ACCIDENTS ON MAIN RURAL HIGHWAYS RELATED TO SPEED, DRIVER, and VEHICLE

Reported by DAVID SOLOMON
Chief, Safety Research Branch
Traffic Systems Research Division
Office of Research and Development

U.S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, *Secretary*

BUREAU OF PUBLIC ROADS
REX M. WHITTON, *Administrator*

United States Government Printing Office, Washington, D.C. : July 1964

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 - Price 35 cents

PREFACE

Significant information on the relation of speed and characteristics of vehicles and drivers involved in accidents on main rural highways is presented in this publication. It is believed that the material presented here is the first based on a nationwide study from which it has been possible to develop an understanding of these relationships. The study was confined to 2- and 4-lane main rural highways of the nonfreeway type, and the findings are limited to these types of main rural highways.

One of the important findings of this study is that the greater the differential in speed of a driver and his vehicle from the average speed of all traffic, the greater the chance of that driver being involved in an accident. For example, a driver traveling at 40 or 80 miles per hour in relation to an average speed of 60 miles per hour for all traffic has a substantially greater chance of being involved in an accident than a driver traveling at the average speed. But, if the average travel speed were only 40 miles per hour on a section of highway, the possibility of a driver being involved in an accident would be least at the average travel speed of 40 miles per hour.

The research that provided the information for this publication was conducted with the cooperation of the States of Arizona, California, Connecticut, Iowa, Minnesota, Missouri, Montana, New Jersey, North Carolina, Oregon, and Virginia. The personnel of the State highway departments in the participating States cooperated in obtaining and tabulating field data. Considerable help was also provided by the motor vehicle and police departments in the participating States.

Many Bureau of Public Roads personnel made substantial contributions to the planning and conduct of the study; particularly Edward H. Holmes, Charles W. Prisk, Asriel Taragin, and Curtis L. Shufflebarger, Jr.

CONTENTS

TABLES AND FIGURES

TABLES

TABLES—Continued

TABLES—Continued

FIGURES

Part I.—INTRODUCTION AND SUMMARY

The relationship between speed, characteristics of drivers and vehicles, and accidents is of principal importance to an understanding of highway traffic operations and safety. Many of these relationships have not been clearly understood in the past. To better define these fundamental relationships, 11 States and the Bureau of Public Roads cooperated in a study of accident involvements related to characteristics of normal traffic on 600 miles of main rural highways in the United States. The accident records of nearly 10,000 drivers, speed observations, and interviews with 290,000 drivers using these highways provided the basic data for analysis in the study reported in this publication. The results of this study were summarized in a report to the Congress, *The Federal Role in Highway Safety*.[1] The present report extends the analysis and provides much greater detail than the earlier summary.

In the course of the study, speed and other characteristics such as age, sex, military status, and residence of the driver; types of vehicles; and the horsepower, body style, and age of passenger cars were related to accidents. Involvement rate was the key to the analysis problem. Accident reports, for example, frequently show the estimated travel speeds of vehicles involved in highway accidents. It is not enough, however, to know that a certain number of drivers involved in accidents were traveling at a particular speed; it is also essential to determine how much driving was done at that same speed. Then, by relating the travel speeds of accident-involved drivers and of all drivers, it is possible to determine the hazard associated with specific driving speeds—the accident-involvement rate. Simply put, an accident involvement is one driver or one vehicle in one accident. Involvement rate represents the number of involvements per 100 million miles of travel.

A description of the procedure used in obtaining the data and the resultant findings relating speed, driver, and vehicle characteristics to reported accidents on main rural highways in the United States are included in this publication. Apart from the accident analysis, some subsidiary analyses of travel patterns and speed also have been included.

Summary

The principal findings of this study in relation to reported accidents on 2- and 4-lane main rural highways (not freeways) are summarized in the following statements.

- The accident-involvement, injury, and property-damage rates were highest at very low speeds, lowest at about the average speed of all traffic, and increased at the very high speeds, particularly at night. Thus, the greater the variation in speed of any vehicle from the average speed of all traffic, the greater its chance of being involved in an accident.

- The severity of accidents increased as speed increased, especially at speeds exceeding 60 miles per hour.

- The fatality rate was highest at very high speeds and lowest at about the average speed.

- Pairs of passenger-car drivers involved in two-car, rear-end collisions were much more likely to be traveling at speed differences greatly in excess of those observed for pairs of cars in normal

[1] *The Federal Role in Highway Safety*, House Doc. 93, 86th Cong., 1st sess., 1959, pp. 71–84

traffic. For example, fully one-third of accident-involved pairs of drivers were traveling at speed differences of 30 miles per hour or more, compared to only 1 percent of pairs of cars in normal traffic.

- Passenger-car drivers under 25 years of age and more than 65 years of age had the highest involvement rates.

- When more than 35 years of age, female passenger-car drivers consistently had higher accident-involvement rates than male drivers. Fewer consistent differences between the two sexes were noted when drivers were less than 35 years of age.

- Involvement rates for members of the Armed Forces were about twice as great as the non-members in comparable age groups.

- Local drivers tended to have higher involvement rates than other drivers, particularly at night.

- During the day, for passenger cars and trucks only small differences existed in involvement rates. However, at night passenger car involvement rates were nearly three times as great as those for trucks having six or more tires.

- Drivers of passenger cars having low horsepower had higher involvement rates than drivers of cars having higher horsepower, regardless of the other variables studied. This may be related to the relatively poor acceleration capability at highway speeds of cars having low horsepower.

- Drivers of older cars had higher involvement rates than drivers of newer cars, but this may have been at least partly related to the low horsepower and poor acceleration of the older cars.

- Difference in makes of passenger cars had little effect on involvement rates.

- The range in involvement rates was considerable, the rate depending on the combinations of driver and vehicle characteristics studied. For example, drivers 40 years of age, traveling at 65 miles per hour in cars 2 years old that had 200 horsepower, averaged only one reported accident in 1,600,000 miles of driving. In contrast, drivers 18 years of age, traveling at 30 miles per hour in cars 6 years old that had 100 horsepower, averaged one reported accident in 12,000 miles of driving. This example merely demonstrates the extremes in involvement rates obtained in the study. Moreover, these and other findings are averages for specific driver groups, are not applicable to individual drivers, and do not prove that individual identifiable drivers are accident prone. The findings in the study reported here do show that as a group some specific classes of drivers are more likely to be involved in accidents than other classes of drivers. Very slow speeds and, to a lesser extent, youth of the drivers had the greatest effect on the involvement rate.

- Computation of injury rates on an occupant-mile basis showed the highest injury rate for occupants of the front left and right seats. The injury rate was about one-half as great for occupants of the center front, left rear, and right rear seats; and one-third as great for occupants of the center rear seats.

- Nearly half of all accident involvements were either rear-end collisions or same-direction sideswipes. However, the proportion of these accident involvements decreased as travel speed increased. Single vehicle, noncollision accident involvements contributed an increasingly greater proportion of all accident involvements as speed increased, particularly at speeds of more than 70 miles per hour. At speeds of 80 miles per hour, noncollision accidents constituted half of all involvements. Although angle collisions usually were less than 15 percent of the total, at speeds of less than 25 miles per hour they constituted more than one-third of all accident involvements. The proportion of head-on collisions or opposite-direction sideswipes increased as speed increased; but this type of accident involvement always was less than 20 percent of the total regardless of speed and day or night conditions.

- Rear-end collisions were the predominant type of collision for every age group; however, drivers over the age of 65 also tended to be involved in angle collisions, and younger drivers also tended to have noncollision accidents that involved only their own vehicle.

- Accidents involving many vehicles were rare. For example, only 1 percent of all accidents involved four or more vehicles and less than 0.1 percent involved six or more vehicles.

- Sex and age of drivers affected the proportionate distribution of travel on main rural highways. Female drivers performed only 13 percent of the day travel and only 7 percent of night travel. Male drivers between 20 and 55

years of age performed the greatest amount of travel per registered driver—older drivers reduced their travel even more at night.

• The mean speed and the variability in speeds showed only a moderate variation for nearly all driver and vehicle characteristics studied. There was a slight decrease in mean speed as age of driver and age of passenger car increased. Average truck speeds were several miles per hour slower than passenger car speeds. The speeds of passenger cars were directly related to their horsepower, speed being greater for those in the higher horsepower groups.

Table 1.—General characteristis of study sections

Study section	State	Location	Length	1957 ADT	Access control	Intersections	Driveways		Terrain
							Business	Residential	
2-LANE SECTIONS									
			Miles			*Number per mile*	*Number per mile*	*Number per mile*	
1	Montana	FAI-15-Wolf Creek to Cascade	31.4	1,000	None	0.2	0.3	1.5	Mountainous.
2	do	FAI-15 Termini FAS 279 to Wolf Creek	27.2	1,100	do	0.2	0.2	0.3	Do.
3	do	FAI-15 Vaughn Junction to Conrad	47.5	1,200	do	1.0	0.1	0.4	Level.
4	Iowa	Iowa 3 from Iowa 241 to Iowa 150	16.1	2,000	do	0.9	0.0	2.2	Rolling.
5	Minnesota	T.H. 52 Rochester to Chatfield	15.5	2,100	do	1.5	0.4	3.2	Do.
6	Virginia	Route 17 Essex County	20.3	2,200	do	1.0	1.9	6.9	Level.
7	Iowa	U.S. 34, Monroe County line to Ottumwa	10.6	2,300	do	1.3	0.4	3.6	Rolling.
8	Arizona	U.S. 80 Dateland	37.0	2,800	do	0.4	0.5	0.1	Level.
9	Missouri	Route 36 West of Chillicothe	11.6	2,900	do	1.2	0.5	3.9	Rolling.
10	North Carolina	U.S. 258 from Richlands to the Junction of North Carolina 53.	10.0	2,900	do	1.2	1.6	7.6	Level.
11	Arizona	St. 69 near New River	31.8	2,900	do	0.5	0.7	0.2	(1)
12	Connecticut	U.S. 44 in Norfolk, Colebrook, Winchester	6.2	3,300	do	1.9	2.9	5.3	Rolling.
13	North Carolina	U.S. 1 from Manly to Tramway	15.0	3,300	do	1.1	1.0	4.0	Do.
14	Oregon	U.S. 20 Albany to Lebanon	10.7	3,700	do	1.7	1.9	11.2	Level
15	Missouri	Route 71 from 35 to the Bates County line	10.4	3,800	do	1.0	0.3	3.8	Rolling.
16	New Jersey	U.S. 206 in Burlington County	20.0	3,800	do	3.2	3.4	8.1	Level.
17	Minnesota	T.H. 14 Mankato to East Section T.H. 60	7.0	3,900	do	1.7	0.7	5.6	Rolling.
18	Arizona	U.S. 66 in Winslow County	20.0	4,100	do	0.2	0.4	------	Level.
19	Oregon	U.S. 30, Scappose to St. Helens	6.1	4,300	do	2.8	2.5	1.6	Do.
20	Iowa	U.S. 30, near West Corner section 10-82-7W	12.2	4,500	do	1.3	0.2	2.3	Rolling.
21	Minnesota	T.H. 13 between T.H. 65 and T.H. 100	8.2	4,600	do	2.8	0.6	3.0	Do.
22	Missouri	Route 40 East of Columbia in Boone and Callaway Counties.	9.8	4,800	Partial	1.3	0.2	2.6	Do.
23	California	U.S. 99 West (FAI 81) 12 miles South of Willows.	91.0	5,200	None	1.3	1.3	2.6	(1)
24	North Carolina	U.S. 301 from Weldon to Enfield	15.0	5,900	do	0.7	1.7	8.2	Level.
25	Minnesota	T.H. 169 Mankato to St. Peter	8.2	6,200	do	1.2	0.7	2.3	Rolling.
26	Connecticut	Connecticut 95 in Groton to Junction Connecticut 27.	5.5	6,600	do	3.8	6.6	7.7	Do.
27	do	Connecticut 8 in Trumbull, Stratford, Shelton	5.5	8,500	do	1.8	3.6	4.2	Do.
4-LANE SECTIONS									
28	Virginia	Route 60 in New Kent County	18.9	5,000	None	1.6	3.0	3.1	Level.
29	Minnesota	T.H. 10, St. Cloud to Becker	15.4	5,600	Partial	1.5	0.5	0.6	Rolling.
30	Missouri	Route 66 West of Rolla in Phelps County	7.6	7,100	do	1.3	0.3	3.4	Do.
31	New Jersey	U.S. 130 in Middlesex County	9.1	11,200	None	3.2	4.6	3.0	Level.
32	do	U.S. 1 in Middlesex County	9.8	14,100	do	2.6	6.5	9.5	Do.
33	California	U.S. 40 (FAI 92) 3 miles West of Davis	16.4	14,600	Partial	1.0	0.4	0.7	Do.
34	do	U.S. 99 (FAI) 2 miles South of Lodi	7.2	16,900	do	2.5	7.8	15.6	Do.
35	Connecticut	Connecticut 15, Wilbur Cross Highway	8.4	24,100	Full	(2)	0.0	0.0	Rolling.

[1] One-half level, other half rolling terrain. [2] 4 access ramps.

Part II.—STUDY PROCEDURE

The 600 miles of main rural highways on which the studies were conducted were comprised of 35 different sections in 11 States. The participating States were Arizona, California, Connecticut, Iowa, Minnesota, Missouri, Montana, New Jersey, North Carolina, Oregon, and Virginia.

Study Sections

Individual study sections were between 5 and 50 miles long, except for one section that was 91 miles long; the average section length was 17 miles. Characteristics of the study sections are enumerated in table 1. Of the study sections, 27 were 2-lane highways on which average traffic volumes ranged from 1,000 to 8,000 vehicles per day. Eight sections were 4-lane divided highways on which average traffic volumes ranged from 5,000 to 24,000 vehicles per day. Only one of the 4-lane sections had full control of access, four had partial control, and three had none. On the average, each 3 miles of the highways studied had four intersections and two entrances to roadside businesses. Two of the study sections were in mountainous terrain; the remainder of the sections were about equally divided between level and rolling terrain.

Design characteristics of the study sections are shown in table 2. Lanes were generally 10 to 12 feet wide, and portland cement concrete and bituminous surfaces were equally represented. Shoulders were usually at least 4 feet wide, and shoulders of half of the sections were at least 8 feet wide. The shoulders were predominantly of gravel, but some were of a low-type of bituminous material. On 4-lane sections, the median was generally grass and between 10 and 50 feet wide. The design speed was 60 or 70 miles per hour for thirty-one of the sections, but on four of these sections the design speed dropped to 40 or 50 miles per hour for short distances. The other four sections had design speeds of 35 or 45 miles per hour.

Speed limits

The day legal speed limit for passenger cars on 28 of the sections varied between 55 and 70 miles per hour. Two sections had a 45-mile-per-hour limit and the five others had a "reasonable and proper" or similar subjective types of speed limits. Night speed limits were 5 or 10 miles per hour lower than the day limits for about half of the study sections. On eight of the sections, both day and night speed limits for trucks were lower than for passenger cars, by 5 to 15 miles per hour.

Average day speeds recorded for drivers at individual study sites ranged from 42 to 59 miles per hour, as shown in table 3; the overall median speed was 50 miles per hour. The average or arithmetic mean speed was slightly higher, 52 miles per hour. Night driving speeds at most locations were similar to those measured during the day, and the overall night and day averages were nearly identical.

Other characteristics

The proportion of male drivers during the day ranged from 81 to 94 percent on the individual study sections, and the overall median was 87 percent. At night, the proportion of male drivers ranged from 85 to 98 percent, and the overall median was 93 percent. Because of the preponderance of male drivers on main rural highways, many studies and operational activities can be directed to them alone with assurance that nearly all drivers will be included.

Among the individual study sections, the average age of drivers during the day ranged from a low of 36 years to a high of 43 years, a rather narrow

Table 2.—Design characteristics of study sections

Study section	Pavement		Shoulder		Median		Design speed	Speed limit			
	Lane width	Type	Width	Type	Width	Type		Passenger cars		Trucks	
								Day	Night	Day	Night
2-LANE SECTIONS											
	Feet		*Feet*		*Feet*		*M.p.h.*	*M.p.h.*	*M.p.h.*	*M.p.h.*	*M.p.h.*
1	10	Bituminous	2	Gravel	NA	NA	60	65	55	50	50
2	10	Btuminous	2	Gravel	NA	NA	60	65	55	50	50
3	12	Bituminous	2	Gravel	NA	NA	70	65	55	50	50
4	9	Portland cement concrete	6	Gravel and earth	NA	NA	45	[11] R	60	50	50
5	10	Portland cement concrete	10	Gravel	NA	NA	60	60	50	60	50
6	10, 11	Bituminous	4–10	Gravel	NA	NA	[8] 60	55	55	45	45
7	9	Portland cement concrete	8	Gravel and earth	NA	NA	35	[11] R	60	50	50
8	12	Bituminous	8	Mixed bituminous	NA	NA	70	60	50	60	50
9	10	Bituminous	5	Earth	NA	NA	35	[12] 70	[12] 65	[12] 70	[12] 65
10	11	Bituminous	8	Grass	NA	NA	60	55	55	55	55
11	12	Bituminous	8	Bituminous surface treatment.	NA	NA	70	60	50	60	50
12	11	Portland cement concrete	8	Oiled	NA	NA	[10] 60	50	50	50	50
13	11	Portland cement concrete	12	Grass	NA	NA	[9] 60	55	55	55	55
14	11	Bituminous	7	Gravel	NA	NA	[5] 70	[11] R	[11] R	[11] R	[11] R
15	12	Bituminous	4	Earth	NA	NA	35	[12] 70	[12] 65	[12] 70	[12] 65
16	10	Portland cement concrete [1]	10	Oiled	NA	NA	(9)	50	50	50	50
17	10	Portland cement concrete	10	Sodded	NA	NA	70	65	55	65	55
18	12	Bituminous	8	Mixed bituminous	NA	NA	70	60	50	60	50
19	10	Bituminous	10	Gravel	NA	NA	[6] 70	[11] R	[11] R	[11] R	[11] R
20	12	Portland cement concrete	10	Gravel and earth	NA	NA	60	[11] R	60	50	50
21	12	Bituminous	6	Gravel	NA	NA	70	60	50	60	50
22	12	Portland cement concrete [2]	10	Earth	NA	NA	60	[12] 70	[12] 65	[12] 70	[12] 65
23	10, 11, 12	Bituminous [3]	0–6	Bituminous	NA	NA	60	55	55	55	55
24	11	Bituminous	8	Grass	NA	NA	[6] 60	55	55	55	55
25	12	Bituminous	6	Gravel	NA	NA	60	60	50	60	50
26	11	Portland cement concrete	10	Oiled	NA	NA	[10] 60	45	45	45	45
27	11	Portland cement concrete	8	Oiled	NA	NA	[10] 70	45	45	45	45
4-LANE SECTIONS											
28	9, 10, 12	Portland cement concrete [1]	4–10	Grass	30–300	Grass, depressed.	[7] 70	55	55	45	45
29	11, 12	Bituminous [2]	6, 8	Gravel	52	Depressed	70	65	55	65	55
30	12	Portland cement concrete	8–10	(9)	40	(9)	60	[12] 70	[12] 70	[12] 70	[12] 70
31	10, 11, 13. 5	Portland cement concrete	8	Gravel	15–30	Grass	(9)	50	50	50	50
32	12	Portland cement concrete	5	Crushed stone	12	Grass with curbs.	(9)	50	50	50	50
33	11, 12, 13	Bituminous [3]	3, 6	Bituminous	[4] 32	Earth	60	55	55	55	55
34	10, 11, 12	Bituminous [3]	2–9	Bituminous	36	High shrubs	60	55	55	55	55
35	12	Portland cement concrete	8	Oiled	10	Grass, depressed.	[10] 70	55	55	55	55

[1] 4 to 30 percent is bituminous.
[2] 50 percent is portland cement concrete.
[3] 5 to 26 percent is portland cement concrete.
[4] 15 percent has a median 6 to 8 feet wide.
[5] 10 percent of section at 40 m.p.h.
[6] 10 to 15 percent of section at 50 m.p.h.
[7] 30 percent of section at 60 m.p.h.
[8] 35 percent of section at 70 m.p.h.
[9] Unknown.
[10] Estimated.
[11] R=Reasonable and proper, basic rate, or a similar subjective limit.
[12] R prior to Aug. 30, 1957.

range. At night, the average age was several years younger.

The average horsepower of passenger cars being driven during the day on the individual study sections ranged from a low of 132 horsepower to a high of 159 horsepower. At night, the range was about the same. These averages, of course, apply to the cars in use during 1954–58. Today the situation may be slightly different.

The proportion of military drivers using the individual study sections differed considerably. During the day the range was from 1 to 14 percent; at night from less than 1 percent to 32 percent. Obviously, the closeness to military installations affects the proportion of military drivers. The percentage of out-of-State drivers on the individual study sections ranged from 3 to 88 percent in the day and from 2 to 76 percent at night. The percentage of commercial vehicles was from 12 to 39 percent during the day and from 5 to 79 percent at night. During the day, the average age of passenger cars on the individual study sections ranged from 3.6 to 5.5 years. The range in age at night was nearly identical.

The 35 study sections are believed to represent a reasonable cross section of main rural highways

Table 3.—Characteristics of drivers and vehicles by study sections, day and night

Study section	State	Driver characteristics										Vehicle characteristics					
		Average speed, m.p.h.		Average age		Percent male		Percent military		Percent out-of-State		Percent commercial		Average age of passenger car		Average horsepower of passenger car	
		Day	*Night*	*Day*	*Night*	*Day*	*Night*	*Day*	*Night*	*Day*	*Night*	*Day*	*Night*	*Day*	*Night*	*Day*	*Night*
2-LANE SECTIONS																	
1	Montana	52.1	47.3	41.2	36.4	90.3	93.5	2.3	0.0	17.3	9.1	20.9	27.5	4.1	4.1	146	140
2	Montana	52.7	50.5	41.8	36.1	88.5	98.3	2.0	3.1	2.7	14.5	22.2	52.1	4.2	4.4	147	139
3	Montana	57.0	54.3	41.1	41.8	88.0	85.1	1.2	0.6	10.8	3.2	21.9	30.0	3.9	3.7	151	160
4	Iowa	55.9	54.0	41.4	38.2	87.1	88.3	0.8	0.1	29.9	16.3	24.3	19.8	4.1	4.4	149	138
5	Minnesota	53.7	(1)	41.1	(1)	83.1	(1)	0.7	(1)	25.1	(1)	12.1	(1)	4.7	(1)	135	(1)
6	Virginia	49.6	51.6	40.1	32.3	86.0	95.0	13.6	32.0	45.5	36.8	18.4	21.3	3.6	4.2	159	143
7	Iowa	47.1	44.9	42.3	37.5	85.0	93.3	1.7	1.0	13.5	10.3	19.0	12.6	5.1	4.9	133	133
8	Arizona	53.0	50.8	43.0	37.5	86.7	91.9	4.1	7.3	74.1	60.0	31.4	35.5	3.9	4.6	156	146
9	Missouri	49.8	44.7	41.3	39.7	88.6	95.7	3.7	4.0	31.3	37.8	28.5	49.6	4.0	4.1	144	150
10	North Carolina	49.0	47.7	36.5	33.7	86.6	85.4	9.7	25.7	12.3	28.4	24.8	9.2	4.2	4.1	138	138
11	Arizona	50.9	52.3	42.6	40.4	85.4	90.3	1.6	0.6	22.6	17.6	25.8	34.1	4.1	4.3	153	151
12	Connecticut	43.7	43.5	41.7	37.0	81.1	91.1	1.1	0.9	26.3	28.7	20.0	27.3	4.5	4.4	141	144
13	North Carolina	48.1	42.0	39.5	35.1	85.2	92.3	5.4	6.6	44.3	39.9	18.4	16.8	3.8	4.0	150	147
14	Oregon	46.9	47.4	41.3	35.4	84.2	88.8	0.9	3.0	6.0	2.7	22.0	6.5	5.3	5.7	132	132
15	Missouri	49.0	48.0	41.8	37.3	89.6	97.5	1.1	1.3	22.1	28.3	26.8	50.5	4.2	4.4	142	138
16	New Jersey	47.2	48.7	40.4	38.2	88.2	95.3	3.5	3.9	26.7	10.8	25.1	64.1	4.2	4.6	143	141
17	Minnesota	50.9	(1)	40.9	(1)	84.6	(1)	0.7	(1)	10.5	(1)	11.8	(1)	5.0	(1)	134	(1)
18	Arizona	53.4	49.9	40.6	36.2	85.2	89.3	2.7	3.5	87.9	76.2	24.1	18.9	3.8	3.9	154	150
19	Oregon	43.7	39.8	42.7	38.2	84.1	92.6	0.6	0.0	7.6	1.5	19.4	5.5	5.5	5.0	131	137
20	Iowa	52.5	51.0	40.4	36.9	88.8	95.3	1.2	0.9	39.6	27.1	31.7	29.7	4.0	4.4	148	142
21	Minnesota	50.2	(1)	39.9	(1)	88.4	(1)	1.5	(1)	6.8	(1)	14.0	(1)	4.4	(1)	141	(1)
22	Missouri	52.1	53.1	40.0	33.9	91.1	94.7	3.0	4.2	30.3	23.6	25.1	35.5	3.9	4.2	148	141
23	California	57.3	54.0	41.6	37.5	84.3	96.4	----	-----	18.3	16.3	22.5	53.8	4.4	5.0	143	139
24	North Carolina	46.4	41.5	42.2	35.1	87.0	93.5	4.6	15.4	70.7	64.6	21.5	16.3	3.7	4.3	156	142
25	Minnesota	49.5	(1)	40.2	(1)	86.5	(1)	0.9	(1)	9.5	(1)	15.2	(1)	4.5	(1)	141	(1)
26	Connecticut	41.8	44.2	40.5	37.6	80.6	94.0	6.1	4.8	40.0	64.4	15.8	42.0	4.7	5.5	137	129
27	Connecticut	44.6	47.4	40.1	36.5	88.6	94.7	0.5	0.1	10.3	11.3	19.6	21.7	4.6	4.9	140	141
Median		49.8	48.0	41.3	37.0	86.6	93.5	1.7	3.1	22.6	23.6	21.9	27.5	4.2	4.4	143	141
4-LANE SECTIONS																	
28	Virginia	48.8	50.3	40.3	37.2	87.0	92.2	6.5	8.9	20.9	11.3	18.5	20.0	3.8	4.0	156	153
29	Minnesota	57.1	(1)	41.0	(1)	89.0	(1)	1.5	(1)	15.5	(1)	18.6	(1)	4.1	(1)	143	(1)
30	Missouri	52.7	48.5	38.5	34.8	88.3	95.4	12.8	18.1	44.4	42.1	23.5	51.2	4.0	4.2	146	142
31	New Jersey	47.9	49.8	39.4	38.4	93.8	98.2	3.6	0.8	30.8	55.9	38.7	79.5	4.3	4.5	140	141
32	New Jersey	46.2	50.4	39.6	39.1	90.0	96.3	1.1	1.3	32.0	52.0	20.1	54.7	4.1	4.6	146	145
33	California	58.9	58.2	40.9	37.5	86.9	89.9	----	-----	11.6	6.6	16.2	41.4	4.3	4.6	146	146
34	California	55.2	56.5	40.8	36.9	86.3	87.6	----	-----	7.9	8.7	21.8	27.0	4.8	5.4	141	138
35	Connecticut	51.4	51.2	40.4	37.6	85.0	90.8	2.4	2.3	54.8	49.0	12.2	35.3	3.9	3.9	148	146
Median		52.1	50.4	40.4	37.5	87.7	92.2	3.0	2.3	25.9	42.1	19.3	41.4	4.1	4.5	146	145
Median for 2 and 4 lanes confined		50.2	49.9	40.8	37.3	86.9	93.4	1.9	3.0	22.6	25.3	21.5	29.9	4.2	4.4	144	141

[1] No data available.

in the United States. It is important to note here that more than half of all highway travel in the United States takes place on rural highways and nearly three-fourths of the rural travel is on main rural highways. Thus, the study sections are representative of highways that accommodate more than one-third of all the vehicle-miles of highway travel in the United States.

Speed Measurements

The average speeds along each study section were first determined by having a driver-observer-recorder team drive a test car over the highway, moving it with the normal flow of traffic and recording its speed at periodic intervals. A number of runs were made and the speed was averaged. A speed profile was drawn showing the average speed in each direction at intervals along the selected highway section. These profiles were studied by State highway department engineers, who selected a site in each section as being representative of the average speed for the entire section. Care was taken in selecting these specific sites for measuring speeds to ensure that representative speed distribution would be obtained. Reduced speed zones and other controlling conditions having a major effect on speed were not selected.

Spot speed observations

Spot speed observations at the selected sites were made during 1957 and 1958 for 290,000 drivers. The speed data obtained presumably is representative of the speed of daily traffic at

typical locations on main rural highways. Concealed, speed measuring devices were used to record the speed of individual drivers at the selected sites on each of the 35 study sections. These speed measurements were made during day and night hours, on weekdays and Sundays, and in the different seasons of the year.

Interview Data

At a distance beyond and well out of sight of the speed observation points, the drivers were stopped and interviewed to obtain information on characteristics other than speed such as the sex, age, military status, and residence of driver; and the type of vehicle including the model year, make, number of cylinders, and body style of passenger cars. Horsepower of the passenger cars was determined from related data in automobile catalogs. The seated locations of passenger-car occupants were also observed and recorded.

Accident Data

Source of the accident data for the analysis was the reports for 10,000 drivers and their vehicles that had been involved in accidents on the 600 miles of rural highways studied. These records were for all accidents that had occurred on the study sections during a period of 3 or 4 years (ending June 30, 1958) and that had been reported to the State authorities. For each driver involved in each accident, information was obtained on his speed and on all other items obtained in the roadside interviews such as sex, age, etc. In addition, these records contained information on the amount of property damage, as estimated by the police officer or sometimes by the driver reporting the accident.

The travel speed of accident-involved drivers was used; that is, the estimated speed at which the driver was traveling prior to the occurrence of the accident. This was not the speed at the moment of impact, but the normal speed of the driver before he was aware of an impending accident. An attempt was made to obtain impact speeds for analysis purposes, but the data were too incomplete to warrant analysis. Travel speed is of greater importance in the analysis because it permits correlation of speeds of accident-involved and nonaccident-involved drivers and permits prediction of accident probability based on normal travel speeds. About 21 percent of the accident-involvement reports contained no estimate of travel speed. For these involvements, the travel speeds were prorated on the basis of the other driver and vehicle characteristics studied. Similar procedures were applied when other data were incomplete—the amount of this incomplete data was relatively small.

Expansion Procedure

Because the accident data were collected over a period of 3–4 years, whereas the interviews and speed measurements were obtained during a single 12-month period, it was necessary to employ an expansion procedure to make the interview data applicable over a span of 3 to 4 years. In this procedure, traffic volume data for the 3–4 year-period were utilized to obtain a basic vehicle-mile estimate toward which the interview data were expanded. Then, the interview data were weighted according to the relative travel during the season of the year that the interview represented. The scrapping of older cars and the entrance of newer cars into the market during the different seasons of the year also was considered. Moreover, in the expansion to back years, corrections were made for differing amounts of travel by newer and older cars. A cross check of the results showed that those obtained with data from the expansion procedure corresponded closely to those obtained from utilization of the interview and accident data for a single year.

Statistical Reliability

On a unit basis, accident data were more difficult and expensive to obtain than interview and speed data. Accordingly, a much larger volume of the latter type of data were obtained—on the average, nearly 30 times as much. This permitted the statistical reliability of the involvement rate to be based on the number of accidents alone because the number of accidents nearly always was much smaller than the number of interviews or speed observations and therefore governed the reliability of the computed rates.

Only involvement rates are shown in some of the more complex tables in this publication, such as tables 9–16; the number of involvements and the vehicle-miles of travel upon which the rates were based have been omitted to permit easier comparisons of the rates. These rates were usually based on at least 30 involvements. When between 10 and 29 involvements were employed

in the calculation, this has been indicated by a footnote in the table. No rates were calculated for less than 10 involvements. This procedure was followed to ensure that the rates were based on an adequate number of accident involvements.

If it is assumed that accident involvements are distributed according to a Poisson Distribution—a reasonable assumption for these rare events—certain statements may be made relative to the statistical reliability of the involvement rates: For 30 accident involvements, 9 of every 10 computed rates will be within 30 percent of the rate expected for an infinitely large sample of accidents; but for only 10 accident involvements, 9 of every 10 computed rates will be within 60 percent of the rate expected for an infinitely large sample of accidents.

On another approach, if two cells have sample sizes of about 30, a difference in involvement rate of 30 percent or more between them could only occur by chance one time in 20 (0.05 level). For the study reported here, differences in involvement rates greater than 30 percent between two cells frequently occurred and, therefore, this method of determining statistical reliability was considered adequate. Moreover, many of the cells were comprised of sample sizes much larger than 30.

Part III.—STUDY FINDINGS RELATED TO SPEED

In the discussion that follows, "accident-involved drivers" are those for whom data were obtained from the accident reports. "Interviewed drivers" are those for whom speeds were observed and who were later interviewed on the study sections, the interviewed group was considered to be a sample representative of all drivers.

Comparison of Speed Distributions

From the speed estimates in the accident reports and from the speed measurements on the highway, the number of accident-involved drivers and interviewed drivers who were traveling at different speeds were tabulated. Converted to a percentage basis, the daytime data are plotted in figure 1, the percentage scale is at the left. The two curves indicate the percentages of drivers in each group that traveled at different speeds. If the two speed distributions had been the same, the two curves would have been identical also thus indicating that the chance of being involved in an accident would be the same at all speeds. But the curves are entirely different.

The largest proportion of both groups traveled at 50 miles per hour (47½–52½ m.p.h.). Fully 25 percent of the interviewed drivers traveled at that speed, but only 17 percent of the accident-involved drivers were traveling at 50 miles per hour prior to the accident. The relation of the two curves indicates that a larger proportion of accident-involved drivers were traveling at lower speeds than the interviewed drivers. Conversely, a larger proportion of interviewed drivers than accident-involved drivers traveled at the higher speeds. For example, 13 percent of the interviewed drivers traveled at 60 miles per hour compared with only 7 percent of the accident-involved drivers.

Thus, within the limits of the study, there is an unmistakable indication that low-speed drivers are more likely to be involved in accidents than relatively high-speed drivers. Note that at extremely high speeds, approaching 80 miles an hour, the difference would disappear.

Relation of Total Travel, Speed, and Involvements

A study of accident involvement based only on percentages of accident-involved drivers traveling at different speeds fails to consider the mileage of travel. The number of drivers involved in accidents at any particular speed must be related to the amount of travel at that speed. To establish this relationship, a determination had to be made of the total vehicle-miles of travel on the study sections during the 3- or 4-year period covered by the accident data. Traffic volume counts taken at periodic intervals by automatic counters placed along the highway formed the basis for this calculation. The number of vehicles counted during the period, multiplied by the length of the section in miles, gave the total vehicle-miles of travel.

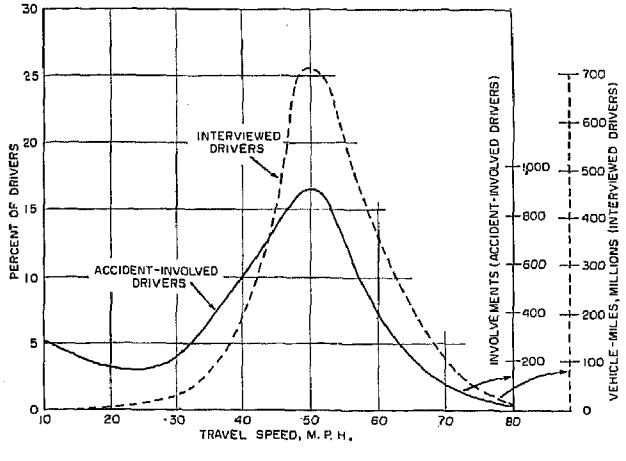

Figure 1.—Travel speeds of accident-involved and interviewed drivers, day.

Table 4.—Ratio of night to day involvement rates by travel speed

Travel speed	Night-to-day accident-involvement rates
M.p.h.	*Ratio*
1–23	0.5
23–32	1.4
33–37	2.0
38–42	1.9
43–47	2.3
48–52	2.0
53–57	2.0
58–62	2.5
63–72	3.5
73 or higher	7.2
ALL SPEEDS	2.0

The total travel mileages were distributed among the speed groups, in relation to the speed measurements taken on the highway. If 10 percent of the drivers, for example, were traveling at 40 miles per hour, then 10 percent of the vehicle-miles of travel was assigned to that speed. Account was taken of hourly, daily, and seasonal variations so that the distribution would properly represent the period for which accident records were available.

The two scales at the right of figure 1 apply to the accident and travel information; these scales are related to the same curves used to represent percentage distributions. The solid-line scale and curve indicate the number of accident-involved drivers; the dash-line scale and curve indicate the vehicle-miles of travel for interviewed drivers. These curves show, for example, that at 50 miles per hour 911 drivers were involved in accidents when total travel was 715 million vehicle-miles.

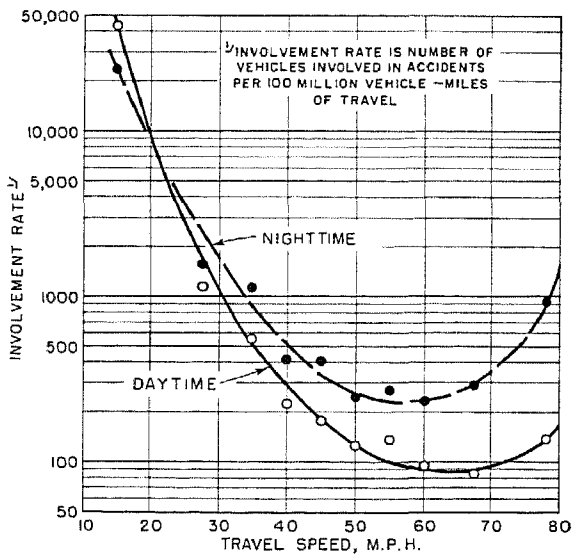

Figure 2.—Involvement rate by travel speed, day and night.

Accident Involvement Rate

By use of the number of accident-involved drivers and total mileage for each range of speed, accident-involvement rates were calculated. These rates were determined by dividing the number of accident-involved drivers by the related vehicle-miles of travel. For the 50-mile-per-hour example, the accident-involvement rate would be 127—the result obtained when 911 was divided by 7.15 (using the commonly accepted travel unit of 100 million vehicle-miles). This accident-involvement rate is in effect a measure of the chance of a driver being involved in an accident at any particular driving speed.

Similar computations were made for each speed group, and the results have been plotted as the solid curve in figure 2. A semilogarithmic scale was employed so that the extreme ranges in involvement rates for the different speeds could be shown on a single graph. The solid curve illustrates that during the day the involvement rate was highest for the very low-speed drivers; the involvement rate reached a low point at about 65 miles per hour, and beyond that speed increased. During the day, a driver traveling at a speed of 20 miles per hour on main rural highways is about 100 times more likely to become involved in an accident than a driver traveling at a speed of 65 miles per hour.

Night accident-involvement rate

The dashed curve in figure 2 shows the accident-involvement rate at night for different travel speeds. Again, the highest involvement rate was at the very low speeds and the lowest rate at moderately high speeds—about 55 miles per hour. In general, as shown in table 4, in the range from 20 to 60 miles per hour the involvement rate at night was about double the day rate. At speeds below 20 miles per hour, there was a statistically significant reversal of this trend. At speeds in excess of 60 miles per hour, the night involvement rate was much greater than the day rate. The sharp upward trend in the involvement rate at night at speeds of more than about 65 miles per hour (fig. 2) points up the desirability of reducing the upper range of driving speeds at night.

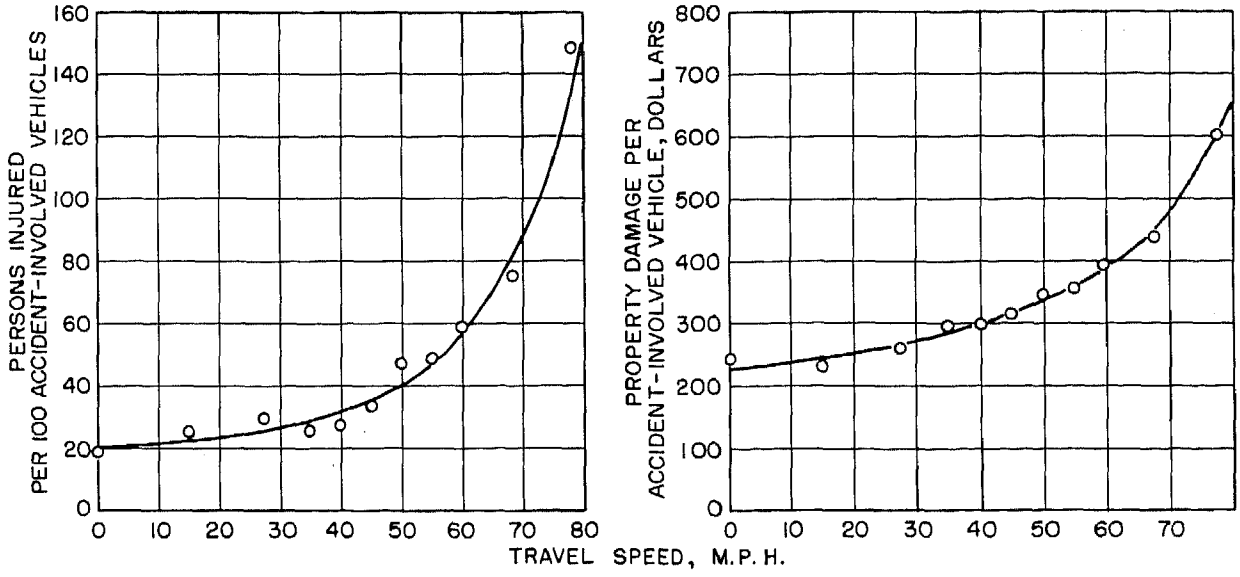

Figure 3.—Persons injured per 100 involvements and property damage per involvement by travel speed, day.

Although reasonably reliable estimates of travel speed just prior to an accident often can be made by experienced traffic-police investigators, not all accidents included in this study were investigated and the involved drivers, especially those who might have violated traffic laws, probably underestimated their speed.

If every driver underestimated his speed by 5 miles per hour, the curves in figure 2 would be modified only slightly and this modification would be for speeds of more than 60 miles per hour. If every driver underestimated his speed by 10 miles per hour, the curves would approach a *U* shape. However, there is no reason to believe that every driver underestimated his speed. Moreover, many of the speed estimates were made by police or other third parties. Hence, regardless of possible biases in obtaining speed estimates for accident-involved drivers, the differences in the involvement rates at the different speeds are substantial enough to suggest that relatively high speed driving is, on the average, safer than either low speed or excessively high speed driving on main rural highways.

Although the study sections were chosen with as few intersections as possible and no major intersections were included, some of the reported accidents did occur at intersections. The data were collected in such a way that the intersection accidents could not be selected. Many of the intersection accidents probably involved at least one relatively slow moving vehicle. Thus in the speed range of 10–30 miles per hour, it is conceivable that up to half of the accident involvements occurred at intersections. But even if the data for these accidents were eliminated, the portion of the curve for low speeds in figure 2 would be reduced only a fraction of a log unit. The basic findings of the study would not be affected; that is, the accident involvement rate is lowest at about the average speed of all traffic and highest at the very low speeds and the very high speeds.

Accident Severity Increases with Speed

As is generally supposed, accidents occurring at moderate and high speeds were considerably more severe than accidents at very low speeds. The left curve in figure 3 shows this speed and accident severity relation for daytime conditions, based on the number of persons injured per 100 accident-involved vehicles. For example, at a speed of 40 miles per hour, 31 persons were injured for each 100 vehicles involved in accidents; and at 65 miles per hour, 70 persons were injured for each 100 vehicles involved in accidents.

Another measure of accident severity considered is the amount of property damage per involvement. As shown in the right curve of figure 3, property damage also increased as travel speed increased but at a somewhat lower rate than the injuries. The relation between speed and accident

731-069—64——3

Table 5.—Involvement, injury, fatality, and property damage rates by travel speed, day and night

Travel speed	Vehicle-miles			Vehicle involvements		Persons						Property damage		
						Injured			Killed					
						DAY								
M.p.h.	*Number*	*Percent*	*Cumulative percent*	*Number*	*Rate* [3]	*Number*	*Rate* [3]	*Per 100 involvements*	*Number*	*Rate* [3]	*Per 100 involvements*	*Amount*	*Rate* [3]	*Per 100 involvements*
Standing	----------	------	------	493	------	90	------	18	1	(2)	(2)	$119,900	----------	$24,000
22 or less	2,736,000	0.1	0.1	1,183	43,238	278	10,161	23	17	621	[1] 1	275,900	$10,084,000	23,000
23–32	28,850,000	1.0	1.1	331	1,147	95	329	29	2			87,300	303,000	26,000
33–37	64,497,000	2.3	3.4	355	550	90	140	25	1			106,000	164,000	30,000
38–42	250,142,000	9.0	12.4	558	223	147	59	26	6	[1] 2	[1] 1	165,900	66,000	30,000
43–47	395,097,000	14.2	26.6	698	177	233	59	33	3			219,400	56,000	31,000
48–52	714,925,000	25.7	52.3	911	127	404	56	44	24	[1] 3	[1] 3	314,400	44,000	35,000
53–57	513,552,000	18.5	70.8	700	136	323	63	46	17	[1] 3	[1] 2	247,850	48,000	35,000
58–62	462,238,000	16.7	87.5	441	95	243	53	55	17	[1] 4	[1] 4	175,100	38,000	40,000
63–72	307,786,000	11.1	98.6	259	84	180	58	69	15	[1] 5	[1] 6	113,700	37,000	44,000
73 or more	38,841,000	1.4	100.0	54	139	68	175	126	12	[1] 31	[1] 22	32,450	84,000	60,000
TOTAL	2,778,664,000	100.0	------	5,983	215	2,151	77	36	115	4	2	1,857,900	67,000	31,000
						NIGHT								
Standing	----------	------	------	255	------	52	------	20	6	(2)	(2)	$65,000	----------	$25,000
22 or less	1,990,000	0.2	0.2	473	23,769	120	6,030	25	2			110,950	$5,575,000	23,000
23–32	13,284,000	1.5	1.7	206	1,551	55	414	27	3	[1] 15	[1] 2	51,550	388,000	25,000
33–37	22,701,000	2.5	4.2	254	1,119	100	440	39	9			78,450	346,000	31,000
38–42	99,996,000	11.2	15.4	418	418	142	142	34	7			144,650	145,000	35,000
43–47	136,057,000	15.2	30.6	559	411	259	190	46	13	[1] 10	[1] 2	194,700	143,000	35,000
48–52	274,039,000	30.7	61.3	686	250	321	117	47	29	[1] 11	[1] 4	263,050	96,000	38,000
53–57	164,739,000	18.5	79.8	454	276	186	113	41	18	[1] 9	[1] 3	165,700	101,000	36,000
58–62	105,028,000	11.8	91.6	250	238	157	149	63	5			105,750	101,000	42,000
63–72	66,181,000	7.4	99.0	195	295	168	254	86	21	[1] 32	[1] 11	92,250	139,000	47,000
73 or more	8,492,000	1.0	100.0	83	977	80	942	96	25	[1] 294	[1] 30	47,900	564,000	58,000
TOTAL	892,507,000	100.0	------	3,833	429	1,640	184	43	138	15	4	1,319,950	148,000	34,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.
[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle miles.

severity at night was nearly identical to that for accidents occurring during the day.

The data collected in this study clearly show that accident severity increased rapidly at the higher driving speeds. Moreover, as shown by figure 2, the accident-involvement rate for accidents during the day also increased at speeds of more than 65 miles per hour. Consequently, as shown in figure 4, the injury rate for accidents during the day; that is, the number of persons injured per 100 million vehicle-miles of travel, increased sharply at speeds of 70 miles per hour or more. At speeds of between 40 and 70 miles per hour the injury rate varied only slightly; but when the speed was less than 40 miles per hour, the injury rate increased sharply and was highest at speeds of less than 30 miles per hour.

At night, the picture was accentuated. As shown in table 4, at speeds in excess of 60 miles per hour, the ratio of the night-to-day involvement rate climbed sharply. Thus the injury rate for night driving, shown in figure 4, began climbing at a somewhat lower speed than the day injury rate and at 80 miles per hour was five times that of the day injury rate. Figure 5 data show similar trends with respect to the property damage rate—the amount of property damage per 100 million vehicle-miles of travel.

Fatal Accidents

The accident severity relations established for injuries and property damage were substantiated by comparisons of data based on fatalities, as shown in table 5. At speeds lower than 63 miles per hour, one to four persons were killed for every 100 vehicles involved in daytime accidents; between speeds of 63 and 72 miles per hour, six persons were killed for every 100 accident-involved vehicles; and the rate climbed to 22 persons killed at speeds of 73 miles per hour or higher.

For the night hours, the number of persons killed per 100 accident-involved vehicles on the average was twice the number killed during the day, but the fatality pattern was similar in that the chance of being killed in an accident increased as speed increased.

Table 6.—Involvement, injury, fatality, and property damage rates by travel speed on 2-lane main rural highways for all types of vehicles, day and night

Travel speed	Vehicle-miles			Vehicle involvements		Persons						Property damage		
						Injured			Killed					
DAY														
M.p.h.	*Number*	*Percent*	*Cumulative percent*	*Number*	*Rate* [3]	*Number*	*Rate* [3]	*Per 100 involvements*	*Number*	*Rate* [3]	*Per 100 involvements*	*Amount*	*Rate* [3]	*Per 100 involvements*
Standing				378		70		18		([2])	([2])	$87,150		$23,000
22 or less	2,412,000	0.1	0.1	785	32,546	166	6,882	21	11	[1] 456	[1] 1	173,250	$7,183,000	22,000
23–32	23,777,000	1.4	1.5	231	972	65	273	28		([2])	([2])	58,050	244,000	25,000
33–37	52,730,000	3.0	4.5	277	525	65	123	23	1	([2])	([2])	80,350	152,000	29,000
38–42	184,367,000	10.5	15.0	420	228	117	63	28	4	([2])	([2])	119,000	65,000	28,000
43–47	263,831,000	15.1	30.1	518	196	160	61	31	1	([2])	([2])	158,650	60,000	31,000
48–52	428,058,000	24.5	54.6	658	154	295	69	45	18	[1] 4	[1] 3	232,250	54,000	35,000
53–57	300,458,000	17.2	71.8	473	157	212	71	45	15	[1] 5	[1] 3	170,000	57,000	36,000
58–62	283,660,000	16.2	88.0	360	127	194	68	54	15	[1] 5	[1] 4	144,300	51,000	40,000
63–72	184,217,000	10.5	98.5	218	118	155	84	71	11	[1] 9	[1] 8	97,400	53,000	45,000
73 or more	25,807,000	1.5	100.0	34	132	36	139	106	8			20,950	81,000	62,000
TOTAL	1,749,317,000	100.0		4,352	249	1,535	88	35	84	5	2	1,341,350	77,000	31,000
NIGHT														
Standing				162		34		21	4	([2])	([2])	$39,850		$25,000
22 or less	1,787,000	0.3	0.3	297	16,620	74	4,141	25	1	[1] 36	[1] 2	69,900	$3,912,000	24,000
23–32	11,641,000	2.1	2.4	132	1,134	41	352	31	2			34,100	293,000	26,000
33–37	20,046,000	3.6	6.0	172	858	76	379	44	9			57,100	285,000	33,000
38–42	81,124,000	14.6	20.6	271	334	97	120	36	4	[1] 10	[1] 3	94,300	116,000	35,000
43–47	91,249,000	16.5	37.1	369	404	172	188	47	13			130,200	143,000	35,000
48–52	152,627,000	27.5	64.6	496	325	245	161	49	27	[1] 18	[1] 5	197,300	129,000	40,000
53–57	89,610,000	16.2	80.8	282	315	131	146	46	15	[1] 13	[1] 4	109,600	122,000	39,000
58–62	69,543,000	12.6	93.4	177	255	113	162	64	5			79,100	114,000	45,000
63–72	31,911,000	5.8	99.2	157	492	127	398	81	16	[1] 50	[1] 10	75,600	237,000	48,000
73 or more	4,601,000	0.8	100.0	54	1,174	41	891	76	19	[1] 413	[1] 35	32,950	716,000	61,000
TOTAL	554,139,000	100.0		2,569	464	1,151	208	45	115	21	4	920,000	166,000	36,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.
[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle-miles.

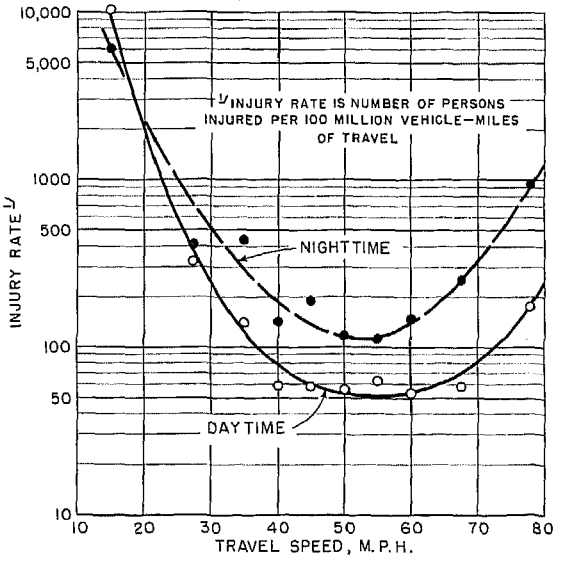

Figure 4.—Injury rate by travel speed, day and night.

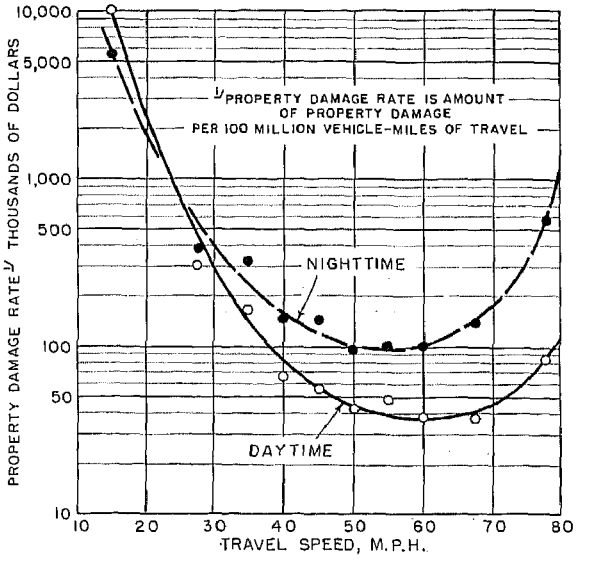

Figure 5.—Property damage rate by travel speed, day and night.

Like the injury rate, the fatality rate—the number of persons killed per 100 million vehicle-miles of travel—climbed sharply at very high speeds, as shown in table 5. This was a result of the compounding effects of moderately high involvement rate at very high speeds and the increased possibility of a fatality when an accident does occur at these speeds. During the day, the average fatality rate for all speeds was 4; but at speeds of 73 miles per hour and more the fatality rate was 31. This relation was even more sharply defined at night, when the average fatality rate was 15; but at speeds of 73 miles per hour and more the fatality rate was 294—nearly 20 times the average rate. This finding again lends support to the desirability of reducing the upper range of night driving speeds.

Three measures have been used to compare accident severity at different speeds: (1) property damage per involvement, (2) persons injured per 100 involvements, and (3) persons killed per 100 involvements. All three measures show that accident severity increased slowly up to speeds of about 60 miles per hour and more rapidly at higher speeds. This was particularly true for the second measure; and the increased severity at higher speeds was most sharply delineated by the third measure employed.

Comparison of 2- and 4-Lane Highways

The relationships between speed and accidents that have been developed were generally consistent for both 2- and 4-lane highways. There were some differences, however, as a careful comparison of data in tables 6 and 7 will reveal. For one thing, the overall accident-involvement rate on 4-lane highways was much lower than that on 2-lane highways. However, only one of the 4-lane sections had full control of access—a condition that other studies have shown invariably produces very low accident rates. Four other study sections had partial control of access and, this partial control coupled with the full control on the one section, could partially account for the lower involvement rate. By way of contrast, all except one of the 2-lane sections had no control of access.

Table 7.—Involvement, injury, fatality, and property damage rates by travel speed on 4-lane main rural highways for all types of vehicles, day and night

Travel speed	Vehicle-miles			Vehicle involvements		Persons						Property damage		
						Injured			Killed					
						DAY								
M.p.h.	*Number*	*Percent*	*Cumulative percent*	*Number*	*Rate*[3]	*Number*	*Rate*[3]	*Per 100 involvements*	*Number*	*Rate*[3]	*Per 100 involvements*	*Amount*	*Rate*[3]	*Per 100 involvements*
Standing	----------	------	------	115	------	20	------	[1] 17	1	------	(2)	$32,750	----------	$28,000
22 or less	324,000	------	------	398	122,840	112	34,568	28	6			102,650	$31,682,000	26,000
23–32	5,073,000	0.5	0.5	100	1,971	30	591	30	2	[1] 12	[1] 2	29,250	577,000	20,000
33–37	11,767,000	1.1	1.6	78	663	25	[1] 212	[1] 32	------			25,650	218,000	33,000
38–42	65,775,000	6.4	8.0	138	210	30	46	22	2			46,900	71,000	34,000
43–47	131,266,000	12.8	20.8	180	137	73	56	41	2			60,750	46,000	34,000
48–52	286,867,000	27.9	48.7	253	88	109	38	43	6	[1] 2	[1] 2	82,150	29,000	32,000
53–57	213,094,000	20.7	69.4	227	107	111	52	49	2			77,850	37,000	34,000
58–62	178,578,000	17.3	86.7	81	45	49	27	60	2			30,800	17,000	38,000
63–72	123,569,000	12.0	98.7	41	33	25	[1] 20	[1] 61	4	[1] 3	[1] 8	16,300	13,000	40,000
73 or more	13,034,000	1.3	100.0	20	[1] 153	32	246	160	4			11,500	88,000	[1] 58,000
TOTAL	1,029,347,000	100.0	------	1,631	158	616	60	38	31	3	2	516,550	50,000	32,000
						NIGHT								
Standing	----------	------	------	93	------	18	------	[1] 19	2	------	(2)	$25,150	----------	$27,000
22 or less	203,000	0.1	0.1	176	86,700	46	22,660	26	1			41,050	$20,222,000	23,000
28–32	1,643,000	.5	.6	74	4,504	14	[1] 852	[1] 19	1			17,450	1,062,000	24,000
33–37	2,655,000	.8	1.4	82	3,089	24	[1] 904	[1] 29	------			21,350	804,000	26,000
38–42	18,872,000	5.6	7.0	147	779	45	238	31	3	[1] 4	[1] 1	50,350	267,000	34,000
43–47	44,808,000	13.2	20.2	190	424	87	194	46	------			64,500	144,000	34,000
48–52	121,412,000	35.9	56.1	190	156	76	63	40	2			65,750	54,000	35,000
53–57	75,129,000	22.2	78.3	172	229	55	73	32	3			56,100	75,000	33,000
58–62	35,485,000	10.5	88.8	73	206	44	124	60	------			26,650	75,000	37,000
63–72	34,270,000	10.1	98.9	38	111	41	120	108	5	[1] 15	[1] 8	16,650	49,000	44,000
73 or more	3,891,000	1.1	100.0	29	[1] 745	39	1,002	134	6			14,950	384,000	[1] 52,000
TOTAL	338,368,000	100.0	------	1,264	374	489	145	39	23	7	2	399,950	118,000	32,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements, rate not computed.
[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle miles.

The involvement, injury, and property damage rates for both 2- and 4-lane highways were lowest at moderately high speeds and highest at the very low speeds. These findings applied for both day and night conditions. At speeds of less than 22 miles per hour, the rates were four to five times as great on 2-lane highways as on 4-lane highways. As speeds increased, the differences in rates between the two types of highways decreased; and at speeds of more than 50 miles per hour, the rates were generally much lower for the 4-lane highways. At speeds of more than 72 miles per hour, the difference again decreased, and, in some cases, a reversal in pattern of data was shown. Little difference existed between the two highway types in the number of persons injured or in the amount of property damage per 100 involvements. But a statistically significant difference was noted at

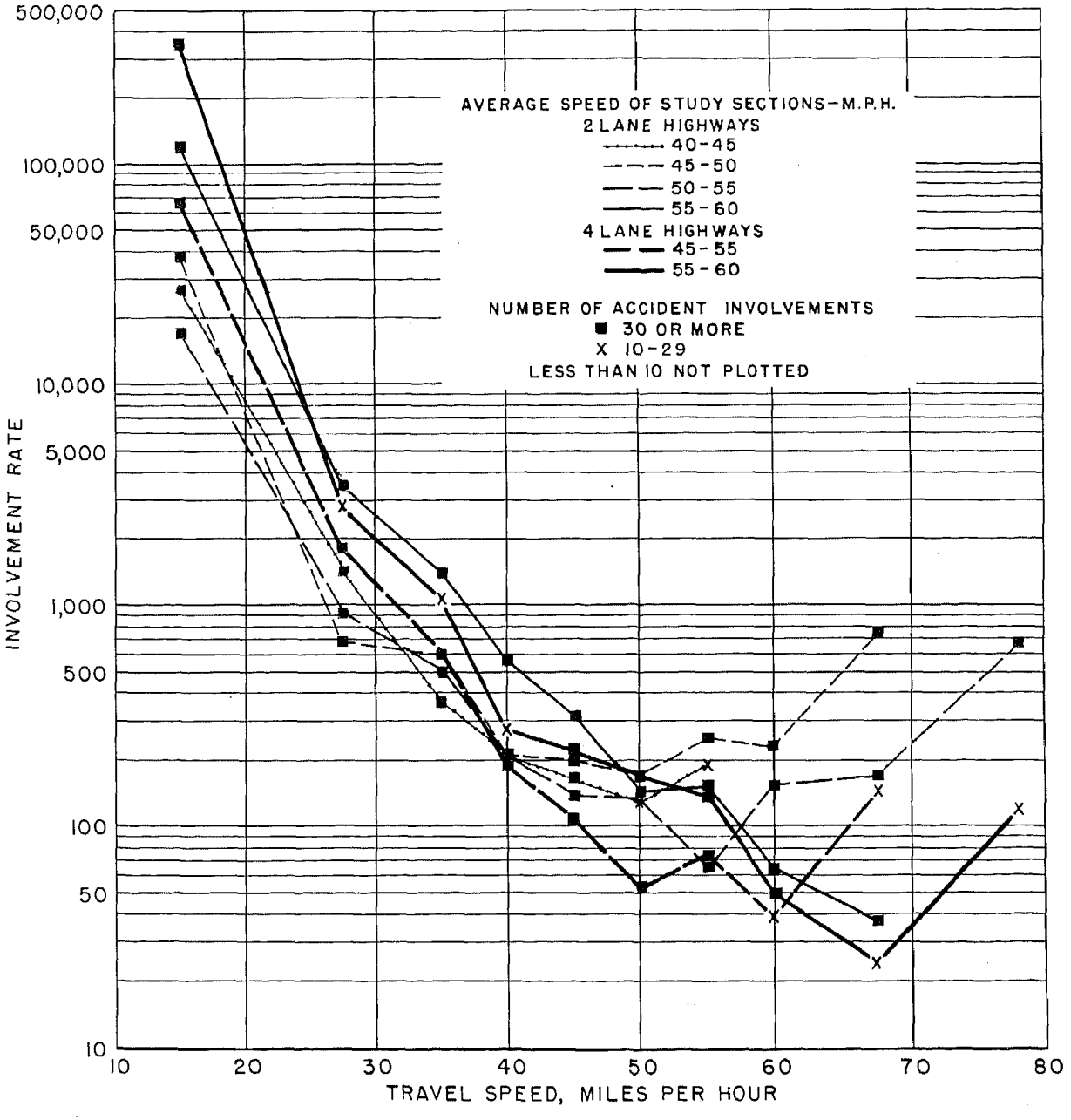

Figure 6.—Involvement rate by travel speed and average speed on study sections on 2- and 4-lane highways, day.

speeds of more than 72 miles per hour, when the number of persons injured per 100 involvements was 51 to 76 percent greater on 4-lane highways than on 2-lane highways.

Speeds on Individual Study Sections

The analyses presented so far were made from the combination of data for the different study sections. The question may well be asked: How does the average speed of travel along an individual study section affect the relation between speed and accidents? Detailed study of the data for the 35 study sections showed that the general patterns were the same regardless of average speeds on the 35 rural highway sections. The principal difference among sections appeared to be the speed at which the involvement rate was a minimum. This minimum point was dependent on the average speed of the individual study section. The highest involvement rate was at the very low speeds regardless of whether the section was a 2- or 4-lane highway or whether the average speed was low or high. The lowest involvement rate was at or slightly above the average speed on the study section. These results are shown in figure 6 for daytime conditions. The study sections are grouped so that average travel speeds are about the same in each group. The curves for night driving were similar, although the involvement rates were greater.

Table 8 contains a summary showing the relation between average speed of study sections and the speed at which the involvement rate was at a minimum. The involvement rate was minimum at a speed that was usually 5 or 10 miles per hour more than the average speed on the study sections. Table 8 data also show that on 2-lane sections the overall involvement rate decreased as average speed increased; on 4-lane sections, the reverse was true. These results should be interpreted with caution, however, because there may be other differences between the groups of study sections. For example, the highways having the lower average speeds also had more intersections and business driveways per mile of highway compared to highways on which the average speeds were higher. Other studies have shown that the presence of intersections and roadside businesses are associated with a large number of accidents.

Close inspection of figure 6 shows that both 2- and 4-lane highways on which the average speeds were in the 55–60 miles per hour group had slightly

Table 8.—Speed when involvement rate was a minimum by average speed of study sections, day and night

Average speed on study sections	Speed when accident-involvement rate was a minimum		Overall accident-involvement rate	
	Day	Night	Day	Night
2-lane sections:	*M.p.h.*	*M.p.h.*	*Rate*	*Rate*
Less than 45 m.p.h.	50	50	289	698
45–50 m.p.h.	50	40	320	587
50–55 m.p.h.	55	55	192	296
55 or more m.p.h.	68	68	182	370
4-lane sections:				
Less than 55 m.p.h.	60	60	138	291
55 or more m.p.h.	68	68	156	470

higher involvement rates at the lower speeds than the other average speed groups. However, if the curves were replotted on the basis of variation from average speeds, these differences would disappear or be reversed. Thus, it is clear that regardless of the average speed on a main rural highway, the greater the driver's variation from this average speed, the greater his chance of being involved in an accident. To show this relation most clearly, the involvement rate at each speed for each study section was related to the variation from average speed on a study section. If, for example, the average speed on a study section were 50 miles per hour, accidents occurring at a speed of 60 miles per hour would be noted as occurring at a variation from average speed of +10 miles per hour. Results of such computations have been summarized in figure 7 for both day and night travel. The

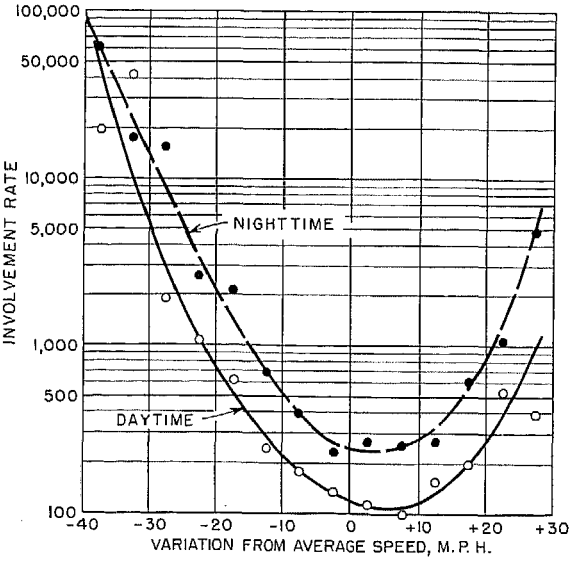

Figure 7.—Involvement rate by variation from average speed on study section, day and night.

lowest involvement rate occurred at the average speed or slightly above it. As speeds departed from the average speed in either direction, the involvement rate increased in a nearly symmetrical fashion. The patterns evident in figures 6 and 7 strongly suggest that a reduction in the variation in speeds among drivers can reduce accidents substantially.

Speed Difference Between Pairs of Vehicles

One type of accident particularly related to speed difference is the rear-end collision, and this type of accident was therefore given special study. To provide a homogeneous sample, only rear-end collisions that involved two passenger cars were investigated. The speed difference is, of course, the difference between the normal travel speeds of the two colliding vehicles. If, prior to the accident, the lead car was traveling at 50 miles per hour and the rear car at 70 miles per hour, the speed difference would be 20 miles per hour.

The solid curve in figure 8 shows that 53 percent of the two-car, rear-end collisions involved drivers who were traveling at a speed difference of less than 20 miles per hour. A much higher percentage of pairs of vehicles in normal highway traffic, 93 percent, traveled at a speed difference of less than 20 miles per hour, as shown by the dashed curve in figure 8 that represents normal traffic. As the speed difference increased beyond 20 miles per hour, the proportional difference between accident-involved vehicles and normal

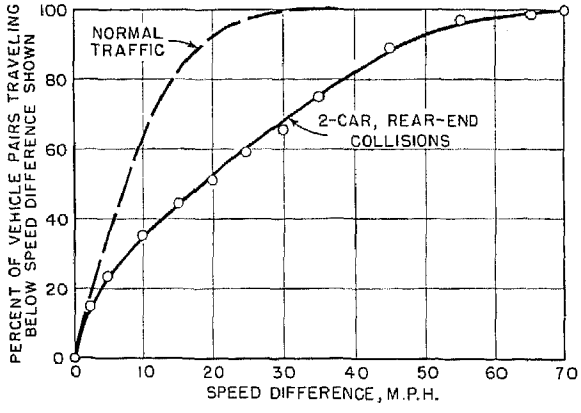

Figure 8.—Speed difference between passenger cars involved in two-car, rear-end collisions compared with normal traffic, day and night combined.

highway traffic increased at an accelerating rate. For example, 32 percent of accident-involved vehicle pairs were traveling at a speed difference of more than 30 miles per hour, but less than 1 percent of normal highway traffic exceeded this speed difference.

In summary, passenger car drivers involved in rear-end collisions were more likely to have been traveling at a speed difference much greater than that for pairs of vehicles in normal traffic. This analysis, as in the preceding sections, indicates that a reduction in the variability of speeds can be an important element in accident reduction.

Part IV.—INVOLVEMENTS RELATED TO DRIVER CHARACTERISTICS

Other characteristics of drivers and their vehicles related to accident-involvement rates were investigated, including sex, age, military status, and residence of the driver. In addition, the type of vehicle; and the body style, age, and horsepower of passenger cars were studied. These relationships are discussed in the following paragraphs.

Travel Speed Related to Driver Characteristics

The extremely high accident-involvement rate that was associated with speeds slower than 35 miles per hour raises the question as to whether other characteristics of the driver or vehicle were involved. One of the more obvious comparisons would relate travel speed to age of the driver. If older drivers, for example, tended to drive at the slower speeds, then the high accident-involvement rate at lower speeds might properly be ascribed to older drivers rather than to the slow speed of travel. Accordingly, a two-way breakdown of involvement rate by both travel speed and age of driver was developed for both day and night conditions.

As data in table 9 show, the involvement rate at travel speeds below 33 miles per hour was the highest for any higher speed group regardless of the driver's age or whether day or night conditions were involved. In fact at speeds less than 33 miles per hour, the involvement rate was at least six times as great as for any higher speed group. The minimum involvement rate for each age group occurred consistently at speeds slightly above 60 miles per hour during the day and slightly below 60 miles per hour at night. Because travel speeds of more than 62 miles per hour were grouped, the slight upward trend in the day involvement rate for the group of highest speed is not always evident in table 9, but it shows clearly in figure 2.

The relation of travel speed to accident involvement was not affected by the sex of the driver, as shown in table 10. Comparisons of travel speed by membership in the Armed Forces shown in table 11; by residence shown in table 12; by vehicle type shown in table 13; by horsepower shown in table 14; by body style shown in table 15; and by vehicle age shown in table 16; all indicate that by far the highest involvement rate occurred at speeds below 33 miles per hour. The data in these tables also show that the involvement rate generally decreased as speed was increased up to about 62 miles per hour; beyond this speed, the involvement rate tended to level off during the day and to increase at night. However, it should be pointed out that during the day, on the average, the involvement rate increased slightly at speeds higher than 70 miles per hour,

Table 9.—Involvement rate by travel speed and age of driver, day and night

Travel speed, m.p.h.	Day					Night				
	Accident-involvement rate by age of driver					Accident-involvement rate by age of driver				
	Under 20	20–24	25–44	45–64	65 or older	Under 20	20–24	25–44	45–64	65 or older
32 or lower	14,909	10,408	4,917	5,273	9,407	9,048	5,246	5,935	5,011	21,235
33–42	608	440	246	237	415	1,057	830	459	457	[1] 849
43–52	400	282	121	111	185	833	694	252	220	[1] 277
53–62	357	244	96	82	132	543	588	198	170	[2]
63 or more	341	200	73	61	[1] 122	1,238	914	277	[1] 115	[2]

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

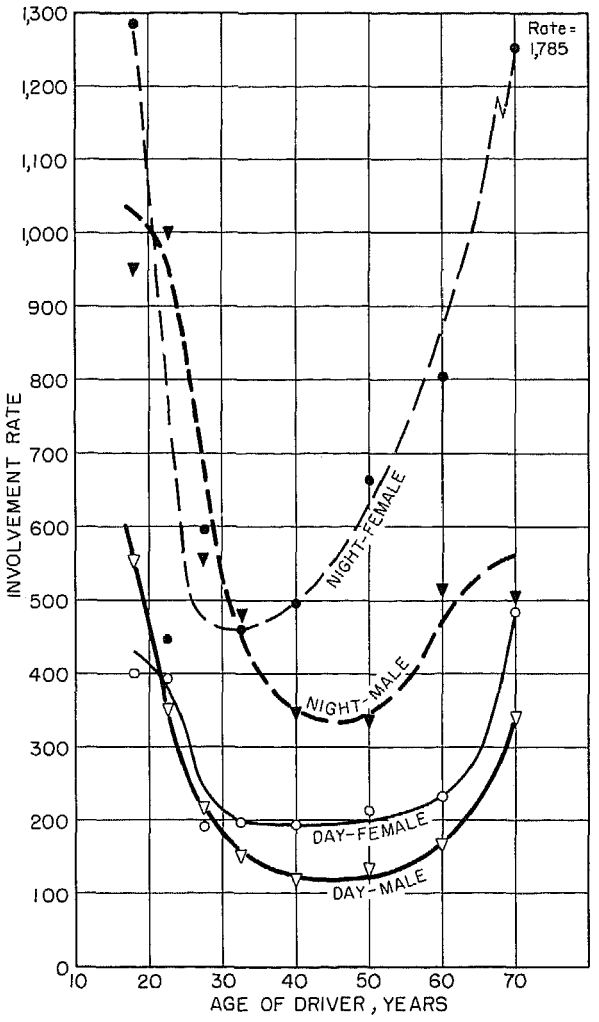

Figure 9.—Involvement rate by sex and age of passenger-car driver, day and night.

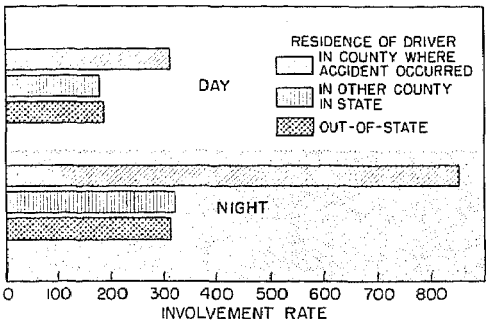

Figure 10.—Involvement rate by residence of driver, day and night.

as shown in figure 2, but grouping of the data above 62 miles per hour in the tables has masked the effect.

Sex of Driver

Male drivers accounted for nearly all travel on the main rural highways included in the study; about 87 percent during the day and 93 percent at night. Thus it is not surprising that the large majority of all drivers involved in accidents were males. On the basis of accident-involvement rate, however, there was much less difference between the two sexes.

Considering the drivers of all types of vehicles during the day, the accident-involvement rate was 210 for males and 247 for females, as shown in table 17. At night, the difference was much greater; the accident-involvement rate for males was 419 and for females 579. However, at night the predominantly male truckdrivers had an exceptionally low involvement rate. Therefore, a more meaningful comparison would be based on drivers of passenger cars only, because very few females drive trucks. This comparison is also shown in table 17. During the day, the difference in rate between the sexes remained about the same. However, at night, the accident-involvement rate for male and female drivers of passenger cars was nearly identical.

Additional data on differences between the sexes as related to travel speed and involvement rate are shown in table 10. During the day, females have a higher accident-involvement rate than males at all travel speeds except the very highest ones shown in table 10. This was also true at night. But it is emphasized that these data apply to drivers of all types of vehicles; at night, if male drivers of trucks were eliminated, the rate for males would approach that of female drivers.

Table 18 shows the relationship between the sex of drivers and the horsepower of the passenger cars they were driving. Because this table applies to passenger cars only, it permits a more reasonable comparison between the two sexes. During the day, females had a slightly higher accident-involvement rate at each of the three horsepower groupings. At night, females had a higher accident-involvement rate when driving cars having less than 110 horsepower. For the higher horsepower groupings, the involvement rates at night were nearly identical for the two sexes.

Driver Age

Both very young and very old drivers had higher involvement rates than drivers in the middle age groups. The exact pattern varied

731-069—64——4

Table 10.—Involvement rate by travel speed and sex of driver for all types of vehicles, day and night

Travel speed, m.p.h.	Day		Night	
	Accident-involvement rate by sex of driver		Accident-involvement rate by sex of driver	
	Male	Female	Male	Female
32 or lower	5,948	7,077	5,881	7,345
33-42	278	309	524	598
43-52	142	168	293	455
53-62	114	142	255	299
63 or higher	98	67	407	[1] 186

[1] Rate based on 10-29 accident involvements.

Table 11.—Involvement rate by travel speed by military status of driver, day and night

Travel speed, m.p.h.	Day		Night	
	Accident-involvement rate by military status of driver		Accident-involvement rate by military status of driver	
	Member	Non-member	Member	Non-member
32 or lower	17,476	5,842	8,157	5,982
33-42	[1] 325	281	759	520
43-52	307	138	839	278
53-62	336	107	861	227
63 or higher	357	85	1,452	310

[1] Rate based on 10-29 accident involvements.

Table 12.—Involvement rate by travel speed and residence of driver, day and night

Travel speed, m.p.h.	Day			Night		
	Accident-involvement rate by residence of driver			Accident-involvement rate by residence of driver		
	Study county	Other, in State	Out-of-State	Study county	Other, in State	Out-of-State
32 or lower	9,119	4,733	4,238	10,902	5,054	3,231
33-42	360	230	286	1,458	380	383
43-52	187	125	142	702	226	245
53-62	153	105	114	524	207	170
63 or higher	118	68	141	778	248	453

Table 13.—Involvement rate by travel speed and vehicle type, day and night

Travel speed, m.p.h.	Day		Night	
	Accident-involvement rate by type of vehicle		Accident-involvement rate by type of vehicle	
	Passenger car and truck, 4 tires	Truck, 6 or more tires, and bus	Passenger car and truck, 4 tires	Truck, 6 or more tires, and bus
32 or lower	6,607	3,821	6,581	3,623
33-42	285	250	627	325
43-52	150	106	438	112
53-62	125	[1] 31	360	[1] 19
63 or higher	95	[2]	415	[2]

[1] Rate based on 10-29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

Table 14.—Involvement rate by travel speed and horsepower of passenger car, day and night

Travel speed, m.p.h.	Day			Night		
	Accident-involvement rate by horsepower of passenger car			Accident-involvement rate by horsepower of passenger car		
	110 or less	111-170	171 or more	110 or less	111-170	171 or more
32 or less	8,274	5,084	5,590	10,220	3,530	2,536
33-42	342	237	220	908	476	353
43-52	189	136	107	608	385	275
53-62	168	94	113	584	280	229
63 or more	140	65	66	854	340	200

with both sex of driver and day or night conditions. Figure 9, which is based on data for passenger car drivers only, shows that during the day male drivers under 20 had the highest accident-involvement rate of any age group. Male drivers between 30 and 60 years of age had a uniformly low involvement rate, which was less than one-third as large as the rate for the group under 20. Beyond age 60, the rate increased again. The pattern for female drivers was similar, except that female drivers more than 70 years of age rather than teenage female drivers had the highest accident-involvement rate.

At night, the accident rate was about twice as high as during the day. The pattern of involvement rate by age of driver was very similar to the day rate in that those under the age of 20 and over the age of 60 had the highest involvement rate. However, at night, teenage female drivers had a higher accident-involvement rate than teenage male drivers.

If the involvement rate for drivers more than 65 years of age is about as high as for drivers 20 to 24 (assuming the same relationships for all classes of highways), why are insurance rates higher for younger drivers than for middle-aged drivers, but generally are not higher for older drivers. The reason is very simple. Older drivers generally drive much less than the younger ones, particularly at night and, therefore, although their accident-involvement rate is the same, they have only one-half to one-third the number of accidents compared to the younger drivers. Hence, correspondingly lower damage claims need to be paid for the older drivers and insurance rates can be lower.

Females under age 25 had about as high an accident-involvement rate as males under 25. Again the question may be asked, why are insurance rates for younger males very high but not

Table 15.—Involvement rate by travel speed and body style of passenger car, day and night

Travel speed, m.p.h.	Day					Night				
	Accident-involvement rate by body style of passenger car					Accident-involvement rate by body style of passenger car				
	2-door sedan	4-door sedan	Soft-top convertible	Hardtop	Station wagon	2-door sedan	4-door sedan	Soft-top convertible	Hardtop	Station wagon
32 or less	7,863	6,023	9,663	[1] 1,986	6,969	12,474	5,645	11,963	(2)	[1] 1,024
33–42	323	255	[1] 264	[1] 104	[1] 167	772	524	[1] 735	[1] 213	[1] 213
43–52	189	131	210	50	128	611	352	896	[1] 114	300
53–62	169	122	157	54	61	544	379	886	[1] 60	171
63 or more	147	110	[1] 102	(2)	[1] 24	793	407	[1] 414	[1] 133	(2)

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

Table 16.—Involvement rate by travel speed and age of passenger car, day and night

Travel speed, m.p.h.	Day				Night			
	Accident-involvement rate by age of passenger car, years				Accident-involvement rate by age of passenger car, years			
	Less than 3	3–5.9	6–9.9	10 or more	Less than 3	3–5.9	6–9.9	10 or more
32 or less	7,477	8,033	7,413	6,570	5,332	5,612	6,957	16,912
33–42	320	303	320	303	462	689	806	1,463
43–52	138	152	176	213	431	440	573	581
53–62	119	118	140	238	336	356	468	519
63 or more	89	88	118	(2)	318	410	770	[1] 1,107

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

Table 17.—Involvement rate by sex of driver for all vehicles and passenger cars only, day and night

Sex of driver	All vehicles						Passenger cars only					
	Day			Night			Day			Night		
	Vehicle-miles	Involvements		Vehicle-miles	Involvements		Vehicle-miles	Involvements		Vehicle-miles	Involvements	
		Number	*Rate*		*Number*	*Rate*		*Number*	*Rate*		*Number*	*Rate*
Male	2,407,469,000	5,065	210	832,715,000	3,487	419	1,828,333,000	3,654	200	474,461,000	2,742	578
Female	371,195,000	918	247	59,797,000	346	579	357,929,000	880	246	55,964,000	332	593
TOTAL	2,778,664,000	5,983	215	892,512,000	3,833	429	2,186,262,000	4,534	207	530,425,000	3,074	580

for younger females? As in the case of older males, the teenage females do much less driving than teenage males particularly at night, and therefore, although their accident-involvement rates are as high as for the younger males, the number of accidents for younger females are only a fraction as large.

A comparison of drivers' age by military status is shown by data in table19. As with the population generally, younger drivers among the military had much higher accident-involvement rates than older drivers. There were few military drivers beyond the age of 45 so it is not possible to make rate comparisons for this age group among the military.

It may be suggested that younger drivers had higher involvement rates because they had older cars that are more likely to be involved in accidents. However, from data in table 20, it may be seen that drivers under 20 generally had the highest involvement rate of any age group during both day and night regardless of the age of the passenger car they were driving. In addition, during the day, drivers more than 65 years of age had higher involvement rates than drivers 25–44 years of age regardless of the age of the vehicle. At night, a similar relationship was evident, although the sample size was small.

Data in table 21 show that, in general, the relation between drivers' age and involvement rate

Table 18.—Involvement rate by horsepower of passenger car and sex of driver, day and night

Horsepower of passenger car	Day		Night	
	Accident-involvement rate by sex of driver		Accident-involvement rate by sex of driver	
	Male	Female	Male	Female
110 or less	297	351	899	1,040
111–170	152	187	426	411
171 or more	133	173	287	268

Table 19.—Involvement rate by driver's age and military status of driver, all vehicles, day and night

Driver's age, years	Day		Night	
	Accident-involvement rate by drivers' military status		Accident-involvement rate by drivers' military status	
	Member	Non-member	Member	Non-member
Under 20	1,133	510	1,569	891
20–24	653	327	1,532	675
25–29	396	209	755	457
30–44	218	155	466	293
45–64	[1] 205	179	[2]	331
65 or older	[2]	383	[2]	847

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

was consistent regardless of body style. In some cases, however, the small sample size caused inconsistencies in the results.

Military Status

Members of the Armed Forces had accident-involvement rates at least twice as great as nonmembers during both day and night. It has been noted earlier, however, that younger drivers had higher involvement rates than other drivers. Most military drivers were in the younger age groups, and it may be suggested that their higher accident-involvement rate is associated with their youth rather than with their military status. Data in table 19 show, however, that for each of the age groups, members of the Armed Forces had involvement rates about twice as great as nonmembers. Beyond age 30, the difference in involvement rate between military drivers and other drivers diminished somewhat, but military drivers had a higher involvement rate for each age group during both day and night.

Military drivers had substantially higher involvement rates than nonmilitary drivers re-

Table 20.—Involvement rate by driver's age and passenger car age, day and night

Driver's age, years	Day				Night			
	Accident-involvement rate by passenger car age, years				Accident-involvement rate by passenger car age, years			
	Under 3	3–5.9	6–9.9	10 or older	Under 3	3–5.9	6–9.9	10 or older
Under 20	409	541	587	763	848	1,124	962	1,639
20–24	372	376	401	376	726	782	1,284	1,651
25–44	161	175	182	296	444	482	593	989
45–64	148	165	222	321	350	475	566	877
65 or older	287	294	494	682	[1] 512	[1] 484	[1] 1,004	[1] 2,716

[1] Rate based on 10–29 accident involvements.

Table 21.—Involvement rate by age of driver and body style of passenger car, day and night

Driver's age, years	Day					Night				
	Accident-involvement rate by body style of passenger car					Accident-involvement rate by body style of passenger car				
	2-door Sedan	4-door Sedan	Soft-top convertible	Hardtop	Station wagon	2-door sedan	4-door sedan	Soft-top convertible	Hardtop	Station wagon
Under 20	695	491	[1] 404	[2] 172	[1] 333	1,351	765	[1] 920	[2]	[2]
20–24	420	379	437	[1] 113	[1] 208	1,405	806	1,492	[1] 189	[1] 209
25–44	205	154	196	68	97	656	423	789	88	293
45–64	217	156	[1] 141	[1] 39	132	573	417	[2]	[1] 131	[1] 128
65 or older	521	321	[2]	[2]	[1] 197	[1] 677	[1] 661	[2]	[2]	[2]

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

gardless of the speed of travel, as shown in table 11. The difference was particularly great at travel speeds of more than 52 miles per hour, when members of the Armed Forces had involvement rates three to four times as great as nonmembers.

Comparing military status with the horsepower of the car driven, as shown in table 22, for both day and night driving, members of the Armed Forces had an involvement rate much greater than nonmembers. The difference was greatest in the lowest horsepower group and least in the highest horsepower group. No reason can be given for the generally higher accident-involvement rate of military drivers. Such a determination is beyond the scope of the study reported here.

Residence of Driver

It has been suggested that out-of-State drivers have higher accident-involvement rates than local drivers. The data gathered in the study discussed here do not support such a conclusion. In fact, as data shown in table 23 and figure 10 indicate, the day involvement rate for local drivers; that is, drivers residing within the county where the study site was located, had involvement rates nearly twice as great as drivers residing in other counties of the State or out-of-State. At night, local drivers had involvement rates more than two and one-half times those of other drivers. It might be suggested that local drivers had higher involvement rates because they drove at slower speeds. However, the data gathered refute this conclusion. Involvement rates by travel speed and residence of driver are compared in table 12 and, for all comparisons except one, local drivers had involvement rates substantially greater than other drivers, regardless of travel speed and day or night travel. At the different speeds there were only moderate differences in involvement rates between out-of-State drivers and drivers from within the State but not residing in the county where the study section was located. Horsepower of passenger cars also did not affect the high involvement rate of local drivers. As shown in table 24, local drivers had the highest involvement rate, day and night, regardless of horsepower.

Table 22.—Involvement rate by horsepower of passenger car and by military status of driver, day and night

Horsepower of passenger car	Day		Night	
	Accident-involvement rate by drivers' military status		Accident-involvement rate by drivers' military status	
	Member	Nonmember	Member	Nonmember
110 or less	710	290	1,963	823
111–170	352	150	742	402
171 or more	229	140	432	276

Table 24.—Involvement rate by horsepower of passenger car and residence of driver, day and night

Horsepower of passenger car	Day			Night		
	Accident-involvement rate by residence of driver			Accident-involvement rate by residence of driver		
	Study county	Other, in State	Out-of-State	Study county	Other, in State	Out-of-State
110 or less	514	238	227	1,710	625	699
111–170	270	113	167	824	285	365
171 or more	209	110	159	453	232	265

Table 23.—Vehicle-miles, number of involvements, and involvement rate by residence of driver, day and night.

Residence of driver	Day			Night		
	Vehicle-miles	Accident Involvements		Vehicle-miles	Accident Involvements	
		Number	*Rate*		*Number*	*Rate*
Study county	686,385,000	2,162	315	181,169,000	1,543	852
Other counties in State	1,301,785,000	2,331	179	437,496,000	1,422	325
Out-of-State	790,494,000	1,490	188	273,847,000	868	317
TOTAL	2,778,664,000	5,983	215	892,512,000	3,833	429

Table 25 and figure 11 data show that during the day, the accident-involvement rate by vehicle type was nearly the same for the four principal types of vehicles. At night, however, the situation changed radically. The involvement rate for passenger cars was higher than for any other type of vehicle; it was 46 percent higher than for trucks having 4 tires, such as panels and pickups, and 254 percent higher than for trucks having 6 or more tires, including combinations.

Travel speeds of the different types of vehicles varied. Trucks with 6 or more tires traveled 3 to 8 miles per hour slower than other vehicle groups and, therefore, a comparison of vehicle type by travel speed could conceivably change the relationships. However, as shown in table 13, the involvement rates for passenger-type vehicles, including trucks having 4 tires, was higher than for trucks having 6 or more tires and for buses at all speeds during both day and night.

Body Style

During the day, the two-door sedan had the highest accident-involvement rate of any of the major body styles, but at night the convertible had the highest rate. The hardtop had the lowest rate of any major body style (fig. 15). These data should be interpreted with caution, however, because the age of the vehicle also had a substantial effect on involvement rate, and the average ages of cars having different types of body styles are probably different. Because the data were not subdivided by body style and age of vehicle, this comparison cannot be developed.

Age of Passenger Car

As the age of passenger cars increased, the accident-involvement rate also increased, as shown in table 26. The rates calculated for cars under 1 year old were unreliable, because of the expansion procedure employed, and are not shown.

It might be suggested that older vehicles were driven at a slower travel speed and thereby affected the accident-involvement rate because at slower speeds, vehicles have much higher accident-involvement rates. The data, as shown in table 16, support this hypothesis only during the day at speeds below 42 miles per hour. They do not support the hypothesis at any higher speed or at night. During the day, there was little difference in accident-involvement rate at speeds below 42 miles per hour regardless of the age of passenger car. At higher speeds, the involvement rate increased directly with age of the car. At night, the involvement rate increased with vehicle age at all speed ranges studied.

It might also be suggested that older vehicles had higher involvement rates because of their lower horsepower and poor acceleration capability. Data shown in table 27 tend to support this

Table 25.—Vehicle-miles, number of involvements, and involvement rate by type of vehicle, day and night

Type of vehicle	Day			Night		
	Vehicle-miles	Accident Involvements		Vehicle-miles	Accident Involvements	
		Number	*Rate*		*Number*	*Rate*
Passenger car	2,186,262,000	4,534	207	530,425,000	3,074	580
Truck, 4 tires	199,765,000	562	281	59,992,000	239	398
Truck, 6 or more tires	374,552,000	780	208	293,198,000	482	164
Bus	17,273,000	46	266	8,437,000	10	119
Other and not known	812,000	61	(1)	460,000	28	(1)
TOTAL	2,778,664,000	5,983	215	892,512,000	3,833	429

[1] Rate calculations not meaningful.

hypothesis. During the day, there was a tendency for the involvement rate to increase as cars having 110 horsepower or less became older. For groups of cars having horsepowers greater than 110, however, the involvement rate remained reasonably constant as vehicle age increased. At night there was no consistent linear trend relating accident-involvement rate to age of passenger car for any of the horsepower groups. However, where adequate data permitted comparisons, vehicles older than 10 years had a higher involvement rate than any of the newer vehicles, regardless of horsepower.

Another factor that might have been related to the higher involvement rate for older cars is the driver's age, as younger drivers who had higher involvement rates also drove older cars. As shown in table 20, generally the involvement rate for day or night increased with age of passenger car regardless of the age of the driver.

Horsepower

It has frequently been suggested that high horsepower is an important factor in accidents. The data collected in the study discussed here do not support such a contention. The highest involvement rate for both day and night occurred at the lowest horsepower of 110 or less, as shown in figure 12 and table 28. Among the higher horsepower groups there was very little difference in involvement rate in relation to increasing horsepower.

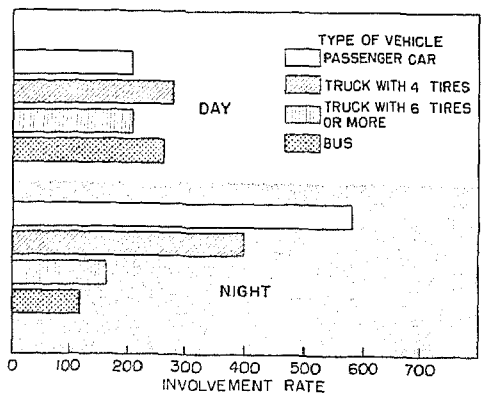

Figure 11.—Involvement rate by type of vehicle, day and night.

It has been suggested that low horsepower cars are driven at slower speeds and that this factor could possibly have accounted for the higher accident-involvement rate of low horsepower cars. However, table 14 data indicate that passenger cars having 110 horsepower or less had the highest involvement rates of any of the three horsepower groups, regardless of travel speed, for both day and night. The horsepower as employed here is gross horsepower or advertised horsepower and is the horsepower rating of the engine on a block; that is,

Table 26.—Vehicle-miles, number of involvements, and involvement rate by age of passenger car, day and night

Age of passenger car	Day			Night		
	Vehicle-miles	Accident involvements		Vehicle-miles	Accident involvements	
Years		*Number*	*Rate*		*Number*	*Rate*
1–1.9	456,489,000	735	161	101,522,000	441	434
2–2.9	379,764,000	616	162	84,634,000	367	434
3–3.9	277,614,000	535	193	63,999,000	316	494
4–4.9	211,779,000	453	214	52,323,000	313	598
5–5.9	199,689,000	471	236	52,282,000	317	606
6–6.9	166,702,000	418	251	45,823,000	323	705
7–7.9	135,795,000	369	272	37,676,000	281	746
8–8.9	93,406,000	266	285	25,695,000	201	782
9–9.9	51,742,000	155	300	14,321,000	119	831
10 or older	86,587,000	343	396	24,993,000	297	1,188

Table 27.—Involvement rate by horsepower and age of passenger car, day and night

Horsepower of passenger car	Day				Night			
	Accident-involvement rate by passenger car age, years				Accident-involvement rate by passenger car age, years			
	Less than 3	3–5.9	6–9.9	10 or older	Less than 3	3–5.9	6–9.9	10 or older
110 or less	261	255	291	396	938	735	815	1,210
111–170	161	158	157	[1] 172	433	421	481	[2]
171 or more	168	149	[1] 239	[2]	374	257	[2]	[2]

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

Table 28.—Vehicle-miles, number of involvements, involvement rate by horsepower, day and night

Horsepower of vehicle	Day			Night		
	Vehicle-miles	Involvements		Vehicle-miles	Involvements	
		Number	*Rate*		*Number*	*Rate*
110 or lower	783,896,000	2,416	308	200,486,000	1,846	921
111–130	422,365,000	689	163	97,712,000	483	494
131–170	394,534,000	603	153	101,048,000	368	364
171–225	387,366,000	558	144	89,939,000	231	257
226–300	190,553,000	261	137	39,726,000	140	352
301 or more	7,548,000	7	93	1,514,000	6	396
TOTAL	2,186,262,000	4,534	207	530,425,000	3,074	580

Table 29.—Involvement rate by driver's age and horsepower of passenger car, day and night

Horsepower of passenger car	Day					Night				
	Accident-involvement rate by driver's age, years					Accident-involvement rate by driver's age, years				
	Under 20	20–24	25–44	45–64	65 or older	Under 20	20–24	25–44	45–65	65 or older
110 or less	688	442	228	248	554	1,189	1,316	742	777	1,649
111–170	360	324	125	128	248	910	635	372	343	[1] 374
171 or more	344	237	124	127	213	[1] 563	416	280	225	[2]

[1] Rate based on 10-29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

disconnected from any equipment. Although net horsepower—the power available to the wheels—would have been a better measure to use, it was not possible to determine net horsepower for this study.

It might also be suggested that low horsepower cars tended to be older, and the high involvement rate was associated with the age of the vehicle rather than low horsepower, but table 27 data show very clearly that passenger cars having 110 horsepower or less had the highest rates regardless of vehicle age for both day and night. In general, the involvement rate for passenger cars having less than 110 horsepower was about twice as great as for any group having higher horsepower.

It might also be thought that low horsepower cars are more likely to be driven by either very young or older drivers who have high involvement rates. However, table 29 data indicate that the age of the driver does not have any substantial modifying effect on the relationship between accident-involvement rate and horsepower. For both day and night and each age group, with only two exceptions, drivers of cars having 110 horsepower or less had about twice the involvement rate of the other two horsepower groups. Data on sex and military status also had similar patterns of relationship, as shown in tables 18 and 22. For each of the comparisons, drivers of cars having 110

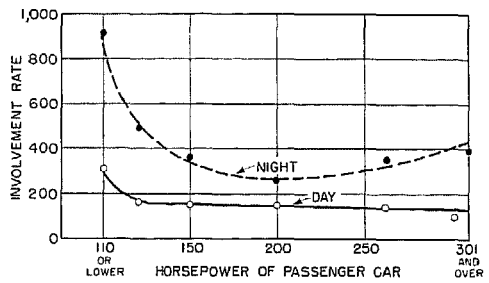

Figure 12.—Involvement rate by horsepower of passenger car, day and night.

horsepower or less had the highest accident-involvement rates.

When the residences of drivers were compared as shown in table 24, drivers of cars in the lowest horsepower group again had the highest accident-involvement rate. This was true for both day and night and, in general, when the horsepower of the cars was 110 or less, the accident-involvement rate was about twice as great as for drivers of any other group of cars of higher horsepower. Data in table 30 show that this high accident rate for drivers of cars in the lowest horsepower group was not affected by the body style of the car or by day and night conditions. One exception was noted; a slightly higher accident-involvement rate occurred at night for drivers of hardtops having a horsepower of 171 or more compared to

Table 30.—Involvement rate by horsepower and body style of passenger car, day and night

Horsepower of	Day					Night				
	Accident-involvement rate by body style of passenger car					Accident-involvement rate by body style of passenger car				
	2-door sedan	4-door sedan	Soft-top convertible	Hardtop	Station wagon	2-door sedan	4-door sedan	Soft-top convertible	Hardtop	Station wagon
110 or less	355	257	324	[1] 99	166	1,175	704	1,468	[1] 127	348
111–170	175	162	210	68	118	518	397	717	[1] 103	312
171 or more	192	156	196	59	79	387	288	[1] 604	147	[1] 96

[1] Rate based on 10–29 accident involvements.

Table 31.—Involvement, injury, fatality, and property damage rates by price of car, day and night

Car	Vehicle-miles		Accident involvements		Persons						Property damage		
					Injured			Killed					
	Number	*Percent*	*Number*	*Rate* [3]	*Number*	*Rate* [3]	*Per 100 involvements*	*Number*	*Rate* [3]	*Per 100 involvements*	*Amount*	*Rate* [3]	*Per 100 involvements*
DAY													
Small [4]	33,236,000	1.5	79	238	44	132	56	5	(2)	(2)	$26,167	$79,000	$33,000
Low-priced [5]	1,145,772,000	52.4	2,467	215	1,029	90	42	54	5	2	774,230	68,000	31,000
Medium-priced [6]	812,680,000	37.2	1,591	196	644	79	41	28	[1] 3	[1] 2	531,004	65,000	33,000
High-priced [7]	194,574,000	8.9	397	204	146	75	37	13	[1] 7	[1] 3	142,449	73,000	36,000
TOTAL	2,186,262,000	100.0	4,534	207	1,863	85	41	100	5	2	1,473,850	67,000	33,000
NIGHT													
Small [4]	7,928,000	1.5	53	668	18	[1] 227	34	0	(2)	(2)	$18,335	$231,000	$35,000
Low-priced [5]	287,710,000	54.2	1,681	584	848	295	50	57	20	3	585,807	204,000	35,000
Medium-priced [6]	190,466,000	35.9	1,126	591	495	260	44	59	31	5	415,691	218,000	37,000
High-priced [7]	44,321,000	8.4	214	483	82	185	38	9	(2)	(2)	71,117	161,000	33,000
TOTAL	530,425,000	100.0	3,074	580	1,443	272	47	125	24	4	1,090,950	206,000	36,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.
[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle-miles.
[4] All foreign, Crosley, Henry J., and Willys.
[5] Ford, Chevrolet, Plymouth, Studebaker, and Rambler.
[6] Pontiac, Buick, Oldsmobile, Edsel, Mercury, Hudson, Kaiser Frazer, Nash, and other U.S.: DeSoto, Dodge.
[7] Cadillac, Lincoln and Continental, Chrysler and Imperial, Packard.

the drivers of cars in the group having 110 horsepower or less. The rate for the lower horsepower group was based on a sample of only 25 involvements, however, and the comparison was not statistically significant.

Because the cars having lower horsepower are much lighter, on the basis of comparable weight-horsepower relationships, these cars might not have higher involvement rates. Although no data were obtained on the weights of cars in the study discussed here, other studies have shown that the range of weights of standard cars during the period of data accumulation for this study was relatively small. For example, one study [2] has shown that fully five-sixths of all cars selected from normal traffic on main rural highways varied no more than 20 percent from the average weight of all cars. This contrasts with differences in involvement rates between cars of low and high horsepower of about 100 percent in the day and close to 300 percent at night (fig. 12).

Acceleration capability

Acceleration capability of cars having low horsepower is poorer than for cars having high horsepower; this was true, at least, for the cars considered during the period (1952–57) of the study published here. Consumers Reports [3] has reported the time required to accelerate from 0 to 60 miles per hour on level grades and the maximum advertised horsepower for several score new cars during this period. A comparison of acceleration and advertised horsepower shows, for example, that 125 horsepower cars generally require 15 to 20 seconds to accelerate from 0 to

[2] Unpublished data obtained by Bureau of Public Roads in connection with braking performance studies in Maryland, Michigan, and California during 1955.

[3] *Consumers Reports*, Consumers Union, Mount Vernon, New York, different issues between 1952 and 1957.

60 miles per hour on a level grade. But, 250 horsepower cars require only 10 to 13 seconds for a similar acceleration. Time to accelerate from 45 to 65 miles per hour was also measured for a smaller sample of cars and was closely correlated with time to accelerate from 0 to 60 miles per hour. In summary, it is probably accurate to state that cars having poor acceleration capability at highway speeds have higher accident-involvement rates on main rural highways than other cars.

Make

When adequate data were available, there was little difference in involvement rate among the different makes. Involvement rates among the major manufacturing groupings varied less than 10 percent from the mean rate for both day and night conditions. A further comparison was made by grouping passenger cars according to size; that is, small cars, which included foreign cars; and low-priced, medium-priced, and high-priced cars. (Compact cars have not been included in these groupings because the data were obtained before the advent of compact cars.) The involvement rate tended to decrease as the price of the cars increased, and this decrease was particularly evident at night. This may be related to the fact that lower-priced cars tend to have lower horsepower and, as has been shown earlier, drivers of low-horsepower vehicles have higher involvement rates. There was also a tendency for the injury rate and the number of persons injured per 100 involvements to decrease as the price of the car increased. The average amount of property damage per 100 involvements was not related to the price of the car. Data related to the price of the cars are shown in table 31, but the differences were generally small among the different price categories.

Table 32.—Involvement rate by travel speed, age and horsepower of passenger car, and age of driver, day and night combined

FOUR VARIABLES	Speed, m.p.h.→		37 or slower			38–47			48–57			58 or faster		
Age of driver ↓	Horse-power ↓	Model year →	1950	1951–54	1955–58	1950	1951–54	1955–58	1950	1951–54	1955–58	1950	1951–54	1955–58
Under 20	Less than 110		7,174	8,191		799			629	454		348	651	
	111–170			[1] 4,538			[1] 859			438			[1] 429	[1] 409
	171–225				[1] 2,697			[1] 553			[1] 235			[1] 324
	226 or more													[1] 347
20–24	Less than 110		6,848	7,579		607	379		508	380	[1] 1,850	500	358	
	111–170			2,109	[1] 3,926	[1] 577	516	[1] 252	[1] 371	471	271		292	[1] 143
	171–225			6,750				[1] 222			312			[1] 183
	226 or more										[1] 634			
25–34	Less than 110		3,113	3,155		333	222		293	215		236	157	
	111–170		[1] 2,676	2,546	1,427	[1] 267	239	235	[1] 127	194	75	[1] 107	110	[1] 64
	171–225			[1] 3,010	2,705			254			173		[1] 214	81
	226 or more				[1] 1,307			[1] 371			269			[1] 73
35–44	Less than 110		2,525	2,244		291	194		162	118	[1] 567	[1] 134	[1] 79	
	111–170		[1] 1,103	1,607	1,823	[1] 119	175	173	[1] 99	132	100		77	
	171–225				1,924			186		[1] 215	121			64
	226 or more				[1] 2,599			[1] 286			149			[1] 73
45–64	Less than 110		2,705	3,046		191	177	[1] 428	195	134		137	122	
	111–170		[1] 1,337	1,638	2,551	[1] 236	226	[1] 74	[1] 137	118	71		76	
	171–225			[1] 1,840	2,187		[1] 151	[1] 117		[1] 156	116			71
	226 or more				2,200			219			170			[1] 48
65 or older	Less than 110		4,874	5,302		335	[1] 309		[1] 192	[1] 161				
	111–170			2,679						[1] 174				
	171–225				[1] 3,033			[1] 569			[1] 169			
	226 or more				[1] 4,358									

[1] Rate based on 10–29 involvements (rates based on less than 10 involvements not shown).

Part VI.—OTHER ACCIDENT RELATIONSHIPS

As discussed previously, the travel speed of the vehicle and the age of the driver are highly related to the accident-involvement rate, and the age or model year and horsepower of passenger cars have somewhat less of an effect. Table 32 data show a combined comparison of these four variables for passenger cars for day and night conditions combined. These data show that, regardless of model year or horsepower of cars, persons driving at slower speeds and younger drivers had the highest accident-involvement rates. Those driving at moderate speeds and middle-aged drivers had the lowest involvement rates.

In order to provide a reasonable sample for each cell, the data were combined in table 32 into broad groups and therefore the increase in the involvement rate at speeds above 70 miles per hour is not apparent. Data in this table also show that, for comparable speeds, horsepower of car, and age of driver, accident-involvement rates were lower when the car was a later model-year. In 28 comparisons made for pairs of cells having sample sizes of 30 or greater, 21 of the comparisons showed a lower involvement rate for the newer cars. Similarly, involvement rates were higher when the cars had horsepower of less than 110.

Range in Involvement Rate

Table 32 data show a considerable range in the involvement rate depending upon the combinations of the four variables that were studied. Moreover, many of the entries in this table involve a sample size of 10 to 29 involvements. Rates were not computed for cells having a sample size of less than 10 involvements. Considering only cells having 30 or more involvements, which provides a reasonable size sample, the lowest and the highest involvement rates may be selected for comparison. Table 33 data show the comparison of the characteristics of driver and their vehicles that provided the lowest and highest involvement rates. The lowest involvement rate was for 40-year-old drivers, traveling at 65 miles per hour on these main rural highways and driving 1956 cars—cars that were about 2 years old at the time of the study and had 200 horsepower. These drivers had an accident-involvement rate of 64; that is, they were involved in one reported accident for each 1,600,000 vehicle-miles of driving. By way of contrast, the highest involvement rate was obtained for 18-year-old drivers traveling at 30 miles per hour and driving 1952 cars, that is, cars about 6 years old at the time of the study and that had about 100 horsepower. These drivers had an involvement rate of 8,191; that is, they were involved in one reported accident for each 12,000 vehicle-miles of travel.

Note that these comparisons do not prove that certain identifiable drivers are accident prone. They do indicate that certain classes of drivers are more likely to be involved in accidents than other classes of drivers. Within each class, some range remains in the probability of being involved in an accident. This comparison and some of the comparisons made previously here suggest that the accident rate might be reduced if more driving

Table 33.—Characteristics associated with lowest and highest accident-involvement rates [1] for passenger cars, day and night combined

Passenger cars	Characteristics associated with accident-involvement rates	
Characteristics:	*Lowest*	*Highest*
Driver's age.....years	40	18
Travel speed.....m.p.h.	65	30
Model year	1956 (2 years old)	1952 (6 years old)
Horsepower	200	100
Accident involvements:		
Rate	64	8,191
Miles driven per involvement	1,600,000	12,000

[1] Based on those combinations of 4 variables for which at least 30 involvements were employed in computing the rates.

Table 34.—Involvement, injury, fatality, and property

Driver's age	Vehicle-miles				Accident involvements				Persons injured		
	Male		Female		Male		Female		Male		
DAY											
Years	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Rate* [3]	*Number*	*Rate* [3]	*Number*	*Rate* [3]	*Per 100 involvements*
Under 20	72,808,000	3.0	17,676,000	4.7	435	597	73	413	174	239	40
20-24	200,183,000	8.3	34,745,000	9.3	732	366	140	403	274	137	37
25-29	279,931,000	11.6	40,433,000	10.9	620	222	93	230	187	67	30
30-34	338,106,000	14.1	49,388,000	13.3	590	174	101	204	182	54	31
35-44	653,584,000	27.2	97,881,000	26.3	934	143	195	199	283	43	30
45-54	483,794,000	20.1	79,437,000	21.3	777	161	173	218	257	53	33
55-64	266,811,000	11.1	41,837,000	11.2	544	204	99	237	185	69	34
65 or older	110,853,000	4.6	11,197,000	3.0	422	382	55	493	126	114	30
TOTAL	2,406,070,000	100.0	372,594,000	100.0	5,054	210	929	249	1,668	69	33
NIGHT											
Under 20	33,488,000	4.0	2,332,000	4.0	334	997	30	1,286	155	463	46
20-24	82,068,000	9.8	11,188,000	19.0	729	888	51	456	392	478	54
25-29	123,005,000	14.8	9,043,000	15.4	589	479	55	608	209	170	35
30-34	145,886,000	17.5	9,780,000	16.6	469	321	46	470	210	144	45
35-44	243,621,000	29.2	15,161,000	25.7	665	273	77	508	231	95	35
45-54	149,246,100	17.9	8,605,000	14.6	395	265	58	674	168	113	43
55-64	46,249,000	5.6	2,121,000	3.6	226	489	18	[1] 849	91	197	40
65 or older	9,988,000	1.2	672,000	1.1	79	791	12	[1] 1,786	38	380	48
TOTAL	833,611,000	100.0	58,902,000	100.0	3,486	418	347	589	1,494	179	43

[1] Rate based on 10-29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

were done by some classes of drivers or less driving were done by other classes. For example, if a way could be found to encourage more driving at about the average speed of all traffic on main rural highways and less driving at either very low or very high speeds, the accident-involvement rate probably could be reduced considerably. Similarly, if even more driving could be done by 40-year-old drivers and less by 18-year-old drivers the involvement rate could possibly be reduced.

It is obvious, of course, that some of these possibilities are not practical. For example, it would be difficult to refuse to license 18-year-old drivers. The use of the motor vehicle is so important to the total economy that to refuse even young adults the freedom to operate motor vehicles would reduce considerably their effectiveness as citizens, as workers, and as functioning human beings. Moreover, such a decision would, in effect, make a group judgment that *all* 18-year-old persons should be denied licenses because a fraction have accidents during any one year.

Similarly, it would not be possible under present conditions to junk each car that was more than 3 years old. However, these data do suggest that a certain minimum horsepower, or more pertinent—acceleration capability, is desirable and drivers of passenger cars that have good acceleration capability are less likely to be involved in accidents than drivers of cars that do not. These accident-horsepower relationships apply primarily to standard size vehicles, as the sample included few small or compact cars.

The results obtained from the data collected in this study are indicative rather than conclusive. In many of the comparisons, the results were consistent regardless of the other variables that were studied. For example, for passenger cars having less than 110 horsepower, the accident-involvement rate was the highest regardless of any of the other variables studied. But it is always possible that other variables not studied might have been associated with low-horsepower cars, and these other variables might have affected the accident-involvement rate.

Severity of Accidents

It has been shown that the severity of accidents increased sharply as the speed increased, but the possibility exists that other characteristics of drivers and vehicles are related to increased severity of accidents. Several combinations of driver and vehicle characteristics were analyzed

damage rates by driver's age and sex, day and night

Persons injured—Continued			Persons killed						Property damage					
Female			Male			Female			Male			Female		
DAY														
Number	*Rate* [3]	*Per 100 involvements*	*Number*	*Rate* [3]	*Per 100 involvements*	*Number*	*Rate* [3]	*Per 100 involvements*	*Amount*	*Rate* [3]	*Per 100 involvements*	*Amount*	*Rate* [3]	*Per 100 involvements*
47	266	64	11	[1] 15	[1] 3	1	(2)	(2)	$136,550	$187,000	$31,000	$26,750	$151,000	$37,000
63	181	45	9	[1] 4	[1] 1	1	(2)	(2)	282,550	116,000	32,000	43,250	125,000	31,000
35	87	38	11			1	(2)	(2)	201,950	72,000	33,000	23,650	59,000	25,000
76	154	75	9	[1] 2	[1] 1	0	(2)	(2)	196,250	58,000	33,000	33,850	69,000	34,000
124	127	64	9			3	(2)	(2)	288,500	44,000	31,000	65,250	67,000	33,000
72	91	42	24	4	2	3	[1] 8	[1] 3	243,800	50,000	31,000	47,450	60,000	27,000
34	81	34	6			1			155,750	58,000	29,000	29,550	71,000	30,000
30	269	55	20	[1] 18	[1] 5	6			112,650	98,000	27,000	20,150	180,000	37,000
481	129	52	99	4	2	16	[1] 4	[1] 2	1,568,000	65,000	31,000	289,900	78,000	31,000
NIGHT														
15	643	[1] 50	18	[1] 54	[1] 5	0	(2)	(2)	$113,050	$338,000	$34,000	$8,050	$345,000	$27,000
23	[1] 206	[1] 45	24	[1] 29	[1] 3	0	(2)	(2)	271,500	331,000	37,000	16,850	151,000	33,000
22	[1] 243	[1] 40	19	[1] 15	[1] 3	0	(2)	(2)	200,100	163,000	34,000	16,050	177,000	29,000
29	[1] 297	[1] 63	19	[1] 13	[1] 4	3	(2)	(2)	171,100	117,000	36,000	16,850	172,000	37,000
22	[1] 145	[1] 30	23	8	3	2	(2)	(2)	217,150	89,000	33,000	23,400	154,000	30,000
28	[1] 325	[1] 48	8			0	(2)	(2)	142,850	96,000	36,000	16,200	188,000	28,000
6	[1] 438	[1] 40	19	[1] 39	[1] 7	0	(2)	(2)	74,000	160,000	33,000	5,900	278,000	[1] 33,000
6			3			0	(2)	(2)	23,300	233,000	29,000	3,600	536,000	[1] 30,000
151	256	44	133	16	4	5	(2)	(2)	1,213,050	146,000	35,000	106,900	181,000	31,000

[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle-miles.

Table 35.—Involvement, injury, fatality, and property damage rates by vehicle type, day and night

Vehicle type	Vehicle-miles	Accident involvements		Persons						Property damage		
				Injured			Killed					
DAY												
	Number	*Number*	*Rate* [3]	*Number*	*Rate* [3]	*Per 100 involvements*	*Number*	*Rate* [3]	*Per 100 involvements*	*Amount*	*Rate* [3]	*Per 100 involvements*
Passenger car	2,186,262,000	4,534	207	1,871	86	41	101	5	2	$1,487,200	$68,000	$33,000
Truck, single-unit, 4 tires	199,645,000	562	281	172	86	31	10	[1] 5	[1] 2	142,000	71,000	25,000
Truck, single-unit, 6 or more tires	124,222,000	290	233	25	[1] 20	[1] 9	1	(2)	(2)	72,200	58,000	25,000
Truck, combination	250,450,000	490	196	41	16	8	3	(2)	(2)	143,650	57,000	29,000
Bus	17,273,000	46	266	13	[1] 75	[1] 28	0	(2)	(2)	9,550	55,000	21,000
Other and not known	812,000	61	(4)	23	(4)	(4)	0	(4)	(4)	18,800	(4)	(4)
TOTAL	2,778,664,000	5,983	215	2,145	77	36	115	4	2	1,873,400	67,000	31,000
NIGHT												
Passenger car	530,425,000	3,074	580	1,444	272	47	125	24	4	$1,096,200	$207,000	$36,000
Truck, single-unit, 4 tires	59,928,000	239	399	103	172	43	7	[1] 3	[1] 2	73,750	123,000	31,000
Truck, single-unit, 6 or more tires	38,355,000	64	167	33	86	52	3			16,900	44,000	26,000
Truck, combination	254,907,000	418	164	47	18	11	2			145,150	57,000	35,000
Bus	8,437,000	10	[1] 119	6	[1] 71	[1] 60	0	(2)	(2)	3,800	45,000	[1] 38,000
Other and not known	460,000	28	(4)	14	(4)	(4)	1	(4)	(4)	8,850	(4)	(4)
TOTAL	892,512,000	3,833	429	1,647	185	43	138	15	4	1,344,650	151,000	35,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.
[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle-miles.
[4] Rate calculations not meaningful.

Table 36.—Involvement, injury, fatality, and property damage rates by model year of passenger car, day and night

Model	Vehicle-miles	Accident involvements	Persons						Property damage		
			Injured			Killed					
DAY											
Year	*Number*	*Number*	*Rate* [2]	*Number*	*Rate* [2]	*Per 100 involvements*	*Number*	*Rate* [2]	*Per 100 involvements*	*Amount*	*Rate* [2]	*Per 100 involvements*
1956–1958	435,729,000	739	170	346	79	47	16	[1] 4	[1] 2	$285,479	$66,000	$39,000
1954–1955	642,029,000	1,059	165	458	71	43	24	[1] 4	[1] 2	397,086	67,000	38,000
1952–1953	440,611,000	879	199	329	75	37	18	[1] 4	[1] 2	298,000	68,000	34,000
1950–1951	375,091,000	929	248	368	98	40	26	[1] 7	[1] 3	265,365	71,000	29,000
1948–1949	179,340,000	503	280	203	113	40	4	} [1] 5	} [1] 2	133,444	74,000	27,000
1946–1947	61,046,000	222	364	83	136	37	5			54,258	89,000	24,000
Before 1946	52,407,000	203	387	76	145	37	7			39,618	76,000	19,000
TOTAL	2,186,262,000	4,534	207	1,863	85	41	100	5	2	1,473,850	67,000	33,000
NIGHT												
1956–1958	101,772,000	361	355	168	165	47	13	[1] 13	[1] 4	$159,450	$157,000	$44,000
1954–1955	139,759,000	653	467	268	192	41	19	[1] 14	[1] 3	258,750	185,000	40,000
1952–1953	108,192,000	558	516	264	244	47	32	30	6	215,750	199,000	39,000
1950–1951	101,686,000	707	695	355	349	50	22	[1] 22	[1] 3	249,450	237,000	34,000
1948–1949	48,379,000	416	860	199	411	48	22	[1] 45	[1] 5	131,450	272,000	32,000
1946–1947	15,518,000	173	1,115	93	599	54	8	} [1] 55	} [1] 4	46,350	299,000	27,000
Before 1946	15,110,000	206	1,362	96	635	47	9			38,750	256,000	19,000
TOTAL	530,425,000	3,074	580	1,443	272	47	125	24	4	1,090,950	206,000	36,000

[1] Rate based n 10–29 accident involvements.
[2] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle-miles.

with respect to severity of accidents. The number of persons killed and injured per 100 involvements, and the amount of property damage per 100 involvements were used as the measures of severity.

No consistent variation occurred in the number of persons injured per 100 involvements among the several age groups of male drivers as shown in table 34. Male drivers under 25 years of age had a severity rate slightly higher than the average but beyond age 25 there was no consistent difference. Among female drivers there was a greater variation with age but this was not consistent and the higher variability was probably the result of the smaller sample size. Similarly, there was no consistency in variation in severity as measured by the amount of property damage. There was an indication that male drivers under the age of 20 and 65 or older accounted for a higher than average number of persons killed per 100 involvements. All of the foregoing comparisons applied generally for both day and night.

Vehicle type related to severity

Other comparisons were made as to the severity of accidents in relation to vehicle type. As shown in table 35, during the day the number of persons injured per 100 involvements was lowest for dual-tired trucks and combinations, a rate about one-fifth of that for passenger cars. This severity applies, however, only to the number of persons in the vehicle in question who were injured per 100 involvements. During the day, for example, only 8 people were injured in truck combinations per 100 of these vehicles involved in accidents but 41 persons were injured for each 100 passenger cars involved in accidents. This is not a surprising finding; it is reasonable to expect that, when a heavy truck hits a passenger car, few people will be injured in the truck. Moreover, the occupancy of trucks is much lower than that of passenger cars. At night, similar results were apparent for truck combinations but dual-tired trucks had an even higher severity rate than passenger cars. This difference in severity may be partly explained by the composition of night traffic. Because trucks and truck-combinations are a much greater percentage of the vehicles on the road at night, the possibility of a single-unit dual-tired truck colliding with a combination is greater.

Data in table 36 show the severity by model year of passenger car. There was no consistent variation in severity as measured by persons injured or killed. However, the amount of property damage decreased as the vehicle became older. This is probably to be expected considering the type of repairs done to old vehicles and their low market value. In addition, older vehicles

Table 37.—Involvement, injury, fatality, and property damage rates by body style of passenger car, day and night

Body styles	Vehicle-miles	Accident involvements			Persons						Property damage		
					Injured			Killed					
	DAY												
	Number	*Number*	*Rate*[3]	*Number*	*Rate*[3]	*Per 100 involvements*	*Number*	*Rate*[3]	*Per 100 involvements*	*Amount*	*Rate*[3]	*Per 100 involvements*
2-door sedan	698,483,000	1,969	282	810	116	41	46	7	2	$624,800	$90,000	$32,000
4-door sedan	935,754,000	1,907	204	754	81	39	39	4	2	618,200	66,000	32,000
Convertible	64,119,000	164	256	80	125	49	3	(2)	(2)	54,350	85,000	33,000
Hardtop	210,403,000	153	73	78	37	51	1	(2)	(2)	59,750	28,000	39,000
Station wagon	264,366,000	307	116	135	51	44	8	(2)	(2)	104,050	39,000	34,000
Other	13,137,000	34	259	6	(2)	17	3	(2)	(2)	12,700	97,000	37,000
TOTAL	2,186,262,000	4,534	207	1,863	85	41	100	5	2	1,473,850	67,000	32,000
	NIGHT											
2-door sedan	167,243,000	1,481	886	757	453	51	63	38	4	$521,050	$312,000	$35,000
4-door sedan	211,669,000	1,153	545	520	246	45	48	23	4	412,700	195,000	36,000
Convertible	19,557,000	186	951	86	440	46	11	[1] 56	[1] 6	67,200	344,000	36,000
Hardtop	61,304,000	84	137	16	[1] 26	19	1	(2)	(2)	31,650	52,000	38,000
Station wagon	68,311,000	157	230	61	89	39	2	(2)	(2)	55,250	81,000	35,000
Other	2,341,000	13	[1] 555	3	(2)	23	0	(2)	(2)	3,100	133,000	[1] 24,000
TOTAL	530,425,000	3,074	580	1,443	272	47	125	24	4	1,090,950	206,000	36,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.
[3] Rate is the number of involvements, persons injured, persons killed, or amount of property damage per 100 million vehicle-miles.

Table 38.—Occupant-mile injury and death rates by seated position in passenger car, day and night

Seated position	Occupant-miles of travel		Occupants injured		Occupants killed		Injury rate[3]		Fatality rate[3]	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Left front	2,186,000,000	530,000,000	849	706	49	66	39	133	2	12
Right front	1,398,000,000	293,000,000	503	356	29	26	36	121	2	9
Center front	401,000,000	93,000,000	81	58	5	4	20	62	[1] 1	[1] 6
Left rear	385,000,000	74,000,000	74	58	3	6	19	78		
Right rear	495,000,000	91,000,000	97	69	4	6	20	76		
Center rear	285,000,000	62,000,000	39	24	0	2	14	[1] 39	(2)	(2)
Rear seat in station wagon and other	23,000,000	4,000,000	6	5	0	0	(2)	(2)	(2)	(2)
TOTAL	5,173,000,000	1,147,000,000	1,649	1,276	90	110	32	111	2	10

[1] Rate based on 10–29 occupants injured or killed.
[2] Less than 10 occupants injured or killed; rate not computed.
Injury and fatality rates are number of occupants killed or injured per 100 million occupant-miles of travel.

Table 39.—Percentage of involvements by type of collision, by sex of driver, day and night

Sex of driver	Accident involvements	Percentage of accident-involvements by type of collision				
		Rear-end	Head-on	Angle	Other	None
	DAY					
Male	5,065	46	13	17	9	15
Female	918	43	12	19	10	16
TOTAL	5,983	46	13	17	9	15
	NIGHT					
Male	3,487	40	15	12	16	17
Female	346	39	16	12	17	16
TOTAL	3,833	40	15	13	15	17

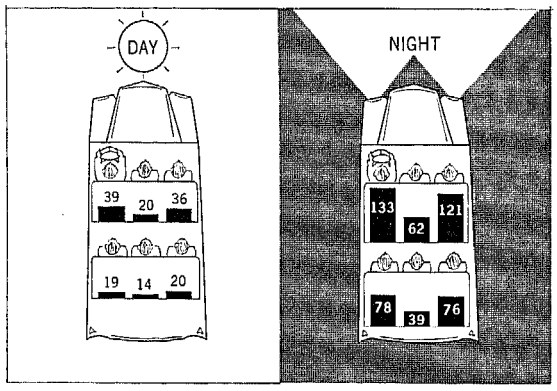

Figure 13.—Occupant-mile injury rates by seated position, day and night.

Table 40.—Involvement rate by type of collision, by travel speed, day and night

Travel speed, m.p.h.	Rate of accident-involvements by type of collision				
	Rear-end	Head-on	Angle	Other	None
DAY					
22 or less	20,066	3,399	16,118	1,462	1,572
23-32	662	118	177	[1] 80	[1] 97
33-37	312	56	50	50	85
38-42	106	37	26	23	33
43-47	81	28	19	19	30
48-52	53	25	16	16	22
53-57	48	19	19	14	36
58-62	31	16	14	11	24
63-72	27	12	10	10	25
73 or more	[1] 36	(2)	(2)	(2)	[1] 70
NIGHT					
22 or less	11,558	2,764	7,688	[1] 854	[1] 502
23-32	813	233	[1] 218	[1] 166	[1] 113
33-37	564	216	[1] 88	[1] 110	[1] 119
38-42	155	76	37	75	66
43-47	166	74	38	80	46
48-52	72	43	24	55	54
53-57	109	41	19	37	64
58-62	70	34	[1] 16	41	71
63-72	91	[1] 21	[1] 15	50	113
73 or more	[1] 224	[1] 130	(2)	(2)	483

[1] Rate based on 10-29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

Table 41.—Percentage of involvements by type of collision, by travel speed, day and night

Travel speed, m.p.h.	Accident involvements	Percentage of accident-involvements by type of collision				
		Rear-end	Head-on	Angle	Other	None
DAY						
Standing	493	78	6	9	5	2
22 or less	1,183	47	8	38	3	4
23-32	331	58	10	16	8	8
33-37	355	56	10	9	10	15
38-42	558	47	16	12	10	15
43-47	698	45	16	11	11	17
48-52	911	41	17	12	12	17
53-57	700	35	14	14	11	26
58-62	441	32	16	15	12	25
63-72	259	32	14	13	12	29
73 or more	54	26	2	7	15	50
TOTAL	5,983	46	13	17	9	15
NIGHT						
Standing	255	64	11	9	15	1
22 or less	473	49	12	33	4	2
23-32	206	52	15	14	12	7
33-37	254	51	20	8	11	10
38-42	418	37	18	9	20	16
43-47	559	40	18	9	21	12
48-52	686	29	17	9	23	22
53-57	454	40	15	7	15	23
58-62	250	30	15	7	18	30
63-72	195	31	7	5	18	39
73 or more	83	23	13	4	11	49
TOTAL	3,833	40	16	12	16	16

are driven up to four miles per hour slower, on the average, than the newer vehicles and, as has been shown, severity is less at the lower speeds.

Data on the severity for different price groups of passenger cars are shown in table 31. As measured by persons injured, the severity generally decreased as price of car increasd. One exception is for small cars at night where the severity was low (34), but the sample size of persons injured was small—only 18 persons were injured. A similar comparison for types of cars from different manufacturers showed that there was very little difference among them with respect to severity.

Considerable variation might be expected in severity among the different body styles of passenger cars. The convertible, for example, might be expected to have a much higher severity rate than other types of body styles. Table 37 shows data confirming that during the day hardtops and convertibles did have a greater proportion of persons injured per 100 involvements compared to 2- and 4-door sedans or station wagons. At night, however accident-severity for 2-door sedans was the highest and the lowest was for hardtops, although the sample size for hardtops was small—16 persons injured.

Seated Location Affects Severity

The car occupancy for normal passenger-car traffic using these main rural highways was 2.4 persons per car in the daytime and 2.2 persons per car at night. These car occupancy ratios included all persons of any age and, therefore, are somewhat higher than those obtained in other studies where young children have been excluded. The seated position of passenger car occupants had a substantial effect upon the probability of their being injured or killed in an accident. As table 38 and figure 13 show, the injury rate; that is, the number of car occupants injured per 100 million occupant-miles of travel, was greatest for those in the left and right front seats as compared to those in the other seated positions. The injury rate was about half as great for the occupants of the center front, left rear, and right rear seats. The injury rate was least for occupants of the center rear seat. These relationships were similar for both day and night conditions. A comparison of fatality rates also indicated that the left and right front seats were significantly more hazardous than other seated locations based on an analysis

Table 42.—Percentage of involvements by type of collision, by driver's age, day and night

Age of driver	Accident involvements	Percentage of accident-involvements by type of collision				
		Rear-end	Head-on	Angle	Other	None
DAY						
Under 20	508	44	14	13	11	18
20–24	872	46	14	13	10	17
25–29	713	47	13	13	9	18
30–34	691	45	13	18	10	14
35–44	1,129	47	13	16	9	15
45–54	950	49	12	18	8	13
55–64	643	49	11	12	7	12
65 or older	477	40	11	30	8	11
TOTAL	5,983	46	13	17	9	15
NIGHT						
Under 20	364	36	13	12	15	24
20–24	780	38	14	9	17	22
25–29	644	41	16	10	17	16
30–34	515	37	16	13	17	17
35–44	742	43	16	10	16	15
45–54	453	43	17	12	16	12
55–64	244	44	15	19	11	11
65 or older	91	43	12	26	12	7
TOTAL	3,833	40	15	12	16	17

Table 43.—Percentage of involvements by type of collision, by vehicle type, day and night

Vehicle type	Accident involvements	Percentage of accident-involvements by type of collision				
		Rear-end	Head-on	Angle	Other	None
DAY						
Passenger car	4,534	45	13	18	9	15
Truck, single-unit, 4 tires	562	47	9	19	8	17
Truck, single-unit, 6 or more tires	290	55	9	17	9	10
Truck combinations	490	54	14	10	11	11
Bus	46	72	15	7	4	2
Other and not known	61	26	2	20	9	43
TOTAL	5,983	46	13	17	9	15
NIGHT						
Passenger car	3,074	40	16	12	16	16
Truck, single-unit, 4 tires	239	41	14	14	12	19
Truck, single-unit, 6 or more tires	64	46	15	15	11	13
Truck combinations	418	43	16	8	18	15
Bus	10	60	10	10	20	0
Other and not known	28	46	0	15	12	27
TOTAL	3,833	40	15	12	16	17

of day and night data combined. The totals for persons killed and injured shown in table 38 do not correspond to totals in some of the other tables because occupancy data were not obtained for all of the study sections.

Type of Collision

On these main rural highways the predominant manner of collision was the rear-end type (including same-direction sideswipe). About 46 percent of all day and 40 percent of night accident involvements were of this type. The other types of collisions were fairly evenly distributed among head-on (including opposite directions sideswipes), angle, other collision, and noncollision types for both day and night conditions. Other collisions, which represent single-vehicle collisions with fixed objects in the roadway, were a much higher proportion of total involvements at night, when visibility was less, than during the day. Practically no variation was recorded among the two sexes with respect to the manner of collision, as shown in table 39. The proportion of each collision category was based on accident involvements not on accidents per se. Thus, other collisions and noncollisions involved only a single vehicle whereas all other collision categories involved two and sometimes three or more vehicles. If the comparison had been based on accidents rather than on accident involvements, the single-vehicle collisions would have approximately doubled in proportion to all collision categories.

Table 44.—Number of vehicles per accident, day and night

Vehicles involved in accidents	Day		Night		Total			
	Accident involvement		Accident involvement		Accident involvement		Vehicles	
Number	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
1	1,135	32.9	1,106	46.3	2,241	38.4	2,241	22.9
2	2,117	61.5	1,155	48.3	3,272	56.1	6,544	66.6
3	159	4.6	105	4.4	264	4.5	792	8.1
4	30	0.9	17	0.7	47	0.8	188	1.9
5	2	0.1	4	0.2	6	0.1	30	0.3
6 or more	1	(1)	2	0.1	3	0.1	21	0.2
TOTAL	3,444	100.0	2,389	100.0	5,833	100.0	9,816	100.0

[1] Less than 0.05 percent.

Travel Speed and Type of Collision

As might have been expected, the travel speed of the vehicle prior to the accident was closely related to the resultant type of collision. The proportion of rear-end collisions was highest at the lower speeds. During the day, fully 77 percent of standing vehicles involved in accidents were involved in rear-end collisions and fewer than 10 percent in each of the other types. In figure 14, the dip shown in the rear-end collision curve for the speed range of 5 to 25 miles per hour was caused by the predominance of angle collisions. Within any speed range, the points in figure 14, do not add to 100 percent because other collision types have been omitted for simplicity.

Angle collisions were a substantial proportion of the total involvements at the lower speed range of 5 to 25 miles per hour, as shown in figure 14. This is the speed of many vehicles at crossroads, driveways, and other points of access. However, the study sections were selected so that crossroads were at a minimum, and the data shown are typical of main rural highways having little roadside development. Main rural highways having considerable roadside development or many more intersections would have a higher proportion of angle collisions than shown here.

Table 40 shows involvement rates that were computed by travel speed and type of collision. For each type of collision, the accident-involvement rates follow the general pattern; that is, the lowest involvement rate was at about the average speed of all traffic and the involvement rate was very high at the very low speeds and, also, tended to increase at the higher speeds, although this effect was somewhat masked by the small sample size at the higher speeds.

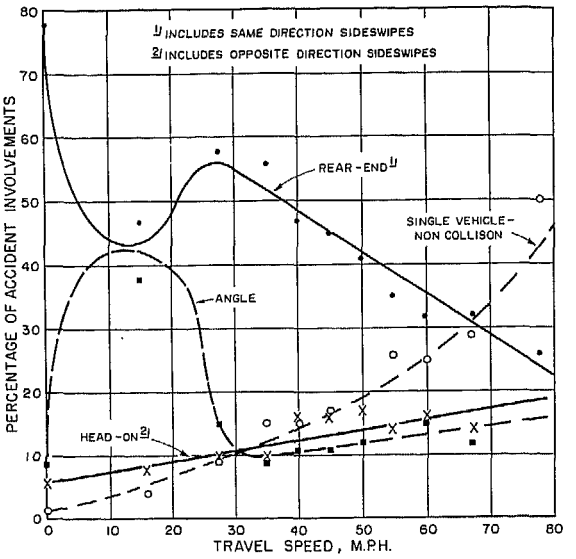

Figure 14.—Percentage of accident involvements by travel speed and type of collision for all vehicles, day.

As figure 14 illustrates, the percentage of head-on collisions increased linearly as speed was increased but even at the higher speeds, head-on collisions accounted for fewer than 20 percent of all accident involvements. Single-vehicle, non-collision involvements were a small proportion of all involvements at the lower speeds, but they increased sharply at speeds in excess of 50 miles per hour and at speeds exceeding 70 miles per hour accounted for up to half of all involvements. As shown in table 41, the pattern of involvement by travel speed and manner of collision was very similar for night conditions.

In general, the age of the driver had little effect upon the type of collision. However, as shown in table 42, drivers 65 years of age or more were

Table 45.—Accidents, persons injured, persons killed, amount of property damage, by vehicle type for one-vehicle accidents, day and night combined

Vehicle type	Accident involvements	Persons				Property damage	
		Injured		Killed			
	Number	*Number*	*Per 100 involvements*	*Number*	*Per 100 involvements*	*Amount*	*Per 100 involvements*
Passenger car	1,807	1,169	65	105	6	$786,370	$44,000
Truck, single-unit, 4 tires	149	95	64	10	[1] 7	63,733	43,000
Truck, single-unit, 6 or more tires	46	22	[1] 48	2	[2]	20,700	45,000
Truck combination	171	40	23	2	[2]	89,401	52,000
Bus	2	4	[2]	0	[2]	850	43,000
Other and not known	66	24	[1] 36	4	[2]	25,689	39,000
TOTAL	2,241	1,354	60	123	5	986,743	44,000

[1] Rate based on 10-29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

much more likely to be involved in angle collisions than other drivers and were much less likely to be involved in noncollision types of single-vehicle accidents as compared to younger drivers. These older drivers have longer reaction times, narrower fields of view, and poorer vision than younger drivers and their performance tends to degrade generally. The process of crossing a stream of traffic at an intersection is a more complex driving maneuver than traveling in the traffic stream, and perhaps older drivers find it difficult to cope with its demands upon them. Table 42 data also show a tendency for a decrease in the proportion of other collision types of single-vehicle accidents as drivers become older.

Table 43 data show the type of collision by vehicle type. The proportion of involvements for each manner of collision was generally similar for the different vehicle types. However, for buses the overwhelming majority of all involvements—72 percent in the day and 60 percent at night—were rear-end collisions. Other collision categories for buses were correspondingly reduced. The sample size, however, was small—only 46 involvements in the day and only 10 at night. Also noteworthy is the fact that combination types of trucks were involved in a much smaller proportion of angle collisions than other types of trucks or passenger cars. This may be partially related to the longer trip lengths of these vehicle types on main highways and the decreased necessity for their entering or leaving the highway at intersections or driveways.

Number of Vehicles Per Accident

Although a majority of all accidents on these main rural highways were two-vehicle collisions, a large proportion of accidents involved only one vehicle, particularly at night: As table 44 shows, 33 percent of all accidents during the day and 46 percent during the night involved only a single vehicle. About 61 percent of accidents during the day and 48 percent of those occurring at night involved two vehicles. Less than 6 percent of accidents during either the day or night involved three or more vehicles. On the basis of the number of vehicles involved in accidents, single-vehicle accidents accounted for 23 percent of the vehicles and two-vehicle accidents accounted for 67 percent of the total. Accidents involving three or more vehicles accounted for only 10 percent of all vehicle involvements. Accidents involving five or more vehicles are often spectacular but they involved fewer than 1 percent of all vehicles involved in accidents recorded in this study.

In single-vehicle collisions, it might be expected that many more people in passenger cars would be injured per 100 accidents compared to trucks because of the greater car occupancy of passenger cars. Data in table 45 show that this is indeed the case. Single-unit, single-tired trucks having similar characteristics to passenger cars also had about the same number of persons injured per 100 involvements. Truck combinations had a frequency of persons injured per 100 accidents that was only one-third that of passenger vehicles. This low ratio might be partially explained by lower occupancy, but the slower speeds and more rigid bodies of truck combinations in relation to passenger cars could also be factors. The amount of property damage per 100 accidents was about the same for different types of vehicles involved in single-vehicle collisions, except that it was slightly higher for combinations.

Table 46.—Accidents, persons injured, persons killed, amount of property damage by vehicle type for two-vehicle accidents, day and night combined

Vehicle type	Accidents	Persons				Property damage	
		Injured		Killed			
	Number	*Number*	*Per 100 involvements*	*Number*	*Per 100 involvements*	*Amount*	*Per 100 involvements*
Two passenger cars	1,911	1,305	68	59	3	$517,461	$27,000
Two trucks	212	79	37	5	(2)	64,957	31,000
Two buses	3	1	(2)	0	(2)	150	(2)
Passenger car and truck	1,027	595	[1] 58	55	5	258,044	25,000
Passenger car and bus	30	18	[1] 60	0	(2)	5,034	17,000
Truck and bus	14	17	[1] 121	1	(2)	6,450	[1] 46,000
Other and not known	75	52	69	7	(2)	21,200	28,000
TOTAL	3,272	2,067	63	127	4	873,296	27,000

[1] Rate based on 10–29 accident involvements.
[2] Less than 10 accident involvements; rate not computed.

Considering only collisions that involved two vehicles, those involving two trucks had only half as many persons injured per 100 accidents compared to those involving two passenger cars, as shown in table 46. This closely approximates the relative vehicle occupancy of the two types of vehicles. Collisions involving a passenger car and a truck caused injuries that were intermediate between either two trucks or two passenger cars. By far the greatest number of persons injured per 100 accidents occurred when a truck and a bus collided; however, the sample was comprised of only 14 accidents in which 17 persons were injured.

The amount of property damage per 100 accidents was least when a passenger car and bus were involved and greatest when a truck and bus were involved. Little difference in property damage per 100 accidents was noted for involvements of other types of vehicles.

About 3 persons per 100 accidents were killed when two passenger cars were involved, but 5 persons per 100 accidents were killed when a truck and a passenger car were involved. On the basis of vehicle occupancy, fewer persons per 100 accidents should have been killed in truck-passenger car accidents. The differences in vehicle structure may be a partial explanation for the difference. Other comparisons involving fatalities could not be made because of inadequate sample size.

In summary, many of the differences in the number of persons injured and killed per 100 accidents for different vehicle type combinations were close to that expected on the basis of relative vehicle occupancy. But differences in speeds and body structure were also factors that may have contributed to the differences.

Highway Features and Accident Involvement

An attempt was made to relate certain highway features to accident involvement rates. As indicated, during the day the accident involvement rate on 2-lane highways was about twice as high as on the 4-lane sections. At night, the involvement rate on 2-lane sections was also higher than on 4-lane sections, but the difference was less.

As shown by data in table 47, there was no consistent relationship between median width and total accident-involvement rate. As suspected, the head-on involvement rate was affected to a considerable extent by the presence of a median. The head-on involvement rate on 2-lane sections was at least five times as great as it was on 4-lane sections, all of which had medians. This was true during both day and night. On 2-lane highways, 16 percent of all involvements during the day and 21 percent of those at night were head-on collisions. On 4-lane sections, the percentage of head-on involvements ranged from 3 to 6 percent. There was no consistent relationship between median width and percentage of head-on collisions, but the sample size was small.

As table 48 data show, there was a tendency for the involvement rate to increase as the number

Table 47.—Median width related to total involvements and head-on collisions on 2- and 4-lane highways, day and night

Median width	Vehicle-miles	Total accident involvements		Head-on collisions [2]		Head-on collisions as a percentage of total
		DAY				
Feet		*Number*	*Rate*	*Number*	*Rate*	
2-lane:						
All sections	1,749,317,000	4,352	249	701	40	16
4-lane:						
Less than 15 [1]	322,087,000	440	137	26	8	6
15–39	484,970,000	928	191	20	4	2
More than 40	222,290,000	263	118	8	4	3
		NIGHT				
2-lane:						
All sections	554,144,000	2,569	464	548	99	21
4-lane:						
Less than 15 [1]	130,874,000	433	331	16	12	4
15–39	164,126,000	663	404	22	13	3
More than 40	43,368,000	168	387	9	21	5

[1] Minimum median width was 8 feet.
[2] Includes opposite direction sideswipes.

Table 48.—Number of intersections per mile related to type of collision, 2- and 4-lane highways, day and night

Number of intersections per mile	Vehicle-miles	Total accident involvements			Type of collision								
					Rear-end [1]			Angle			Head-on [2]		
					DAY								
		Number	*Percent*	*Rate*	*Number*	*Percent*	*Rate*	*Number*	*Percent*	*Rate*	*Number*	*Percent*	*Rate*
2-lane:													
0–0.9	458, 651, 000	1, 105	100	241	447	40	97	91	8	20	191	17	42
1–1.9	1, 138, 435, 000	2, 737	100	240	1, 255	46	110	406	15	36	436	16	38
2 or more	152, 231, 000	510	100	335	237	46	156	125	25	82	74	15	49
4-lane:													
0–1.9	693, 880, 000	765	100	110	378	49	54	166	22	24	25	3	4
2 or more	335, 467, 000	866	100	258	450	52	134	234	27	70	29	3	9
					NIGHT								
2-lane:													
0–0.9	174, 527, 000	620	100	355	164	26	94	46	7	26	116	19	66
1–1.9	320, 386, 000	1, 536	100	479	527	34	164	150	10	47	338	22	105
2 or more	59, 231, 000	413	100	697	141	34	238	65	16	110	94	23	159
4-lane:													
0–1.9	183, 512, 000	699	100	381	408	58	222	99	14	54	15	2	8
2 or more	154, 856, 000	565	100	365	298	53	192	84	15	54	32	6	21

[1] Includes same direction sideswipes.
[2] Includes opposite direction sideswipes.

of intersections per mile increased. As expected rear-end and angle collisions, particularly, tended to increase as the number of intersections per mile increased. This was true for 2-lane highways both during the day and night and for 4-lane highways during the day. There was also a tendency for head-on collisions to increase with number of intersections per mile for 2-lane highways at night and for 4-lane highways during both the day and night.

Highways having few intersections per mile also had few driveways per mile. An analysis combining the number of intersections per mile and driveways per mile produced results similar to the analysis in which intersection data alone were used. This analysis points up the safety benefit of controlling access to the highway.

As table 49 data show, during the day the total involvement rate increased as shoulder width increased on 2-lane highways. At night, 2-lane highways having shoulders 6–9 feet wide had a lower involvement rate than either narrower or wider shoulders. Similar results were noted for the predominant rear-end collisions. Rates for head-on and angle collisions increased as shoulder width increased. These results appear incongruous and may have been associated with other variables that were not studied.

Table 49.—Shoulder width related to type of collision, day and night

Shoulder width	Vehicle-miles	Total accident involvements		Type of collision								
				Rear-end [1]			Head-on [2]			Angle		
				DAY								
Feet		*Number*	*Rate*	*Number*	*Percent*	*Rate*	*Number*	*Percent*	*Rate*	*Number*	*Percent*	*Rate*
2-lane:												
0–5	740, 896, 000	1, 605	217	640	40	86	267	17	36	233	15	31
6–9	679, 018, 000	1, 777	262	829	47	122	273	15	40	208	12	31
10 or wider	329, 403, 000	970	294	470	48	143	161	17	49	181	19	55
4-lane:												
All	1, 029, 347, 000	1, 631	158	828	51	80	54	3	5	400	25	39
				NIGHT								
2-lane:												
0–5	209, 509, 000	947	452	302	32	144	188	20	90	79	8	38
6–9	225, 487, 000	988	438	299	30	133	219	22	97	95	10	42
10 or wider	119, 148, 000	634	532	231	36	194	141	22	118	87	14	73
4-lane:												
All	338, 368, 000	1, 264	374	706	56	209	47	4	14	183	14	54

[1] Includes same direction sideswipes.
[2] Includes opposite direction sideswipes.

Part VII.—RELATIVE TRAVEL AND SPEED PATTERNS

Although the principal purpose of this study was to determine the relation between accidents and characteristics of drivers and vehicles, certain other findings are also important and worth noting. In particular, the relation between speed, relative amount of travel, and certain characteristics of drivers and vehicles are discussed in the following paragraphs.

As has been indicated, relative amount of travel varied considerably and depended upon the characteristics of driver and vehicle. For example, female drivers accounted for only 13 percent of the vehicle-miles of travel during the day and for only 7 percent of travel during the night hours. However, the mean speeds of male and female drivers were nearly identical—52.6 miles per hour during the day, and about 51.0 miles per hour at night. If only passenger-car drivers are compared, the speed of male drivers averaged about 1 mile per hour faster than that for female drivers.

Speeds and Characteristics of Drivers and Vehicles

Table 50 data show mean speeds and variability in speeds for the driver and vehicle characteristics studied. The measure of variability employed was the standard deviation. The higher the standard deviation, the greater the variability in speeds. A common interpretation of the standard deviation is that one standard deviation encompasses 68.3 percent or about two-thirds of all speeds: two standard deviations encompass 95.5 percent of all speeds: and three standard deviations encompass 99.7 percent of all speeds.

For example, as shown in table 50, during the day male drivers had a mean speed of 52.6 miles per hour and a standard deviation of 9.2 miles per hour. This means that about two-thirds of all male drivers traveled at speeds ranging between 43 and 62 miles per hour; and 95.5 percent of the male drivers traveled at speeds between 34 and 71 miles per hour. The actual data fitted these simplified statistics within 1 or 2 miles per hour. The statistics apply to all drivers on all 35 study sections; but on any single study section, the variability was less.

The difference in both mean speeds and standard deviations between nonmembers and members of the Armed Forces was only about 1 mile per hour. Those in the Armed Forces were the faster drivers but this is probably associated with their younger ages rather than their Armed Forces membership.

Residence of driver had a small effect on mean speeds and the effect was different for day and night driving. During the day, in-State drivers from counties remote from the study section averaged 3 to 4 miles per hour faster than the other three groups. At night, out-of-State drivers averaged 3 miles per hour slower than the others. The standard deviation was greatest for local drivers and least for out-of-State drivers.

There was a tendency for younger drivers to drive slightly faster than older drivers during both day and night. The range in mean speeds between the youngest and oldest age groups was about 3 miles per hour. During the day, there was little difference in variability in speeds among the age groups. At night, however, the middle-aged drivers showed less variability in speeds than either younger or older drivers.

As other studies have shown, there is a considerable difference in mean speeds depending upon the vehicle type. During the day, drivers of truck combinations and single-unit, dual-tired trucks traveled 6 to 7 miles per hour slower on the average than drivers of passenger cars, as shown in table 50. At night, the speeds for trucks were only 3 to 5 miles per hour slower than for passenger cars. Single-unit trucks having 4 tires, such as

panels and pickups, had speeds between these extremes during the day and very close to passenger-car speeds at night. The heavier trucks, having 6 or more tires including combinations, had less of a variance in speeds at night as compared to passenger cars and buses. Also, drivers of all types of commercial vehicles traveled up to 2 miles per hour faster at night than in the day, and passenger-car drivers averaged about 2 miles per hour slower at night.

Tendency was for higher horsepower cars to be driven at higher speeds, and the range in speed between the lowest and highest horsepower groups was about 3 miles per hour during the day and nearly 6 miles per hour at night. There was little difference in the variance in speeds among the horsepower groups during either the day or night.

Speeds at which sports cars tended to be driven were much higher than for any other body style

Table 50.—Mean and standard deviation of speed distributions and percentage of vehicle-miles of travel for characteristics of driver and vehicle, day and night

Characteristics	Mean speed		Standard deviation		Driver sample		Vehicle-miles	
	Day	Night	Day	Night	Day	Night	Day	Night
	M.p.h.	*M.p.h.*	*M.p.h.*	*M.p.h.*	*Number*	*Number*	*Percent*	*Percent*
All	52.6	51.0	9.1	8.8	219,000	71,000	100	100
Driver:								
Sex:								
Male	52.6	50.9	9.2	8.8	190,000	66,000	87	93
Female	52.6	51.2	9.0	9.5	29,000	5,000	13	7
Military status:								
Member of Armed Forces	53.5	52.0	8.5	9.6	7,000	4,000	3	5
Nonmember	52.6	50.9	9.2	8.7	212,000	67,000	97	95
Residence:								
In State:								
Study county	51.2	52.0	9.4	9.6	53,000	14,000	25	20
Adjacent county	52.6	52.5	9.0	8.8	45,000	15,000	20	21
Other county	55.4	52.7	9.1	8.8	60,000	20,000	27	28
Out-of-State	52.3	49.6	8.6	8.0	61,000	22,000	28	31
Age:								
Under 20	53.7	52.3	9.4	10.0	7,000	3,000	3	4
20-24	53.2	52.0	9.0	9.5	19,000	7,000	9	10
25-29	52.8	51.1	9.0	8.7	25,000	10,000	12	15
30-34	52.7	51.1	9.2	8.8	31,000	12,000	14	18
35-44	52.8	50.7	9.4	8.2	58,000	21,000	27	29
45-54	52.4	50.5	9.2	8.6	45,000	13,000	20	18
55-64	52.2	50.1	9.1	9.5	24,000	4,000	11	5
65 and older	51.0	49.8	9.1	9.6	10,000	1,000	4	1
Type of vehicle:								
Passenger car	53.7	51.9	9.1	9.7	173,000	42,000	79	60
Trucks:								
Single-unit, 4 tires	49.9	51.8	9.1	8.9	15,000	5,000	7	7
Single-unit, 6 or more tires	46.6	47.3	7.8	6.9	10,000	3,000	4	4
Combination	47.9	49.0	6.9	6.0	20,000	20,000	9	28
Bus	54.4	54.5	7.8	8.7	1,000	1,000	1	1
Passenger car:								
Horsepower:								
Less than 110	52.0	50.6	8.8	9.2	62,000	16,000	36	38
111-130	53.6	51.4	8.8	9.4	33,000	8,000	19	18
131-170	54.5	52.9	9.2	10.1	31,000	8,000	18	19
171-225	55.2	53.4	9.2	9.7	31,000	7,000	18	17
226-300	56.0	54.1	9.3	10.0	15,000	3,000	9	8
301 or more	54.7	56.4	8.6	9.3	1,000	(2)	(1)	(1)
Body style:								
2-door sedan	52.8	51.7	8.9	9.1	55,000	14,000	32	32
4-door sedan	53.0	51.6	8.6	9.3	75,000	17,000	43	40
Soft top convertible	54.4	51.8	9.5	9.7	5,000	1,000	3	4
Hard top	54.4	52.7	9.2	9.6	17,000	5,000	10	12
Station wagon	56.3	52.9	9.3	11.8	20,000	5,000	12	13
Sports car	60.3	57.2	10.2	9.9	1,000	(2)	(1)	1
Age (years):								
Under 1	54.9	53.4	9.1	9.8	10,000	2,000		
1-1.9	55.3	53.6	9.2	10.1	36,000	8,000	21	19
2-2.9	54.7	52.6	9.1	9.7	30,000	7,000	17	16
3-3.9	54.1	52.1	8.9	9.7	22,000	5,000	13	12
4-4.9	53.5	52.0	8.9	9.5	17,000	4,000	10	10
5-5.9	53.1	51.3	8.8	9.5	16,000	4,000	9	10
6-6.9	52.3	50.8	8.7	9.2	13,000	4,000	8	8
7-7.9	51.9	50.8	8.8	9.0	11,000	3,000	6	7
8-8.9	51.5	50.5	8.8	9.4	7,000	2,000	4	5
9-9.9	50.8	49.3	8.7	9.5	4,000	1,000	2	3
10 or more	49.4	49.2	9.0	8.9	7,000	2,000	4	5

[1] Less than 0.5 percent. [2] Less than 500 drivers.

of passenger car and averaged 60 miles per hour in the day and 57 miles per hour at night. There was less difference in mean speed at which the cars having other body types were driven, particularly at night. During both day and night hours, newer cars were driven at the higher speeds. For example, during the day, cars less than 3 years old were driven at a mean speed of 55 miles per hour, and cars more than 10 years old were driven at a mean speed of only 49 miles per hour. There was little difference in variance in speed among the various passenger car age groups.

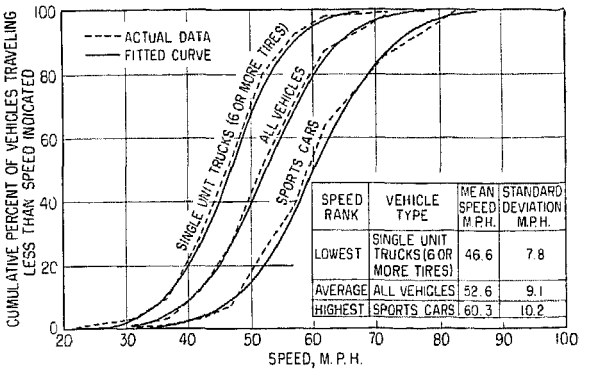

Figure 15.—Cumulative percent of vehicles traveling less than speed indicated, day.

Summation

In summary, for nearly all driver and vehicle characteristics studied, only a moderate variation was noted in the mean speeds and the variability in speeds. For all characteristics studied, single-unit trucks having 6 or more tires had the lowest mean speed, 46.6 miles per hour, and the sports cars had the highest mean speed, 60.3 miles per hour as shown in table 50. Figure 15 data show the cumulative speed distributions of the actual day data (dashed curves) for these extremes. The mean values for night data were closer together and are not shown. These two distributions demonstrate the range in speed distribution obtained for the various characteristics of drivers and vehicles on the 35 study sections. On any single study section the variance in speeds would be somewhat less.

Figure 15 also shows fitted cumulative frequency distributions (solid curves) computed from the mean speed and standard deviation and assuming a normal distribution of the data. It is evident that the difference between the actual data and the fitted curves are very small indeed, thus indicating that the actual data does follow

Table 51.—Percent of registered drivers and vehicle-miles and the ratio between the two by age and sex of driver, day and night

Age of driver	Percent of registered drivers[1]	Vehicle-miles					
		Total		Percentage		Ratio (Percent of vehicle-miles to percent of registered drivers)	
		Day	Night	Day	Night	Day	Night
MALE							
Under 20	6.9	72,808,000	33,488,000	3.0	4.0	0.43	0.58
20-24	8.2	200,183,000	82,068,000	8.3	9.9	1.01	1.21
25-29	10.5	279,931,000	123,065,000	11.6	14.8	1.10	1.41
30-34	12.6	338,106,000	145,886,000	14.1	17.5	1.12	1.39
35-44	23.3	653,584,000	243,621,000	27.2	29.2	1.17	1.25
45-54	18.7	483,794,000	149,246,000	20.1	17.9	1.07	0.96
55-64	12.6	266,811,000	46,249,000	11.1	5.5	0.88	0.44
65 or over	7.2	110,853,000	9,988,000	4.6	1.2	0.64	0.17
TOTAL	100.0	2,406,070,000	833,611,000	100.0	100.0	1.00	1.00
FEMALE							
Under 20	5.7	17,676,000	2,332,000	4.8	4.0	0.84	0.70
20-24	8.9	34,745,000	11,188,000	9.3	19.0	1.04	2.13
25-29	14.2	40,433,000	9,043,000	10.8	15.4	0.76	1.08
30-34	14.8	49,388,000	9,780,000	13.3	16.6	0.90	1.12
35-44	27.5	97,881,000	15,161,000	26.3	25.7	0.96	0.93
45-54	17.6	79,437,000	8,605,000	21.3	14.6	1.21	0.83
55-64	8.3	41,837,000	2,121,000	11.2	3.6	1.35	0.43
65 or over	3.0	11,197,000	672,000	3.0	1.1	1.00	0.37
TOTAL	100.0	372,594,000	58,902,000	100.0	100.0	1.00	1.00

[1] Interpolated from motor-vehicle use study data for 15 States.

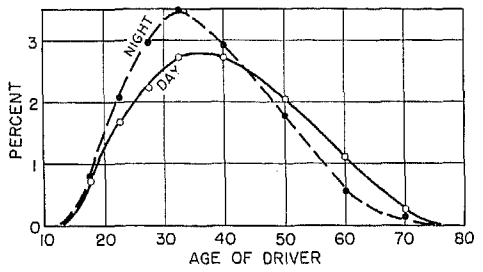

Figure 16.—Percent of travel, by age of driver, day and night.

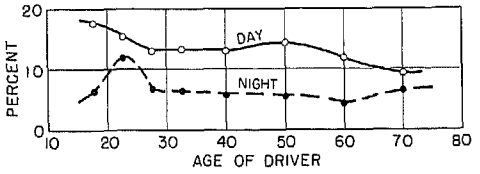

Figure 17.—Percent of travel, by female drivers, day and night.

closely a normal distribution. Thus, given the mean value and the standard deviation as shown in table 50, the speed distribution for any characteristic may be closely specified. The middle pair of curves in figure 15 show a cumulative speed distribution for all vehicles. A noncumulative speed distribution for all vehicles is shown as the dashed curve in figure 1.

Relative Travel

The proportion of travel by drivers varied considerably depending upon their age. During the day, for example, 35-year-old drivers contributed nearly 3 percent of the total vehicle-miles of travel; and 20- and 60-year-old drivers each contributed little more than 1 percent of the travel, as shown in figure 16. At night, the younger drivers increased their proportion of the total travel; while older drivers, particularly those 65 and older, did much less driving than during the day.

Table 51 data also show these relationships by 5-year, 10-year, or other age groupings. In addition, a ratio between the percentage of vehicle-miles and the percentage of registered drivers has been computed for each age group, and this is probably a more meaningful way to compare relative travel by different age groups. During the day, for example, a ratio of 0.43 was computed for male drivers under 20. This may be interpreted as follows: During the day, the average male driver under 20 traveled only 43 percent as much on these main rural highways as the average male driver of all age groups combined (ratio, 1.00). At night the comparable ratio for male drivers under 20 was 0.58.

Male drivers between 25–44 years old traveled 10–17 percent (ratios of 1.10–1.17) more than the average driver in the day and 25–41 percent more at night. Also, drivers beyond the age of 65 traveled about 64 percent as much as the average driver in the day, but only 17 percent as much at night.

On the average, female drivers accounted for 13 percent of the vehicle-miles of travel during the day but only 7 percent of the travel during the more critical night hours. In general, the proportion of female drivers was nearly constant for the different age groups as shown in figure 17. One obvious exception was the 20- to 24-year-old female who at night contributed 12 percent of all travel by drivers of this age group—nearly twice the percentage of any other age group of females at night. In the day, there was a tendency for female drivers under age 25 to contribute somewhat more travel than older female drivers.

Table 52.—Percent and cumulative percent of vehicle-miles by age of driver and passenger car, day and night

Age of driver	Day								Night							
	Age of passenger car, years								Age of passenger car, years							
	Less than 3		3–6		6–10		10 or older		Less than 3		3–6		6–10		10 or older	
	Percent	*Cumulative percent*	*Percent*	*Cumulative percent*	*Percent*	*Cumulative percent*	*Percent*	*Cumulative percent*	*Percent*	*Cumulative percent*	*Percent*	*Cumulative percent*	*Percent*	*Cumulative percent*	*Percent*	*Cumulative percent*
Under 20	2	2	3	3	6	6	7	7	4	4	5	5	10	10	12	12
20–24	7	9	9	12	12	18	12	19	12	16	16	21	16	26	15	27
25–44	52	61	50	62	46	64	39	58	58	74	55	76	52	78	42	69
45–64	35	96	33	95	30	94	31	89	24	98	23	99	20	98	29	98
65 or older	4	100	5	100	6	100	11	100	2	100	1	100	2	100	2	100

The ratios shown in table 51 also compare the different age groups of female drivers. In general, the older and younger female drivers drove less than the average female driver but the difference was less pronounced than for male drivers. The relatively large amount of night travel by 20- to 24-year-old female drivers also shows up clearly in table 51.

As shown in table 50, members of the Armed Forces contributed 3 percent of the travel during the day and 5 percent at night. The higher proportion of night travel by members of the Armed Forces is to be expected because military drivers were predominantly in the younger age groups who increased their share of all travel at night. During the day, for example, 38 percent of the drivers who were members of the Armed Forces were under age 25 compared to only 11 percent of the nonmember drivers. Similarly, only 1 percent of the drivers in the Armed Forces were older than age 44 compared to 17 percent of nonmembers.

As data in table 50 show, combination trucks contributed only 9 percent of all travel in the day, but at night the proportion increased sharply to 28 percent of all travel. This should not be interpreted as indicating more truck travel at night. Rather, as other studies have shown, trucks provide a more consistent traffic volume throughout the 24 hours of the day. However, passenger cars show much greater variation in traffic volume, peak volumes occur during the day (except in a few winter months) and very low traffic volumes occur shortly after midnight. Thus, trucks constituted a higher percentage of the lower proportion of night traffic volumes. The proportion of travel by passenger cars was correspondingly reduced from 79 percent of all traffic in the day to 60 percent at night.

Table 50 data also show that local drivers residing within the study county did relatively less travel at night and out-of-State drivers slightly more travel at night. There was little difference in day or night distributions of travel by horsepower, body style, or age of passenger car. Newer cars contributed the greater proportion of all travel. Cars newer than 4 years, for example, provided about half of all travel, day and night, and cars older than 10 years provided less than 5 percent of the travel. This has important implications when important modifications are considered in the vehicle. Any such changeover would have a nearly universal effect within 10 years—at least on main rural highways.

It might be expected that younger drivers would be more likely to drive older cars and conversely older drivers would be more likely to drive newer cars. The data support the first part of this statement but not the latter part. In other words, both older and younger drivers drove older cars while middle-aged drivers, drove the newer cars. During the day, for example, drivers under the age of 20 drove only 2 percent of cars less than 3 years old but, a very large amount by contrast, 7 percent of cars more than 10 years old, as shown in table 52. Similarly, drivers 65 or older drove only 4 percent of the cars that were less than 3 years old but operated a fully 11 percent of the cars that were more than 10 years old. However, drivers in the 25- to 44-year-old age group drove 52 percent of the cars less than 3 years old but only 39 percent of the cars more than 10 years old.