of driver age is not clear.

This estimate, that the fatality risk for a car driver in a collision with a light truck is roughly double that in a similar collision with a car of the same weight, has an interesting consequence. A look at the NCAP test results shows that light trucks seem to be not more crashworthy than cars in terms of head injury criterion, chest deceleration, and femur load. If the crasworthiness of light trucks is not greater than that of cars in frontal impacts, the doubled fatality risk in collisions between cars and light trucks reflect the latter's aggressivity. The data in table A.2-O show that in 1996, 4,370 car occupants died in collisions with light trucks. If the doubling of the risk also holds for other car occupants 2,000 people were killed who would not have been killed, if they had collided with a car instead of a light truck. In addition to this figure are those killed because light trucks are, on the average, heavier than cars. The last row of table A.2-O contains collisions involving more than two vehicles, some of which may include collisions between a car and a light truck. This could add to the number of people killed because of a mismatch between cars and light trucks.

4.3 Risk Ratio by Impact Site

In the previous section, only three impact types were distinguished front-front, front-left, and front-right. (Front-rear impacts were not studied because they rarely result in a fatality.) FARS provides information on the impact point on a vehicle by the clock positions. This seems to allow a much closer look at potential relations between aggressivity and impact site. To compensate for the increase in detail, the controls for vehicle weight and victim age were not used.

Collisions can be organized by the impact positions on the two vehicles in a 12-by-12 table. (A mathematician would put it on the surface of a torus because the table is periodic in each dimension.) Many of the 144 cells of the table contain few or no cases. Restricting the analysis to the most interesting situations where a light truck strikes a car anywhere with its front (clock positions 11, 12, or 1) excludes only relatively few cases (e.g., fewer than 15 percent in collisions between cars and light pickup trucks).

If the absolute fatality risk for the driver of the striking vehicle (11, 12, 1 impacts) does not depend on where the other vehicle is struck, the ratio of drivers killed in the struck vehicle to drivers killed in the striking vehicle reflects the combination of crashworthiness of the struck vehicle combined with the aggressivity of the striking vehicle in relation to the location of the impact. The assumption that the absolute fatality risk in the striking vehicle does not depend on where the other vehicle is struck can hold strictly only when the struck vehicle is not moving. If both vehicles are moving, then the delta v experienced by the striking vehicle depends on the relative magnitudes and directions of the velocity changes of the two vehicles, which in turn are related to collision configuration and impact location. Since delta v is the best single predictor of fatality risk, the risk even in the striking vehicle may be correlated with the location of the impact on the struck vehicle.

To establish a baseline, collisions between two cars were considered. Figure 4.3-1 shows the ratio of drivers killed in the struck car to drivers killed in the striking car (clock positions 11, 12, and 1) by impact on the struck car. (For front-front collisions, cases were randomly assigned to be striking or struck.) As to be expected, the ratio is close to 1 in front-front collisions. It is 12:1 in front-left side collisions. This is not surprising, because only the thin door structure separates the driver of the struck vehicle from the front of the striking vehicle. However, it is surprising that the risk ratio is as high as 5 for right-side impacts, where the distance between the driver and the striking vehicle is a few feet. That the 4 o'clock impact has a higher fatality ratio is probably a random variation, but an error analysis would be required to confirm this.

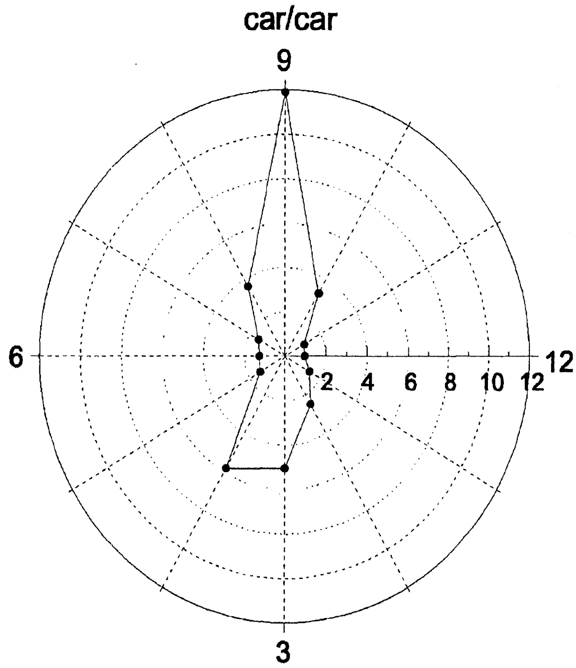

Figure 4.3-1. Ratio of Driver Fatalities in Cars Struck to Those in Striking Cars. The Striking Cars Have Impact Points 11, 12, or 1, the Struck Cars' Impact Points Are Shown by the Clock Positions.

Figure 4.3-2a shows the risk ratio for the driver of a car struck by a pickup truck, separated for standard and compact pickup trucks. Since all but the points for 9 o'clock impacts are crowded in the center of the graph, figure 4.3-2b shows them on a different scale, where the points for 9 o'clock impacts cannot be shown.

In 9 o'clock impacts by a standard pickup truck, the fatality ratio for the car driver is about 75, more than six times as large as in impacts by another car (figure 4.3.2-a). However, to put this into perspective, consider that even in 12 o'clock impacts the risk ratio for the car driver is nearly 5. (Refer to figure 4.3-2b.) Thus, the risk ratio in 9 o'clock impacts by a standard pickup is about 15 times as high as in 12 o'clock impacts. This is no longer dramatically different from the ratio 12:1 of the fatality ratios for being struck by another car at 9 o'clock, and at 12 o'clock; it is 25 % higher.

This argument attempted to control for two factors: 1) the variation of car crashworthiness with impact location on the vehicle, and 2) the overall higher aggressivity of heavier and stiffer light trucks. What remains is the interaction between the impact location on the car and the characteristics of the impacting vehicle, presumably resulting from structural differences. At this stage, one can only speculate on which differences may cause the effect; therefore, only the pattern is presented without any attempt to explain it.

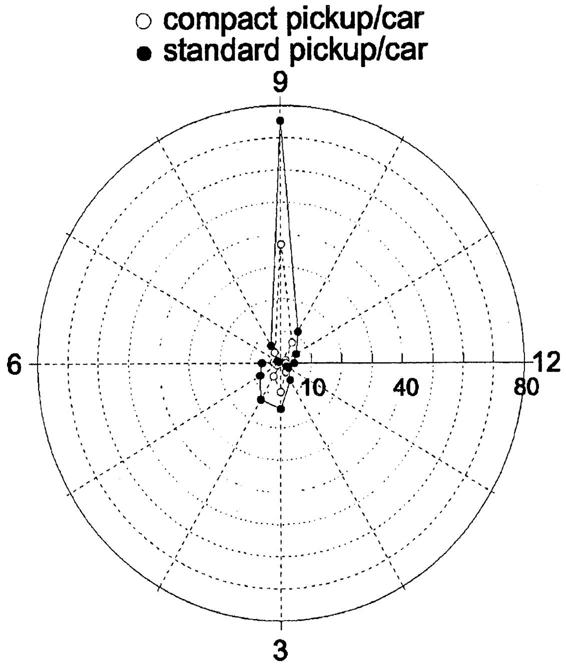

Figure 4.3-2a. Ratio of Driver Fatalities in Cars Struck to Those in Striking Pickup Trucks, for Compact and for Standard Pickup Trucks. The Striking Pickup Trucks Have Impact Points 11, 12, or 1, the Struck Cars Have Impact Points Shown by the Clock Positions.

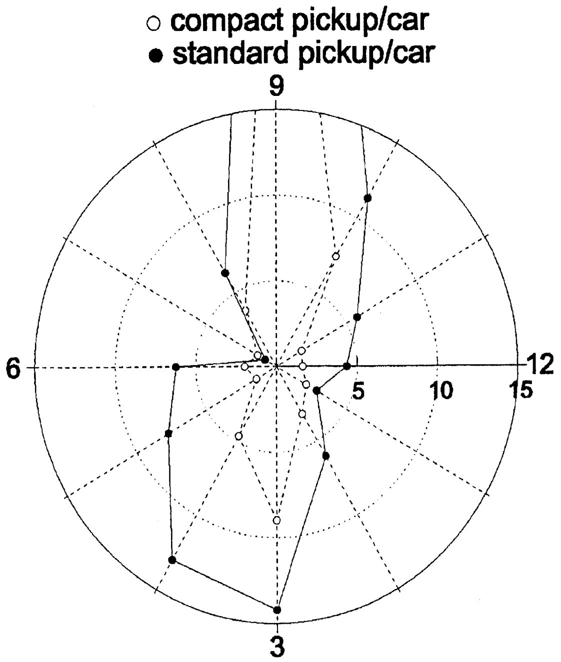

Figure 4.3-2b. Ratio of Driver Fatalities in Cars Struck to Those in Striking Pickup Trucks, for Compact and for Standard Pickup Trucks. The Striking Pickup Trucks Have Impact Points 11, 12, or 1, the Struck Cars Have Impact Points Shown by the Clock Position. The Data Are the Same as in Figure 4.3-2a, but Only the Center of it is Shown.

These arguments are mathematically formalized by defining the following variables:

Car-car collisions

$cc(i)$ drivers killed in a struck car with impact i

$cs(i)$ drivers killed in a car frontally striking other car at impact site i

Truck-car collisions

$ct(i)$ car drivers killed when struck by a truck at impact site i

$ts(i)$ truck drivers killed when frontally striking a car at impact site i

The straightforward fatality ratio for car-car collisions is

$$\frac{cc(i)}{cs(i)}$$

It is implicitly standardized approximately relative to front-front collisions. A more symmetric standardization is relative to all impact directions combined. To do that, define

$$scc=\sum_i cc(i)$$

$$scs=\sum_i cs(i)$$

and the relative risk in car-car collisions as

$$rcc(i)=\frac{cc(i)}{cs(i)}/\frac{scc}{scs}$$

Similarly, one defines for car-truck collisions as

$$rct(i)=\frac{ct(i)}{ts(i)}/\frac{sct}{sts}$$

Then,

$$r(i)=\frac{rcc(i)}{rct(i)}$$

Figure 4.3-3a shows this for collisions between a standard pickup and a car. If there were no directional effect, it can be expected that the points will scatter around a circle, which they do not seem to do. For 9 o'clock, the ratio is largest: 1.4. For impacts in the 1 to 4 o'clock area, the ratio is small, around 0.5. A few features of the diagram are unexpected: the high ratio for 5 o'clock impacts and the extremely low ratio for 7 o'clock impacts. This low ratio is based on relatively few cases.

This raises the question of whether the sparsity of such impacts is real, or whether it is an artifact of the data collection. Reviewing the state accident-report forms on which the FARS impact information is based showed that a number of different systems to code the impact on a vehicle are used by the states. In some systems some or even most impact codes can be directly translated into the 12 clock positions used by FARS. In others, no impact code can be unambiguously translated into a clock position. Therefore, errors in the clock positions are inevitable. Some may be random, others may be systematic, because all data from one state are coded by a FARS analyst who may follow certain individual patterns to resolve ambiguities.

One way to reduce the effect of errors that may shift a value randomly to the left or the right by one, and possibly even by two, is to "smooth" the data. Simple smoothing by weighted 3-point moving averages was done alternatively with weights 1/4, 1/2, 1/4 and with weights1/6, 2/3, 1/6; there was no practical difference between the two weight schemes. The second scheme was used because it flattened "peaks" slightly less than the first scheme. Smoothing was applied to the original counts before the ratios were formed. This approach allowed the calculation of ratios where one original count was zero.

Figure 4.3-3b shows the result of smoothing the data on which figure 4.3-3a is based. The effect is noticeable: The pattern of a distorted pear appears. It is relatively high r(i) in the range from 9 to 12 o'clock, and 5 and 6 o'clock, and has relatively low values for the other clock positions.

Figures 4.3-4a and b show corresponding information for compact pickup trucks. The smoothed version shows, as expected, a much smoother pattern than the original version. Both have in common that the r(i) for 9 and 10 o'clock is higher than 1, all others lower than 1, except 8 o'clock, which is ambiguous.

For utility vehicles and vans, only the smoothed versions are shown because several fatality counts were zero; therefore, for some impact points, ratios could not be calculated.

For compact utility vehicles, figure 4.3-5, the r(i) is relatively high for 8 to 12 o'clock, for all other positions it is low. Large utility vehicles (figure 4.3-6) show very high r(i) for 9 and 10 o'clock, but very low values for 2 to 7 o'clock. For minivans, even the smoothed pattern of figure 4.3-7 shows great irregularities, probably because of the low case numbers. This makes it doubtful whether the very high value for 7 o'clock is "real." Large vans (figure 4.3-8) show a clear pattern with relatively high r(i) from 9 to 12 o'clock, and low values from 2 to 8 o'clock.

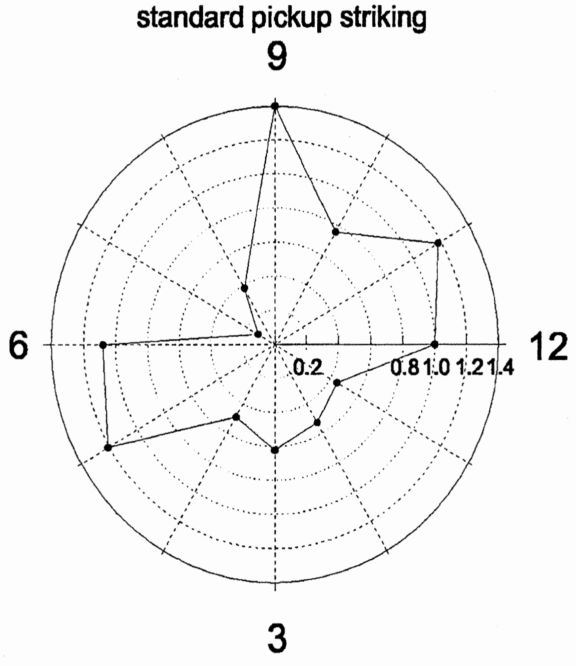

Figure 4.3-3a. r(i) for Drivers of Cars Being Struck by Standard Pickup Trucks. The Pickup Trucks Have Impact Points 11, 12, or 1, the Cars Have Impact Points Shown by the Clock Position.

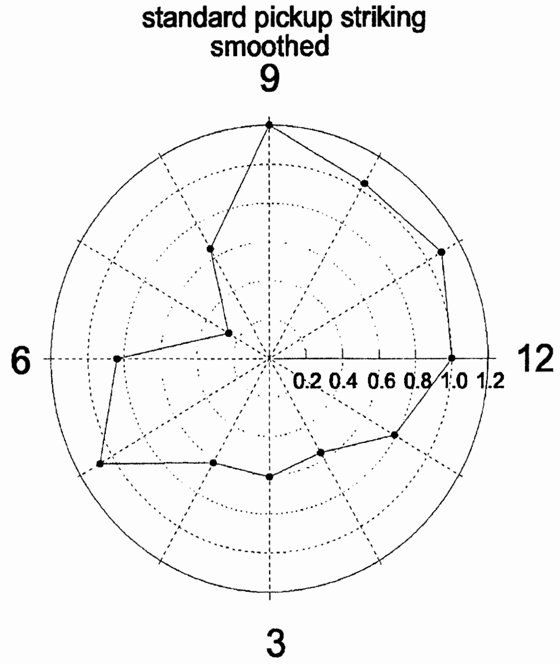

Figure 4.3-3b. r(i) for Drivers of Cars Being Struck by Standard Pickup Trucks. The Pickup Trucks Have Impact Points 11, 12, or 1, the Cars Have Impact Points Shown by the Clock Positions. Points Are Obtained by 3-point Weighted Moving Averaging.

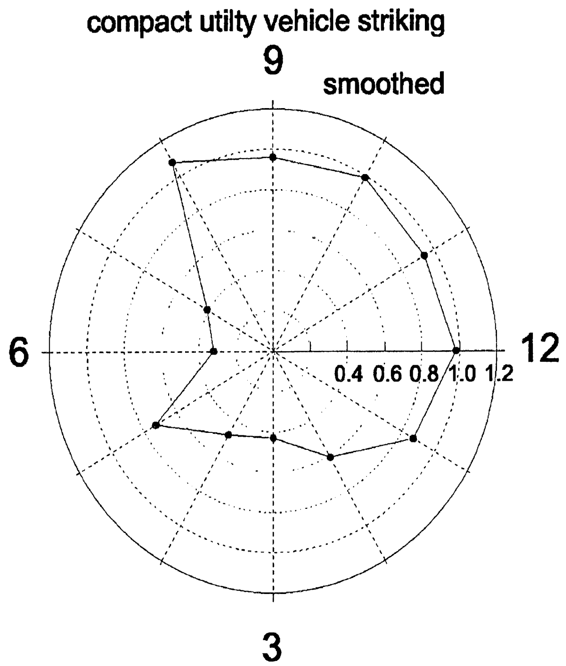

Figure 4.3-4a. r(i) for the Drivers of Cars Being Struck by Compact Pickup Trucks. The Pickup Trucks Have Impact Points 11, 12, or 1. The Cars Have Impact Points Shown by the Clock Positions.

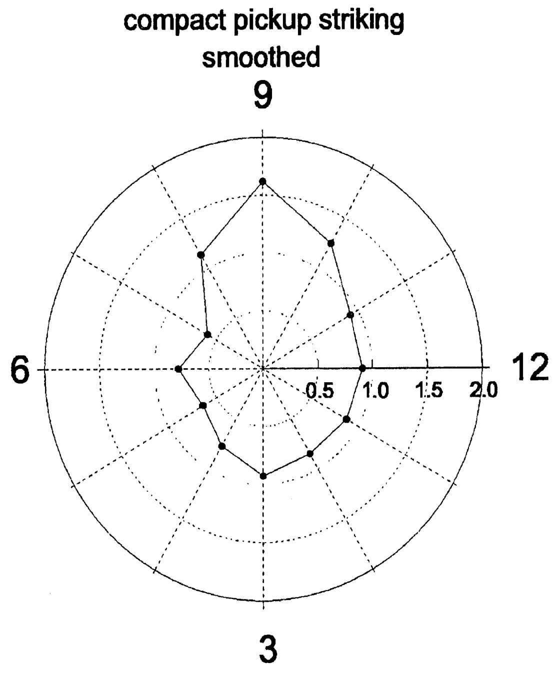

Figure 4.3-4b. r(i) for the Drivers of Cars Being Struck by Compact Pickup Trucks. The Pickup Trucks Have Impact Points 11, 12, or 1. The Cars Have Impact Points Shown by the Clock Positions. Points Are Obtained by the 3-point Weighted Moving Averaging.

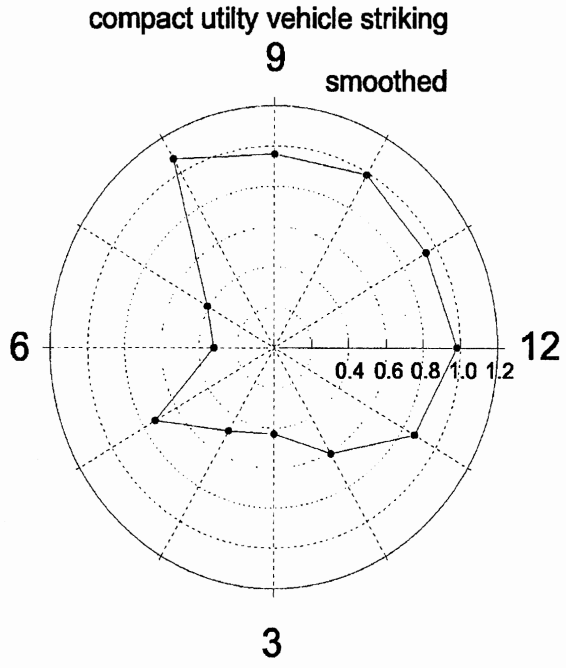

Figure 4.3-5. r(i) for the Drivers of Cars Being Struck by Compact Utility Vehicles. The Utility Vehicles Have Impact Points 11, 12, or 1. The Cars Have Impact Points Shown by the Clock Positions. Points Are Obtained by 3-point Weighted Moving Averaging.

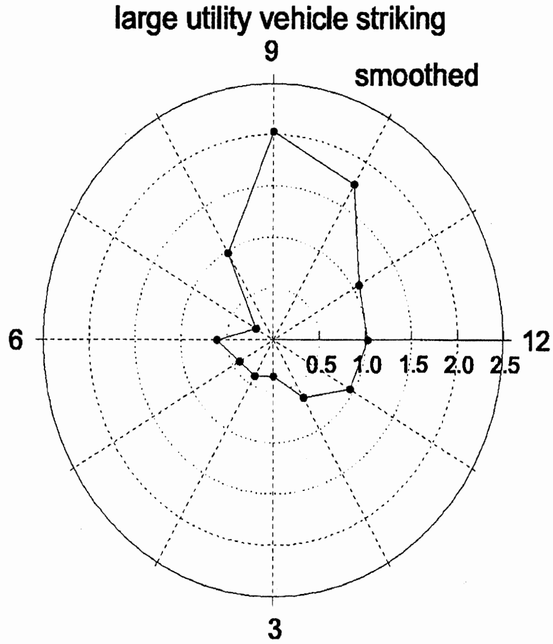

Figure 4.3-6. r(i) for the Drivers of Cars Being Struck by Large Utility Vehicles. The Utility Vehicles Have Impact Points 11, 12, or 1. The Cars Have Impact Points Shown by the Clock Positions. Points Are Obtained by 3-point Weighted Moving Averaging.

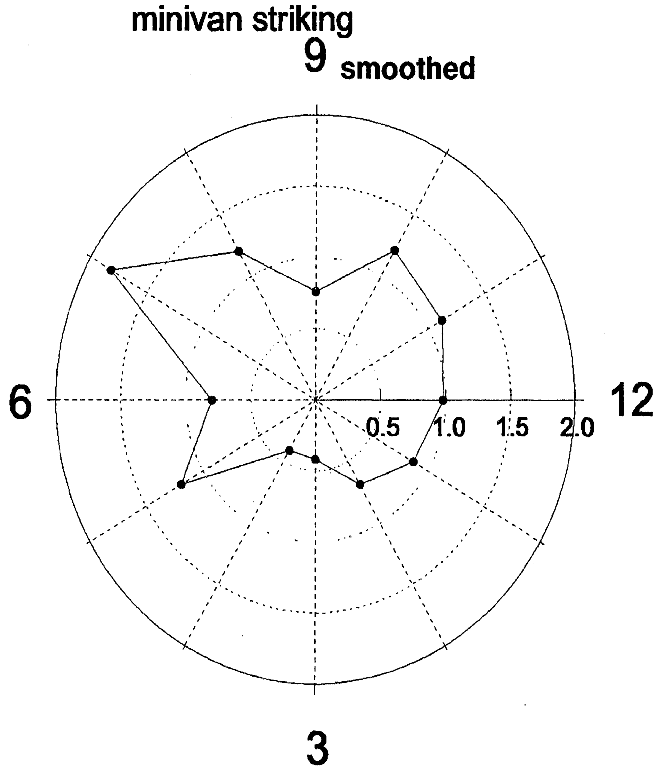

Figure 4.3-7. r(i) for the Drivers of Cars Being Struck by Minivans. The Utility Vehicles Have Impact Points 11, 12, or 1. The Cars Have Impact Points Shown by the Clock Positions. Points Are Obtained by 3-point Weighted Moving Averaging.

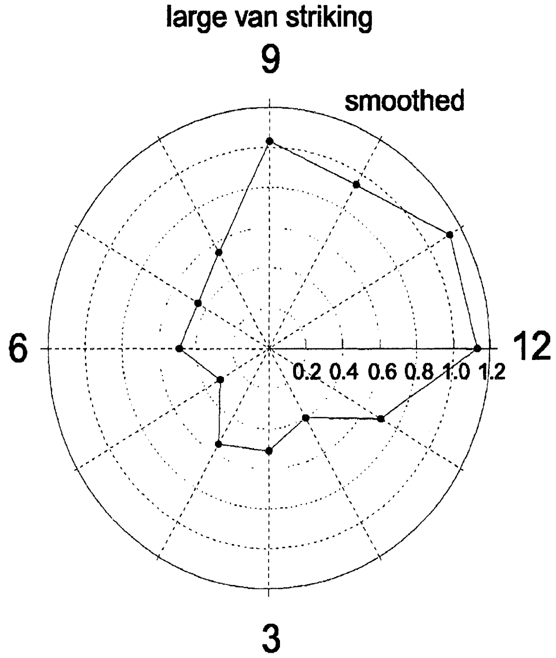

Figure 4.3-8. r(i) for the Drivers of Cars Being Struck by Large Vans. The Utility Vehicles Have Impact Points 11, 12, or 1. The Cars Have Impact Points Shown by the Clock Positions. Points Are Obtained by 3-point Weighted Moving Averaging.

Comparing the graphs for the six vehicle classes, a pattern appears, though it is not very strong. In all cases, the r(i) is high for 10 o'clock impacts, and in 5 of the 6 cases, 9, 11, and 12 also have high values of the r(i). In a few cases, high or very high values of r(i) appear for certain impacts toward the rear.

Because of the obvious random variation of the points in the figures, patterns are not clear. To show common patterns more clearly, figures 4.3-9 and 4.3-10 present averages of the points shown in figures 4.3-3b, 4.3-4b, 4.3-5, 4.3-6, 4.3-7, and 4.3-8, respectively. In figure 4.3-9, data for all light trucks, except vans, are averaged. Two types of averages are used: 1) unweighted averages giving the same weight to each point from the several figures averaged, and 2) weighted averages where each of the several points was weighted with the total number of collisions on which the figure is based. The first type of average better shows any common pattern, but may show more random variability than the second type of average, which is dominated by the patterns for the more common collision types. If the two averages differ systematically, then there are systematic differences between the averaged data. The reverse, however, does not hold. Even if the two types of averages show no systematic differences, the data points may differ systematically. Note that averaging the smoothed data point is a procedure very different from averaging the original data and developing the graphs from them.

The averaged data suggest that, for a car driver, impacts by a light truck in the left-front quadrant are more dangerous than to be expected from the combinations of the higher risks when being struck by a light truck anywhere.

On the other hand, it is surprising that the r(i) values are small for impacts on the right side. This shows a much lower relative risk to the car driver when being struck by a truck on the right side, after correcting separately for the first order effects of being struck on the right side, and being struck by a light truck.

There may be a systematic difference between the weighted and the unweighted averages. For impacts 8, 9, and 10, the unweighted points show higher risk ratios; for impacts 3, 4, 5, and 6 they show lower risk ratios. In the weighted points, pickups have the strongest influence; in the unweighted points the influence of utility vehicles, especially of the fairly rare, large utility vehicles, is strong.

Understanding how structural incompatibilities between vehicles could have a detrimental effect in same-side, front quarter impacts and a beneficial effect in opposite side impacts is difficult. It appears more likely that the difference is due to precollision factors such as the speed at which such collisions occur. Left-front-quarter impacts could occur in driving environments with higher travel speeds than in environments where many right-side impacts occur.

Figure 4.3-10 shows the average for vans. Except for the impact position 5-8, there is no noticeable difference between weighted and unweighted averages. The pattern is very different from that for the other light truck classes. Though risks on the left side are also usually higher than on the right side, there is no "peak" at 9 o'clock. This raises the question of whether the pattern differs between vans and other light trucks because of physical differences between these vehicle classes, or because they are used in different driving environments, where the precrash pattern in terms of collision configuration and closing speed differ.

To get more reliable results, more cases are needed. Also, analyzing separately groups of states that use similar coding schemes for impacts appears worthwhile. This could eliminate some "noise" resulting from differences in the coding schemes.

An important question is whether being struck by the front of another vehicle, or by one of its front corners has a different effect. Again, to study this question it seems advisable to separately study groups of states in which corner impacts may be better identifiable than in others. This reduces the number of cases and would require data from a larger time period to compensate. Besides addressing these questions, studying the potential effects of driving environments appears worthwhile.

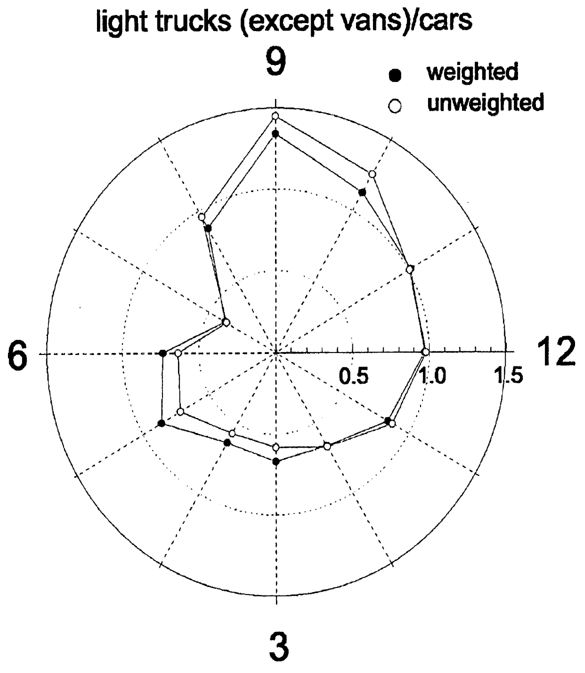

Figure 4.3-9. Averages of the r(i) Shown in Figures 4.3-3b, 4.3-4b, 4.3-5 and 4.3-6. Solid Dots Show Average Weighted with the Number of Collisions, Open Dots Show Averages with Equal Weights.

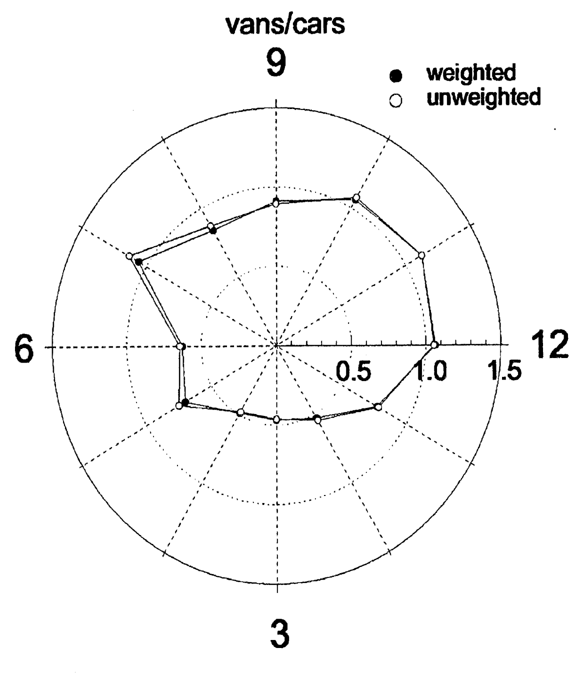

Figure 4.3-10. Averages of the r(i) Shown in Figures 4.3-7 and 4.3-8. Solid Dots Show Averages Weighted with the Number of Collisions, Open Dots Show Averages with Equal Weights.

5. OVER- AND UNDERRIDE

Structural mismatch between cars and light trucks may be one reason for the aggressivity of light trucks. Over- or underride in a collision may show mismatch in the height of critical vehicle structures. To explore this possibility, information on over- and underride in the FARS files were considered.

Since 1980, FARS provides "underride" and since 1982 "override" as part of the vehicle impact codes. The FARS Analytic Reference Guide[5] explains "Note the striking vehicle, not the vehicle struck, determined the underride/override condition." Since 1994, the following, more detailed code is provided.

0 No Underride or Override With Motor Vehicle in Transport
1 Underride (Compartment Intrusion)
2 Underride (No Compartment Intrusion)
3 Underride (Compartment Intrusion Unknown) With Other Vehicle
4 Underride (Compartment Intrusion)
5 Underride (No Compartment Intrusion)
6 Underride (Compartment Intrusion Unknown)
7 Override, Motor Vehicle in Transport
8 Override, Other Vehicle
9 Unknown if Override or Underride

These codes are explained:

"Note that the striking vehicle, not the vehicle struck, determines the underride/override condition. After the crash in the case of an override or underride situation, one vehicle is over the other. If the striking vehicle is over the other, the crash is an override, if the striking vehicle is under the other the crash is an underride."

The coded information for the years 1994 and 1995 was explored. Surprisingly, few vehicles were coded as overriding or underriding. Bivariate tables of override and underride codes for two vehicles in a collision were produced. Table 5-1 summarizes the findings.

Table 5-1. Override and Underride in 1994 and 1995 Collisions.

Light truck the car is colliding with	Override		Underride		All Collisions
	Car	Truck	Car	Truck	
Compact utility vehicle	0	3	1	0	1,318
Large utility vehicle	0	0	0	0	284
Compact pickup truck	2	3	1	2	2,236
Standard pickup truck	1	20	0	2	2,709
Minivan	0	1	0	0	894
Large van	0	3	0	1	883

The only vehicle classes with enough cases to justify a closer look are standard pickup trucks. Table 5-2 identifies the makes and series of these vehicles.

[5]J.M. Tessmer, *FARS Analytic Guide 1975 to 1997*, DOT HS 808 540.

Table 5-2. Standard Pickup Trucks Reported in FARS 1994 and 1995 to Override Cars in Collisions.

Truck Model Code	Number of Cases
Chevrolet, C, K, R, V-series	6
GMC, C, K, R, V-series	2
Dodge, D, W-series	2
Ford, F-series	10

The most widely used pickup truck models appear in the table. There is no suggestion that specific models are over represented. Thus, it does not appear promising to look for vehicle specific mismatch based on the over- and underride information in the FARS files.

6. FINDINGS

The findings must be interpreted with caution, because only FARS data could be used. This did not allow for calculation of absolute risks, only relative risks. Therefore, the effects of aggressivity and crashworthiness of light trucks could not be separated. However, if the assumption is made that the fatality risk in a striking (frontal impact, clock positions 11, 12, and 1) vehicle does not depend on where it strikes the other vehicle, then the findings can be interpreted as relating to absolute risks in the struck vehicle. This assumption, however, may not be correct. In addition, there might be slight differences in precrash factors, in terms of correlations between collision configuration and closing speeds, among collisions of cars with other types of vehicles.

The strongest effect on the relative fatality risks in a collision is the weight ratio of the two vehicles. A weight ratio of 2:1, not rare in actual collisions, results in a fatality risk ratio of about 10:1, even in collisions between two cars.

Nearly as strong is the effect of impact location. Being struck in the left side by another car increases a driver's fatality risk five times compared with being struck in the front. However, since the ages of striking and struck drivers seem to differ, the actual ratio is ten times the risk in frontal impacts.

In addition to these large effects, which are already present in car-car collisions, being struck by a light truck is worse than by a car of the same weight as the truck at the same point. Very roughly, the risk factor is twice as high. Besides these effects, it is relatively worse to be struck by a light truck on the left side than on the right side. The latter difference seems larger for pickup trucks and utility vehicles than for vans.

One consequence of the higher risk ratio in collisions between light trucks and cars is that in 1996 roughly 2,000 car occupants died that would have survived if their vehicles had collided with cars instead of light trucks of the same weight. The effect of the higher risk ratio, on the average, is the higher weight of light trucks.

7. RECOMMENDATIONS

7.1 What Is Needed?

The scatter of the data points in the graphs suggests that they are subject to fairly large errors. Two factors can contribute to such errors: 1) the random variation of collision counts, and 2) the effects of confounding factors, some of which are systematic, some of which are random. To reduce the first errors components, the number of cases must be increased. To reduce the second component, the confounding factors must be controlled. The simplest way to control these factors is to restrict the analysis to cases where the variance in the confounding factor or factors is slight. This reduces the number of cases used, and thereby increases the first type of error. A much more difficult approach is to develop a model that includes the confounding factors and thereby controls for their influence. However, if the model does not fit the data well, the control for the confounding factors may be unsatisfactory, and may even introduce systematic errors. Increasing the number of cases, and controlling for confounding factors, to the extent practicable, is necessary to obtain more reliable results.

This study used only FARS data. Therefore, only the ratios of fatality risks could be studied. This means that the effect of crashworthiness and aggressivity of light trucks could not be separated. To do this, the involvements in all collisions, including nonfatal collisions, must be known because that allows estimating fatality risk per collision involvement. That requires using other databases, alone or in conjunction with FARS. Such databases are GES or state data files. GES data are statistically valid matches to FARS data, but the number of cases is small. State data often have very many cases, but individual states' data are not nationally representative and thus do not match FARS. Neither GES, nor individual states' data files contain enough fatal accidents to study fatality risks at the level of detail needed here. Therefore, work to combine FARS with other databases is needed.

The present study dealt only with fatality risks, which are of greatest societal concern. However, injury risks should not be neglected. Injury information on many cases is available in GES and state data files. However, injury severity is given by the police scale KABCO or a similar scale. The class of most severe injuries, A, includes injuries of the levels 3 to 5 on the much more precise AIS scale, and may include many injuries at the AIS 2 level. Differences in injury risks in the AIS 3 to 5 range are unrecognizable with the KABCO scale. Only shifts from AIS ≥ 3 to AIS < 3, and to some extent from AIS 2 to AIS 1 can be recognizable on the KABCO scale. In addition, there are local variations and errors in the practical application of the KABCO scale; therefore, a qualitative indicator of differences of injury risks at the lower end of the injury scale can be obtained.

To understand the injury mechanism in collisions between vehicles fully, and identify sources of aggressivity, even the abbreviated injury scale is not good enough; a comprehensive injury scale that describes injuries by body region is necessary. This information is available only in the Crashworthiness Data System component of NASS. However, the case numbers are so small that statistical analyses would be too imprecise. Only "clinical" analyses appear promising.

Many states collect some information on the body part injured. However, it is not known to what extent it is transferred to the data files or if there are studies that have used this information.

The current study distinguished only three, (sometimes six) classes of light trucks according to the vehicle type code in FARS. These codes reflect body style, but not other physical similarities or differences among vehicles. Physical characteristics that contribute to aggressivity may differ within such vehicle classes, and may be similar for certain vehicles in different vehicle classes. Therefore, introducing physical characteristics into the analysis is necessary. This can be done in two ways. If a specific physical characteristic, for example, stiffness in frontal impacts, is expected to be related to aggressivity, a quantitative measure of it can be included in the analysis. However, if differences are of a qualitative kind, such as that between a unibody and a frame construction, vehicles must be grouped according to such characteristics and such groups treated as categorical variables in the analysis. This may also be done if there are classes of vehicles that are sufficiently similar in several characteristics, even if the numerical values of some may differ. In any case, including vehicle characteristics into the analysis to learn which characteristics contribute to aggressivity is necessary.

7.2 What to Do?

The following suggestions are for work that can be based on the findings of the current study and of a previous study: "*Vehicle Aggressivity: Fleet Characterization Using Traffic Collision Data.*"[6] More extensive or detailed studies could be done, but delaying such work until more modest studies that can provide guidance to subsequent work are completed will be more efficient.

The first and simplest step is to add 1996 FARS data to the database. This will increase the case numbers and thereby the statistical precision, and it will also allow a finer level of detail in the analyses.

The second step is to obtain or develop data on light trucks of the model years 1994 to 1997, similar to the data developed by Kahane for the model years 1985 to 1993. Not only will that greatly increase the case numbers, but it will include more of the currently produced vehicles.

To clearly separate aggressivity from crashworthiness, data on nonfatal accidents are needed. As a first step, GES data can be used. The data are nationally representative, are a statistical match to FARS data, and the format is also largely similar. A serious problem is that neither VINs nor make/model codes are always available. However, in a previous study an approach was developed that determines make/model codes for two-thirds to three-quarters of passenger cars. Though this could not provide very precise results at the make/model level, it could allow approximate separation of the effects of aggressivity and crashworthiness.

A second step in this direction would be to add two or more state databases (with one state's data, national representativeness would be too questionable). Some states provide the VINs for most accident-involved vehicles. The analysis would use the collision data and vehicle information from the state files. GES data would only be used to "expand" the states' data to the national level, using selected "marginal" totals (possibly also 2-dimensional margins, perhaps even some 3-dimensional margins) from GES and each state to make the expansion. Comparing the expanded values from two or more states even allows for heuristic error estimates. Using state data, however, is a relatively major effort compared with using only GES data.

To understand why light trucks are aggressive, empirical measures of aggressivity must be related to physical characteristics. A few quantitative measures are available or easily obtainable, for instance stiffness in frontal impacts or the height of the "frame" (which might not be a frame in the technical sense). The analysis may want to combine, for certain comparisons, vehicles with the same or very similar platforms, even across body styles. If differences in aggressivity become apparent, an engineering review of the design characteristics with those of other, less aggressive platforms might suggest specific features increasing aggressivity.

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[6] *Loc.cit.*, Ref. 4.

The FARS impact codes are not precise enough to allow distinguishing all impact points, because they are obtained from sometimes very different codes in the state accident-report forms. By selecting states where the codes can be translated with little ambiguity into FARS codes, a database can be created where the effect of a full-frontal impact, and a frontal-corner impact may be distinguishable. In addition, combining the database with the information on collision configuration, the ability to distinguish between impact location, and impact direction is possible. Impact direction is likely to be a confounding factor, and controlling for it could improve the accuracy of the findings, and possibly provide additional insight.

Finally, more sophisticated, but not necessarily more complex, statistical methods should be used. Currently, logistic regression is a technique favored by many analysts. It has the advantage that it provides probabilities in the correct 0 to 1 range, and uses, implicitly, the correct weighting for a binomial dependent variable. Its disadvantages are usually overlooked: that it implies a very specific functional relation for which no physical reason exists to be even only approximately correct. Adding terms to the model changes the relation only relatively little; therefore, the models could be quite misleading.

Isotonic regression was used because it requires only the minimal assumption that the risk does not decrease (or, in relation to certain variables, does not increase) with increasing independent variables. Isotonic regression also provides the correct variance structure for a binomial dependent variable. Its disadvantages are that it works only with one independent variable and gives a step function.

Therefore, more approaches should be explored. Examples are smoothing with kernel smoothers, or with splines. While their results are only tables, not analytic functions, they can be as close to the original data as needed, without imposing an assumed analytical form on them. If an analytical function is needed, as is usually the case, it can be fit in a second step to the smoothed data. This may be the most flexible procedure because it avoids the shortcomings of the currently used techniques.

APPENDIX: TABLES OF TRAFFIC DEATHS BY COMBINATION OF MOTOR VEHICLE TYPES INVOLVED, CALENDAR YEARS 1982 THROUGH 1996

Table A.1-A. Taxonomy of Vehicle Occupant Deaths in 1982. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text (Section 3).

Other Vehicle	**Vehicle with Deaths**													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	1315	2391	4126	3047	313	249	390	0	2812	0	672	20	1906	440
car														
0	154	169	182	79	1	6	12	0	65	0	5	2	140	21
1	51	181	151	69	7	8	17	0	70	0	11	0	178	12
2	192	646	683	363	18	8	42	0	195	0	26	0	462	52
3	279	847	1047	627	14	9	65	0	293	0	38	5	536	72
utility														
1	5	22	24	7	0	0	2	0	10	0	1	0	6	2
2	23	37	36	28	0	3	2	0	15	0	0	0	28	3
van														
1	47	103	162	82	5	0	10	0	48	0	6	0	99	10
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	196	531	680	450	20	9	45	0	310	0	27	0	459	53
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	236	483	867	718	13	26	101	0	537	0	160	5	203	56
bus	6	19	34	33	2	1	5	0	14	0	2	0	20	3
cycle	2	8	10	3	0	0	0	0	2	0	0	0	75	4
other	67	81	130	102	5	2	21	0	73	0	15	0	64	35
over 1	204	421	537	337	7	5	36	0	161	0	57	3	205	33

Table A.2-A. Taxonomy of Vehicle Occupant Deaths in 1982. This table differs from Table A.1-A only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths**										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	1315	2391	4126	3047	565	405	2812	672	20	1906	422
car											
0	154	169	182	79	7	13	65	5	2	140	20
1	51	181	151	69	15	17	70	11	0	178	12
2	192	646	683	363	26	45	195	26	0	462	49
3	279	847	1047	627	23	69	293	38	5	536	68
utility	30	60	61	37	4	4	25	1	0	34	5
van	51	108	170	90	5	10	53	7	0	102	10
pickup	196	531	680	450	29	48	310	27	0	459	50
truck	236	483	867	718	40	109	537	160	5	203	47
bus	6	19	34	33	3	5	14	2	0	20	3
cycle	2	8	10	3	0	0	2	0	0	75	4
other	61	75	121	92	6	24	68	14	0	61	32
over 1	204	421	537	337	12	36	161	57	3	205	33

Table A.1-B Taxonomy of Vehicle Occupant Deaths in 1983. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	**Vehicle with Deaths**													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	1210	2465	4087	2842	319	258	341	0	2777	0	685	22	1882	408
car														
0	129	169	180	95	0	4	11	0	48	0	7	0	142	10
1	61	177	185	73	8	6	9	0	60	0	16	0	215	3
2	186	651	694	393	18	7	43	0	198	0	33	1	427	34
3	191	754	920	543	28	12	41	0	274	0	27	1	477	48
utility														
1	5	15	13	9	0	0	1	0	1	0	0	0	9	0
2	21	44	38	22	1	3	1	0	16	0	1	0	28	3
van														
1	38	116	125	85	2	1	13	0	42	0	9	0	69	3
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	170	622	694	416	11	21	33	0	284	0	33	0	411	50
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	233	583	936	704	13	26	92	0	543	0	149	21	164	79
bus	9	20	42	30	1	1	1	0	15	0	4	3	22	1
cycle	7	12	13	9	0	0	0	0	2	0	0	0	71	6
other	52	127	124	118	3	2	9	0	73	0	14	0	85	20
over 1	136	457	586	343	9	11	58	0	163	0	49	5	193	10

Table A.2-B. Taxonomy of Vehicle Occupant Deaths in 1983. This table differs from Table A.1-B only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths**										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	1210	2465	4087	2842	581	359	2777	685	22	1882	386
car											
0	129	169	180	95	4	15	48	7	0	142	6
1	61	177	185	73	14	9	60	16	0	215	3
2	186	651	694	393	25	46	198	33	1	427	31
3	191	754	920	543	40	43	274	27	1	477	46
utility	26	60	51	31	4	2	17	2	0	38	3
van	41	125	141	93	4	14	45	10	0	75	3
pickup	170	622	694	416	32	34	284	33	0	411	49
truck	233	583	936	704	39	100	543	149	21	164	71
bus	9	20	42	30	2	1	15	4	3	22	1
cycle	7	12	13	9	0	0	2	0	0	71	6
other	49	117	108	110	4	8	70	12	0	78	20
over 1	136	457	586	343	20	60	163	49	5	193	8

Table A.1-C. Taxonomy of Vehicle Occupant Deaths in 1984. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	Vehicle with Deaths													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	1052	2636	4439	2622	284	260	364	0	2819	0	876	23	2011	421
car														
0	104	159	159	61	4	5	13	0	51	0	7	0	118	4
1	41	234	228	91	7	9	14	0	66	0	21	0	238	16
2	198	758	718	402	14	17	41	0	228	0	22	1	492	31
3	192	799	976	458	11	14	42	0	280	0	32	1	511	47
utility 1	4	21	13	8	0	0	0	0	7	0	2	0	10	1
2	16	37	46	31	2	3	2	0	14	0	1	0	27	8
van														
1	49	142	154	79	0	1	5	0	62	0	5	0	96	7
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	169	601	781	419	15	13	57	0	331	0	31	1	434	56
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	230	613	961	688	15	26	107	0	524	0	155	16	211	68
bus	18	32	40	33	1	2	7	0	16	0	2	0	20	3
cycle	3	7	16	6	1	0	1	0	2	0	0	0	63	1
other	45	129	157	109	2	2	12	0	73	0	16	0	98	22
over 1	165	544	606	321	4	9	60	0	213	0	66	4	197	39

Table A.2-C. Taxonomy of Vehicle Occupant Deaths in 1984. This table differs from Table A.1-C only by the aggregation of subclasses of light trucks.

Other Vehicle	Vehicle with Deaths										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	1052	2636	4439	2622	545	371	2819	876	23	2011	413
car											
0	104	159	159	61	9	14	51	7	0	118	3
1	41	234	228	91	16	15	66	21	0	238	15
2	198	758	718	402	31	41	228	22	1	492	31
3	192	799	976	458	25	43	280	32	1	511	46
utility	20	61	60	39	5	2	21	3	0	37	9
van	49	150	158	85	1	5	63	5	0	101	7
pickup	169	601	781	419	28	57	331	31	1	434	56
truck	230	613	961	688	41	112	524	155	16	211	63
bus	18	32	40	33	3	7	16	2	0	20	3
cycle	3	7	16	6	1	1	2	0	0	63	1
other	45	118	152	103	4	12	72	16	0	93	22
over 1	165	544	606	321	14	62	213	66	4	197	36

Table A.1-D. Taxonomy of Vehicle Occupant Deaths in 1985. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	**Vehicle with Deaths**													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	964	2785	4156	2234	277	335	362	0	2801	0	729	32	1997	458
car														
0	71	162	175	56	3	6	18	0	34	0	16	0	123	17
1	60	272	272	95	6	11	11	0	61	0	17	0	244	22
2	147	764	819	330	13	37	45	0	214	0	31	0	506	62
3	178	740	926	375	12	25	51	0	236	0	48	0	459	59
utility														
1	4	18	18	8	1	1	1	0	13	0	1	0	7	1
2	15	86	84	43	2	0	6	0	20	0	2	0	34	7
van														
1	33	107	207	79	4	5	8	0	53	0	7	0	96	6
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	141	678	674	373	15	21	50	0	343	0	31	0	387	64
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	190	743	1007	639	12	33	104	0	545	0	206	12	250	81
bus	10	46	43	30	0	0	11	0	22	0	0	0	18	4
cycle	3	12	7	5	0	0	0	0	5	0	0	0	77	3
other	38	148	220	116	8	6	23	0	79	0	12	2	87	27
over 1	160	598	699	349	8	12	52	0	214	0	88	11	208	47

Table A.2-D. Taxonomy of Vehicle Occupant Deaths in 1985. This table differs from Table A.1-D only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths**										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	964	2785	4156	2234	614	374	2801	729	32	1997	444
car											
0	71	162	175	56	9	18	34	16	0	123	17
1	60	272	272	95	17	14	61	17	0	244	19
2	147	764	819	330	50	48	214	31	0	506	59
3	178	740	926	375	37	52	236	48	0	459	58
utility	20	104	103	51	4	7	33	3	0	43	8
van	33	109	217	84	13	8	54	7	0	100	7
pickup	141	678	674	373	36	50	343	31	0	387	64
truck	190	743	1007	639	45	107	545	206	12	250	78
bus	10	46	43	30	0	11	22	0	0	18	4
cycle	3	12	7	5	0	0	5	0	0	77	3
other	37	146	209	111	10	23	78	12	2	81	26
over 1	160	598	699	349	20	53	214	88	11	208	46

Table A.1-E. Taxonomy of Vehicle Occupant Deaths in 1986. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	**Vehicle with Deaths**													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	802	3228	4919	2386	276	382	396	0	3190	0	788	29	1961	464
car														
0	45	131	140	45	2	1	8	0	27	0	7	0	78	8
1	55	349	337	103	8	5	20	0	93	0	20	0	281	21
2	151	868	975	343	22	19	57	0	265	0	33	2	516	52
3	145	764	909	344	7	32	38	0	236	0	31	0	434	61
utility														
1	2	23	21	4	0	0	2	0	5	0	1	0	17	1
2	5	70	105	33	1	3	7	0	32	0	3	0	38	5
van														
1	28	171	189	96	4	2	13	0	64	0	6	0	96	13
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	116	672	878	381	15	30	56	0	364	0	15	0	392	57
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	149	717	1051	623	17	40	121	0	466	0	186	7	213	60
bus	15	27	40	13	0	2	2	0	17	0	3	0	19	2
cycle	0	6	7	4	0	0	1	0	4	0	0	0	74	6
other	31	166	181	92	1	6	16	0	86	0	11	0	85	39
over 1	134	668	818	369	16	33	85	0	241	0	81	1	193	44

Table A.2-E. Taxonomy of Vehicle Occupant Deaths in 1986. This table differs from Table A.1-E only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths**										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	802	3228	4919	2386	659	414	3190	788	29	1961	445
car											
0	45	131	140	45	3	8	27	7	0	78	8
1	55	349	337	103	13	20	93	20	0	281	21
2	151	868	975	343	41	59	265	33	2	516	50
3	145	764	909	344	41	40	236	31	0	434	57
utility	8	93	127	38	4	9	37	4	0	57	6
van	31	184	201	99	6	14	66	7	0	101	13
pickup	116	672	878	381	45	62	364	15	0	392	51
truck	149	717	1051	623	57	125	466	186	7	213	56
bus	15	27	40	13	2	2	17	3	0	19	2
cycle	0	6	7	4	0	1	4	0	0	74	6
other	27	153	168	88	7	17	84	10	0	78	37
over 1	134	668	818	369	49	88	241	81	1	193	41

Table A.1-F. Taxonomy of Vehicle Occupant Deaths in 1987. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle / **Vehicle with Deaths**

Other Vehicle	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	862	3222	4989	2030	262	460	491	0	3363	0	766	24	1689	444
car														
0	20	127	148	45	3	0	11	0	34	0	4	0	89	12
1	49	395	374	100	5	15	22	0	106	0	18	3	288	25
2	133	999	1047	296	20	36	61	0	280	0	36	1	511	62
3	112	691	842	336	16	27	48	0	257	0	32	0	305	33
utility														
1	2	32	34	7	1	0	2	0	5	0	1	0	8	0
2	13	73	118	34	0	7	5	0	39	0	3	1	37	4
van														
1	45	215	225	83	4	5	14	0	89	0	3	0	74	11
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	103	813	864	351	19	23	60	0	423	0	22	0	337	68
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	182	762	1067	544	16	62	124	0	523	0	174	13	198	74
bus	11	52	48	27	3	2	15	0	17	0	5	0	23	3
cycle	2	10	12	1	0	0	0	0	3	0	0	0	55	3
other	51	130	226	84	5	10	18	0	101	0	22	8	93	38
over 1	141	750	863	340	6	36	72	0	262	0	79	1	213	32

Table A.2-F. Taxonomy of Vehicle Occupant Deaths in 1987. This table differs from Table A.1-F only by the aggregation of subclasses of light trucks.

Other Vehicle / **Vehicle with Deaths**

Other Vehicle	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	862	3222	4989	2030	729	518	3363	766	24	1689	410
car											
0	20	127	148	45	3	12	34	4	0	89	11
1	49	395	374	100	20	22	106	18	3	288	25
2	133	999	1047	296	56	65	280	36	1	511	58
3	112	691	842	336	43	52	257	32	0	305	29
utility	15	106	152	41	8	7	45	4	1	46	4
van	60	228	251	87	9	15	94	5	0	78	13
pickup	103	813	864	351	42	61	423	22	0	337	67
truck	182	762	1067	544	78	126	523	174	13	198	72
bus	11	52	48	27	5	15	17	5	0	23	3
cycle	2	10	12	1	0	0	3	0	0	55	3
other	36	116	200	80	15	19	95	20	8	88	34
over 1	141	750	863	340	42	80	262	79	1	213	24

Table A.1-G. Taxonomy of Vehicle Occupant Deaths in 1988. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle / **Vehicle with Deaths**

Other Vehicle	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	916	3368	5317	1865	255	458	475	0	3662	0	689	16	1538	431
car														
0	47	153	173	39	2	8	8	0	52	0	8	0	68	3
1	59	364	398	96	15	16	21	0	104	0	13	1	250	20
2	166	960	1115	281	18	46	63	0	337	0	40	1	462	53
3	105	627	771	231	7	30	59	0	238	0	28	2	249	57
utility														
1	3	28	39	4	2	0	3	0	5	0	0	0	7	0
2	23	120	112	44	3	10	11	0	38	0	6	0	45	10
van														
1	31	218	284	84	4	7	18	0	108	0	14	0	91	8
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	151	923	1036	324	16	33	69	0	387	0	14	1	378	55
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	154	762	1146	507	15	38	127	0	522	0	199	0	167	77
bus	7	25	47	22	0	2	3	0	18	0	0	1	14	1
cycle	3	12	4	3	0	1	2	0	3	0	2	0	34	6
other	37	138	217	85	0	15	16	0	99	0	18	1	77	27
over 11	146	723	954	341	11	20	65	0	307	0	81	31	176	40

Table A.2-G. Taxonomy of Vehicle Occupant Deaths in 1988. This table differs from Table A.1-G only by the aggregation of subclasses of light trucks.

Other Vehicle / **Vehicle with Deaths**

Other Vehicle	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	916	3368	5317	1865	716	492	3662	689	16	1538	411
car											
0	47	153	173	39	10	8	52	8	0	68	3
1	59	364	398	96	31	22	104	13	1	250	19
2	166	960	1115	281	64	64	337	40	1	462	52
3	105	627	771	231	37	66	238	28	2	249	50
utility	26	148	152	51	15	14	45	6	0	52	10
van	35	227	312	88	11	19	117	14	0	102	8
pickup	151	923	1036	324	52	74	387	14	1	378	47
truck	154	762	1146	507	53	132	522	199	0	167	72
bus	7	25	47	22	2	3	18	0	1	14	1
cycle	3	12	4	3	1	2	3	2	0	34	6
other	33	129	188	78	15	16	88	18	1	66	26
over 1	146	723	954	341	33	67	307	81	31	176	36

Table A.1-H. Taxonomy of Vehicle Occupant Deaths in 1989. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	Vehicle with Deaths													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	689	3416	5113	1707	233	549	551	0	3656	0	623	20	1421	421
car														
0	39	138	146	30	0	8	14	0	32	0	7	0	48	10
1	53	393	429	92	3	19	28	0	144	0	16	0	195	29
2	144	933	1166	297	13	51	83	0	315	0	31	1	412	54
3	63	532	743	198	12	17	47	0	189	0	18	0	188	27
utility														
1	2	43	32	13	0	0	2	0	20	0	2	0	11	1
2	20	138	172	33	0	4	7	0	38	0	4	0	38	14
van														
1	26	235	302	85	4	9	17	0	90	0	5	0	74	9
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	104	919	1088	334	11	48	74	0	454	0	30	0	321	56
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	114	736	1150	420	20	60	163	0	539	0	144	26	115	63
bus	0	40	45	26	1	5	7	0	13	0	2	0	12	4
cycle	4	9	11	3	0	0	0	0	1	0	0	0	26	3
other	27	165	250	95	0	4	30	0	106	0	19	2	57	46
over 1	139	711	959	292	10	44	118	0	273	0	74	1	160	48

Table A.2-H. Taxonomy of Vehicle Occupant Deaths in 1989. This table differs from Table A.1-H only by the aggregation of subclasses of light trucks.

Other Vehicle	Vehicle with Deaths										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	689	3416	5113	1707	790	572	3656	623	20	1421	392
car											
0	39	138	146	30	8	16	32	7	0	48	8
1	53	393	429	92	23	31	144	16	0	195	25
2	144	933	1166	297	64	85	315	31	1	412	52
3	63	532	743	198	29	48	189	18	0	188	26
utility	22	187	209	46	4	11	59	6	0	49	13
van	28	246	320	92	13	20	92	5	0	81	11
pickup	104	919	1088	334	59	79	454	30	0	321	51
truck	114	736	1150	420	81	165	539	144	26	115	60
bus	0	40	45	26	6	9	13	2	0	12	2
cycle	4	9	11	3	0	0	1	0	0	26	3
other	25	148	227	88	4	30	103	19	2	50	41
over 1	139	711	959	292	54	126	273	74	1	160	40

Table A.1-I. Taxonomy of Vehicle Occupant Deaths in 1990. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	**Vehicle with Deaths**													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	781	3182	5197	1481	220	607	527	0	3740	0	508	16	1443	457
car														
0	37	127	140	32	2	8	7	0	44	0	5	0	60	19
1	67	318	398	77	6	16	49	0	123	0	11	0	207	28
2	140	945	1079	261	23	48	80	0	335	0	17	0	418	46
3	98	435	628	155	9	28	56	0	194	0	10	1	198	40
utility														
1	5	40	47	4	1	1	1	0	10	0	0	0	7	1
2	19	115	163	40	1	13	14	0	72	0	2	0	31	7
van														
1	34	271	318	77	1	7	25	0	92	0	4	1	69	6
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pickup														
1	145	879	1071	304	22	53	74	0	411	0	23	0	328	78
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
truck	141	730	1086	377	14	70	143	0	579	0	112	5	149	56
bus	10	37	50	20	1	3	3	0	20	0	1	0	15	1
cycle	2	7	9	1	0	0	0	0	5	0	0	0	48	1
other	36	155	195	52	2	8	10	0	78	0	10	0	71	37
over 1	146	723	945	260	11	31	93	0	276	0	53	9	134	32

Table A.2-I. Taxonomy of Vehicle Occupant Deaths in 1990. This table differs from Table A.1-I only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths**										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	781	3182	5197	1481	831	557	3740	508	16	1443	423
car											
0	37	127	140	32	10	9	44	5	0	60	17
1	67	318	398	77	22	51	123	11	0	207	26
2	140	945	1079	261	72	82	335	17	0	418	43
3	98	435	628	155	39	59	194	10	1	198	35
utility	25	157	212	45	16	16	82	2	0	38	7
van	37	280	335	80	8	27	95	4	1	77	7
pickup	145	879	1071	304	75	76	411	23	0	328	76
truck	141	730	1086	377	84	148	579	112	5	149	51
bus	10	37	50	20	4	4	20	1	0	15	0
cycle	2	7	9	1	0	1	5	0	0	48	0
other	32	144	176	48	10	12	75	10	0	63	32
over 1	146	723	945	260	43	97	276	53	9	134	27

Table A.1-J. Taxonomy of Vehicle Occupant Deaths in 1991. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	Vehicle with Deaths													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	679	3081	5074	1259	576	301	253	290	1468	1890	512	18	1285	594
car														
0	27	110	146	41	8	2	6	2	15	7	5	0	53	7
1	41	358	402	62	23	7	20	15	59	49	7	1	168	26
2	142	878	1109	277	61	22	44	27	147	133	26	0	367	76
3	58	382	528	129	18	17	19	17	82	65	11	0	130	38
utility														
1	17	97	118	25	12	3	7	4	35	18	3	0	29	6
2	10	78	102	27	4	2	8	4	8	6	0	0	24	6
van														
1	11	89	111	30	4	1	3	3	15	9	4	0	28	3
2	24	134	157	43	7	3	7	13	34	28	2	0	43	7
pickup														
1	44	250	294	84	26	2	12	3	59	42	6	0	88	19
2	48	482	693	163	34	8	35	19	142	171	22	0	194	37
truck	139	611	1045	355	60	34	71	57	215	287	100	8	120	114
bus	7	32	53	6	2	2	3	4	11	12	0	2	13	3
cycle	0	13	6	1	1	1	0	0	0	0	0	0	40	4
other	24	153	218	49	8	6	14	4	27	26	12	1	73	65
over 1	135	598	834	192	49	17	61	35	126	117	52	1	151	67

Table A.2-J. Taxonomy of Vehicle Occupant Deaths in 1991. This table differs from Table A.1-J only by the aggregation of subclasses of light trucks.

Other Vehicle	Vehicle with Deaths										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	679	3081	5074	1259	963	596	3571	512	18	1285	242
car											
0	27	110	146	41	10	8	26	5	0	53	3
1	41	358	402	62	31	35	121	7	1	168	12
2	142	878	1109	277	94	75	303	26	0	367	38
3	58	382	528	129	39	37	158	11	0	130	22
utility	29	194	257	59	25	29	78	3	0	64	7
van	40	241	299	81	16	29	99	9	0	78	5
pickup	102	800	1086	268	80	72	448	34	0	298	52
truck	139	611	1045	355	121	142	542	100	8	120	33
bus	7	32	53	6	4	8	24	0	2	13	1
cycle	0	13	6	1	2	1	0	0	0	40	3
other	7	48	51	13	10	11	36	3	1	39	22
over 1	135	598	834	192	81	100	265	52	1	151	26

Table A.1-K. Taxonomy of Vehicle Occupant Deaths in 1992. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	Vehicle with Deaths													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	856	2599	4699	1117	607	205	276	336	1383	1905	449	15	1114	397
car														
0	34	116	161	32	7	4	12	5	25	19	6	0	54	8
1	59	271	317	65	12	4	22	17	57	55	3	0	143	18
2	164	780	1065	224	64	11	77	41	178	145	22	0	287	42
3	77	376	530	122	30	3	19	28	63	64	9	1	136	22
utility														
1	34	119	159	36	6	3	7	1	22	14	4	0	33	9
2	21	60	75	15	9	3	1	2	7	12	2	0	16	6
van														
1	22	82	116	11	7	1	6	2	21	6	2	0	26	4
2	22	120	210	36	6	5	11	15	30	24	4	0	40	5
pickup														
1	45	259	364	78	13	0	16	9	51	56	8	1	73	12
2	95	468	758	155	38	12	31	17	124	160	12	1	165	39
truck	148	641	1002	325	61	25	81	76	226	307	90	1	83	57
bus	11	46	66	10	1	0	0	1	12	8	3	0	11	8
cycle	0	8	11	0	0	0	1	0	1	0	0	0	40	1
other	17	87	124	44	7	6	8	12	26	14	6	1	41	18
over 1	159	595	870	199	65	11	57	39	134	123	51	8	133	29

Table A.2-K. Taxonomy of Vehicle Occupant Deaths in 1992. This table differs from Table A.1-K only by the aggregation of subclasses of light trucks.

Other Vehicle	Vehicle with Deaths										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	856	2599	4699	1117	887	644	3350	449	15	1114	228
car											
0	34	116	161	32	11	18	45	6	0	54	6
1	59	271	317	65	17	44	114	3	0	143	10
2	164	780	1065	224	81	122	333	22	0	287	22
3	77	376	530	122	34	48	128	9	1	136	19
utility	59	203	270	59	33	18	65	7	0	57	7
van	48	217	351	57	23	38	95	7	0	76	1
pickup	143	750	1142	235	68	79	399	21	2	241	43
truck	148	641	1002	325	90	168	550	90	1	83	25
bus	11	46	66	10	2	3	23	3	0	11	2
cycle	0	8	11	0	1	1	1	0	0	40	0
other	6	25	43	24	7	6	19	3	1	20	13
over 1	159	595	870	199	81	103	263	51	8	133	11

Table A.1-L. Taxonomy of Vehicle Occupant Deaths in 1993. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	**Vehicle with Deaths** car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	656	2563	4825	1140	722	193	296	280	1466	1840	436	9	1069	437
car														
0	32	90	148	29	10	7	7	6	20	15	3	0	48	9
1	47	298	387	82	26	5	19	11	52	48	10	0	144	25
2	143	816	1192	236	80	13	65	53	182	116	30	1	336	45
3	63	332	525	105	19	3	35	15	57	56	12	1	123	18
utility														
1	20	158	218	43	10	3	8	4	22	16	2	0	49	2
2	5	43	81	12	7	1	8	1	11	8	2	0	13	5
van														
1	17	89	156	28	5	1	8	5	18	19	5	0	45	10
2	25	136	182	53	15	1	20	14	25	30	3	0	44	9
pickup														
1	40	252	375	61	21	3	16	6	87	52	6	0	94	16
2	76	484	718	147	48	11	47	22	147	170	18	1	166	49
truck	125	663	1118	305	86	17	109	98	256	294	98	4	101	86
bus	7	23	47	17	9	0	1	3	13	15	1	0	5	1
cycle	3	9	13	1	1	0	1	0	2	4	1	0	22	2
other	20	108	162	30	6	6	13	6	25	38	5	0	52	31
over 1	110	555	901	221	51	17	75	29	149	136	60	2	138	37

Table A.2-L. Taxonomy of Vehicle Occupant Deaths in 1993. This table differs from Table A.1-L only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths** car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	656	2563	4825	1140	989	626	3379	436	9	1069	240
car											
0	32	90	148	29	18	13	38	3	0	48	5
1	47	298	387	82	36	33	105	10	0	144	12
2	143	816	1192	236	102	123	312	30	1	336	17
3	63	332	525	105	25	50	115	12	1	123	13
utility	30	226	335	64	24	25	70	8	0	71	5
van	45	254	380	85	29	60	110	8	0	97	9
pickup	123	754	1122	209	94	100	470	24	1	266	42
truck	125	663	1118	305	118	219	568	98	4	101	41
bus	7	23	47	17	9	4	28	1	0	5	1
cycle	3	9	13	1	2	1	6	1	0	22	1
other	5	36	55	16	5	4	37	1	0	29	22
over 1	110	555	901	221	70	107	300	60	2	138	17

Table A.1-M. Taxonomy of Vehicle Occupant Deaths in 1994. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text.

Other Vehicle	Vehicle with Deaths													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	600	2640	4882	1017	875	200	339	325	1386	1824	491	10	1010	398
car														
0	32	103	138	33	6	3	13	5	30	20	2	0	40	9
1	50	246	362	57	44	7	24	16	58	39	10	0	163	16
2	126	831	1278	227	82	17	59	43	191	141	16	0	312	50
3	62	327	430	86	20	3	24	3	68	51	8	0	86	20
utility														
1	23	169	256	59	10	1	17	1	33	17	2	0	43	6
2	10	45	58	17	5	4	3	2	17	9	0	1	9	4
van														
1	16	99	169	37	9	0	16	2	19	22	3	0	51	1
2	28	132	212	46	13	2	18	12	33	27	6	0	43	6
pickup														
1	46	257	457	88	22	3	21	19	71	57	7	0	70	18
2	79	544	858	174	49	12	61	26	185	185	11	0	149	46
truck	141	651	1171	298	97	16	113	109	293	312	119	5	123	81
bus	5	31	52	9	3	0	3	8	7	5	0	0	7	2
cycle	2	5	8	2	0	0	0	0	0	0	0	0	27	3
other	29	96	164	32	13	7	17	4	33	33	6	0	44	33
over 1	113	566	1014	202	76	12	100	53	140	156	54	2	143	26

Table A.2-M. Taxonomy of Vehicle Occupant Deaths in 1994. This table differs from Table A.1-M only by the aggregation of subclasses of light trucks.

Other Vehicle	Vehicle with Deaths									
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	600	2640	4882	1017	1158	700	3269	491	10	1010	220
car											
0	32	103	138	33	9	18	54	2	0	40	5
1	50	246	362	57	52	41	101	10	0	163	10
2	126	831	1278	227	107	102	340	16	0	312	34
3	62	327	430	86	26	29	120	8	0	86	14
utility	42	241	351	88	27	26	90	2	1	61	7
van	48	247	434	88	28	54	118	9	0	102	5
pickup	129	816	1332	268	98	135	515	18	0	222	40
truck	141	651	1171	298	139	228	616	119	5	123	38
bus	5	31	52	9	3	11	12	0	0	7	2
cycle	2	5	8	2	0	0	0	0	0	27	3
other	12	38	57	9	12	9	37	6	0	24	23
over 1	113	566	1014	202	98	155	302	54	2	143	8

Table A.1-N. Taxonomy of Vehicle Occupant Deaths in 1995. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text (Section 3).

Other Vehicle	Vehicle with Deaths														
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	791	2332	5334	967	998	198	384	315	1565	1933	452	20	959	477
car														
0	49	121	176	37	7	4	8	7	25	22	6	0	43	5
1	42	229	332	55	34	5	20	14	60	56	9	0	134	17
2	153	803	1265	207	86	12	96	48	203	137	13	0	281	63
3	76	248	403	75	26	3	27	18	72	52	12	0	111	19
utility														
1	32	186	267	50	16	1	20	8	36	32	4	0	37	9
2	7	45	71	11	2	0	6	1	12	14	1	0	19	2
van														
1	26	123	206	37	13	4	15	6	28	33	2	0	47	4
2	24	137	221	49	24	1	29	5	46	25	1	0	44	4
pickup														
1	56	290	471	84	27	2	25	10	78	43	6	0	87	28
2	100	522	898	183	87	8	76	41	173	171	10	0	167	33
truck	148	556	1131	290	99	10	133	88	261	331	105	8	92	59
bus	6	38	64	5	3	0	4	9	11	11	0	0	7	2
cycle	1	7	12	1	0	1	1	1	2	0	0	0	26	1
other	20	84	131	37	14	1	7	4	30	25	8	0	45	60
over 1	187	560	1072	217	84	16	81	49	157	156	70	4	122	39

Table A.2-N. Taxonomy of Vehicle Occupant Deaths in 1995. This table differs from Table A.1-N only by the aggregation of subclasses of light trucks.

Other Vehicle	Vehicle with Deaths										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	964	2785	4156	2234	614	374	2801	729	32	1997	444
car											
0	71	162	175	56	9	18	34	16	0	123	17
1	60	272	272	95	17	14	61	17	0	244	19
2	147	764	819	330	50	48	214	31	0	506	59
3	178	740	926	375	37	52	236	48	0	459	58
utility	20	104	103	51	4	7	33	3	0	43	8
van	33	109	217	84	13	8	54	7	0	100	7
pickup	141	678	674	373	36	50	343	31	0	387	64
truck	190	743	1007	639	45	107	545	206	12	250	78
bus	10	46	43	30	0	11	22	0	0	18	4
cycle	3	12	7	5	0	0	5	0	0	77	3
other	37	146	209	111	10	23	78	12	2	81	26
over 1	160	598	699	349	20	53	214	88	11	208	46

Table A.1-O. Taxonomy of Vehicle Occupant Deaths in 1996. The columns indicate in which vehicle the occupants were killed, the rows the other vehicle in a collision. "none" indicates single vehicle crashes, "over 1" collisions involving more than two vehicles. Cars are distinguished by weight, light trucks by body style, as defined in the text (Section 3).

Other Vehicle	**Vehicle with Deaths**													
	car				utility		van		pickup		truck	bus	cycle	other
	0	1	2	3	1	2	1	2	1	2				
none	648	2355	5402	897	1161	200	477	321	1461	1973	433	11	936	388
car														
0	23	84	150	35	18	1	17	2	17	19	2	1	41	13
1	47	223	362	70	40	1	32	8	47	40	12	0	125	23
2	171	743	1329	233	98	10	98	31	172	142	33	3	314	50
3	41	230	397	55	41	8	25	13	58	47	8	0	95	21
utility														
1	43	202	381	55	21	1	23	4	43	41	1	0	57	15
2	11	37	74	9	5	0	10	0	11	9	0	0	11	2
van														
1	22	151	213	39	12	3	15	4	22	30	1	0	36	8
2	31	104	218	22	22	1	25	15	30	33	1	0	39	8
pickup														
1	59	259	456	73	31	3	28	13	71	65	6	0	63	19
2	103	458	963	203	75	9	87	26	190	216	10	0	139	61
truck	111	581	1217	255	114	14	157	102	277	332	108	2	93	63
bus	7	33	62	17	5	1	6	10	11	17	0	0	16	1
cycle	1	6	5	1	2	0	0	0	1	0	0	0	21	5
other	18	86	154	23	9	3	16	4	28	41	3	0	51	26
over 1	121	630	1157	251	77	11	129	65	190	172	53	4	123	42

Table A.2-O. Taxonomy of Vehicle Occupant Deaths in 1996. This table differs from Table A.1-O only by the aggregation of subclasses of light trucks.

Other Vehicle	**Vehicle with Deaths**										
	car				utility	van	pickup	truck	bus	cycle	other
	0	1	2	3							
none	648	2355	5402	897	1437	835	3482	433	11	936	227
car											
0	23	84	150	35	22	19	37	2	1	41	9
1	47	223	362	70	46	43	90	12	0	125	12
2	171	743	1329	233	113	135	319	33	3	314	34
3	41	230	397	55	55	40	105	8	0	95	13
utility	59	269	491	71	29	43	116	1	0	76	17
van	57	270	482	67	49	59	130	4	0	89	8
pickup	165	728	1434	277	128	161	563	16	0	206	54
truck	111	581	1217	255	145	270	613	108	2	93	31
bus	7	33	62	17	6	16	28	0	0	16	1
cycle	1	6	5	1	2	0	1	0	0	21	5
other	6	30	52	9	8	11	36	1	0	25	22
over 1	121	630	1157	251	98	197	364	53	4	123	27