HIGHWAY RESEARCH BOARD
Bulletin 120

Traffic Accidents and Violations

National Academy of Sciences—
National Research Council
publication 407

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Bulletin 120

Traffic Accidents and Violations

PRESENTED AT THE
Thirty-Fourth Annual Meeting
January 11–14, 1955

1956

Washington, D. C.

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Role of Roadway Elements in Pennsylvania Turnpike Accidents

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This paper presents a few of the results from a 2-year study of accident causation on the Pennsylvania Turnpike, data from which serve as a barometer indicating how well the roadway in modern high speed highway design is working. The curve and grade elements are discussed from the standpoint of the accident rate and the vehicle involvement rate.

The broad combinations of curves and grades are tabulated against the percentage of accidents for each combination. The combinations considered are straight and level, straight and upgrade, straight and downgrade, curved level, curved upgrade, and curved downgrade.

The large number of critical incidents or the actions that led to the accidents were classified into nine broad driver-behavior groups. Certain groups of incidents which showed a statistically significant relationship to certain of the six road course combinations are indicated.

The total number of vehicles which used the pike and the vehicle miles of exposure were used to establish a perspective of the real boundaries encompassing the data used in the foregoing discussions.

The data indicate that the modern design is working well. It is strongly indicated that in this man-machine-roadway system, the roadway design is ahead of the man-machine part of the system. Two courses of action are briefly stated in conclusion and mention is made of the challenge which the statistically significant relationships between accidents and road course present to the designer.

● THE highways being built today are a tribute to the men designing and building them. They reflect an alertness to the present day needs for expediting our mass automotive traffic safely. They are a tribute to the advances made in the engineering and construction fields to meet todays demands.

If this advancement is to continue these men will need to know, from time to time, how well the driving public is adapting itself to the facilities they are providing. This knowledge must be objective rather than subjective if we are to progress most efficiently.

One barometer indicating the success of the designed facility, or in plain words how well the design is working, is the accident experience and the precipitating factors which produce the accident population. While the listing of accident figures alone provides some sense of proportion such a listing is lacking in meaning unless we know what took place to establish these proportionalities.

Such a barometer can be found in the design and accident experience on the Pennsylvania Turnpike.

The segments in the design being discussed today are the grade and curve combinations.

The setting for these combinations is the mountainous and valley areas across the State of Pennsylvania. These grades and curves go to make up the two 24-foot traffic lanes separated by a 10-foot medial strip bordered on each side by berm of at least 10 feet wide. There is a minimum sight distance of 1000 feet along the entire length of the pike and the roadway is isolated along its entire length by wire fencing.

The grades are gentle. The curves are superelevated and spiraled in from the tangents. The steepest grade is 3 percent and no curve has a greater curvature than 6 degrees.

There are several places in this design where economic considerations demanded the use of a series of 4-deg. to 6-deg. curves on the steepest 3-percent grade. These are the exception rather than the rule, and in the interest of indicating how well the

public has accepted this modern design, these particular places will not be considered as special cases. Rather the paper today will deal with the general design characteristics of this turnpike. In this way we will get a better picture of the ability of the public to use a modern highway, recognizing that those special cases mentioned will be held to a minimum in modern design.

Briefly then the subject matter today will be the accident experience and the accident precipitating factors on one of todays best designed highways. It should be borne in mind that between 4 and 5 months of winter weather moderates the effect of the design.

The data from which the facts have been abstracted for this paper were gathered from two sources: (1) the more than 9,000 Pennsylvania state-police accident reports covering each accident that occurred on the pike from the year 1940 through the year 1953, and (2) an accumulation of facts through personal interviews with patrons on the turnpike.

The police accident reports gave the accident frequencies or the number of accidents according to grades or curves. These same reports for the years 1952 and 1953 gave one set of critical incidents which precipitated the accidents. By critical incident is meant the thing that actually triggered off the events resulting in an accident. The personal interviews with the patrons on the pike established the critical behaviors that almost resulted in an accident.

Before discussing the data it should be pointed out that by level roadway is meant any road surface up to 0.5 percent grade, also that straight means anything from dead straight to 0.5 deg. of horizontal curvature.

TABLE 1
PERCENTAGE OF VEHICLE INVOLVEMENT BY ROADWAY ELEMENT

Roadway	Percent of Involvements	
	Passenger Cars	Trucks
Straight and Level	38.4	33.9
Straight and Downgrade	22.1	21.1
Straight and Upgrade	15.6	24.9
Curved and Level	4.6	2.8
Curved and Downgrade	12.9	9.9
Curved and Upgrade	6 4	7.4

The accident records then show that the accident rate (that is, the number of accidents per million vehicle miles) is identical for both straight and curved road surfaces. The accident experience from 1940 through 1953 showed this rate to be 1.5 accidents per million vehicle-miles. When broken down on a yearly basis, the rate for the curved road and the straight road run very close to each other year after year. The vehicle-involvement rate (as opposed to the accident rate) for straight roadway ran 2.5 vehicles involved per million vehicle-miles, whereas that for the curved road ran 2.1 vehicles per million miles.

Consider now the combination of grades and straight or curved roadway. It was not practical to assess accurate values of vehicle mile exposures for the combinations of grades and degrees of curvatures while making the study. Our data in these cases, therefore, are given in terms of accident percentages for these combinations. Reference to Table 1 will show the percentages broken down according to the broad combinations for both passenger cars and trucks.

A combination breakdown showing the percentage of vehicle involvements for the broad combinations is shown in Table 2.

Listed according to their accident frequencies these combinations are: (1) straight and level, (2) straight and downgrade, (3) straight and upgrade, (4) curved and downgrade, (5) curved and upgrade, and (6) curved and level.

In summary, the overall straight roadway data as compared to the overall horizontal curved roadway data indicates that the curved roadway has served the patron of the Pennsylvania Turnpike as well as or better than the straight roadway. We, therefore, need to look further if we are to determine why a supposedly ideal roadcourse, such as straight and level, has not served the driver appreciably better than the curved roadway.

Let us then consider the combination of external events or conditions and human behaviors which triggered off the events leading to the accidents and which in effect established the percentages and rates just given. It has been possible to group these incidents under nine broad categories on the first level of reasoning. It must be remembered that the task of determining such things as psychological behaviors from police accident reports is a rather difficult one. For that reason some of the categories may

appear rather broad in nature. Nevertheless, they are adequate at this point in the turnpike safety-research program to give a clearer picture of how the driving public makes use of the road course. The nine behavior categories into which all accidents on the turnpike were classified are as follows:

1. Failure on the part of the driver to cope with the road conditions was important in 22 percent of all accidents.

These failures, by and large, resulted in skids on wet, snowy, or icy road surfaces. Unfortunately there was not enough information available to determine what manipulations the operator went through to produce the skid. If this fact were known many of the accidents under this category would quite likely appear under the category of deficiencies in routine driving skills, or under illegal or unsafe actions.

2. Drivers commission of illegal and unsafe actions, were involved in 21. 5 percent of all accidents.

These behaviors ranged from parking on the slow speed lane to entering the pike from the exit lane and pulling out into the high speed lane in the face of a passing vehicle.

3. Driver inattention appeared to have been primarily responsible for 17. 2 percent of all accidents.

This inattention ranged from falling asleep to reading a road map while driving.

TABLE 2
PERCENTAGE OF ACCIDENTS BY ROADWAY ELEMENT

Roadway	Percent of Accidents	
	Passenger Cars	Trucks
Straight and Level	32 1	35. 6
Straight and Downgrade	21. 3	20. 9
Straight and Upgrade	17. 4	19. 2
Curved and Level	6. 1	3. 4
Curved and Downgrade	14. 6	11. 4
Curved and Upgrade	8. 5	9. 5

4. Vehicular failures which were not successfully handled accounted for 13. 8 percent of all accidents.

Blow outs, loss of steering, failure of brakes, trouble with hitches on tractor house trailer combinations, etc., constitute the category of vehicle failures not successfully handled.

5. Deficiencies in routine driving skills accounted for 11. 7 percent of all accidents.

These driving skills are exemplified by the driver who, detecting that he has a wheel or wheels off the pavement cuts back sharply rather than making the correction gradually and safely.

6. Misperception was the primary factor in 8. 2 percent of all accidents.

Misperception as it is used here is two-fold in nature: (1) loss of vision because of snow, slush, mud or rain deposited on windshield and (2) ambiguity of cues resulting in the driver doing such things as following in behind a vehicle ahead of him which has gone to the berm to park. This driver follows the one preceding him onto the berm with the impression that the leading vehicle has actually taken a turn in the roadway.

7. Failure to avoid objects in the road accounted for 3. 6 percent of all accidents.

While everything from a fallen rock to a deer in the road was hit the most frequent objects causing this trouble were animals in spite of the fact that the roadway is isolated by a fence.

8. Intoxication or drunken driving accounted for only 1. 2 percent of the accidents on the Pennsylvania Turnpike.

9. Miscellaneous behaviors or failures accounted for the remaining 0. 8 percent of all accidents.

The foregoing are not only the behaviors and failures which caused property damage, injury and loss of life on the turnpike but are also the same behaviors and failings described by patrons when interviewed about near-miss accidents. This indicates an accident potential emcompassing most drivers, over and above those represented by the accident statistics.

We have seen the accident distribution by roadway element and we have seen the factors that precipitated these accidents. Let us now consider the relationships found between these two. In other words, what part did the road design play in these accidents as we know it at this point in the research study.

Interestingly enough some statistically significant relationships were found and are listed in Table 3. These are the behaviors and errors that proved to be significantly higher for one of the six types of roadway element than for the others.

TABLE 3
BEHAVIORAL AREAS OF HIGHER THAN EXPECTED ACCIDENT FREQUENCY BY ROADWAY ELEMENT

Pennsylvania Turnpike (1952-1953)

Roadway Element	Passenger Cars	Trucks
Straight Level	Failure to Avoid Objects in Road	-
Straight Up	Asleep	Asleep
	Misperception	Misperception
Straight Down	Vehicle Failures	-
Curved Level	Deficiencies in Routine Driving Skills	-
Curved Up	-	-
Curved Down	Failure to Cope with Road Conditions	Failure to Cope with Road Conditions
	Deficiencies in Routine Driving Skills	

The significantly high number of accidents classified as failure to avoid objects in the road for the straight and level roadway combination tie in with other factors such as higher speed. The higher speed ranges as you well know afford the passenger car driver less time to avoid objects in the road. This fact is probably amplified to some extent by the driver's lapsing into a feeling of well being. Laxity and higher speed would contribute to the surprise element too. Consider a driver's surprise at night should a deer suddenly jump into the path of the car or should a pheasant appear in the windshield, even during the daylight hours. Note that trucks did not experience this same difficulty, possibly because of weight and size, the lower speed, and the greater ability of the truck driver to handle his vehicle.

The straight-and-upgrade roadway apparently is the place where drivers really feel at ease. It is here that falling asleep was a factor in the accidents significantly more often. Perhaps he relaxes his attentiveness and also overtakes more vehicles.

The straight-and-downgrade segment of the road is significantly high in passenger-car vehicular failures which were not successfully handled. It would be expected that tire and brake failures would be much more difficult to cope with on the downgrade. It is, therefore, not surprising to find a larger proportion of vehicular failure accidents on this type of roadway. It is interesting to note that trucks did not experience the same difficulty. This suggests the hypothesis that truck drivers are better prepared to cope with such vehicular failures.

The curved-and-upgrade combination showed no significant relationship to driver behaviors. This means that the eight precipitating factors (omitting the miscellaneous category) mentioned previously took place on curved-and-upgrade roadway in accordance with the observed frequency of these types of behaviors on the other types of roadway.

The curved-and-downgrade sections of the roadway are the places where drivers precipitated skids significantly more often. Such things as tangential steering to get around curves particularly when traction is low is conducive to this occurrence. As mentioned, it is unfortunate that the source of data did not carry statements that would allow us to determine the actual manipulation that led to the skid. The other factor significantly high in curved down driving is deficiencies in routine driving skills for the passenger car driver. This is the point where the driver gets his greatest test of skill and we would expect to find this category statistically high.

These behaviors and failures in relation to the roadway element are the only ones which showed significant relationships to the design of the highway for this type of analysis. It must be remembered that all of the behaviors and failures still occurred on each of the roadway combinations, even though no significant relationship was found. To clarify this point, passenger-car drivers did fall asleep on the curved-and-downgrade combination, causing 25 accidents, even though the analysis did not show any special relationship between this behavior and curved-down roadway.

Let us now look briefly at the boundaries encompassing this data, thereby gaining a better perspective of the overall picture. The data set up in this paper today was the result of 57 million vehicles using the turnpike from 1940 through 1953. These vehicles established an exposure of 5.57 billion vehicle-miles. From this exposure some 9,000 accidents involving only 13,400 vehicles were recorded ranging from a scratched fender to a multiple fatality. Only a small part of these accidents showed a statistically significant relationship with the various types of roadway element. A continuation of the study is now examining in greater detail such relationships. For example, an analysis

based on accidents per mile for the various types of roadway is now in progress.

What conclusions can be drawn from this perspective and the information preceding it?

Considering the three main components in the driving operation, the driver, his vehicle, and the roadway, it is strongly indicated that the roadway design is well ahead of the driver and his vehicle. The future, therefore, calls for two courses of action: First, to improve the driver and vehicle and present the challenge for improvement to the highway designers in those cases where significant relationship of behavior to design can be shown. Second, as these improvements are made continue with objective studies to determine how well the improved components are working together.

Relation of Accidents to Speed Habits and Other Driver Characteristics

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New York State Department of Public Works

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The purpose of this study is to relate accident experience to speed habits and other driver characteristics. It is an extension of the New York State driver report titled, "Speed Habits of Automobile Drivers Observed Repeatedly on a Rural Highway," presented at the 33rd Annual Meeting of the Highway Research Board. In that report, the individual speed habits of drivers, speed consistency by groups of drivers and the association of the driver and vehicle characteristics with differences in average speed were explored. Spot speeds, time of day and registration numbers of cars were recorded. Driver characteristics and the identity of the drivers were determined by use of a post-card survey; 8,587 speed observations were obtained, during the morning and evening peak hours, on a two-lane rural highway, at two adjacent locations presenting tangent and horizontal curve characteristics; 1,600 different drivers and 22 observation periods were involved.

All highway accident cases of record (from October 1949 through 1953) maintained by the New York State Motor Vehicle Bureau were examined and the reported details and accident type extracted for each driver. The drivers were divided into accident and no-accident groups. Accident information for the accident group was collated by driver with their respective speed, headroom, and other driver and car characteristics. Various driver and vehicle characteristics for each group were combined for comparative analysis and the relation of accidents to road and light conditions and accident type are discussed.

It appears that faster drivers have more accidents than slower drivers, especially when judged by their speeds in the afternoon, and that drivers who have very short headways in the morning have more accidents than those who do not. Higher accident rates are associated with younger drivers, larger amounts of travel, and newer cars. The majority of the accidents of record, for which information was available, occurred on dry road surfaces, during daylight, and involved other vehicles.

To complete the data, a home-interview questionnaire for the drivers was conducted furnishing information related to those medical and social characteristics more frequently associated with accidents. Comparative analysis of these human factors for the accident and no-accident groups of drivers are presented.

The interview data established that: (1) accident drivers are definitely an older group of people and do more driving per year than the no-accident drivers, (2) nearly half of the drivers in each group, both accident and no-accident drivers, claim they don't get drowsy while driving, (3) fewer than 10 percent in each group claim any difficulty in hearing, (4) fewer than 3 percent in each group claim any emotional illness history, (5) of the accidents described to interviewers, about two thirds occurred on working days and one third on days off from work, (6) nearly 90 percent of the accidents reported occurred on routes traveled frequently and (7) the accidents per driver of the accident group have a life-time rate of 1.8 accidents per driver while the no-accident group drivers (no accidents from January 1951 through 1953) have a life-time accident rate of 0.8 accidents per driver.

● IT has been frequently stated that high speed is the cause of accidents. Law enforcement agencies control speeds along the highways by patrolling and by placing warning signs on the highway in an effort to restrict speeds in an area. It is claimed that by lowering speeds, the number of accidents have been reduced.

There are also many who assert that there is no relationship between accidents and speeds. This is based on the belief that one individual, because of his quicker thinking and faster reflexes, may be a far better and safer driver at 60 mph. than his contemporary whose time and judgement rate him as a 30-mph. driver.

Consideration should also be given to the variations which exist in the vehicles themselves. The most-modern vehicle in excellent condition equipped with the latest and most-efficient driving mechanisms can be operated with greater ease and safety than a car equipped with faulty brakes and in poor mechanical condition.

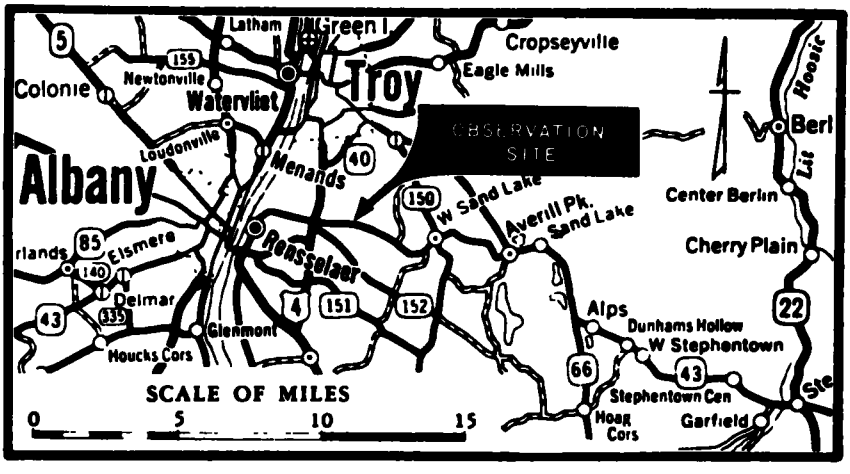


Figure 1. Location of the observation site for collection of speed, headway and other driver data.

An operator's physical condition plays an important part in his driving ability. For example, it is to be expected that a driver would be far more alert in the morning after a good night's rest than in the late afternoon or evening after a fatiguing day.

The third variable is related to driving conditions and includes: (1) physical characteristics of the roadway, (2) weather conditions, and (3) light conditions.

However, we may assume that the average experienced driver has weighed all of these factors and will normally drive at a speed which he considers safe for the conditions as they exist.

Can we say, therefore, that a fast driver has a greater number of accidents than one who normally travels at a lower speed?

The main purpose of the present study is to explore this question. A related question is this: If some drivers have more accidents than others, what else is different about them? We shall attempt to find out what characteristics of the drivers and their cars are associated with differences in accident rates.

A third question is also of interest: What is the relationship between accidents by accident type, road and light conditions? These factors have been examined for the study drivers whose accident records are on file with the Motor Vehicle Bureau.

In addition, a home-interview study was conducted in the summer of 1954, during which a portion of the study drivers were questioned about their driving habits, medical and social characteristics, attitudes, accidents, and the particular situation surrounding the accidents in which they had been involved. These results are reported in the supplement of the report.

COLLECTION OF DATA

For a previous companion study[1] of the speed habits of drivers, an observation site was selected on a rural two-lane highway about 5 miles east of Albany, New York (Figure 1). Data concerning 1,604 drivers and cars observed were collected. These data, with the addition of information about the accidents in which the drivers of these cars were involved, are used in the present report.

Two locations were established at the site. The westerly, near the center of a level tangent, is referred to as the tangent. The other, referred to as the curve location is about 600 feet to the east and at the end of the tangent. Figure 2 shows the plan and profile of the study area.

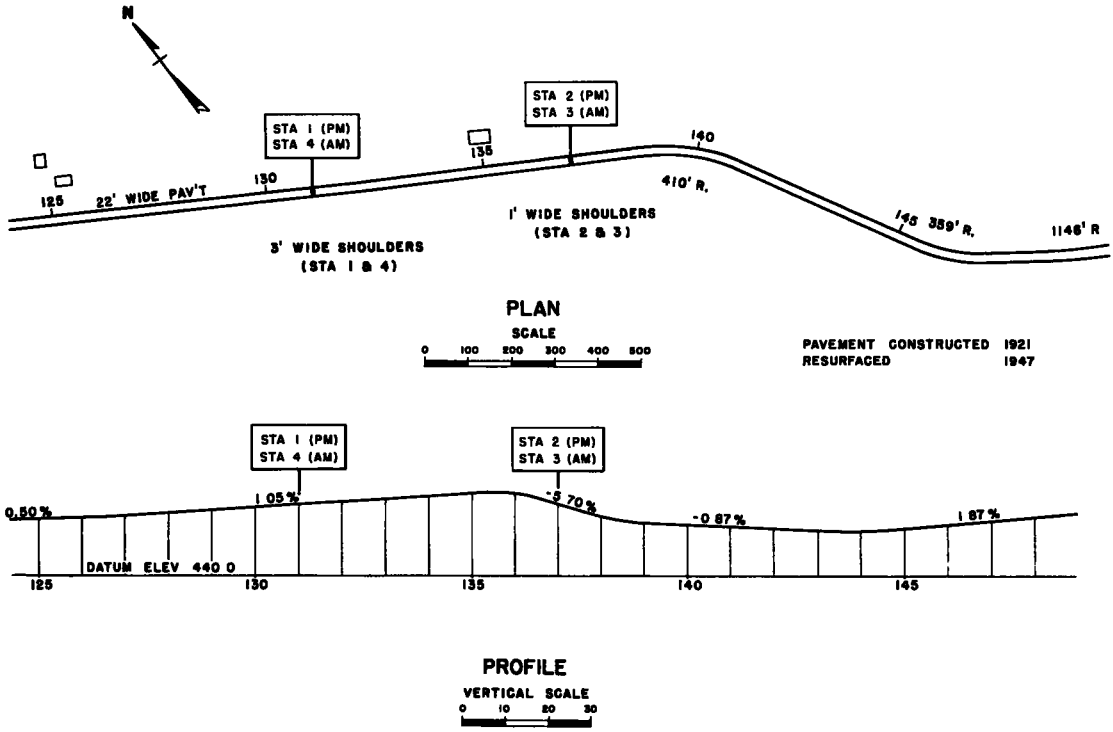


Figure 2. Plan and profile of the observation site for collection of speed, headway and other driver data.

To identify the various observations, they have been given station numbers as follows: Station 1, tangent location, traffic eastbound; Station 2, curve location, traffic eastbound; Station 3, curve location, traffic westbound; and Station 4, tangent location, traffic westbound. The photographs in Figure 3 show the drivers' view of these locations.

The companion study describes in detail the technique and equipment used in collecting the field data.

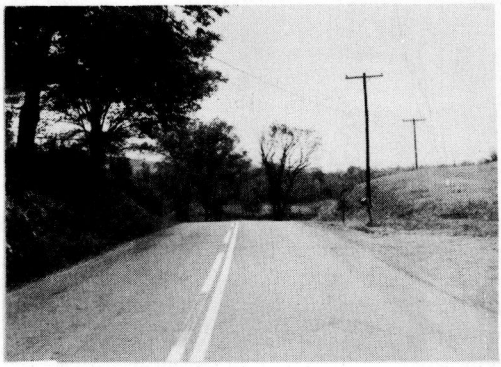
Speed information for vehicles passing the two established locations, citybound in the morning and outbound in the afternoon for eight summer week days in 1950 and six in 1951, was mechanically recorded. In addition, for the vehicles observed in 1951, the time of day to the nearest 0.0001 hour was mechanically recorded. Only the data for passenger cars with New York State registration plates were used in the analysis. Immediately after the observations in 1951 were completed, the names and addresses of the car owners were secured by a commercial firm, and by means of a postal-card

[1] "Speed Habits Observed on a Rural Highway," Highway Research Board Proceedings, Vol. 33, pp. 409-428.

questionnaire, statistical information about the drivers and cars were obtained.

The names and addresses secured were later used to search the accident record files of the Motor Vehicle Bureau. The accident-record files contained the reports submitted

APPROACHING STATION 1



APPROACHING VERTICAL CURVE

APPROACHING STATION 2

VIEWS WHEN OUT BOUND

AT STATION 3

APPROACHING STATION 4

VIEWS WHEN CITY BOUND

Figure 3.

TABLE 1

ACCIDENTS BY YEAR OF ACCIDENT

Year	No. of Accidents[a]
1950	149
1951	128
1952	127
1953	98
Total	502

[a] With 30% of the study drivers no longer registered in 1954, the progressive annual decrease in the number of accidents is of about the expected size. There is no evidence of any change in reporting standards over the period considered.

by drivers for automobile accidents in which a personal injury was sustained or when the property damage was $50 or more. The reports of record for the observed drivers were searched for the four year period 1950 through 1953, and all pertinent information was coded and entered on punch cards. These cards were collated with the cards containing the observed and postal card information for analysis.

RELATION OF ACCIDENTS TO SPEED

Accident Records

For the 4-year period from January 1, 1950, through December 31, 1953, 502 automobile accident records are on file with the Motor Vehicle Bureau for the 1,393 drivers whose accident record files were searched.[2] The number of accidents of record in each year for these drivers is listed in Table 1 and shown graphically in Figure 4. Accidents in which the cars used by the study drivers were struck while parked are not included. Except for this exclusion, there was no attempt to designate responsibility for the accidents; therefore, all other accidents involving these individuals as drivers have been included irrespective of negligence. It will be noted that the number of accidents decreased from year to year. An examination of the 1953 reregistration of the drivers included in the sample shows a decrease of about 20 percent over the same period. This is the normal attrition to be expected due to death, moving out of the state, and associated reasons. The rate of decrease for the recorded accidents represents a similar reduction.

Accidents by Faster and Slower Drivers for Each Station

Using the speed data collected at each station, the individual drivers were arranged in order of their average observed speeds and divided into two approximately equal groups. Thus, the drivers were divided into the "faster half" at Station 1 and the "slower half" at Station 1; into the "faster half" at Station 2 and the "slower half" at Station 2; and similarly at Stations 3 and 4. Table 2 shows, for each of these groups of drivers, how many had no accidents, how many had one accident, how many had two accidents, and so on. The table also gives the average number of accidents per driver for each group of drivers.

Figure 5 presents these accident rates in a bar diagram, showing how the faster half of the drivers compare with the slower half at each station. The drivers who constituted the faster half at Station 1 had a significantly higher accident rate than

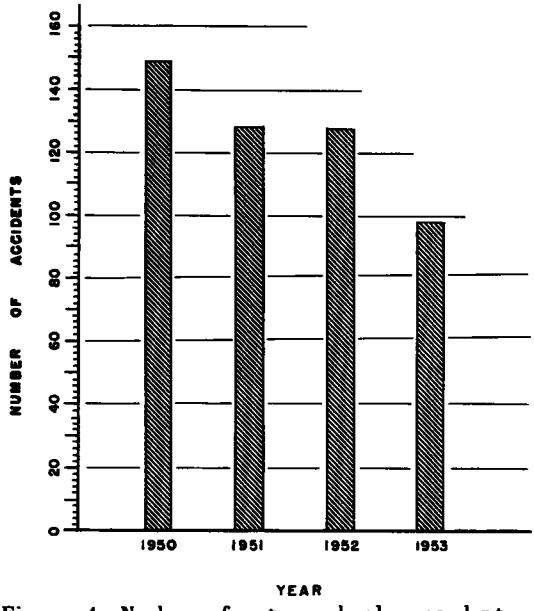


Figure 4. Number of motor vehicle accidents of record involving the study drivers during years 1950 through 1953.

[2] There were 1,604 drivers observed in the study. No speeds were secured for 35 of these drivers and 176 drove fleet cars or could not be positively identified.

TABLE 2

ACCIDENTS BY FASTER AND SLOWER DRIVERS AT EACH STATION

Station	Average Speed of Driver (mph)	Number of Drivers with 0 Acc.	1 Acc.	2 Acc.	3 Acc.	4 Acc.	5 Acc.	Drivers Totals (Number)	Accidents Totals (Number)	Accidents per Driver
1	0 - 44 0	446	97	30	6	2	1	582	188	0.323
(Tangent, PM)	44.1 & over	386	132	44	9	0	0	571	247	0.433
2	0 - 38.3	422	103	27	8	2	0	562	189	0.336
(Curve, PM)	38.4 & over	385	127	42	7	0	1	562	237	0.422
3	0 - 38.2	224	71	12	1	0	0	308	98	0.318
(Curve, AM)	38.2 & over	215	63	27	3	0	1	309	131	0.424
4	0 - 44.0	217	80	16	4	0	1	318	129	0.406
(Tangent, AM)	44.1 & over	200	56	23	0	0	0	279	102	0.366

those in the slower half. The faster half at Station 2, comprising many but not all of the same drivers as the faster half at Station 1, also had a significantly higher accident rate than the slower half at the same station. Stations 1 and 2 are the stations where traffic was observed in the afternoon.

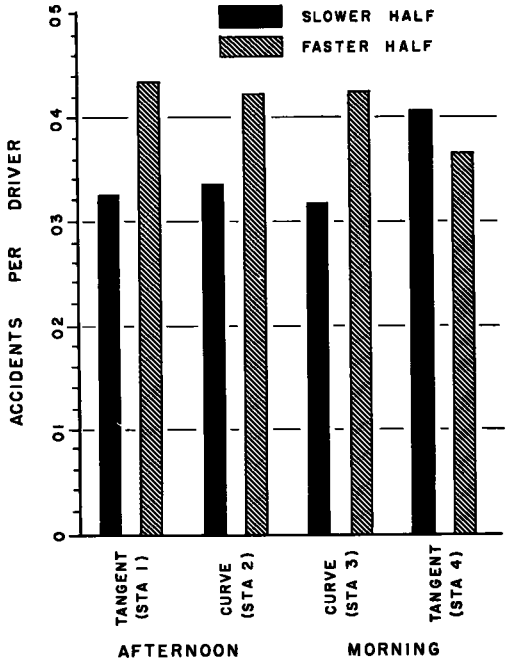


Figure 5. Comparison of accidents per driver (1950-1953) for the slower half and faster half at each station.

The drivers who were in the faster half at Station 3, the curve in the morning, also had a higher accident rate than the slower drivers at the same station. But Station 4, the tangent in the morning, gives a different result. Here the difference in accident rates between the faster half and slower half is small, too small to be statistically significant, and is in the opposite direction from the other differences. Apparently the faster half at the morning tangent were a markedly different group of drivers from the faster half at any of the other stations.

Accidents by Drivers in the Speed Groups over and below 50 mph. for the Tangent Locations

A similar comparison is presented in Table 3. Here the accident records are compared for those drivers whose average observed speeds at the tangent location (morning and afternoon combined) were between 35 and 45 mph., on the one

TABLE 3

ACCIDENTS BY AVERAGE SPEEDS OF DRIVERS OBSERVED AT THE TANGENT LOCATIONS

Station	Average Speed of Driver (mph)	Number of Drivers with 0 Acc.	1 Acc.	2 Acc.	3 Acc.	4 Acc.	5 Acc.	Drivers Totals (Number)	Accidents Totals (Number)	Accidents per Driver
1	35-44.9	400	93	25	5	2	1	526	171	0.325
(Afternoon)	50 & over	133	50	18	2	-	-	203	92	0.453
4	35-44.9	194	72	16	3	-	1	286	118	0.413
(Morning)	50 & over	74	20	9	-	-	-	103	38	0.369

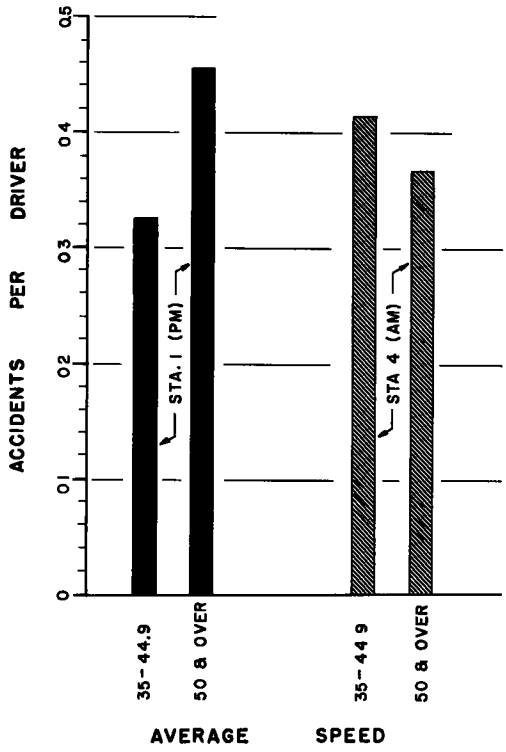


Figure 6. Accidents per driver (1950-1953) by speed at the tangent location.

hand, and over 50 mph., on the other. Again, it is seen that the group of drivers who drove the fastest in the afternoon (Station 1) had more accidents per driver than the slower group of drivers. In the morning (Station 4) the difference is in the opposite direction, but again it is too small to be statistically significant. These comparisons are illustrated graphically in Figure 6.

Speeds of Accident and No-Accident Groups of Drivers

In our comparisons, so far, we have considered the accident records of drivers when classified by speed behavior. Let us now group the drivers according to their accident records and see how their speeds differ. Figures 7 and 8 show the distributions of individual speed observations in the afternoons and mornings, respectively, with separate curves for those drivers who had at least one reported accident on file (accident driver) and for those drivers who did not have an accident record on file (no-accident driver) during the 4-year period of investigation. At both of the afternoon stations (see Figure 7) the accident group had slightly higher speeds than the no-

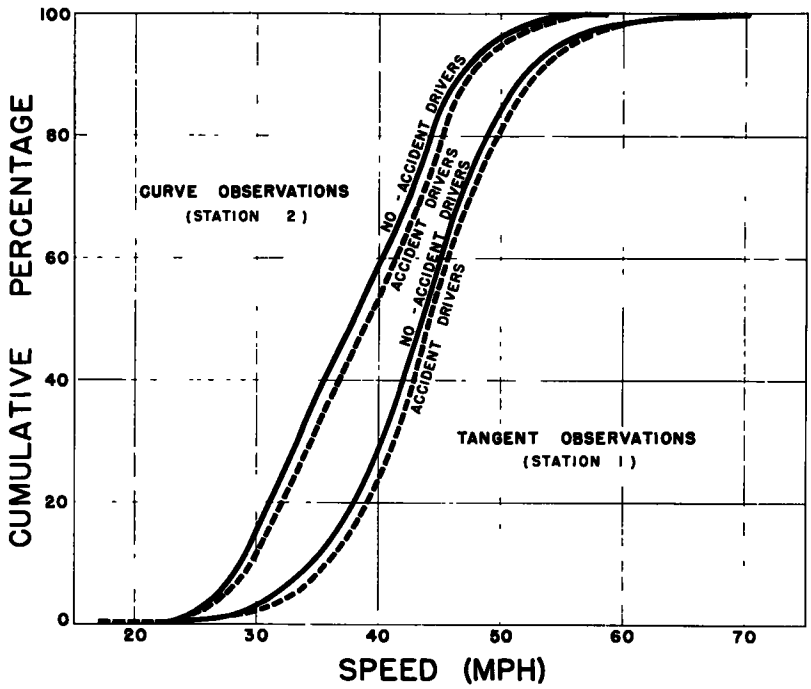


Figure 7. Distributions of afternoon speed observations for accident and no-accident drivers.

accident group at all percentile values. At the morning stations (Figure 8), it is the no-accident group whose speeds are slightly higher at both locations for all percentile values, except near the lower end of the speed range. The average speeds for each group of drivers at each of the four stations and the tangent stations combined are given in Table 4.

TABLE 4

NUMBER OF DRIVERS AND AVERAGE SPEED AT EACH LOCATION FOR ACCIDENT AND NO-ACCIDENT DRIVERS

Station	Accident Drivers		No-Accident Drivers	
	Number	Ave. Speeds (mph)	Number	Ave. Speeds (mph)
1 (tangent, PM)	321	45.4	832	44.5
2 (curve, PM)	317	39.5	807	38.6
3 (curve, AM)	178	38.1	439	38.5
4 (tangent, AM)	180	43.7	417	44.4
1 & 4 combined	398	44.7	995	44.5

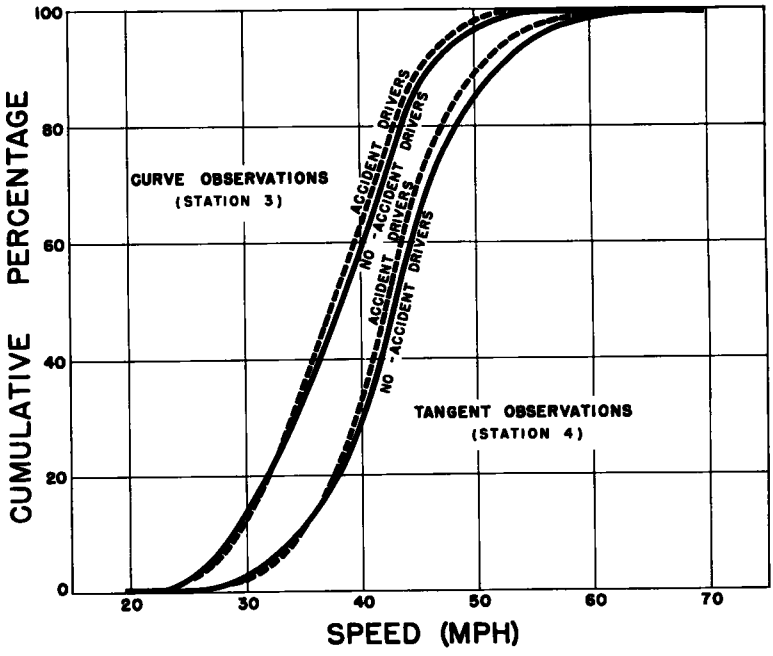


Figure 8. Distributions of morning speed observations for accident and no-accident drivers.

TABLE 5

ACCIDENT AND SPEED DATA FOR DRIVERS RELATED TO THEIR SHORTEST HEADWAYS OBSERVED IN THE MORNING AND AFTERNOON

Time of Day	Shortest Headway Observed		Number of Accidents	Number of Drivers	Accidents per Driver	Average Speeds of Drivers	
	.0001 of Hour	Seconds				Tangent (mph)	Curve (mph)
Morning	6 & under	2 & under	31	60	0.517	46.2	39.1
	7 - 12	2.5 - 4.3	5	17	0.294	45.2	38.6
	13 - 26	4.7 - 9.4	4	32	0.125	44.9	39.6
	27 & over	10 & over	61	161	0.379	44.8	37.9
Afternoon	6 & under	2 & under	38	112	0.339	45.3	39.4
	7 - 12	2.5 - 4.3	24	64	0.375	44.7	38.4
	13 - 26	4.7 - 9.4	35	79	0.443	45.4	40.4
	27 & over	10 & over	124	285	0.436	45.1	39.8

RELATION OF ACCIDENTS TO DRIVER AND CAR CHARACTERISTICS

Headway and Accidents

For the observations in 1951, a timing device, giving the time of day to the nearest 0.0001 hour that each car passed the stations, was operated in conjunction with the speedmeter. The drivers for these time observations have been classified according to the shortest interval of time at which they followed the car ahead.

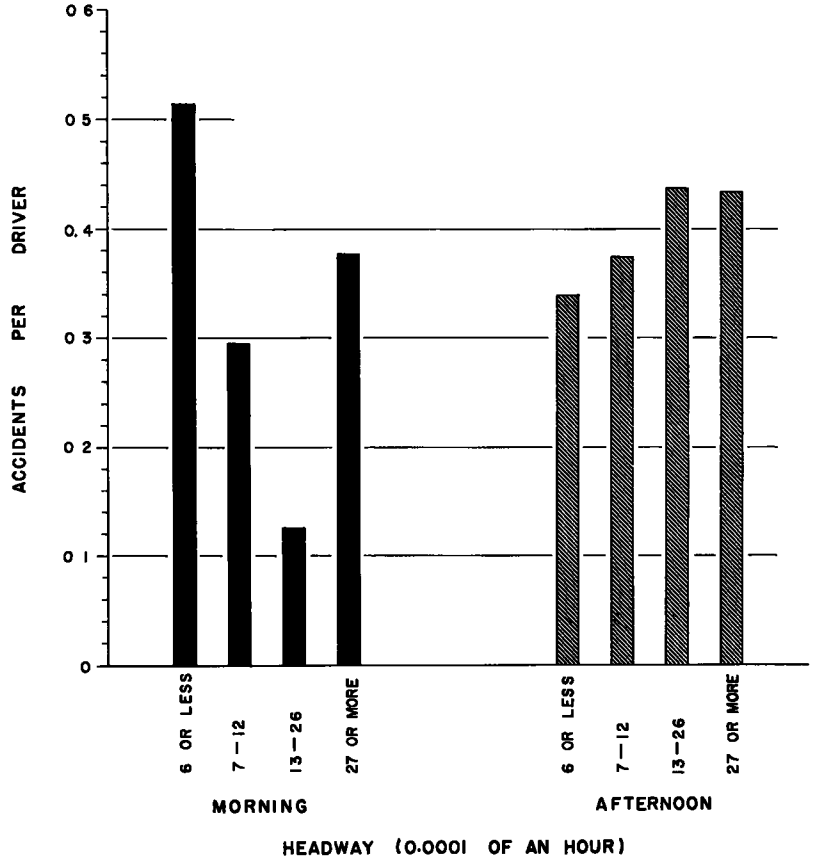


Figure 9. Accidents per driver (1950-1953) by minimum headway observed in the morning and afternoon.

Table 5 has been prepared grouping the drivers observed in 1951 according to their shortest headways recorded in the mornings and afternoons in relation to their accident records on file for the 4-year period under investigation. Accidents per driver and average speeds under tangent and curve locations for each group of drivers are shown. Figure 9 illustrates the relation between accidents per driver and the morning and afternoon headway groupings.

Drivers who had very short headways in the morning had higher accident rates than those whose minimum headways were longer. Drivers whose minimum headways exceeded 0.0027 hour (9.7 seconds) were assumed to be uninfluenced by other traffic and are, therefore, excluded from this comparison.

Apparently the drivers with short headways in the morning did not necessarily

TABLE 6

ACCIDENTS PER DRIVER BY AGE OF DRIVER

Age of Driver (years)	No. of Accidents	No. of Drivers	Accidents per Driver
Under 30	38	72	0.507
30-39	38	95	0.400
40-49	49	130	0.377
50-59	31	84	0.369
Over 59	8	35	0 229
Unknown	338	977	0.346
Totals	502	1393	0.360

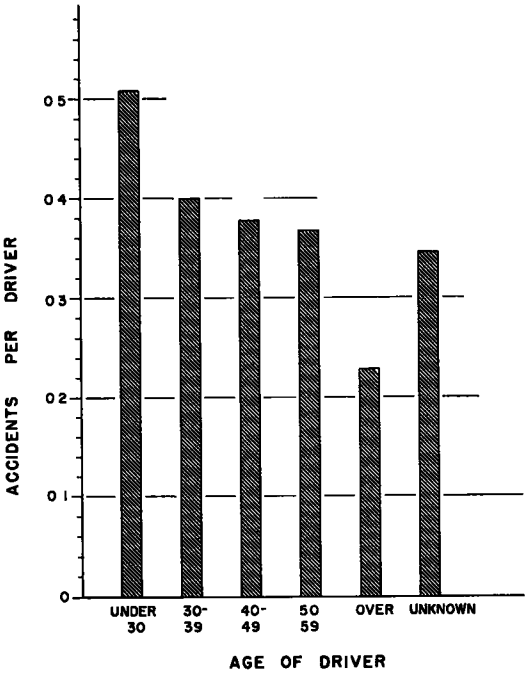


Figure 10. Accidents per driver (1950-1953) by age of driver.

have short headways in the afternoon, and vice versa, for the classification of the drivers by their minimum afternoon headways gives a different result from that described above. When the drivers are classified by their afternoon headways, there is no significant difference in accident rates between the various groups, and such variation as exists is in the opposite direction from the trend discussed in the preceding paragraph.

Age of Driver and Accidents

In Table 6 and Figure 10, the drivers are arrayed by their age, in 10-year groups, as reported from the post-card survey, according to accidents per driver. For each age group, the table gives the number of drivers, the number of accidents involving these drivers for the period of investigation, and the average number of accidents per driver. Although the accident rates decrease steadily for the increasing age groups of the drivers, a test of significance shows that the decrease may be entirely due to chance. The average accidents per driver for the known drivers shown in Table 6 is 0.390. It is only the drivers under 30 and over 59 years of age whose accident rates appear to differ appreciably from this average rate.

TABLE 7

ACCIDENTS PER DRIVER BY MILES DRIVEN PER YEAR

Miles Driven per Year	No. of Accidents	No. of Drivers	Accidents per Driver
Under 5,000	28	100	0.280
5,000 - 10,000	47	125	0.376
10,000-15,000	42	102	0.412
Over 15,000	43	84	0.512
Unknown	342	982	0.348
Totals	502	1393	0.360

Annual Mileage and Accidents

A similar classification in which the drivers are grouped by their annual mileage, in 5,000 mile groupings, is presented in Table 7 and Figure 11. Here we find a steady increase in the accident rate with increasing annual mileage. This is to be expected, as exposure to accidents increases with the amount of travel. The average number of miles driven per year for the known drivers shown in Table 7 is about 10,000 miles per year. This relatively high mileage is to be expected, as the majority of the drivers are daily

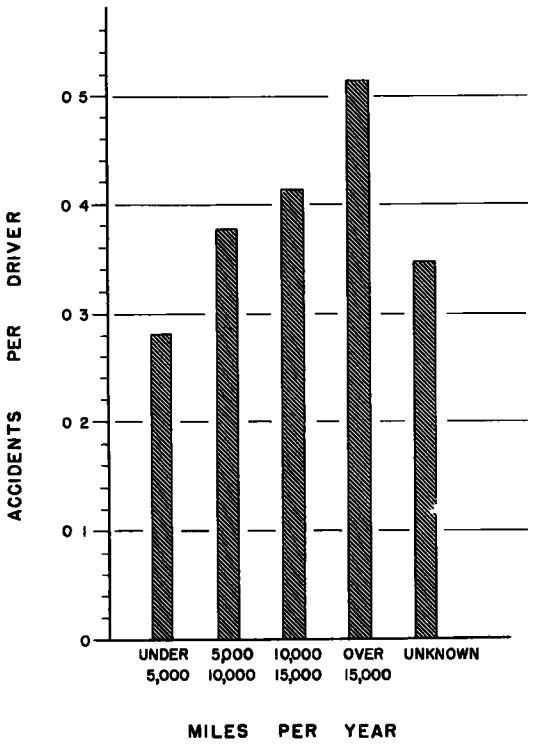


Figure 11. Accidents per driver (1950-1953 by annual mileage.

TABLE 8

ACCIDENTS PER DRIVER BY AGE OF CAR

Age of Car (Year)	No of Accidents	No of Drivers	Accidents per Drivers
0 - 3	230	536	0.429
4 - 6	102	336	0.304
7 - 12	83	228	0.364
13 & over	83	281	0.295
Unknown	4	12	0.333
Totals	502	1393	0.360

commuters. The accident rate per driver for those traveling over 15,000 miles per year is almost twice that for those traveling under 5,000 miles per year.

From this it follows that the high-mileage drivers have considerably fewer accidents per vehicle-mile than the low-mileage drivers. This point would be worth investigating further, if the mileage data had been stated more precisely or had covered the same period as the accident records. In fact, however, the drivers were simply asked to indicate which of the six mileage groups they belonged in, and the question was asked during the earlier part of the period covered by the accident survey.

Age of Car and Accidents

Table 8 has been prepared grouping all the cars observed in both years into four age-of-car groups. For each group are shown the number of drivers, the number of accidents involving these drivers for the period, and the average number of accidents per driver. Figure 12 illustrates the relation between accidents per driver in the four age groups of the cars.

It is noted from Figure 12 that the accident rates vary somewhat with the ages of the cars but that there is no consistent pattern to the variation. The highest accident rate is associated with the newer cars, while the lowest rate is associated with the older cars.

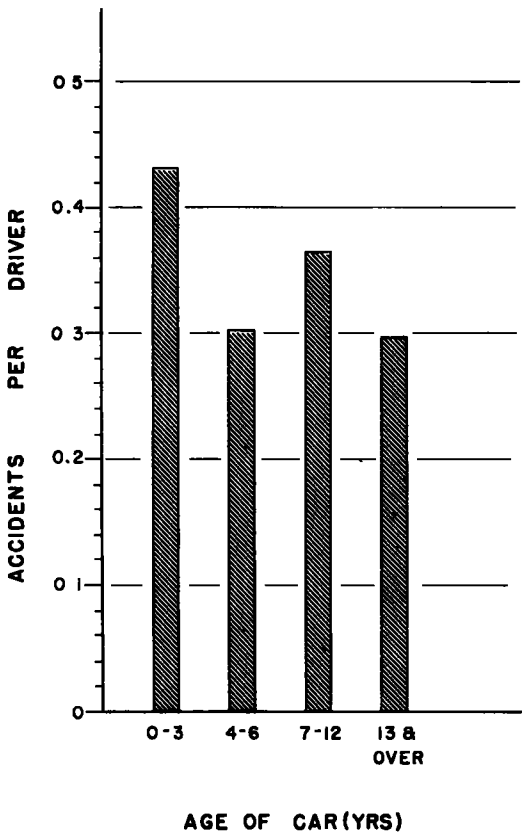


Figure 12. Accidents per driver (1950-1953) by age of car.

RELATION OF ACCIDENTS TO ROAD AND LIGHT CONDITIONS AND ACCIDENT TYPE

Accidents by Road Condition and Light Condition

Table 9 lists the various conditions of the road surface upon which the accidents took place related to the light condition prevailing at the time. All of the listings are in terms of number of accidents. The road condition was missing from a total of 288 of the 502 accident records investigated. Information is not available to show the number of rainy, snowy, or icy days that prevailed during the period of accident reporting. Also, similar information about the traffic volumes during the different hours of the day is lacking. These data are necessary for a valid estimation of the accident producing qualities that each of the road and light conditions may contain.

It is noted that, of all the accidents reported under conditions of dry road surfaces, 71 percent occurred in daylight, or 33 percent of all the accidents for which the road condition was reported.

There were 61 accidents reported as occurring in daylight under conditions of wet, snowy, and icy road surfaces, or 29 percent of all the accidents for which the road condition was reported.

TABLE 9

ACCIDENTS BY ROAD CONDITION AND LIGHT CONDITION

Road Condition	Light Condition: Light	Dawn or Dusk	Dark	Unknown	Totals
Dry	71	6	24	-	101
Wet	20	2	17	-	39
Snowy	8	3	7	-	18
Icy	33	3	17	3	56
Unknown	165	11	77	35	288
Totals	297	25	142	38	502

TABLE 10

ACCIDENTS BY ACCIDENT TYPE AND LIGHT CONDITION

Accident Type	Light Condition: Light	Dawn or Dusk	Dark	Unknown	Totals
Pedestrian	14	2	2	1	19
Motor Vehicle	271	20	119	14	424
R.R. Train	1	-	1	-	2
Motorcycle	1	-	-	-	1
Fixed Object	2	1	17	-	20
Bicycle	4	-	1	-	5
Non Collision	2	2	1	-	5
Other Collisions	-	-	1	-	1
Unknown	2	-	-	23	25
Totals	297	25	142	38	502

Of all the accidents reported under conditions of dry road surfaces, 24 percent occurred on dark, unlighted highways. This represents 11 percent of all the accidents for which the road condition was reported.

Accidents by Accident Type and Light Conditions

In Table 10, the accidents that were recorded during the period of investigation are classified by accident type (pedestrian, motor vehicle, etc.) according to the light condition existing at the time of the accident; 89 percent of the accidents involved collisions with other motor vehicles; 66 percent of the accidents for which the light condition was known occurred under daylight conditions and 29 percent occurred during hours of darkness. The daylight accidents predominate for most of the accident types; however, most of the accidents involving fixed objects occurred under dark conditions.

CONCLUSIONS

Relation of Accidents to Speeds

It appears that faster drivers have more accidents than slower drivers, expecially when judged by their speeds in the afternoon. The individual speeds of the drivers with accident records are slightly higher than those for the drivers without accident records; while in the morning, it is the drivers without accident records whose speeds are slightly higher.

Relation of Accidents to Driver and Car Characteristics

It appears that drivers who have very short headways in the morning have more accidents than those who do not. No relation was found between afternoon headways and accident rates.

Higher accident rates are associated with younger drivers, larger amount of travel, and newer cars.

Relation of Accidents to Road and Light Conditions and Accident Type

The majority of the accidents of record, for which information was available, occurred on dry road surfaces, during daylight, and involved other vehicles. Accidents with fixed objects usually occurred during hours of darkness.

ACKNOWLEDGMENTS

The authors wish to acknowledge the stimulating influence and generous assistance given by O. K. Norman and Morton S. Raff, of the Highway Transport Research Branch of the Bureau of Public Roads, in developing procedures for the field work and analysis.

The files of the New York State Bureau of Motor Vehicles were searched for the accident data contained in this report by members of the staffs of Deputy Commissioners Victor F. Veness and James L. Cain.

Grateful appreciation is expressed for the assistance and advice given, in the preparation for the collection of the interview data, by George James, Walter Boek, William Beadenkopf, and Mrs. Adele Polan, of the New York State Health Department. The

collection of the interview data was supervised by Francis A. J. Ianni, of Russell Sage College, Troy, New York.

Appendix

Interview Data

Recently, a mutual interest in the subject of highway safety was explored by the New York State Department of Public Works and the Department of Health. In conferences with representatives of the Department of Public Works and the United States Bureau of Public Roads, the Department of Health's interest in the significance of the automobile accident, death and injury toll was developed into exploratory epidemiological field studies of accidents, using the home interview method, in the city of Oneonta and the natural trading area of Saratoga Springs[3]. These information and advisory conferences resulted in the feeling that a greater contribution could be made to the reduction of accidents if the talents of both departments were concentrated on a joint project.

Departmental approvals were obtained in early 1954 for a joint interview type of study directed toward the extension of the West Sand Lake Highway Study into the field of medical and social aspects of accidents.

OBJECTIVE

The objective of the home interview research was to acquire a knowledge about the relationship between the drivers observed on the West Sand Lake Highway and their driving behavior, medical and social characteristics, attitudes, accidents and the particular situation surrounding the accidents they had been involved in.

METHOD

The drivers for whom road measurements were taken in the summers of 1950 and 1951 on the West Sand Lake Highway, were divided into two groups for study. In one group were those drivers who had motor vehicle accidents of record with the Motor Vehicle Bureau from January 1, 1950 through December 31, 1953. This group contained over 400 drivers. The other group consisted of over 1,000 drivers who had not had a motor vehicle accident of record with the Motor Vehicle Bureau during this period.

Random selected for the interview were 300 drivers from the accident group with the most recent accident records and 300 drivers from the group with no-accident records. A third group consisting of 200 drivers (counterparts) who were involved in accidents with the accident group drivers completed the selection.

The schedule of questions from the Saratoga Springs research was the basis for developing the instrument to collect the interview data. It was modified to adequately cover these general areas.

1. Driving habits and experience: (a) amount of driving; (b) type of driving, when and where; (c) speed that interviewees report as usual for them on a rural highway.
2. Past history of accidents and traffic violations: (a) how many since started driving; (b) what type; and (c) frequency.
3. Description of accidents since January 1, 1946: (a) personal circumstances of driver just prior to accident and (b) description of accident.
4. Attitude on traffic regulations: (a) speed and (b) other.
5. Medical aspects: (a) use of alcohol and tobacco; (b) use of medication; and (c) state of health.
6. Social stress: (a) use of driving to relieve tension; (b) development of tension from driving; and (c) amount of worrying.
7. Other characteristics: (a) age; (b) sex; and (c) economic level.

Some 282 questions were used covering these areas.

The interviews were conducted during a 7-week period from July 15 to August 31, 1954, at the homes of drivers in the three groups. Most of the drivers resided in the

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[3] A method of determining some epidemiological aspects of motor vehicle accidents, New York State Department of Health, Albany, N. Y., Public Health Reports, in press.

TABLE 11

PLANNED VERSUS COMPLETED INTERVIEWS

Reason for No Interview	Number
1 - Could not locate interviewee.	68
2 - Questionaire not returned from counties outside of local area.[a]	57
3 - Interviewee on vacation.	48
4 - Refusal.	28
5 - Interviewee dead or paralyzed.	15
6 - Interviewee in armed service.	11
7 - Interviewee hospitalized.	8
8 - Interviewees from out of state	5
9 - Interviewee in prison	1
10 - Miscellaneous.	44
Total interview not completed	285
Total interviews completed	517
Total interviews planned for	802

[a] The permanent addresses of 91 cases were scattered throughout the state. County health officers were contacted to complete these interviews.

Capital Area in the vicinity of Albany. Those who resided in other counties were contacted by arrangements made by the health department with their local county health officers.

The interviewing was done, under the supervision of Francis Ianni, by senior students of the Sociology Department Russell Sage College. The interviews followed a constant pattern which was specified in detail in a questionnaire schedule. Pretesting of the questions was conducted by personnel of the Health and Public Works Departments.

Interviews were successfully obtained for 517 of the 802 individuals planned for. Interviews were not obtained on the remaining 285 persons for a variety of reasons. Table 11 shows this category. It is to be noted that the cooperation of the individual was splendid. Only 28 of the drivers refused to be questioned.

The individual questionnaire items were coded and transferred to punch cards. Four cards were required for each completed questionnaire. An additional card was punched for each motor vehicle accident described by the interviewee. Tabulations were run from the cards, for each item for the accident group of drivers, the no-accident group of drivers and the counterpart drivers.

RESULTS

In addition to the objective of acquiring new knowledge, it is expected that the application of the findings will help to increase highway safety by the development of a general health and education program. It will also be valuable as a pretest for more extensive inter-departmental research.

To better understand the attrubutes of the drivers and to obtain a cross section of their more important characteristics and driving habits, items from pertinent areas of the questionnaire were selected for presentation and discussion at this time. Inasmuch as our primary interest lies in comparing the accident drivers with the no-accident drivers, the counterpart group of drivers have been omitted from the discussion. The counterpart group of drivers were interviewed to obtain a description of the accidents from both drivers involved.

The related data for the accident and no-accident groups of drivers are presented under five headings: (1) general characteristics of the drivers, (2) exposure, (3) speed, (4) skill, and (5) safety-mindedness. The last four headings cover the factors that generally are recognized as determining a driver's possible susceptibility to accidents. Tables 12 through 27 present the statistical data from the questionnaires for the accident and no-accident drivers. Bar diagrams have been prepared to illustrate these data. The analysis includes 161 accident drivers and 196 no-accident drivers.

General Characteristics of the Drivers

Sex. Table 12 shows the composition of the sample by sex for each group of drivers, and Figure 13 depicts the percentage of the drivers by sex in each group. The percentage of males is slightly lower in the no-accident group than in the accident group while the percentage of females in the no-accident group is about twice that in the accident group. In the sample, 85 per-

TABLE 12

INTERVIEW DATA-SEX OF DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Sex	Accident Drivers[a]		No-Accident Drivers[b]	
	Number	Percent	Number	Percent
Male	145	90.1	160	81.6
Female	16	9.9	36	18.4
Totals	161	100	196	100

[a] In Tables 12-27 this heading refers to drivers for whom there were records of motor vehicle accidents in the three years 1951-1953.

[b] In Tables 12-27 this heading refers to drivers for whom there was no record of any motor vehicle accidents in the four years 1950-1953.

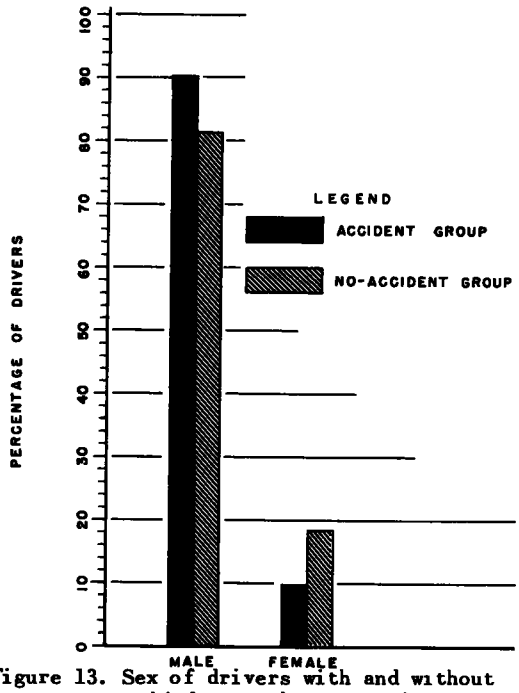

Figure 13. Sex of drivers with and without motor-vehicle-accident records.

cent were males and 15 percent were females.

Age Distribution of Drivers. The composition of the sample by age for each group of drivers is shown in Table 13. Figure 14 depicts the percentage of the drivers for each group by age groups. About 3 percent of the drivers were under age 25 in both the accident and no-accident groups. About 5 percent of the drivers in each group were over 65 years of age. The median age is 47 years in the accident group and 44 years in the no-accident group.

The age distribution for the sample when compared with the driving population of upstate New York[4] shows that those drivers 30 years of age or under comprise 11 percent of the sample distribution and 26 percent of the upstate while the sample shows a 32 percent distribution for the drivers between the ages of 41 to 50 as compared to a 21 percent distribution for the upstate.

It is of interest to compare this distribution with the one presented in Table 6, where the average number of accident drivers was computed for several age groups. The suggestion from that table that older drivers had lower accident rates seems to conflict with the fact that the accident group is older on an average than the no-accident group.

In attempting to explain the difference between the two tables, it may be noted that in the earlier table it is only the drivers under 30 and over 59 whose accident rates appear to differ appreciably from the average. Moreover, it is not the same group of drivers whose characteristics are compared in the two tables. The age distribution in Table 6 involves only those drivers who were observed in 1951 and answered the postal car questionnaire, while the drivers listed in Table 13 included many who were not in this group.

Motor-Vehicle-Accident History of Drivers. In order to determine what proportion of the drivers had been involved in motor-vehicle accidents and the relative number of accidents for each group of drivers, information was collected pertaining to the number of motor vehicle accidents, regardless of type, that they had been involved in during their lifetime up to the present date. Table 14 shows this information. This statistical record was extended to collecting the details of each postwar motor vehicle accident reported as occurring since the first of January 1946.

There were 262 motor vehicle accidents reported for the no-accident drivers. The rate for the accident group is 1.6 and it is 0.8 for the no-accident group. Figure 15 depicts the percentage distribution of the drivers for each group according to their

TABLE 13

INTERVIEW DATA-AGES OF DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Age of Driver Years	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Under 21	1	.6	1	.5
21 - 25	4	2.5	5	2.6
26 - 30	10	6.2	17	8.7
31 - 35	18	11.3	25	12.8
36 - 40	25	15.5	32	16.3
41 - 45	15	9.3	26	13.3
46 - 50	25	15.5	41	20.9
51 - 55	25	15.5	16	8.2
56 - 60	15	9.3	11	5.6
61 - 65	13	8.1	7	3.5
66 - 70	7	4.4	7	3.5
Over 70	2	1.2	3	1.5
Not Stated	1	.6	5	2.6
Totals	161	100	196	100
	Median Age 47		Median Age 44	

[4] Based on a sample of licenses of drivers registered with the New York State Bureau of Motor Vehicles in upstate New York for 1954.

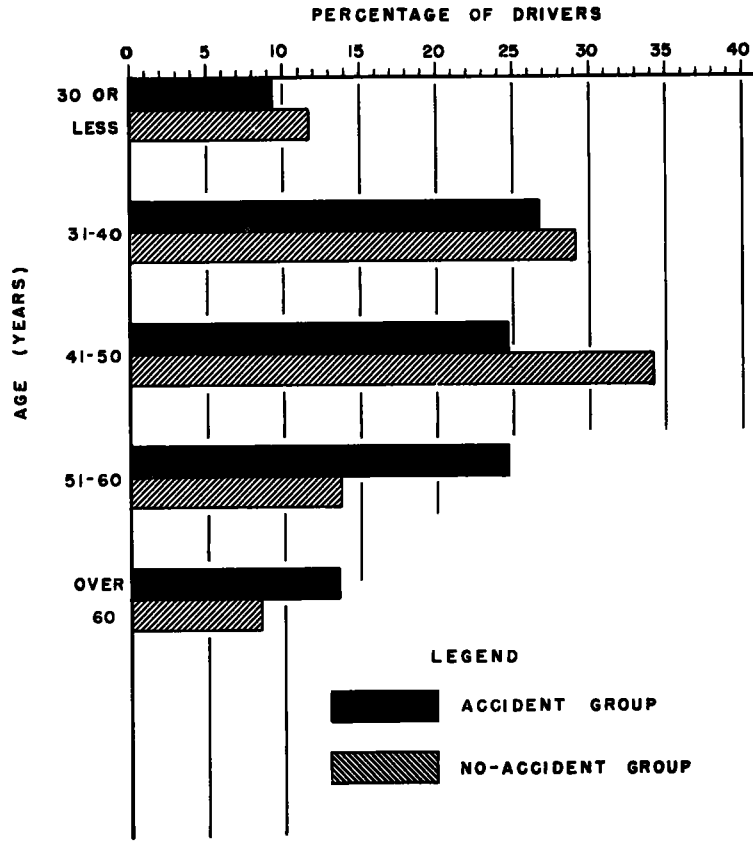

Figure 14. Age distribution of drivers.

accident history. It is to be noted that 13 percent of the accident drivers reported no accidents to the interviewers, although the Motor Vehicle Bureau records show accidents involving them in the period from January 1, 1951, to December 31, 1953.

From the details of the motor-vehicle accidents described to the interviewers as occurring since January 1, 1946, about two thirds happened on regular working days and a third on days off from work. Nearly 90 percent occurred on routes traveled frequently.

Non-Motor-Vehicle Accidents Since January 1946. In an attempt to show the relation between motor-vehicle and non-motor-vehicle accidents for the two groups of drivers, information was collected pertaining to the number of non-motor-vehicle accidents which kept the interviewees from work or their normal activities for a day or more. Table 15 shows the number and percentage of accident drivers and no-accident drivers with non-vehicle accidents and those with one or two since January 1946. Figure 16 depicts the percentage distribution of the drivers for each group according to the number of accidents. It is interesting to note that, although the total number of non-vehicle accidents for

TABLE 14

INTERVIEW DATA-MOTOR VEHICLE ACCIDENTS IN LIFETIME OF DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Number of Motor Vehicle Accidents in Entire Lifetime as Reported to Interviewer.	Accident Drivers[a]		No-Accident Drivers[b]	
	Number	Percent	Number	Percent
None	21	13.0[c]	94	48.0
One	65	40.5	59	30.1
Two	36	22.4	20	10.2
Three	24	14.9	12	6.1
Four	7	4.3	4	2.0
Five	5	3.1	1	.5
Not Stated	3	1.8	6	3.1
Total Drivers	161	100	196	100
Total Accidents	262		156	
Accidents per Driver	1.6		.8	

[a] In Tables 12-27 this heading refers to drivers for whom there were records of motor vehicle accidents in the three years 1951 - 1953.

[b] In Tables 12-27 this heading refers to drivers for whom there was no record of any motor vehicle accidents in the four years 1950 - 1953.

[c] These drivers reported no accidents to the interviewer, although the Motor Vehicle Bureau records show accidents involving them in 1951 - 1953.

each group of drivers is only about 10 percent of the corresponding number of lifetime motor-vehicle accidents (Table 14), in each case the rate of accidents per driver for the accident drivers is twice that of the corresponding rates for the no-accident drivers.

Years of Driving Experience. In Table 16, driving experience is examined for each group of drivers. These data were based upon the question: "When did you first drive

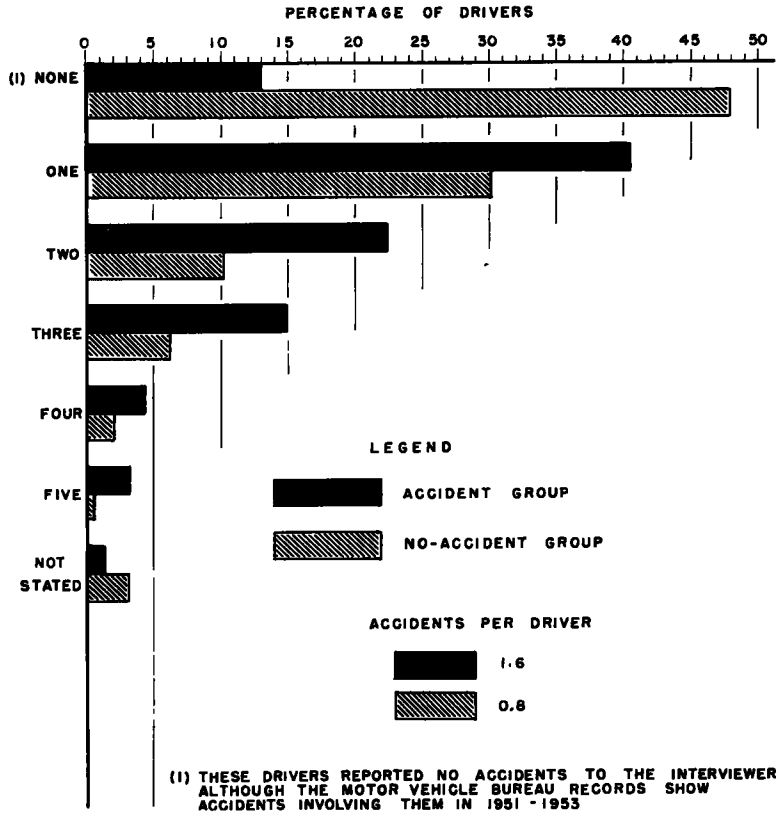

Figure 15. Motor vehicle accidents in lifetime of drivers.

a car?" Additional questions were asked about the number of years in which no driving was done in order to make an estimate of the number of years of actual driving. The average number of years of driving experience for the accident drivers is 26 years, dating back to 1928, and for the no-accident drivers, it is 24 years, dating back

TABLE 15

INTERVIEW DATA-NON-MOTOR VEHICLE ACCIDENTS SINCE JANUARY 1946 FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS. FROM OCTOBER 1949 THROUGH 1953

Non-Motor Vehicle Accidents Number	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
None	134	83.2	173	88.3
One	22	13.7	15	7.6
Two	2	1.2	-	-
Not Stated	3	1.9	8	4.1
Total Drivers	161	100	196	100
Total No. Accidents	26		15	
Accident per Driver	16		.08	

TABLE 16

INTERVIEW DATA-YEARS OF DRIVING EXPERIENCE FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Driving Experience Number of Years	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Less than 4	2	1.3	1	5
5 - 9	6	3.7	13	6.6
10 - 14	22	13.7	19	9.7
15 - 19	14	8.7	25	12.8
20 - 24	24	14.9	38	19.4
25 - 29	30	18.6	42	21.4
30 - 34	28	17.4	25	12.7
35 - 39	25	15.5	17	8.7
Over 39	10	6.2	15	7.7
Not Stated	-	-	1	.5
Totals	161	100	196	100
Ave. No. of Years	26		24	

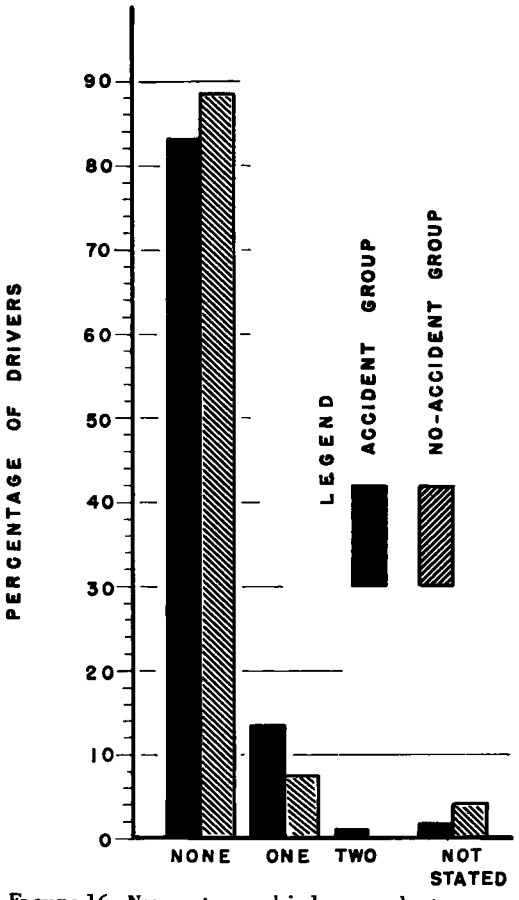

Figure 16. Non-motor-vehicle accidents since January 1946 for drivers.

to 1930. This is to be expected from the age distributions of the two groups.

Smoking. In the area of social characteristics, an attempt was made to find out something about the smoking habits of the drivers. In Table 17 and Figure 17, the smoking habits for the accident and no-accident groups are examined. These data were based upon the question: "Do you smoke? If no, did you ever smoke?" and "Why did you happen to stop?" A far larger proportion of the accident drivers than the no-accident drivers are smokers. Based on a chi-square test and a 5-percent level for statistical significance, a smaller proportion of the accident drivers than the no-accident drivers never smoked.

These data were further examined to see whether the apparent conclusion about smoking might be simply a reflection of the higher proportion of men in the accident group. On the extreme assumption that all the women are non-smokers, it still remains true that there are significantly more smokers in the accident group than in the no-accident group.

TABLE 17

INTERVIEW DATA-SMOKING RECORD FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Description of Smoking	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Smokes now	122	75.8	106	54.1
Does not smoke now but used to smoke	21	13.0	25	12.8
Does not smoke now and never smoked	17	10.6	63	32.1
Not Stated	1	.6	2	1.0
Totals	161	100	196	100

Miscellaneous. From the information collected under the general health section of the interview, it is of interest to note that fewer than 10 percent of the drivers in each group claimed any difficulty in hearing. Three of the drivers in the accident group and two in the no-accident group use hearing aids most of the time. In answer to the question, "Have you ever had any emotional illnes?," fewer than 3 percent of the drivers in each group claimed any emotional illness.

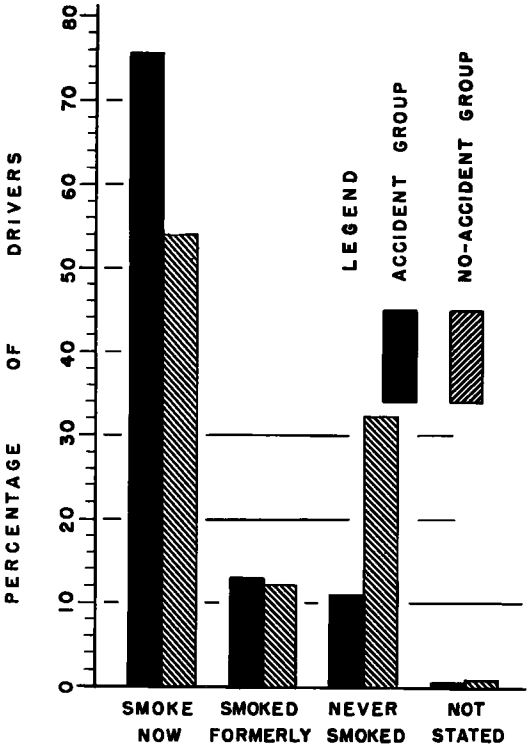

Figure 17. Smoking record for drivers.

Exposure

Annual Mileage. Table 18 presents for each group of drivers the number of miles the individual stated he had driven during the past year. Wide variations exist within each

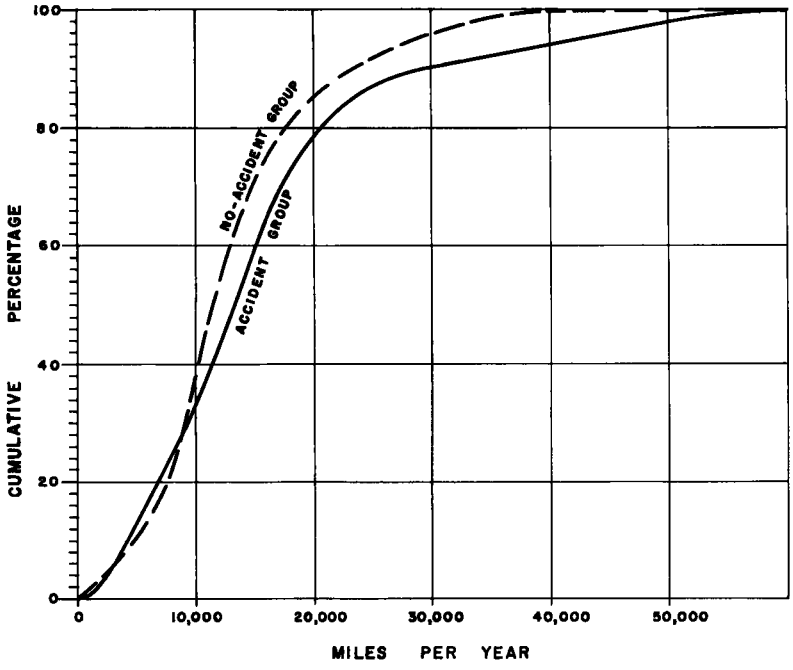

Figure 18. Distributions of miles driven in year preceding interview.

group. The median number of miles for the accident group of drivers is 12,000 miles per year. It is slightly lower for the no-accident group, at 11,000 miles per year. These two estimated average annual mileages are considerably higher than the national estimated average of 8,000 miles per driver[5]. This is to be expected as the

TABLE 18

INTERVIEW DATA-MILES DRIVEN IN YEAR PRECEDING INTERVIEW FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Miles Driven Preceding Year	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Under 1,000	1	.6	4	2.0
1,000 - 5,000	20	12.4	15	7.7
5,000-10,000	31	19.3	52	26.5
10,000-15,000	43	26.7	62	31.6
15,000-20,000	31	19.3	28	14.3
20,000-25,000	14	8.7	11	5.6
25,000-30,000	5	3.1	8	4.1
30,000-40,000	6	3.7	7	3.6
40,000-50,000	7	4.3	-	-
Over 50,000	3	1.9	1	.5
Did not drive	-	-	1	.5
Not stated	-	-	7	3.6
Totals	161	100	196	100
Median Miles	12,000		11,000	

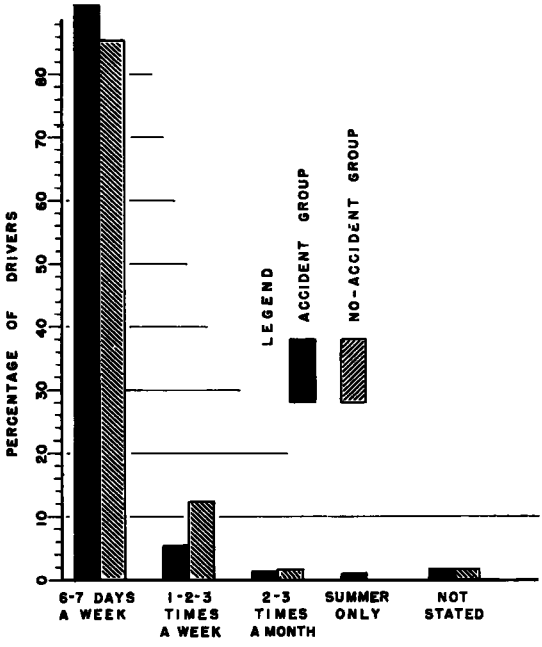

Figure 19. Frequency of driving.

[5] Accident Facts - Page 43, 1953 edition published by the National Safety Council.

TABLE 19

INTERVIEW DATA-FREQUENCY OF DRIVING FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Frequency of Driving	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
6-7 days a week	146	90.8	167	85.3
1, 2, 3 times a week	9	5.6	22	11.2
2-3 times a month	2	1.2	3	1.5
Summer only	1	.6	-	-
Does not drive now	1	.6	1	.5
Not stated	2	1.2	3	1.5
Totals	161	100	196	100

majority of the drivers are daily commuters. Figure 18 depicts for each group of drivers the distribution of the miles driven in the year preceding the interview.

Frequency of Driving. In Table 19 an examination is made of the frequency of driving for each group of drivers. Figure 19 depicts the percentage distribution of the drivers in each group according to their frequency of driving. Most of the drivers in each group use their cars nearly every day.

Speed

Opinion of Own Driving Speed. In Table 20, examination is made of each group of drivers' opinion of their own driving speed. These data are based upon the question: "What kind of a driver do you consider yourself, would you say that you are a slow or a fast driver?" About 70 percent of the drivers in each group consider their driving speeds as representative of the average driver on the road. Equal percentages of the accident drivers, about 16 percent in each case, consider their driving speeds slower or faster than the average. A greater percentage of the no-accident drivers consider their driving speeds slower rather than faster than the average. Figure 20 presents the percentage distribution of these data.

The average of the observed speeds at the tangents of the West Sand Lake highway study was computed for the accident and no-accident drivers in each of the three

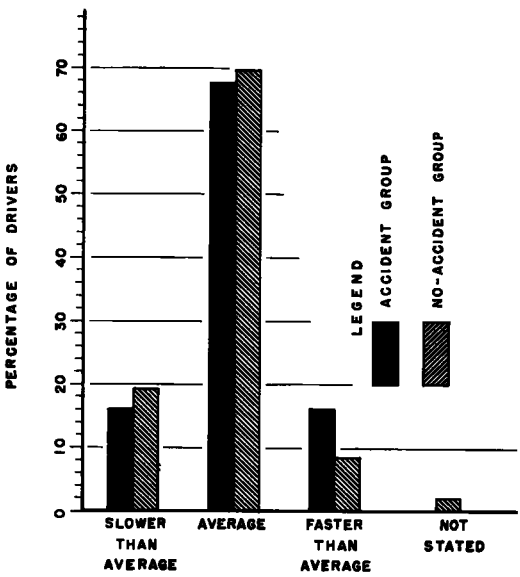

Figure 20. Opinion of own driving speed.

TABLE 20

OPINION OF OWN DRIVING SPEED FROM INTERVIEW AND AVERAGE OF RECORDED SPEEDS AT TANGENTS OF STUDY SITE FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Degree of Speed	Accident Drivers			No-Accident Drivers		
	Number	Percent	Average[a] Speed at Tangents mph.	Number	Percent	Average[a] Speed at Tangents mph.
Slower than average	26	16.1	44.0	38	19.4	42.0
Average	109	67.8	44.2	137	69.9	44.2
Faster than average	26	16.1	44.3	17	8.7	44.9
No opinion	-	-		1	.5	
Not stated	-	-		3	1.5	
Totals	161	100	44.2	196	100	43.8

[a] Average of observed speed for Group of Drivers at Stations 1 and 4 of Speed Study Combined.

TABLE 21

USUAL SPEED ON LONG TRIPS (FROM INTERVIEW) AND AVERAGE OF RECORDED SPEEDS AT TANGENTS OF STUDY SITE FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Speed on long trips mph.	Accident Drivers			No-Accident Drivers		
	Number	Percent	Average[a] Speed at Tangents mph.	Number	Percent	Average[a] Speed at Tangents mph.
Less than 37	4	2.5	For all	1	.5	For all
37 - 41	10	6.2	drivers	13	6.6	drivers
42 - 46	17	10.6	in this	20	10.2	in this
47 - 51	78	48.4	group	108	55.1	group
52 - 56	28	17.4		28	14.3	
57 - 61	14	8.7	44.2	16	8.2	43.8
62 - 66	3	1.9	mph.	2	1.0	mph.
67 - 71	2	1.2		-	-	
Not stated	5	3.1		8	4.1	
Totals	161	100		196	100	
Median Speed	50 mph.			49 mph.		

[a] Average of observed speed for Group of Drivers at Stations 1 and 4 of Speed Study Combined.

opinion categories of degree of speed (Table 20). It is to be noted that the judgement of the drivers, as to their category of degree of speed, is properly related to the corresponding average of the observed speeds at tangents. The average of the observed speeds at tangents for those drivers who consider themselves to be "average speed drivers" is 44.2 mph.

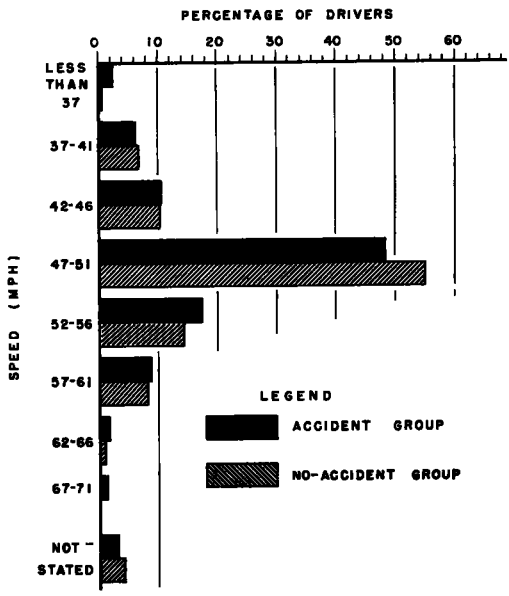

Figure 21. Usual speed on long trips.

Usual Speed on Long Trips. In Table 21, the usual speeds that the interviewees stated they drove on long trips, on the open road are shown for both groups of drivers. A trip of 50 miles or more was defined as a long trip. The median speed for accident and no-accident drivers is about 50 mph. The average of the observed speeds at tangents for each group of drivers is shown. It is noted that about 30 percent of the drivers in each group stated that they exceed the 50-mph. legal speed limit. This agrees with the percentage of passenger cars exceeding the 50-mph. speed limit as indicated by the state-wide speed study[6]. Figure 21 depicts the percentage distribution of the drivers according to 5-mile groupings of the stated speed on long trips.

Opinion of 50-mph. Speed Limit. In Table 22 and Figure 22, the opinion of the interviewees as to the New York State speed limit is examined for both groups of drivers. Over 70 percent of both groups of drivers

[6] Speed characteristics on rural highways, New York State Department of Public Works in cooperation with the United States Bureau of Public Roads.

TABLE 22

INTERVIEW DATA-OPINION OF 50 MPH. SPEED LIMIT ON OPEN HIGHWAY FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

50 mph Speed Limit on Open Highway	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Too high	15	9.3	13	6.6
Too low	20	12.4	19	9.7
About right	114	70.8	154	78.6
No opinion	12	7.5	10	5.1
Totals	161	100	196	100

are of the opinion that the legal speed limit of 50 mph. is about right.

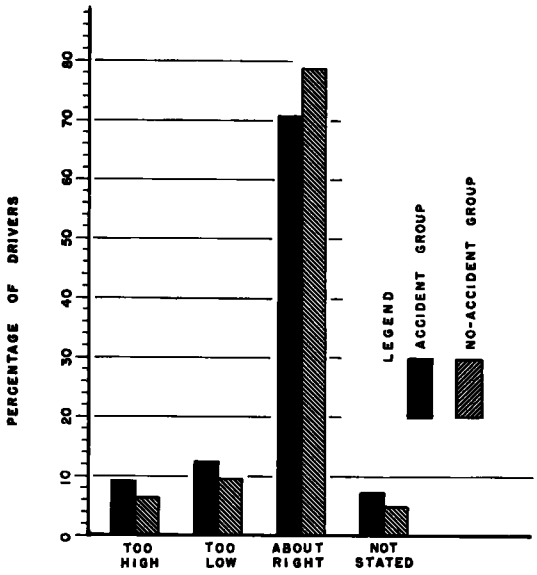

Figure 22. Opinion of 50-mph. speed limit on open highways.

Skill

Opinion of Own Driving Skill. In Table 23 and Figure 23, examination is made of each group of drivers' opinion of their own driving skill. About 50 percent of the drivers in each group consider themselves as relatively skillful drivers. About 30 percent of the drivers in each group considered themselves as about average drivers; 16 percent of the accident drivers and about 12 percent of the no-accident drivers consider themselves as better than average drivers. Very few of the drivers consider themselves below average.

Instructor When First Learning to Drive. In Table 24 and Figure 24, the drivers in each group are classified according to who taught them to drive. Very few of the drivers in either group received professional instruction. About 65 percent were taught to drive by a friend or relative, and about 25 percent taught themselves. Among people learning to drive today, the portion learning without professional instruction is probably much lower.

Number of Times Driver Examination Was Taken. In Table 25 and Figure 25, an examination is made for each group of drivers of the number of times a driver test had to be taken in order to receive a driving license. Of the drivers who took examinations, 77 percent of the accident group and 83 percent of the no-accident group passed the test the first time. The difference between these percentages is not statistically significant. About 14 percent of all the drivers never took a driver examination. These are the drivers who obtained their driving licenses before an examination was required by statute.

Safety Mindedness

Drowsiness while Driving. When asked about drowsiness while driving, nearly 50

TABLE 23

INTERVIEW DATA-OPINION OF OWN DRIVING SKILL FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Degree of Skill	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Skillful	80	49.8	104	53.1
Better than average	26	16.1	24	12.2
About average	52	32.3	56	28.6
Below average	1	.6	4	2.0
Not stated	2	1.2	8	4 1
Totals	161	100	196	100

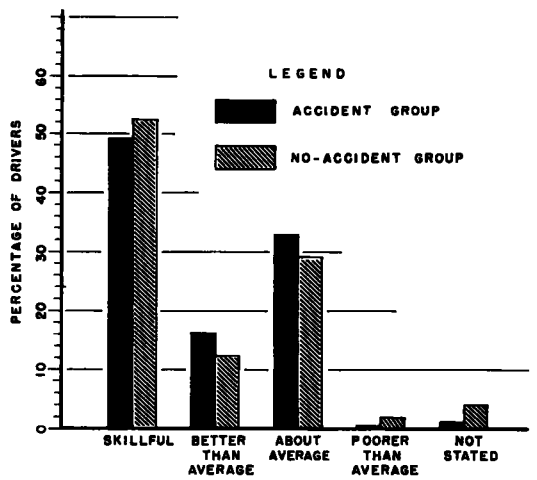

Figure 23. Opinion of own driving skill.

TABLE 24

INTERVIEW DATA-INSTRUCTOR WHEN FIRST LEARNING TO DRIVE FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Instructor when Learning to Drive	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Friend or relative	95	59.0	130	66.3
Self	50	31.1	48	24.5
Commercial Driving School	8	4.9	4	2.0
Auto dealer	4	2.5	6	3.1
Army	3	1.9	2	1.0
Not stated	1	.6	6	3.1
Totals	161	100	196	100

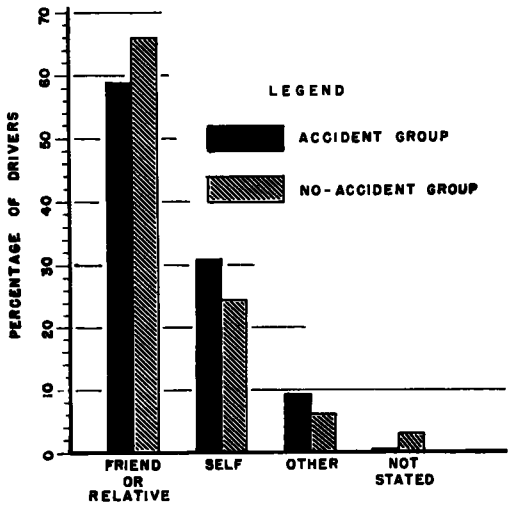

Figure 24. Instructor when first learning to drive.

TABLE 25

INTERVIEW DATA-NUMBER OF TIMES DRIVER EXAMINATION WAS TAKEN FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS FROM OCTOBER 1949 THROUGH 1953

Times Driver Examination Was Taken	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Once	100	62.1	144	73.5
Twice	26	16.2	25	12.8
Three times	3	1.9	3	1.5
Five times	1	.6	-	-
Six times	-	-	1	.5
Never took an exam	29	18.0	20	10.2
Not stated	2	1.2	3	1.5
Totals	161	100	196	100
Average	1.04 Times		1.08 Times	

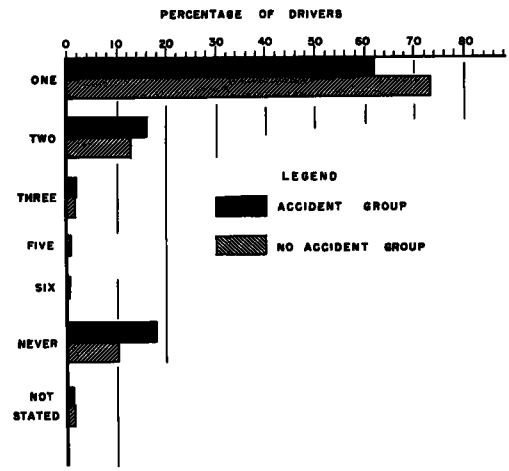

Figure 25. Number of times driver examination was taken.

TABLE 26

INTERVIEW DATA-REASONS FOR BECOMING DROWSY WHILE DRIVING FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Reasons for Becoming Drowsy	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Don't get drowsy	77	47.3	100	48.1
Long trips	27	16.6	27	13.0
Tired, fatigued at start	24	14.7	27	13.0
Driving over familar road	5	3.1	4	1.9
Straight, monotonous road	5	3.1	10	4.8
Lack of sleep	7	4.3	9	4.3
Excessive heat, hot days	3	1.8	9	4.3
Eye strain	1	.6	-	-
Humming of motor	2	1.2	2	1.0
After drinking	-	-	1	.5
Night driving	3	1.8	1	.5
Long night trips	-	-	5	2.4
Other	2	1.2	3	1.4
Not stated	7	4.3	10	4.8
Totals	163	100	208	100
Total drivers with reasons	77		86	
Total reasons	79		98	
Drivers Interviewed	161		196	

percent of the drivers in each group claimed they do not get drowsy, as shown in Table 26 and Figure 26. About 15 percent of the drivers for both groups indicated that they had become drowsy on long trips, and about 14 percent said they become drowsy when they were fatigued at the start of trip. The balance of the drivers advanced other reasons for becoming drowsy.

Driving Speed after Drinking. In an attempt to explore driving speeds and the use of alcohol, the interviewees were asked how they thought their speeds were affected by drinking. Table 27 lists the answers for each group of drivers and Figure 27 shows the percentage distribution. About 45 percent of all drivers interviewed claimed that they do not drink before driving. About 20 percent of both the accident and no-accident drivers indicated no change in driving speed after drinking. Of the remaining drivers, more think they drive

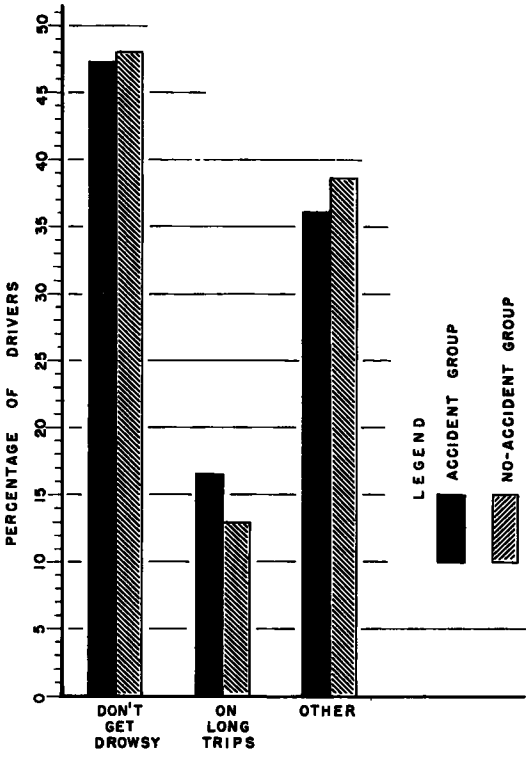

Figure 26. Reasons for becoming drowsy while driving.

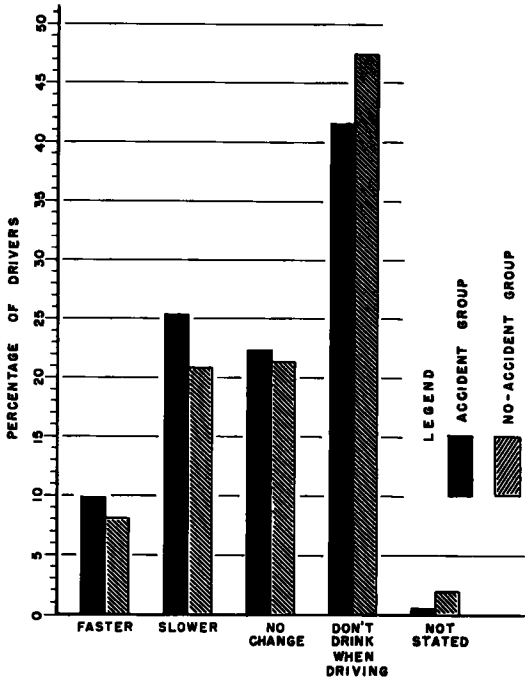

Figure 27. Opinion of driving speed after drinking.

slower after drinking than those who think they drive faster.

TABLE 27

INTERVIEW DATA-DRIVING SPEEDS AFTER DRINKING FOR DRIVERS WITH AND WITHOUT MOTOR VEHICLE ACCIDENT RECORDS

Driving Speed after Drinking	Accident Drivers		No-Accident Drivers	
	Number	Percent	Number	Percent
Faster	16	9.9	16	8 2
Slower	41	25.5	41	20 9
No change	36	22.4	42	21.4
Does not drink when driving	67	41.6	93	47 5
Not stated	1	.6	4	2.0
Totals	161	100	196	100

SUMMARY

General Characteristics of the Drivers

This analysis is based on data from 161 accident drivers (motor-vehicle-accident records from January 1, 1951, through December of 1953) and 196 no-accident drivers (no motor-vehicle-accident records from October 1, 1949 through December 1953) whose speeds and headways were observed on the West Sand Lake Highway in 1950 and 1951. There is a higher proportion of men in the accident group than in the no-accident group. The ratio of females to males in the total sample is 1 to 6. The drivers in the accident group have a lifetime accident rate of 1.6 accidents per driver and in the no-accident group the rate is 0.8 accidents per driver.

Of accidents described to interviewers, about two thirds occurred on working days and a third on days off from work. Nearly 90 percent of the accidents occurred on routes traveled frequently. The average driving experience for the accident drivers dates back to 1928 and to 1930 for the no-accident drivers. Fewer than 10 percent in each group claim any difficulty in hearing, and fewer than 3 percent in each group claim any emotional illness.

Exposure

The accident drivers drive an average of 12,000 miles per year and the no-accident driver, 11,000 miles per year. Most of the drivers in each group use their cars nearly every day.

Speed

About 70 percent of the drivers in each group consider their driving speed as representative of the average driver on the road; 30 percent of the drivers in each group claim they often exceed the 50-mph. legal speed limit on trips. About 20 percent of the drivers in each group are of the opinion that the speed limit is too low.

Skill

Some 50 percent of the drivers in each group consider themselves as relatively skillful drivers, and 30 percent consider themselves as good as the average, with most of the balance considering themselves better than the average. A great majority of the drivers in both groups passed their driving examination the first time. Very few of the drivers received professional instruction.

Safety Mindedness

Nearly half of the drivers in each group claim they do not get drowsy while driving. About 45 percent say they do not drive after drinking. More of the drivers think they drive more slowly after drinking than those who think they drive faster.

The Habitual Traffic Violator

HARRY W. CASE, ISMAR REITER, ERNST A. FEBLOWICZ, and
ROGER G. STEWART, Institute of Transportation and Traffic Engineering
University of California at Los Angeles

The individual who becomes a habitual traffic violator has been the cause of much concern to those who are associated with automotive transportation in the United States. Constantly increasing road congestion makes urgent the isolation, analysis, and correction of such individuals. To throw some light on this subject a study of habitual violators was undertaken. Three hundred habitual violators were interviewed by trained interviewers to determine the factors surrounding their violation and obtain information concerning their psychological characteristics. A more-detailed analysis was made of one hundred cases.

The entire group of 300 had 1,774 violations during a 12-month period. Of these, 76 percent were moving violations. The most-common class of moving violations was failure to heed traffic-control devices and the next-most-frequent class was speeding violations. Workers, occupationally classifiable as skilled, were 55 percent of the group. Native-born Californians were 24 percent. Males represented 92 percent of the group. The entire group had a median age of 29 and a mode of 23. The majority of cars (59 percent) were 1943 or more-recent models. When distributions of estimated intelligence and personality were made for the group, a close approximation to a normal distribution was evident.

A more-detailed clinical analysis of the data of 100 cases revealed that there was a tendency to view both law and police with a positive rather than negative view. Also, a tendency appeared to exist to not commit the type of violation which they classified as being the "most serious."

For the 300 cases, the factor which appears to differentiate them from other populations is a habit of committing traffic violations for which they are apprehended.

● FOR many years the habitual traffic violator has been the recipient of many statements and reports that tend to picture his personality and mentality in categories that range from psychotic to neurotic (1) and moronic to subnormal. Assertions have been made by authorities that if it were possible to reshape the attitudes of these individuals, much of the danger and many of the accidents resulting from traffic mishaps and violations could be avoided (5). On the other hand, it has been maintained that the attitudes of the violators have little to do with violations or accidents, but that the fault lies in the highway (4), the motorcar, or in the antiquity of the laws.

In an effort to start the unraveling of this complex picture, a study was undertaken by the Institute of Transportation and Traffic Engineering at the University of California at Los Angeles in cooperation with the Municipal Traffic Court of the City of Los Angeles and the Department of Motor Vehicles of the State of California. The procedure consisted of interviewing, just prior to their court hearing, motor-vehicle operators who had a multiple-violation record. The operator was told that his participation was entirely voluntary. If he wished to cooperate, he could answer a number of questions concerning himself and his traffic record. During the entire 12-month period in which the study was conducted, only two individuals failed to participate in the experiment. All of the individuals were told that the experiment was connected in no way with the court and that it would have no bearing upon the ensuing court action.

The interviewers were two Ph. D. candidates in psychology attending UCLA. Both had had extensive interviewing experience prior to working on this study. All individuals interviewed were selected on the basis of multiple moving violations within the past 12-month period. Care was taken to see that, when the individual was removed from the courtroom for the interview and when he was returned, the seating arrangement pre-

vented him from communicating with others who would be interviewed subsequently. Over a 12-month period 300 cases were interviewed.

From the interview and an analysis of the citation, the interviewers obtained data on: population groupings, age, sex, occupational status classified according to skill level, state of birth, miles driven per day, type of car driven, age of the vehicle, type of violation, and an estimate of the intelligence and personality classification of the individual. Intelligence was divided into six categories, ranging from below normal or dull to decidedly above normal. The personality evaluation consisted of placing the individual, on the basis of the interview, in one of the following categories: withdrawing, conforming, normal, aggressive, hostile, and unknown.

The interview was conducted in an informal but carefully structured manner in order to reveal the intellectual capacity of the violator, as well as allowing him to exhibit his personality pattern. In order to standardize the interview, 50 individuals were interviewed whose records are not included in the study. Some of the interviews were conducted by one interviewer with the other sitting in and making his own notes for future comparison. Then the remaining violators in this group of 50 were interviewed successively and independently by each interviewer. Their interview notes were compared for equivalence. Before the 50 cases had been completed, there was a minimum variation between the reports of the interviewers.

The 300 cases on which this study is based received a total number of 1,774 recorded violations. This number represents the total of all violations on record during the 12-month period up to and including the date of the issue of the last citation. A citation (ticket) may include more than one violation (count). Of the total violations committed, 1,341 (76 percent) were of the moving type, while 369 (21 percent) were of the nonmoving classification. The remaining 64 (4 percent) were violations of the municipal code rather than of the state motor-vehicle code. All data reported in this study concern only violations of the state motor-vehicle code.

Of the total moving violations, the greatest percentages were: 38 percent for failure to heed traffic-control devices, 26 percent for speeding, and 17 percent for violations of the right of way. Of the violations for failure to heed traffic-control devices, 62 percent were issued for failure to stop at a red light and 37 percent were for failure to stop at a stop sign. Of the speeding violations, 84 percent were for violations in a 25-mph. zone, 8 percent in a 55-mph. zone, 6 percent in a 35-mph. zone, 1 percent in a 15-mph. zone, and 1 percent not specified. Of the violations of right of way, 37 percent were for failure to yield right of way on left-hand turns and the remainder were of miscellaneous types. With respect to the group of nonmoving violations, 55 percent were for registration or license violations, 30 percent were for improper or defective lighting equipment, and 15 percent for other illegal or defective equipment.

Table 1 shows the five most-frequent violations, which account for 53 percent of the total number of violations. Table 2 indicates that it is the male offender who receives the traffic ticket and the probability is that he will be from either the white or Negro population. In terms of occupational status (Table 3), it appears that it is the group of individuals who are most-commonly known as skilled workers (artisans, white collar, etc.) who fall most frequently into the category of the habitual violator (55 percent). Table 4 shows it is the California-born population (24.0 percent) who receives the greatest single number of tickets, Texans being the next-most-frequent violators (9.7 percent).

TABLE 1

MOST-FREQUENT VIOLATIONS

Identification	Frequency	% of Total
Running red light	310	17.5
Speeding in 25-mph. zone	291	16.4
Failure to stop at stop sign	184	10.3
Left turn at intersection, turner must yield	83	4.7
Left turn from wrong lane	81	4.6
Total	949	53.5

The above five most-frequent violations account for 53 percent of all violations in this study.

The individuals' ages range from 16 to 54, with the median at 29 and the mode at 23. The highest percentage (25 percent) is for the 21-to-25 group (Table 5). The greatest number of violators (32.7 percent)

falls into the group that drives (their own estimates between 26 and 50 miles per day (Table 6). Fords (23.3 percent) and Chevrolets (19.3 percent) were the most-frequent vehicles, and the majority of the vehicles (59.3 percent) were 1943 or more-recent models (Table 7).

Estimated intelligence (Table 8), based

TABLE 2

DISTRIBUTION BY POPULATION GROUPINGS AND SEX

Population Grouping	Frequency	Percentage
White	166	55.3
Negro	96	32.0
Mexican	24	8.0
Oriental	13	4.3
Unknown	1	.3
Total	300	99.9
Sex	**Frequency**	**Percentage**
Male	277	92.3
Female	23	7.7
Total	300	100

TABLE 4

STATE OF BIRTH

State	Frequency	Percentage
California	72	24.0
Texas	29	9.7
New York	24	8.0
Louisiana	21	7.0
Illinois	17	5.7
Others	137	45.7
Total	300	100.1

TABLE 6

MILES PER DAY

Estimated miles driven per day	Frequency	Percentage
1-25	52	17.3
26-50	98	32.7
51-75	44	14.7
76-100	37	12.3
101-125	5	1.7
126-150	13	4.3
Over 150	17	5.7
Unknown	34	11.3
Total	300	100

Range = 1-300

TABLE 3

OCCUPATIONAL STATUS

Skill Level	Frequency	%
Unskilled	18	6
Semiskilled (workers, white collar, etc.)	69	23
Skilled (artisans, white collar, etc.)	165	55
Professional	5	1.7
Owner of good-sized business	1	.3
Student	25	8.3
Housewife	1	.3
Other	16	5.3
Total	300	99.9

TABLE 5

AGE DISTRIBUTION

Age of Individual	Frequency	Percentage
16-20	37	12.3
21-25	75	25.0
26-30	57	19.0
31-35	51	17.0
36-40	43	14.3
41-45	21	7.0
46-50	11	3.7
51-55	5	1.7
Total	300	100

Range = 16-54 years
Median = 29 years
Mode = 23 years

TABLE 7

MAKE AND AGE OF CAR DRIVEN

Make of car driven	Frequency	%
Ford	70	23.3
Chevrolet	58	19.3
Plymouth	22	7.3
Buick	22	7.3
Oldsmobile	21	7.0
Others	107	35.7
Total	300	99.9
Age of car driven	**Frequency**	**%**
1942 or earlier	122	40.7
Since 1942	178	59.3
Total	300	100

TABLE 8

INTELLIGENCE APPRAISAL

Intelligence appraisal	Frequency	%
Below normal or dull	0	
Slightly below normal	40	13.3
Normal	173	57.7
Slightly above normal	85	28.3
Decidedly above normal	0	
Unknown or undetermined	2	.7
Total	300	100

TABLE 9

PERSONALITY EVALUATION

Personality Evaluation	Frequency	%
Withdrawing	1	0.3
Conforming	51	17.0
Normal	175	58.3
Aggressive	66	22.0
Hostile	5	1.7
Unknown or undetermined	2	0.7
Total	300	100

upon the content of the interview, educational level, and occupation, revealed that the majority of individuals (57.7 percent) were normal, and similar estimates of their personality (Table 9) revealed essentially the same thing (58.3 percent).

The second part of the study consisted of making a more-intensive analysis of the interviews of the last 100 cases. In this section of the study, the time of the interview was lengthened, and more care was devoted to ascertaining the relationships surrounding the offender and the offense. The analysis consisted of attempting to ascertain in its broadest concepts: the offender's attitude toward the law; his attitude toward police enforcement; his concept of himself with regard to driving; his concept of a good or bad driver; his belief as to how he could improve; his reasons for pleading guilty or not guilty; his concept of what was the worst-possible driving offense, his intelligence level; his personality characteristics; and additional data or conclusions. It was thought that by studying the relationships between these various concepts, considerable information could be elicited concerning the individual's attitudinal frame with reference to the traffic laws and situations in which he was involved.

From a comparison of intelligence versus personality (Figure 1) it appears that the population is normal. When the violators' opinions pertaining to the law were analyzed, 60 percent of the 100 cases had opinions that are substantially in accord with the law, only 12 percent indicated negative opinions or dissatisfaction with the legal standards, and the remaining 28 percent had no opinion or failed to answer. However, the attitudes of this group of violators with respect to the police and their enforcement of the law show a somewhat different picture. The percentage of those who expressed favorable opinions was 55 percent, (compared with 60 percent), the group showing resentment was 30 percent (compared with 12 percent), and the no opinion or failure to answer group was 15 percent (compared with 28 percent) of the total. When both sets of opinions are interrelated, it appears that the violators are more opinionated about the police than about the traffic laws, and that the criticism of the traffic laws is more favorable than the criticism of police.

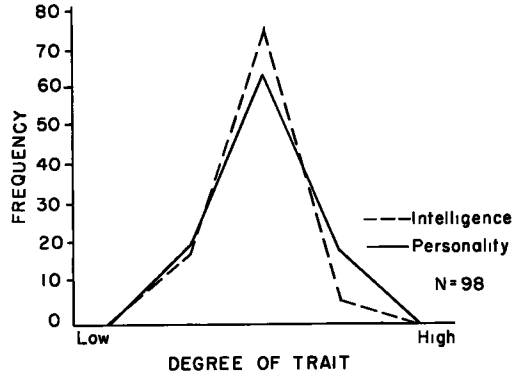

Figure 1. Comparison of intelligence versus personality for 98 violators.

The individual's concept of himself as a driver resulted in some interesting revelations: 86 percent thought that they were at least fair drivers, only 9 percent thought of themselves as poor drivers, and the remainder failed to express or had no opinion. On the other hand, in response to the question as to what constituted a good or a bad driver, the greatest number of individuals believed that a good driver obeyed the law, while a bad driver did not. Similarly for this group, the individual's attitude is indicated as being next in importance, skill third, and technique and physical condition fourth and fifth, respectively.

When asked as to how they could improve

their own driving situation, 36. 8 percent gave general solutions such as "be more careful," 23. 7 percent had specific solutions applying to their situation such as "watch traffic lights," 4. 4 percent who believed they received their ticket because of external forces had suggestions such as "look out for the police," etc. An additional 4. 4 percent gave extreme solutions, such as "stop driving;" 20. 2 percent had no idea how to solve their problem; 10. 5 percent failed to answer the question. The conclusion might be drawn that the majority of individuals in this sample considered themselves to be the source of their traffic-law troubles but that 20. 2 percent had no solution to the problem.

When their statements regarding why they would plead guilty were analyzed, it was found that: 38 percent plead guilty because they feel they are guilty; 24 percent would plead not guilty but do not want to take the time that this involves; 25 percent have assorted reasons for pleading guilty, such as it is better to plead guilty since they believe that the policeman's word carries more weight in court or they believe that it would cost more money to plead not guilty than to plead guilty; 13 percent did not state their reasons.

Of 61 individuals who were asked what they considered to be the worst driving offenses, 36 percent believe that drunken driving is the worst-possible offense, 16 percent believe that speeding is the worst offense, and 5 percent believe that hit-and-run offenses are the worst type. These three categories account for 57 percent of the total "worst offenses" listed. Miscellaneous classifiable offenses account for 13 percent of the individuals. The remaining 30 percent were not classifiable for various reasons. A comparison of what the individual believed was the worst offense was made against his violation record during the past 12-month period. Of the group which named classifiable offenses, 86 percent had not been convicted for the offense they stated as being the "worst."

For this group of 100 offenders, the personality picture, as indicated on the basis of the individual's actions and statements during the interview, was as follows: 44 percent were classified as being normal, 13 percent were best described as aggressive or excessively extroverted, 28 percent appeared to be introverted perhaps with some personal problems, only 13 percent were classified as individuals who probably needed some clinical attention and treatment, and 2 percent were not classifiable.

If an attempt is made to formulate a prototype of the habitual traffic violator by means of the percentage modes of the various distributions resulting from the study conducted in Los Angeles, he is revealed to be white, male, between the ages of 21 and 25, employed in a semiskilled or skilled job, of average intelligence and a normal personality, and driving a Ford or Chevrolet made since 1942. This would lead to the conclusion that he probably does not differ from the average population of motor-vehicle operators except that he has a habit (2) of committing moving traffic violations for which he is apprehended. Yet he seems to have an awareness of both the necessity of law and the police enforcement of it and believes that they are necessary and useful. He has opinions as to what constitutes the most-serious type of offense and shows a tendency to commit violations in areas other than those that he believes to be the most serious. These conclusions may place an entirely different emphasis on the problem of traffic violations and tentatively appear to substantiate the belief that prevention or correction through training (3) may ultimately be one of the solutions to the problem, rather than through the use of punitive measures after the habit pattern has been formed.

ACKNOWLEDGMENT

The authors wish to gratefully acknowledge the contributions of Parks Stillwell, Judge of the Municipal Court, City of Los Angeles, and Paul Mason, Director of the Department of Motor Vehicles, State of California, who have made this study possible and Slade Hulbert of the Institute of Transportation and Traffic Engineering, University of California, Los Angeles, who has given generously of his time in the discussion and analysis of the problem.

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Comparison of Types of Traffic Violations For Different Years

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It is well known that the accident-reporting index varies considerably from area to area even within a given jurisdiction and from time to time. There is evidence that the reporting is done best in the more-highly populated areas and poorest in the sparsely populated areas. Before the passage of a financial responsibility law in Iowa the reporting index was shown by Lauer to vary considerably from year to year. Publicity programs also have a great deal to do with the accident reporting index in a given locality.

The National Safety Council has shown that there is a wide variation between states. The frequently quoted ratio of around 175 accidents per fatality is only an average found throughout the United States. It is conceivable that other factors may operate, notably the discharge of certain military groups, the incidence of the number of persons taken into the draft, seasonal variation, and travel due to vacations, football, etc.

The present study is a comparison of the violation and accident records in Iowa for two consecutive periods, 1948-50 and 1950-52. Two samplings of 7,692 drivers and 7,334 drivers were systematically drawn from the Iowa license files during these two periods. Comparisons are made on the basis of age and sex.

It was originally hypothesized that there might be a difference between these two periods from the effects of driver education, a larger patrol and other factors which might influence the incidence of violations or accidents during these periods. Tabular data will be given which show that differences between two 3-year periods are relatively minor and that high agreement is found in the general nature of the age curves for the two samples. A relative consistency in the nature of violations from year to year is indicated.

● IT has long been known that traffic accident and violation reports vary with the nature of financial responsibility laws, particular interest of the enforcement agencies at the moment, administration policies and other factors. For instance, Lauer (2, 3) has reported variations in traffic flow and speed characteristics of different age groups at different hours of the day. The greatest number of excessive speeds was noted at hours when the patrol was off duty.

McMurray and Lauer (6) have called attention to the variations in accident frequency from month to month and from season to season as reported by accident statistical bureaus. Frequently the fluctuations are chance variations.

It would appear that a study of accident trends from one year to another or from one period of years to another period, might be of considerable importance to traffic enforcement groups to guide strategy in reducing the total number of accidents and violations occurring during a given period.

Outside of purely local tendencies to step up the enforcement index when frequency of involvement becomes noticeable, there has been very little done in the way of scientific study on the relationship between violations and accidents. Likewise little has been done on variations in reporting of violations and accidents from one period of time to another.

Lauer (3) has studied the age at which violations occur. Siebrecht (7) in plotting the age of drivers at the time of their accidents, obtained curves which differed only slightly for successive trienniums. To all intent and purposes the differences could have been chance variations. A very definite pattern was established throughout the age range group.

Further, Siebrecht and Bennett (8) in reporting on the relationship between traffic violations and the kind of training drivers have received, found significant differences between the untrained and trained drivers with respect to the frequency and type of violations of the drivers.

PROBLEM AND PURPOSES OF THE PRESENT STUDY

The present study is an attempt to break down violations into type and number of arrests for each type. This has been done for each of two samplings of the population of drivers in Iowa taken in 1950 and 1953 respectively.

If we wish to state the problem in the form of a hypothesis we may use the null form and say that two samplings of accidents and violations taken for successive three-year periods do not differ significantly by type. A number of assumptions need be made regarding results obtained which are basic to the present study. These may be given as follows:

1. It is assumed that the accident files were kept in the same condition during the 1950-1-2 period that they were for the 1947-8-9 period. There is bound to be a lag in the removal of names of persons from the files of those who are not driving at a given time due to moving out of the state, marriage, etc. It may be further assumed that the number of delinquent licenses in the files was approximately the same for 1950-1-2 as it was for 1947-8-9.
2. Since there was no major change in the number of the highway patrolmen on the road during these two periods, the enforcement index is assumed to have remained approximately the same. The latter assumption is not strictly valid since in 1947 it was known that the drivers license responsibility law was going into effect and there was more emphasis made on securing complete records. However, an increase from $25 to $50 minimum damage required for a report would tend to offset this effect.
3. The number of drivers, cars registered, and mileage driven are increasing, however, and allowance should be taken of these factors.

With these assumptions and under conditions of the study to be described it would seem reasonable that the results might be used as an index to the number of accidents and types of violations which are likely to occur within the next three or more years providing no fundamental changes are made in the methods of enforcement, the amount of damage necessary for an accident to be reported and a fairly stable population of drivers of given ages. If for example, the older drivers should suddenly decrease the amount of driving they do and the younger persons increase their number and mileage driven, it is likely that a different set of values might be obtained.

If on the other hand the effects of driver education might notably stimulate the youthful drivers to be more careful and if policies and other methods may bring reduction in accidents among the older groups of drivers it is conceivable that the forms of the frequency curves might change.

From the standpoint of enforcement it would seem that this type of analysis might be periodically desirable in order that the public may be appraised of the facts regarding violation and accident trends. Too frequently the accident reporting bureaus merely indicate numbers of drivers having certain types of accidents or violations. The frequency of involvement is given without any statistical evaluation to show whether or not these differences are due to chance or whether they are real changes. Usually no basis of comparison, such as the number of drivers in an age group, are stated.

METHOD AND PROCEDURE

The present study is a statistical analysis of the types of violation occurring during two 3-year periods. Systematic sampling of the population of driver licenses in the files in 1950 was made by drawing every 200th card. This gave a total of 7,692 cases. By simple computation this would indicate that there were 1,592,400 licenses in the file at that time. Many of these licenses, however, belonged to service men or persons who had moved out of the state, were deceased, or otherwise had ceased driving. Consequently the sample shrunk to some extent and in the present analysis there was no attempt made to utilize the complete 7,692 cases. For reasons given an N of 6,414 cases was used, for this study, both men and women.

The 1953 sampling was obtained by drawing every 250th card in a systematic manner. There were 7,334 licenses drawn. For reasons stated above, shrinkage resulted in an N of 5,437 cases used in this study. The authors assume that the shrinkage would be more or less uniform throughout the various age and sex groups, and consider the samp-

ling as representative of what was found in the files. By likewise making an estimate from this sampling it would seem that in 1953 there were close to 1,833,500 licenses for both sexes in the files.

According to the Bureau of Public Roads, Department of Commerce, quoted in the 1955 Pocket Almanac, Iowa had 1,336,214 licensed drivers in 1953. The authors are not in position to reconcile this discrepancy between the sampling and the quoted number of licenses but it is assumed that the difference would be accounted for partly by the number of inactive licenses in the files at the time. It is also possible that this estimate is based on an earlier figure which has grown considerably during the last several years due to the fact that many more women and younger people are being licensed today. At least as large or larger proportion of the male population is being licensed; hence it would be expected that the figures would grow with the increase in driving population.

It is estimated at the present that there are about 162,000,000 persons in the United States, whereas the 1950 census showed slightly over 150,000,000. The State of Iowa has not grown proportionately but the 1950 census showed 2,621,073 people in Iowa as against 2,500,000 in 1940. From the State Bureau of Vital Statistics' estimate most larger communities in Iowa have shown some increase since 1950 although the state population has not materially changed. Many smaller centers have lost slightly during the past 5 years.

RESULTS

Results of this study are presented in a number of tables which will be referred to in order. The tables have been numbered as follows: (1) Comparison of Total Violation Involvement of Men Drivers, (2) Comparison of Frequency of Violations by Types for Men Drivers, (3) Comparison of Total Violation and Accident Involvement of Men Drivers, (4) Comparison of Total Violation Involvement of Women Drivers, and (5) Comparison of Total Violation and Accident Involvement of Women Drivers. The statistical significance of differences between the two samples of drivers has been given when such was feasible to calculate.

Only comparisons of the total number of accidents and violations were made for women. The records of women were so sparse that it would not be representative and no test of significance could be made if broken down into the separate types of violations.

This study involved a grand total of 11,851 men and women drivers of motor vehicles in Iowa. Of this number 6,414 were included in the 1950 sample and 5,437 in the 1953 sample. Slightly more than seven of ten drivers in each sample were men.

Violation Involvement of Men Drivers

Almost the same percentages of the men drivers in each sample were found to be violators - 27.45 percent of the 1950 sample and 27.30 percent of the 1953 sample. When the two samples are compared with respect to the frequency of violations per driver involved — 0, 1, 2, 3, 4, or 5 or more violations — no statistically significant differences between the two samples were found. The nearest approach to significance occurred when the samples were compared with respect to drivers having three violations; the chi-square value of 3.574 is just under the 5 percent level of significance (see Table 1). The chi-square values of differences between the two samples for the various frequency of involvements are all given in Table 1.

According to the reporting system used by the Department of Public Safety in Iowa, drivers may be charged with one or more of thirteen specific violations. These include operating a motor vehicle while intoxicated (O.M.V.I.), speeding, improper parking, failure to yield the right of way, following too closely, improper passing, improper turning, backing, failure to signal, leaving the scene of an accident, failure to slow down for pedestrians, and "other violations."

When the two samples of male drivers were compared with respect to involvement in specific kind of violations, significant differences beyond the 1 percent level were obtained for violations of speeding and improper passing, and for the general category "other violations" (see Table 2). There were more than expected in both these categories for 1953.

The difference between the two samples with respect to the violation "failure to stop

TABLE 1

COMPARISON OF TOTAL VIOLATION INVOLVEMENT OF MEN DRIVERS OF TWO SAMPLES

Men Drivers with No Violations

Sample	Involvement	Observed	Expected	0-E	$(0-E)^2$	$(0-E)^2/E$
1950	0 violations	3435	3438.36760	- 3.36760	11.34072	.00329
	Others	1300	1296.63240	3.36760	11.34072	.00874
1953	0 violations	2871	2867.60584	3.39416	11.52032	.00401
	Others	1078	1081.39416	- 3.39416	11.52032	.01065
		8684	8684.00000			x^2-- .02669

Men Drivers with One Violation

1950	1 violation	851	830.99250	20.00750	400.30005	.48171
	Others	3884	3904.00750	-20.00750	400.30005	.10253
1953	1 violation	673	693.04950	-20.04950	401.98245	.58001
	Others	3276	3255.95050	20.04950	401.98245	.12346
		8684	8684.00000			x^2--1.28771

Men Drivers with Two Violations

1950	2 violations	254	256.82640	- 2.82640	7.98853	.03110
	Others	4481	4478.17360	2.82640	7.98853	.00178
1953	2 violations	217	214.19376	2.80624	7.87429	.03676
	Others	3732	3734.80624	- 2.80624	7.87492	.00210
		8684	8684.00000			x^2-- .07174

Men Drivers with Three Violations

1950	3 violations	100	113.40325	-13.40325	179.64711	1.58414
	Others	4635	4621.59675	13.40325	179.64711	.03887
1953	3 violations	108	94.57855	13.42145	180.13532	1.90461
	Others	3841	3854.42145	-13.42145	180.13532	.04673
		8684	8684.00000			x^2- 3.57435

Men Drivers with Four Violations or More

1950	4 or more viol.	95	95.41025	- .41025	.16830	.00176
	Others	4640	4639.58975	.41025	.16830	.00004
1953	4 or more viol.	80	79.57235	.42765	.18288	.00229
	Others	3869	3869.42765	- .42765	.18288	.00004
		8684	8684.00000			x^2-- .00413

for stop signs" falls slightly short of the 5 percent level. The differences for the remaining kinds of violations were non-significant by the chi^2 criterion. However, slight shifts in the frequency of violations of specific kinds were noted. Slightly larger percents of drivers in the 1953 sample were charged with speeding, improper passing, and failure to stop for stop signs, and approximately 3 percent fewer drivers charged with violations were found under the caption "other violations." This may reflect better cooperation on the part of the courts since the patrol may be able to make a specific charge hold better in recent months.

A third comparison made between the two samples of men drivers has to do with the frequency of both total violation and total accident involvements. The two samples were compared with respect to the following kinds of involvement: accidents only, violations only, both accidents and violations, and neither accidents or violations. Chi-square tests of significance show the differences between the two samples to be significant beyond the 1 percent level for all four comparisons (see Table 3).

Hence the null hypothesis of no difference between the two samples with respect to conditions studied was not sustained. The tendency was for male drivers in the 1950 sample to be more involved in violations and for those of the 1953 sample to be more

TABLE 2

COMPARISON OF FREQUENCY OF VIOLATIONS BY TYPES, MEN DRIVERS

Men Drivers Charged with OMVI (Operating Motor Vehicle while Intoxicated)

Sample	Involvement	Observed	Expected	0-E	$(0-E)^2$	$(0-E)^2/E$
1950	O. M. V. I.	160	146.12210	13.87790	192.59610	1.31804
	Others	4575	4588.87790	-13.87790	192.59610	.04197
1953	O. M. V. I.	108	121.86614	-13.86614	192.26983	1.57771
	Others	3841	3827.13386	13.86614	192.26983	.05023
		8684	8684.00000		x^2---	2.98795
	Men Drivers Charged with Speeding					
1950	Speeding	349	396.93505	-47.93505	2297.76901	5.78877
	Others	4386	4338.06495	47.93505	2297.76901	.52967
1953	Speeding	379	331.04467	47.95533	2299.71367	6.94683
	Others	3570	3617.95533	-47.95533	2299.71367	.63563
		8684	8684.00000		x^2--	13.90090[a]
	Men Drivers Charged with Improper Passing					
1950	Improper Passing	108	135.23160	-27.23160	741.56003	5.48362
	Others	4627	4599.76840	27.23160	741.56003	.16121
1953	Improper Passing	140	112.78344	27.21656	740.74113	6.56781
	Others	3809	3836.21656	-27.21656	740.74113	.19309
		8684	8684.00000		x^2-	12.40573[a]
	Men Drivers Charged with Failure to Stop at Stop Sign					
1950	Fail - Stop Sign	273	294.42230	-21.42230	458.91493	1.55869
	Others	4462	4440.57770	21.42230	458.91493	.10334
1953	Fail - Stop Sign	267	245.54882	21.45118	460.12339	1.87397
	Others	3682	3703.45118	-21.45118	460.12339	.12424
		8684	8684.00000		x^2---	3.66024
	Men Drivers Charged with Failure to Stop at Stop Light					
1950	Fail - Stop Light	52	58.33520	- 6.33520	40.13475	.68800
	Others	4683	4676.66480	6.33520	40.13475	.00858
1953	Fail - Stop Light	55	48.65168	6.34832	40.30116	.82836
	Others	3894	3900.34832	- 6.34832	40.30116	.01033
		8684	8684.00000		x^2---	1.53527
	Men Drivers Charged with "Other" Violations					
1950	"Other" viol.	678	617.72810	60.27190	3632.70192	5.88074
	Others	4057	4117.27190	-60.27190	3632.70192	.88230
1953	"Other" viol.	455	515.18654	-60.18654	3622.41959	7.03127
	Other	3494	3433.81346	60.18654	3622.41959	1.05492
		8684	8684.00000		x^2---	14.84923[a]
	Men Drivers Charged with "Miscellaneous" Violations[b]					
1950	"Miscellaneous"	92	92.66395	- .66395	.44082	.00475
	Others	4643	4642.33605	.66395	.44082	.00009
1953	"Miscellaneous"	78	77.28193	.71807	.51562	.00667
	Others	3871	3871.71807	- .71807	.51562	.00013
		8684	8684.00000		x^2----	.01164

[a] Significant at 1 percent level

[b] Includes charges for: Improper parking, failure to have right of way, following too closely, improper turning, backing, failure to signal, leaving scene of accident, and failure to slow down for pedestrian.

TABLE 3

COMPARISONS OF TOTAL VIOLATION AND ACCIDENT INVOLVEMENT OF MEN DRIVERS OF TWO SAMPLES

Sample	Involvement	Observed	Expected	0-E	$(0-E)^2$	$(0-E)^2/E$
		Men Drivers with "Accidents Only"				
1950	Accidents only	550	695.19270	-145.19270	21080.92013	30.32385
	Others	4185	4039.80730	145.19270	21880.92013	5.21829
1953	Accidents only	725	579.79218	145.20782	21085.31098	36.36701
	Others	3224	3369.20782	-145.20782	21085.31098	6.25823
		8684	8684.00000		x^2--	78.16738[a]
		Men Drivers with "Violations Only"				
1950	Violations only	779	703.90510	75.09490	5639.24400	8.01136
	Others	3956	4031.09490	- 75.09490	5639.24400	1.39893
1953	Violations only	512	587.05834	- 75.05834	5633.75440	9.59658
	Others	3437	3361.94166	75.05834	5633.75440	1.67575
		8684	8684.00000		x^2---	20.68262[a]
		Men Drivers with "Both Violations and Accidents"				
1950	Viol. & Accid.	521	592.72730	- 71.72730	5144.80556	8.67988
	Others	4214	4142.27270	71.72730	5144.80556	1.24202
1953	Viol. & Accid.	566	494.33582	71.66428	5135.76902	10.38923
	Others	3383	3454.66418	- 71.66428	5135.76902	1.48661
		8684	8684.00000		x^2---	21.79774[a]
		Men Drivers with "Neither Violations nor Accidents"				
1950	No Viol. or Accid.	2885	2743.17490	141.82510	20114.35899	7.33251
	Others	1850	1991.82510	-141.82510	20114.35899	10.09845
1953	No Viol. or Accid.	2146	2287.82366	-141.81366	20111.11416	8.79053
	Others	1803	1661.18634	141.81366	20111.11416	12.10647
		8684	8684.00000		x^2---	38.32796[a]

[a] Significant beyond the 1 percent level.

involved in accidents. The percentage-wise trends of involvements are evident from the following summary:

Sample	No. of Drivers	Only Accidents	Only Violations	Both Accidents & Violations	Neither Accidents nor Violations
1950	4735	11.62	16.45	11.00	60.93
1953	3949	18.36	12.97	14.33	54.34

Whether these differences are real or an artifact due to enforcement policy cannot be easily determined.

Violation Involvement of Women Drivers

As stated earlier, three of ten drivers in each of the two samples were women drivers. The number of women drivers for the 1950 sample was 1,679 and for the 1953 sample, 1,488. In both of the samples less than 5 percent of the women drivers were charged with violations as compared with about 27 percent of the men drivers. A general characteristic of the women drivers in the two samples was the relatively low frequency of involvement in violations as well as accidents, thus making impossible any detailed analyses of specific violations similar to that made for men drivers due to the small number of cases in each category.

TABLE 4

COMPARISONS OF TOTAL VIOLATION INVOLVEMENT OF WOMEN DRIVERS OF TWO SAMPLES

Sample	Involvement	Observed	Expected	0-E	$(0-E)^2$	$(0-E)^2/E$
	Women Drivers with No Violations					
1950	0 violations	1612	1605.30869	6.69131	44.77362	.02789
	Others	67	73.69131	-6.69131	44.77362	.60758
1953	0 violations	1416	1422.69168	-6.69168	44.77858	.03147
	Others	72	65.30832	6.69168	44.77858	.68564
		3167	3167.00000		x^2--	1.35258
	Women Drivers with One Violation					
1950	1 violation	58	64.67508	-6.67508	44.55669	.68893
	Others	1621	1614.32492	6.67508	44.55669	.02760
1953	1 violation	64	57.31776	6.68224	44.65233	.77903
	Others	1424	1430.68224	-6.68224	44.65233	.03121
		3167	3167.00000		x^2--	1.52677
	Women Drivers with Two Violations or More					
1950	2 or more viol.	9	9.01623	- .01623	.00026	.00003
	Others	1670	1669.98377	.01623	.00026	.00000
1953	2 or more viol.	8	7.99056	.00944	.00008	.00001
	Others	1480	1480.00944	- .00944	.00008	.00000
		3167	3167.00000		x^2---	.00004

TABLE 5

COMPARISONS OF TOTAL VIOLATION AND ACCIDENT INVOLVEMENT OF WOMEN DRIVERS IN TWO SAMPLES

Sample	Involvement	Observed	Expected	0-E	$(0-E)^2$	$(0-E)^2/E$
	Women Drivers with "Accidents Only"					
1950	Accidents only	78	111.33449	-33.33449	1111.18822	9.98062
	Others	1601	1567.66551	33.33449	1111.18822	.70881
1953	Accidents only	132	98.66928	33.33072	1110.93689	11.25919
	Others	1356	1389.33072	-33.33072	1110.93689	.79962
		3167	3167.00000		x^2--	22.74824[a]
	Women Drivers with "Violations Only"					
1950	Violations only	49	52.48554	- 3.48554	12.14898	.23147
	Others	1630	1626.51446	3.48554	12.14898	.00746
1953	Violations only	50	46.51488	3.48512	12.14606	.26112
	Others	1438	1441.48512	- 3.48512	12.14606	.00842
		3167	3167.00000		x^2---	.50847
	Women Drivers with "Both Violations and Accidents"					
1950	Viol. & Accid.	18	21.20577	- 3.20577	10.27696	.48463
	Others	1661	1657.79423	3.20577	10.27696	.00619
1953	Viol. & Accid.	22	18.79344	3.20656	10.28202	.54710
	Others	1466	1469.20656	- 3.20656	10.28202	.00699
		3167	3167.00000		x^2---	1.04491
	Women Drivers with "Neither Violations nor Accidents"					
1950	No Viol. nor Accid.	1534	1493.97420	40.03580	1602.06466	1.07235
	Others	145	185.02580	-40.03580	1602.06466	8.65860
1953	No Viol. nor Accid.	1284	1324.02240	-40.02240	1601.79250	1.20979
	Others	204	163.97760	40.02240	1601.79250	9.76836
		3167	3167.00000		x^2--	20.70910[a]

[a] Significant beyond 1 percent level.

When the women drivers were compared with respect to the frequency of violations — 0, 1, 2 or more — no significant differences were found (see Table 4). The majority of the women drivers involved were charged with a single violation only.

Like the men drivers, the women drivers of the two samples were compared with respect to both violation and accident involvement under the following four conditions: accidents only, violations only, both accidents and violations, and neither accidents nor violations (see Table 5).

Differences between the drivers of the two samples were found to be significant beyon the 1 percent level with respect to involvement in "accidents only" and "neither accident nor violations." No significant differences were found with respect to involvement in "violations only" and "both accidents and violations." Percentage-wise, the trend of involvement of the women drivers of the two samples with respect to the four conditions is given in the following summary:

Sample	No. of Drivers	Only Accidents	Only Violations	Both Accidents & Violations	Neither Accidents nor Violations
1950	1679	4.65	2.92	1.07	91.36
1953	1488	8.77	3.36	1.48	86.29

SUMMARY AND CONCLUSIONS

This study is concerned with the violation and accident involvement of two samples each of men and women drivers of motor vehicles in the State of Iowa. Included in the samples were 11,851 cases, 6,414 in the 1950 sample and 5,437 in the 1953 sample. About seven of ten drivers were men. The two samples were compared with respect to violations and accidents and tests of significance were computed where possible to do so.

Within the limits of the study, the samples used and other limitations of the study, the following conclusions are offered:

1. The null hypothesis of no significant difference between the drivers of the two samples with respect to records of total violation involvement was sustained. No significant differences were found between either the men or the women drivers when they were compared with respect to frequency of violations, that is, 0, 1, 2, 3, etc. violations. This seems to hold notwithstanding the fact that there were more cars, more drivers and greater mileage driven in 1953. Several implications may be made which will not be elaborated here.

2. When the two samples were compared with respect to records of involvement in specific kinds of violations, significant differences beyond the 1 percent level were obtained between the men drivers of the two samples for speeding and improper passing. None of the differences between drivers involved in the remaining specific violations were significant. Because of the meager records similar comparisons for the women drivers of the two samples were not possible.

3. When the two samples were compared with respect to violations and accidents, differences significant beyond the 1 percent level were found between the men drivers for the following involvements: accidents only, violations only, both violations and accidents, and neither violations nor accidents. For the women drivers of the two samples, significant differences beyond the 1 percent level were found for involvement in "accidents only" and for "neither accidents nor violations." No significant differences were found for "violations only" and "both accidents and violations" involvement.

4. It is noteworthy that certain types of violations stated on the form are rarely, if ever, used. It might be worthwhile to consider the advisability of dropping them if there is no occasion for enforcement.

5. It is quite generally agreed that the quickest method of securing conformity with traffic ordinances is by strict enforcement. Thus a periodic comparison and evaluation of the records should be of considerable use to enforcement agencies. It appears that keeping the enforcement index at the most effective level is highly desirable. Further implications will not be discussed here.

6. The technique used in this study might well be applied to the evaluation of efficiency in patrol districts or other geographical areas of distribution. It would provide a

more precise measuring instrument than has been conventionally used for such purpose by enforcement agencies and traffic engineers.

7. There seemed a slight tendency for women to have more accidents against their records in 1953. Whether this is real, or merely a reflection of enforcement policy is not known.

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Automobile-Crash Injuries

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The study was aimed at the control and reduction of personal injury to the occupant and toward reduction of physical damage to the vehicle. Conducted in three phases, the research covered:

1. Experimental investigation of the kinematics of human occupants of an automobile during crash decelerations. By use of high-speed photographic techniques it was found that the general motion characteristics of occupants of the vehicle, under imposed crash conditions, were of a predictable nature, as were the zones of physical contact.
2. Investigation of methods of reducing property damage cost in automobile accidents. In this phase of the project, impact tests and fabrication and repair studies completed on automobile body components, disclosed that the greatest promise for reduced property damage costs lay in the use of more impact resistant fabrication materials.
3. Investigation of methods of achieving protection for the passenger. Accessory equipment and replacement parts on existing vehicles were developed for safer "packaging" of the occupant, including seat belts, padding materials and steering wheel protectors.

●THE engineering research program in Automobile Crash Safety performed at the Cornell Aeronautical Laboratory, which I am privileged to explain on behalf of the sponsor Liberty Mutual Insurance Company, is a relatively small gain in a vast area of undeveloped preventive research: This research which employs the engineering laboratory, when combined with full scale research from the highway, will be another step toward establishing, eventually, a more-balanced and less-harmful man-machine relationship. The tremendous progress made in the industrial plant to safeguard the workman from machine hazards and thereby increase his productive capacity can be duplicated on the highway. Certainly, the already-staggering and ever-increasing list of traffic casualties compels more concentrated research and development in the field of human-automotive engineering.

As insurance people, we are aware of our lack of qualification to criticize automobile design and engineering, nor is it our desire to do so. We are concerned primarily with the elimination of unsafe acts or conditions which may result in damage, injury, or interruption, due to human limitations. We are convinced that the modern automobile represents a social hazard insofar as man, through mental and physical limitations is unable to cope with the potential energy of the vehicle he operates and insofar as the automobile body, because of material and fabrication weaknesses, is easily damaged upon impact, with little protection provided the occupants.

Late in 1951, representatives of Liberty Mutual Insurance Company conferred with principals at the Cornell Aeronautical Laboratory on possible areas of research in automotive safety. This request was motivated as a result of a previous investigation of property damage claims, the steadily rising cost of automobile repair work, and the serious nature of injuries sustained by occupants involved in collision accidents.

PHYSICAL DAMAGE CASE STUDY

One analysis of physical damage by F. J. Crandell, Liberty Mutual Insurance Company, covered 1,002 claim cases totalling nearly $200,000 and included accidents which occurred both in the central business district and on circumferential arteries of metropolitan Boston. The analysis was divided according to end collisions, side swipes, 90-degree collisions and fixed object collisions, with each general subject further divided into damage to front end, rear end, left front, right front, left rear, right rear, left side and right side. A summary of findings follows:

The amount of money paid out for end collisions is equal to the amount paid out for side swipes. Each type costing about $73,000; 50% of the ex-

pense of side swipes resulted from damages to the front of the car, and about 70% of the expense of end collisions is attributed also to the front end.

A total of the repair cost for side-swipes and end collisions (Front Portion) is 399 cases totalling $87,883.10.

In side swipes about 20% of the repair cost is used for the rear portion of the vehicle, while in end collisions about 30% of the cost is due to the rear end.

A total of the repair cost for side swipes and end collisions (Rear Portion) is 286 cases totalling $38,678.97.

In side swipes the sides of the autos require about 30% of the repair costs, each side's repair expenses being about the same.

In 90° collisions, the left and right sides require approximately the same amount of money for repairs.

A total of the repair cost for side swipes and 90° collisions (side portions) is 301 cases totalling $63,663.38.

Of all the repair expenses paid (968 cases, $190,225.45) the end collisions make up 40% of the expenses and cases; the side swipes make up 40% of the expenses and cases; and the 90° collisions make up 20% of the expenses and cases. (Out of the 1,002 cases investigated, only 34 were collisions with fixed objects necessitating a sum of $5,971 for repairs to the automobiles.)

In examining both front and rear of the auto, damage to the front portion costs about 60% more to repair than the rear portion.

The sides of the vehicle cost about 60% more to repair than the rear portion.

In comparing the front and sides, there are about 131 more accidents occurring to the front of the vehicle which give a difference of $48,612.82 in claims paid.

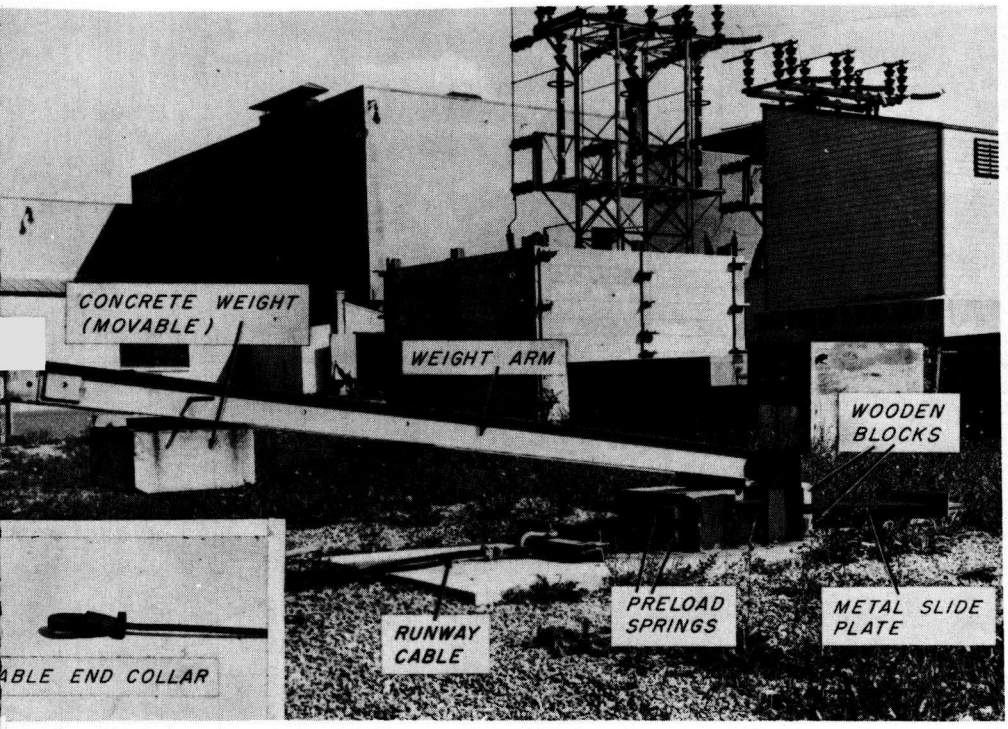


Figure 1. Friction snubbing device for simulating an automobile crash.

TABLE 1

TOTAL COST FOR PARTS AND LABOR, 1940 AND 1951
(Sample Items)
Report of Joint Staff - Automobile Manufacturers and Insurance Industries - Detroit - 1953

Item	1940	1951	Increase
Hood Top Panel (l. or r., painted)	$ 8.10	34.40	325%
Radiator Grille Assembly (comp. with upper molding)	10.70	43.00	302%
Bumper Face Bar (1940, single bar; 1951, 3 sections)	4.05	16.44	306%
Rear Fender (r. painted; 1940, individual part; 1951, replacement sec.)	9.80	35.85	265%
Average	8.16	32.42	300%

With the greatest number of cases and the greatest loss arising from damage to the front of the car, followed closely by side damage loss, it is interesting to note comparative costs on repair parts and labor for 1940 and 1951 (see Table 1). During the calendar year of 1951, the Liberty Mutual Insurance Company, representing only one of many casualty companies, paid out over $12 million on property damage settlements. This figure is only approximately one half the total cost of settling personal injury claims in the same period. These expenditures indicate the need for definite research with methods of controlling and reducing human injury and property damage resulting from automobile accidents

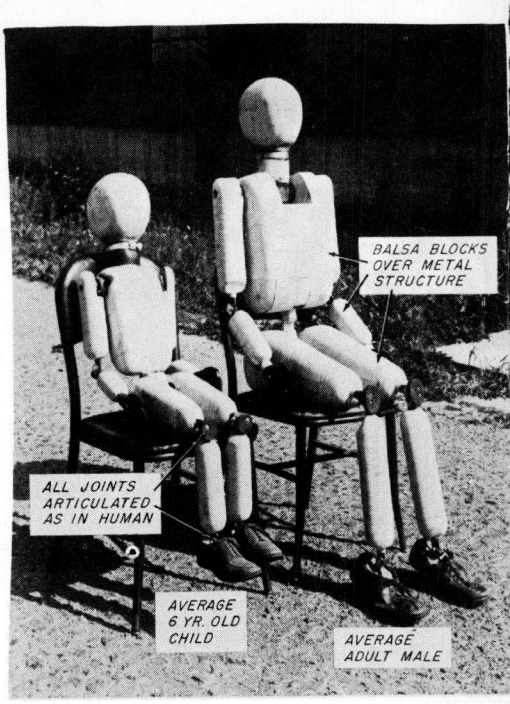


Figure 2. C.A.L. crash dummies (dynamically similar to human counterparts).

CORNELL RESEARCH PROGRAM

Due to the complexity of the overall problem of automotive safety and the wide range of variables involved, it was decided that the problem would be approached from two directions only: First and most fundamental, the time and motion characteristics imposed on the human occupant of a vehicle subjected to crash-level decelerations; and secondly,

Figure 3. Crash snubbing test vehicle.

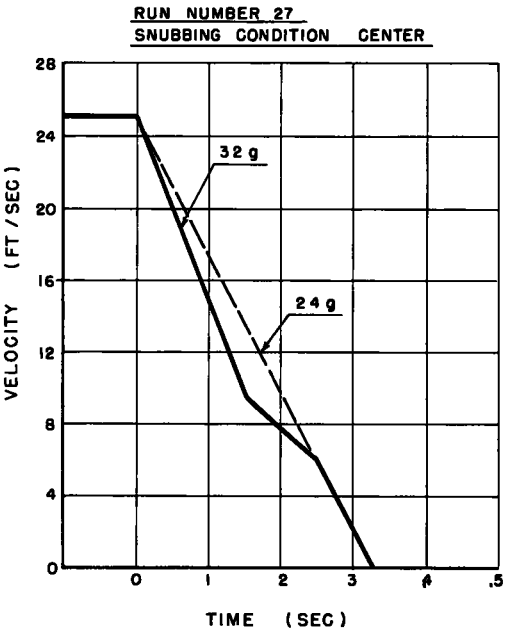


Figure 4. Automobile crash snubbing tests kinematics of the automobile.

the investigation and development of materials and equipment to improve the crash resistance of the vehicle and provide optimum protection for the occupant.

All available data on property damage and crash injuries previously collected under Hugh DeHaven, of the Cornell Medical College, were incorporated in the research, as were available data on crash-resistant materials.

The Automobile Crash Safety Research was conducted in three phases between October 1952 and October 1953, as summarized below:

Phase I. This initial and most-comprehensive phase of the research consisted of the experimental investigation of the kinematics of the human body in relation to the interior arrangement of an automobile during crash decelerations (this phase is illustrated by a 12 minute 16-mm. sound-color film).

The test equipment consisted of (1) a standard two-door passenger car, Figure 3, with auxiliary parts added, including directional steering control, ignition mod-

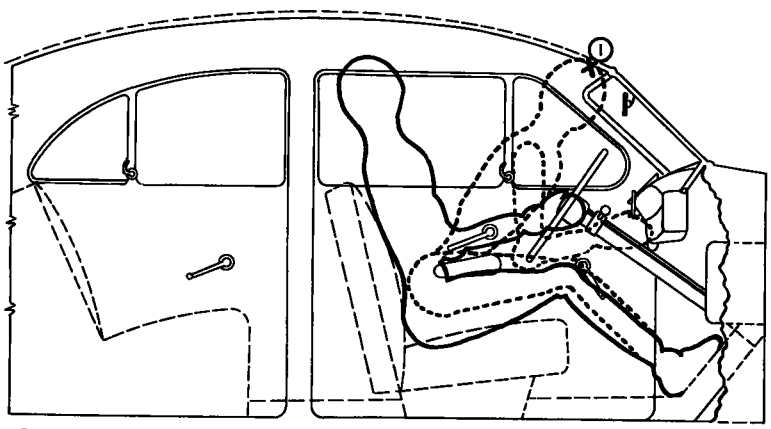


Figure 5. Kinematics and hit locations for dummies.

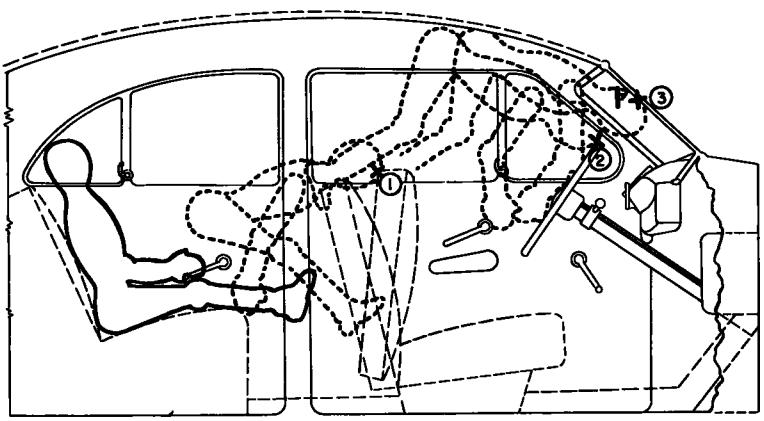
ifier, a wire screen reference grid, external throttle, and reinforcement of the front end of the car frame; (2) a crash-snubber device, Figure 1, designed to create sufficient frictional resistance to simulate crash deceleration. The snubbing force is transmitted through a 200-foot steel cable, with the kinetic energy absorbed by two large hardwood blocks at the pivot point; and (3) two dummies made of tubular steel skeleton and balsa wood, Figure 2. One dummy, 40 lb. in weight, is proportioned to represent an average adult of 153.4 lb., 5 feet 9 inches in height. The smaller dummy, weighing 22½ lbs., approximates a 6-year-old child of 45 lb.

A typical test run, No. 27, is described as follows:

Dummy position; - Adult in right front seat; 6 year old in left rear seat.
Car onset velocity; - 25 ft./sec. (17 mph)
Snubbing configuration; - Center
Average deceleration; - 2.4g
Reference figures; - 12 through 15
The kinematics of the automobile are presented (Figure 4). The diagrammatic time history of the action of the dummies relative to the car is presented (Figures 5, 6, 7).

It will be noted that the adult dummy pivoted about the hip joints to an angle which resulted in a normal blow of the head to the headliner region adjacent to the top windshield molding. This resulted in a rebound back into the seat rather than a subsequent glancing blow to windshield as previously described. The small dummy progressed forward relative to the car until his head contacted the top of the front seat back in a glancing blow. This initial contact caused a tendency to sommersault the dummy into an attitude such that his second hit was to the upper steering wheel rim. A terminal hit consisted of striking the back of the head to the windshield.

Other runs were conducted with controlled stopping distances from 1.5 to 3 feet from an onset velocity of 10 to 20 mph. and simulated both center and off-center collisions. By use of high-speed photographic techniques, it was found that the general motion characteristics of occupants of the vehicle were of a predictable nature. The paths of occupant motion and the zones of physical contact were relatively the same for imposed crash conditions of both head-on and left and right front angular collisions.



① -TEST NO - 27 (ON CENTER LINE)
② - CAR VELOCITY - 25 FT/SEC
③ -"G" GROUP - 24
④ -REMARKS - 6 YEAR OLD CHILD - REAR SEAT - LEFT SIDE

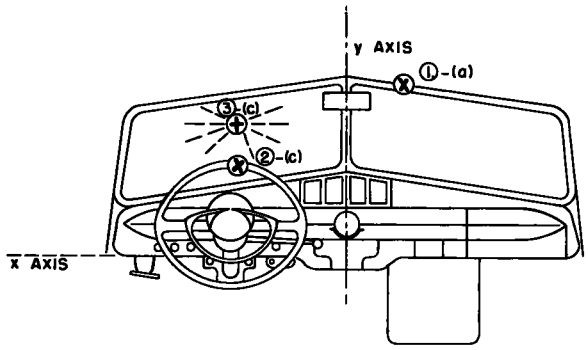
Figure 6. Kinematics and hit locations for dummies.

The specific initial motion characteristics of an occupant of the front seat of a vehicle during crash decelerations can be predicted to a close degree of accuracy, provided the vehicle motions are known. This is not true of the occupant of the rear seat, since the path of travel is longer and the action violent and subject to variation, depending upon whether or not contact is made with the back of the front seat in forward motion.

The hit area for front end collisions was determined by the head travel, and may be defined by a vertical arc sector extending 30 deg. down from eye-level and 45 deg. up from this same horizontal; laterally, 30 deg. right and 30 deg. left from a vertical reference plane through the body. The driver invariably received a potentially injurious

blow to the torso against the steering wheel. If the magnitude of deceleration is above 2 g's, the driver, if not impaled on the steering wheel post, receives a sharp head blow against the upper windshield or windshield molding.

Experimentation with restraining belts during some test runs indicated, that when



① – TEST NO – 27 (ON CENTER LINE)

② – CAR VELOCITY – 25 FT/SEC

③ – "G" STOP – 24

④ – REMARKS – 6 YEAR OLD DUMMY – LEFT REAR – (HIT FRONT SEAT BACK, STEERING WHEEL RIM AND WINDSHIELD)

ADULT DUMMY – RIGHT FRONT – HIT SUN VISOR WITH HEAD

Figure 7. Hit locations of dummies.

properly installed, they are extremely effective in achieving the type of body control which would greatly reduce the possibility of serious injury in an automobile accident.

Phase II. In this phase of the project an investigation was conducted of methods to reduce property damage cost in automobile accidents. The problem of redesign of automotive parts or substitution of more shock resistant materials had to be approached with full appreciation of material and fabrication costs, styling and vehicle performance.

The investigation of the problem was based on the premise that, to be acceptable to either the public or automobile manufacturers, any resulting development should not materially alter the current style trends in automotive design.

Known physical properties of substitute materials were studied and compared to establish static strength and stiffness characteristics of the material selected. These were followed by experimental tests to correlate the shock and impact resistance of the material with the static strength characteristics previously established. In addition, preliminary investigations were conducted on attachment design, repair techniques and adaptability to an automotive type finish.

A thermoplastic sheet material produced by the United States Rubber Company was found to have the desired characteristics. Based on an analytical comparison of the static strength of this material and steel when used for automobile body components, the thermoplastic part would have an impact resistance approximately eighteen times greater than an equivalent steel part and be 25% lighter in weight. Drop tests, (using an 8 lb. steel ball) to establish the impact resistance under dynamic conditions, disclosed an improvement factor of approximately 14. A drop height of approximately 41 ft. resulted in damage to a $\frac{3}{16}$ inch thermoplastic panel, comparable in nature and degree of permanent deflection, to a 3 ft. drop on an .040 inch thick steel panel.

The material can be formed to typical automotive body contours by hot draw molding methods believed to be adaptable to high production rates with

relatively low cost tooling. It can also be worked with ordinary tools and machinery. Attachment or bonding between two pieces of thermoplastic or to other materials can be affected by use of conventional screws, bolts, rivets or by proper cements. Damage to the material can be repaired by methods which compare favorably in complexity and cost to the equivalent repair

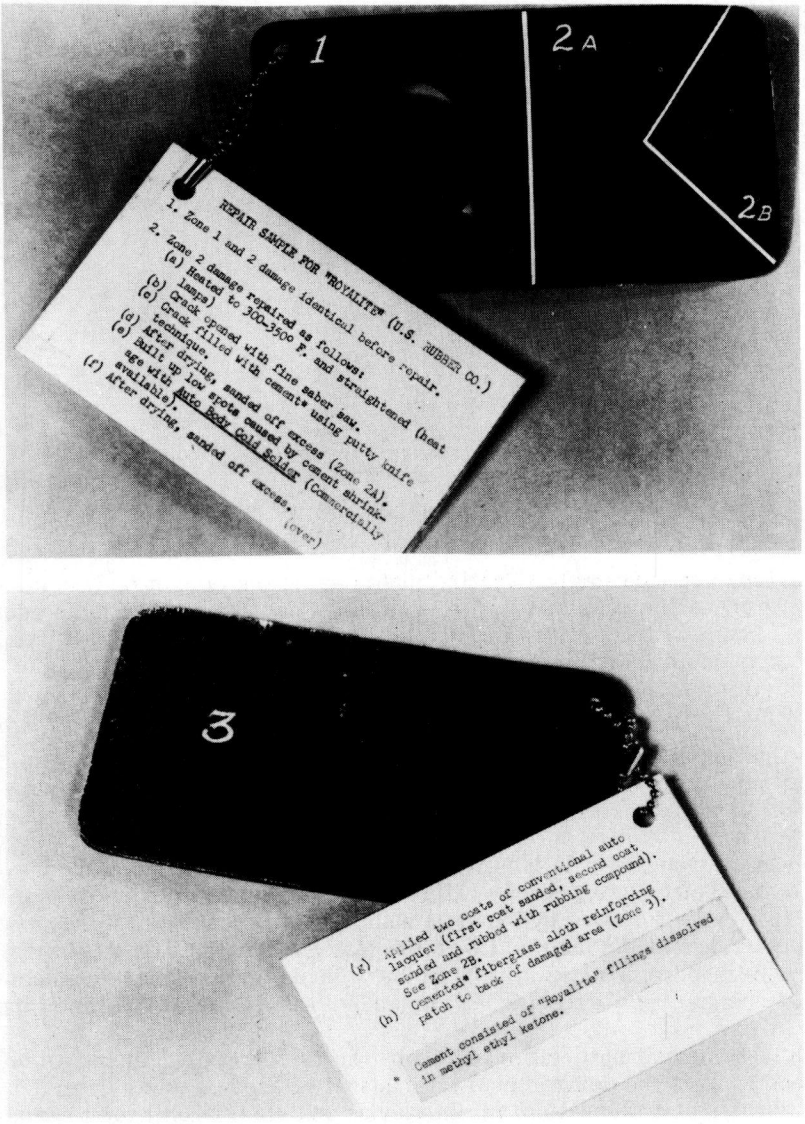


Figure 8. "Royalite" repair sample - demonstration unit.

of a steel component. Localized heating and "ironing" will restore a dented piece to the original contour (Figure 8). Cracks and tears can be repaired by filling with an appropriate cement.

The experimental impact testing disclosed one serious problem; at reduced temperatures (below $0^{\circ}F$), the thermoplastic sheet material tested became brittle and lost its impact tolerance. Verbal assurance by the manufacturer that this characteristic can be improved was received. However, this problem will need to be pursued further before unqualified recommendations can be made.

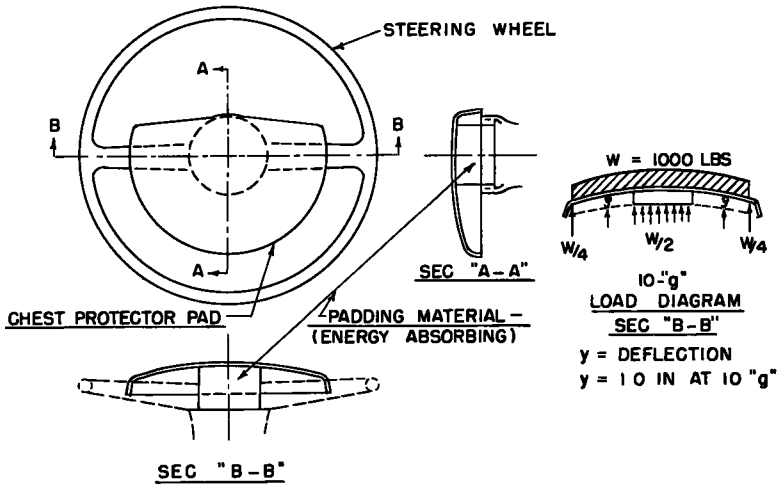


Figure 9. Chest protector pad general assembly and load diagram.

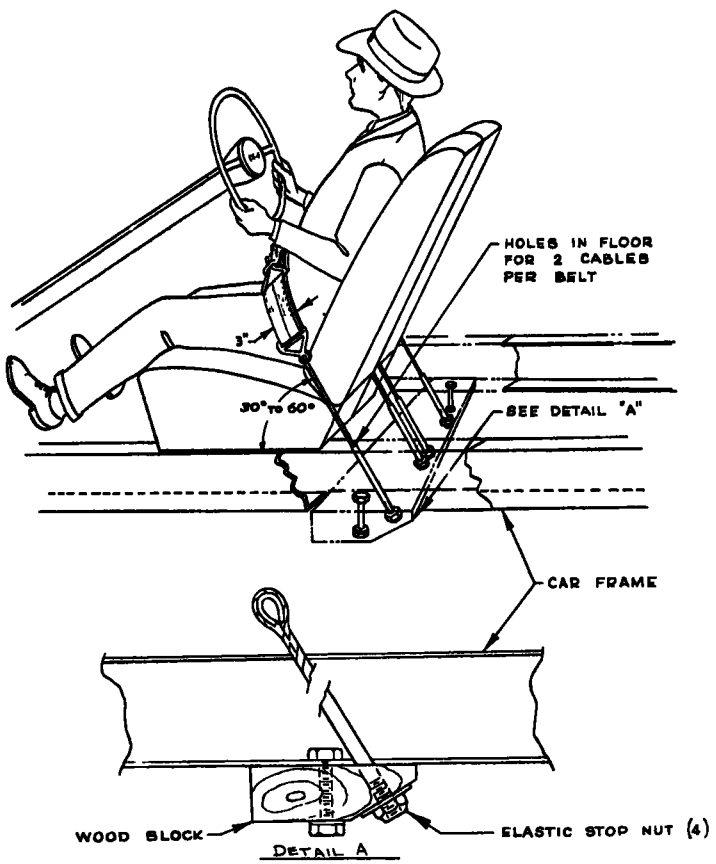


Figure 10. Suggested automobile seat belt installation.

Phase III. Phase III of the project was related to the protection or "safe packaging" of the occupant of a vehicle with emphasis placed on the development of items which could be readily installed as accessory equipment or replacement parts on existing vehicles. The primary efforts were directed toward the development of a "Chest Protection Pad," to be mounted on the steering wheel for protection of the driver against the known high injury potential of the steering wheel column. This device, designed to distribute an impact force over a wide area of the body and to absorb the energy of a body blow, was demonstrated to achieve a reduction of injury potential by a factor of approximately 4. The "Chest Protector Pad" consisted of a contoured sheet plastic shell to be attached to the steering wheel spokes with an energy absorbing padding material inserted between the column end and the shell (Figure 9).

Although no direct research efforts were expended, two additional facets of body protection are reviewed and are summarized below.

Seat belt design and installation design criteria are presented along with suggested design details for installation. The most pertinent point to consider is that the belt components, assembly installation fittings and anchorage should withstand a minimum static tensile load of 1500 lb., (Figure 10). The belt width should not be less than 2 inches and the angle of load application should be between 30 and 60 degrees to the horizontal.

Based on the results of earlier studies, an ideal padding material can be defined as one which is energy absorbing rather than energy storing but will have complete but slow recovery. It should have as low a spring rate as possible, consistant with the maximum thickness that can be utilized and the maximum impact energy anticipated (bottoming of the material under load cannot be tolerated).

CONCLUSION

We believe the monies, time, and effort expended in this particular research progra have been completely justified from the standpoint of tangible experimentation with applicable results. Already, the research into motion characteristics of occupants, described above, has been incorporated as part of a larger research study sponsored by an automotive manufacturer to determine the hazards of front interior components of on of their vehicles.

Unquestionably, there still remains considerable research and development required in the field of automobile crash injury and human survival. To accomplish this search for means of eliminating the top rank hazard to human life, more funds must be earmarked for preventive research devoted to crash injury.

To make the results of such research effective in reducing fatalities and injuries resulting from car crashes, it will be necessary to create a demand from the buying publi for such protection in their vehicles. This program of education, based on scientific proof, requires a campaign of practical demonstration of designed safety features which can be incorporated in their automobiles. It requires the same self-preservation motivation and professional showmanship which have shocked the public into understanding and combatting the evils of polio, cancer and tuberculosis.

Finally, the automotive industry, faced with the growing public demand for proven crash safety installations, can be expected to provide the designs needed.

In view of the necessary brevity of this presentation, I invite those of you who may be interested in specific details of this research, to write to Liberty Mutual Insurance Company, Loss Prevention Department, 175 Berkeley Street, Boston 17, Massachusetts You will, upon request, be provided a copy of Report No. YB-846-D-1 as prepared by A. C. Smith of the Cornell Aeronautical Laboratory.

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