The Teen-Aged Driver

An Evaluation of Age, Experience, Driving Exposure and Driver Training as They Relate to Driving Record

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•ONE OF the most vexing problems currently confronting traffic safety experts, driver licensing administrators, and legislators is the optimal minimum age for issuing driver licenses. The problem is a complex one, involving philosophical, socioeconomic and legal problems as well as traffic safety considerations.

The current minimum age for issuing an unrestricted driver license in California is 16, with parental approval being required until the licensee is 21 years of age. Exceptions to this are emancipated minors, persons who are 18 or above and married. Monetary liability for all others is accepted by parents before the license can be issued.

Over the years there have been a number of attempts to raise the minimum licensing age in California. Proponents of such measures have offered a variety of reasons and advantages for an increase in the minimum age to 18. One of their basic reasons involves the assumption that the average 16-year-old is not sufficiently mature to drive an automobile and, therefore, represents a greater hazard to himself and the public welfare than do drivers in their higher teens.

Although it is an undisputed fact that teenagers have a far higher accident and violation rate than older drivers (Table 1), reliable data for 16-19-year-old drivers by single year of age have been lacking. As a consequence, the California Department of Motor Vehicles, when first confronted in 1963 with attempts to raise the minimum age, had no data to either support or refute the previously stated assumption concerning the 16-year-old driver. The department's Research and Statistics Section therefore undertook a pilot study of the problem in 1963 and shortly thereafter issued a limited number of copies of a report titled "Accident and Violation Experience of California Drivers Aged 16 Through 19." Since 16- and 17-year-olds were found not to have more accidents and violations than 18- and 19-year-olds, the study concluded that: "...there is no evidence, in a review of driving records, to support an increase in the minimum age for driver licensing."

This pilot study presented a reliable evaluation of the age factor solely in terms of driving records which one may define as the "absolute risk potential." However, the lack of exposure data precluded an evaluation of driving performance controlled for differences in mileage between age groups, or what one may define as the "relative risk factor." Also, the sample size was too small to yield sufficiently precise results on certain issues.

Because of these additional considerations and the continuing importance of the problem, it was decided to conduct a large-scale survey, utilizing a much larger sample and collecting data on a number of variables (such as mileage) which are not available from driver record file information. By extending the scope of the study in this fashion, it was hoped that the contribution of such factors as age, experience and immaturity could be separated and individually assessed.

Because some proponents of the age increase are proposing that licensing prior to 18 years of age be contingent on the successful completion of an approved behind-the-wheel driver training course, data were obtained which would allow comparison of this factor with accident and violation records.

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TABLE 1

AVERAGE (MEAN) ACCIDENTS AND VIOLATIONS FOR TEEN-AGE AND ADULT DRIVERS

Group[a]	Accidents		Violations	
	Males	Females	Males	Females
Teen-age	0.157	0.074	0.581	0.172
Adult	0.078	0.040	0.258	0.102

[a]Teen-agers are defined here as individuals 16-20 at the beginning of the driver record interval. Adults are individuals over 20 at the beginning of the driver record interval. Source: 1964 Driver Record Study.

The present analysis will proceed in stepwise fashion, with any decision regarding the aforementioned problems being contingent on answers to the following questions:

1. What is the relationship between age and driving record, irrespective of mileage?
2. What is the relationship between age and driving record when variations in exposure are controlled?
3. Are inexperience, immaturity (as measured by age) and parental control important factors in the accident and violation experience of young drivers?
4. Do drivers who have had behind-the-wheel driver training possess better accident and violation records than those who have not taken driver training?

It should be emphasized at the outset that the sole purpose of the study was to test hypotheses relative to the traffic safety aspect of this problem. This study will not attempt to evaluate the sociological, ethical, and economic considerations with which the issue is entwined. This should in no way be construed as a belief on the part of this department or the research staff that these issues are unimportant, but rather that these considerations were not felt to be relevant to the purpose of this study.

METHODOLOGY

Early in 1964, a random sample of 225,000 drivers of all ages was selected from the driver license files in connection with a study unrelated to the present one ("1964 California Driver Record Study"). A large amount of data (including age and driver record) had been collected in connection with the Driver Record Study and stored on computer tape. Inasmuch as these data were already collected and contained in computer processing format, they provided a convenient pool from which a representative sample of teen-age drivers could be extracted. All records belonging to subjects who, at the time of coding, were between 17 and 20½ years of age, who had been licensed for at least one year, and whose license had not expired, were retrieved from the tape and converted to card form. The driving records of 10,250 teen-aged drivers were thus derived for analysis. The recorded driver records of the group correspond to the interval one year prior to the original date of selection, and they represented subjects who were between 16 and 19½ years of age at the beginning of the recorded driving record interval.

The following information for each subject was extracted for subsequent analysis:

1. Age,
2. Months license in force,
3. Age when first licensed,
4. Sex,

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DEPARTMENT OF MOTOR VEHICLES
Driver Questionnaire

NOTE: All questions can be answered by either a check mark or a short answer using either a pen or pencil. Please ignore the small numbers next to each question; these are for the use of IBM tabulating machine operators. *This data will be used for research purposes only.*

1. Did you attend a high school which offered a driver education class with behind-the-wheel instruction? Yes 1 ☐ No 2 ☐
   If *yes*, did you take and pass the course? Yes 1 ☐ No 2 ☐
   If *not offered*, do you think you would have taken such a course if it had been offered? .... Yes 1 ☐ No 2 ☐
2. While you were learning to drive, did you receive instruction from any of the following sources? (Please check all those which apply.)
   Friend or relative ..... 1 ☐
   School Driver Education Class (*with* behind-the-wheel instruction) ..... 2 ☐
   School Driver Education Class (*without* behind-the-wheel instruction) ..... 3 ☐
   Commercial driver training class ..... 4 ☐
   Self-instruction ..... 5 ☐
   Other (Please specify) ..... 6 ☐
3. Under question number 2, please encircle the check mark beside the source of instruction which you feel was the *most valuable* to you.
4. On the average, how many *miles per week* did you drive last year (1963)? .....
5. Approximately what percentage of that distance did you drive at night? .....%
6. Approximately what percentage of that distance did you drive on freeways or expressways (both day and night driving)? .....%
7. Approximately how many *hours per week*, on the average, would you estimate you spent driving in 1963? .....
8. Approximately how many miles (total) did you drive last year (1963)? .....
9. On the average, how many *miles per week* have you driven during the current year (1964)? .....
10. Approximately how many miles would you estimate you have driven during the entire time you have had a license? .....
11. Are you married? ..... Yes 1 ☐ No 2 ☐
    If *yes*, please write in the month and year of your marriage ....
12. Was the vehicle which you drove *most* during 1963 registered in your name? ..... Yes 1 ☐ No 2 ☐
13. Were you responsible for paying the purchase cost of the vehicle which you drove most during 1963?
    Yes, responsible for paying the total cost ..... 1 ☐
    Yes, responsible for paying part of the cost ..... 2 ☐
    No, not responsible for paying the cost ..... 3 ☐
14. During 1963, did your parents regulate your driving privileges in any of the following ways? (Please check as many as apply.)
    Regulated the distances which you could drive ..... 1 ☐
    Regulated the hours during which you could drive .. 1 ☐
    Regulated the speeds you could drive ..... 1 ☐
    Regulated the places you could drive ..... 1 ☐
    Withheld your driving privileges altogether for any period of time ..... 1 ☐
    Did not regulate your driving in any of these ways .. 1 ☐
15. From your own experience so far, who do you feel generally present the greater safety hazard on the highways: drivers under 20 years of age, or those over 50 years of age?
    Drivers under 20 are the greater hazard ..... 1 ☐
    Drivers over 50 are the greater hazard ..... 2 ☐

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Figure 1. Questionnaire mailed to survey participants.

5. Driver license number,
6. Number of accidents, and
7. Number of violations.

SURVEY OF DRIVING HABITS OF CALIFORNIA DRIVERS

As Chief of the Division of Drivers Licenses I am responsible for the licensing of drivers in California. We are attempting to acquire more information about the driving habits, needs, and opinions of California drivers. The opinions of youth are often overlooked in sampling the thinking of our population. I have asked the Survey Research Center of the University of California to conduct a survey of a selected group of young drivers. I would like to personally ask you to cooperate in this study.

Enclosed with this letter is a questionnaire card for you to fill out. Your answer to question 15 on the relationship between age and driving safety will be of special interest to us. However do not restrict your answers to just this question. Analysis of the data is possible only if the questionnaire is filled out completely. If you are not sure of the correct answer to any of the questions make the best guess that you can. Your responses to the questions will be confidential and will be used for research purposes only. In no way will your answer to any question influence the status of your present license or the issuance of a future drivers license.

Simply fill out the questionnaire card and drop it in the nearest mail box. NO POSTAGE STAMP IS REQUIRED. Our study will be successful only if a large percentage of the young drivers in our sample reply. Your cooperation is appreciated.

Sincerely,

Ronald V. Thunen

RONALD V. THUNEN, Chief
Division of Drivers License

Figure 2. Letter accompanying questionnaire.

Three weeks ago, we sent you a questionnaire asking about your driving habits. You are one of a carefully selected sample of young drivers from whom we are seeking this information. So far, a considerable proportion of the people have returned the questionnaire, but yours has not been received. Please fill out the enclosed questionnaire card and return it to us. NO POSTAGE STAMP IS NECESSARY.

Your answer to question 15 on the relationship between age and driving safety will be of special interest to us. However, do not restrict your answers to just this question. Analysis of the data is possible only if the questionnaire is filled out completely. If you are not sure of the correct answer to any of the questions make the best guess that you can. Your responses to the questionnaire will be confidential and will be used for research purposes only. In no way will your answer to any question influence the status of your present license or the issuance of a future drivers license. Your cooperation is greatly appreciated.

Sincerely,

Ronald V. Thunen

RONALD V. THUNEN, Chief
Division of Drivers License

Figure 3. Follow-up letter mailed to non-respondents.

TABLE 2

RESPONSE CATEGORY BY SEX

Group	Total	Males	Females
Respondents	6,664	3,878	2,786
Non-respondents	2,955	1,835	1,120
Non-recipients	631	360	271
Total	10,250	6,073	4,177

TABLE 3

AVERAGE (MEAN) ACCIDENTS AND VIOLATIONS BY RESPONSE CATEGORY

Group	Accidents	Violations
Respondents	0.126	0.386
Non-respondents	0.131	0.517
Non-recipients	0.090	0.366
Total sample	0.125	0.422

For the purpose of this study, a violation is defined as a moving traffic violation incident reported to the department by any court (juvenile and others) or probation office during the time interval in question. The date of violation was used for placing the violation in time and multiple violations relating to one incident were counted as a single violation.

The Survey Research Center of the University of California was contracted to aid in the constructing of a questionnaire, the mailing of the questionnaire, and the coding and punching of the returned information. The questionnaire (Fig. 1) was designed to tap the following areas:

1. Method of learning to drive;
2. Driver education and driver training experience;
3. Exposure (miles driven, time, and place);
4. Driving experience (total miles driven in life);
5. Marital status;
6. Extent of parential regulation on vehicle use; and
7. Purchase of vehicle and registration thereof.

The questionnaires were mailed with an accompanying letter (Fig. 2) from the Survey Research Center on September 4, 1964. All subjects who had not returned this initial questionnaire by October 5 were mailed a second letter (Fig. 3) and questionnaire. By October 30, the rate of return had decreased to such an extent that it was decided to terminate the sampling and compile all data collected up to that time. Based on the outcome of the mailing, the original sample could be categorized into three distinct groups: respondents, non-respondents, and non-recipients, representing, respectively, 65.0 percent, 28.8 percent, and 6.2 percent of the original pool of subjects (Table 2).

The questionnaire data for each subject were collated with their matching driver record data. In the case of non-respondents and non-recipients, each subject's questionnaire code number was collated with the driver record information, and the fact that the subject was a non-respondent or non-recipient was punched into his data card for later analysis. (Non-recipients include those individuals whose questionnaires

were returned by the Post Office or by parents indicating the subject was in the armed forces, or had moved and could not be reached.) Detailed machine edit checks were then performed on all cards to insure accuracy and any errors discovered were corrected, although no attempt was made to correct inconsistent responses in the questionnaires. The edit checks were performed in order to establish that the coding and keypunching had been performed accurately.

The data regarding the respondents were then analyzed via a multiple regression program. More will be said about this later. In addition, the data (including non-respondents and non-recipients) were tabulated in a variety of ways for additional descriptive and analytic purposes.

Response Bias

The initial step in the analysis was to determine whether a response bias developed, in the sense that those who responded to the questionnaire had different accident and violation records than the non-respondent and non-recipient groups. It was anticipated at the outset that such a response bias would develop, and this was subsequently indicated [F (violation bias) = 32.59 $P < 0.001$; F (accident bias) = 3.16 $P < 0.05$] (Table 3).

Throughout this report a value which has less than 5 chances in 100 of occurring by chance is considered significant. For certain technical reasons, most of the probabilities cited should be considered as approximations. They are, however, of sufficent precision for decision-making purposes.

The respondents had significantly fewer violations on their records than did the non-respondents [$t = 22.2$ $P < 0.01$]; however, the difference between the respondents' and non-respondents' accident records was not significant [$t = 0.61$ $P > 0.50$]. Non-recipients and respondents do not have significantly different violation records [$t = 0.62$ $P > 0.50$], but non-recipients had significantly better accident records [$t = 2.34$ $P < 0.05$]; part of this reduction is probably a result of some of this group having left the state during 1963. Thus, the violation response bias can be attributed to differences between respondents and non-respondents and the accident bias attributed to differences between the respondents and non-recipients.

For comparisons among the various age groups, the existence of a response bias, in itself, is not a particularly relevant factor. What is relevant, however, is whether some age groups are more biased than others. If so, the validity of the entire study would be suspect, since unequally biased age groups would be compared and inferences made on the basis of distorted comparisons. Shown in Table 4 are accidents and violations by age group and response category.

Statistical tests of significance indicate that differences in response bias at various ages can be attributed to chance variation [F (age by violation bias) = 0.523 $P > 0.50$; F (age by accident bias) = 0.772 $P > 0.50$]. Thus, we can conclude that the relationship between age and driver record found for respondents can be generalized to the overall population of teen-aged drivers. For all other relationships the effects of a possible response bias could not be assessed. On logical grounds, however, there is no reason to suspect that these other relationships have been appreciably affected by a response bias.

Since a large amount of the data was obtained via questionnaire, some comments concerning the validity and reliability of this technique seem in order. Although such techniques are invariably subject to a certain amount of random and nonrandom errors relative to the items being measured, it is generally safe to assume that the questionnaire responses are highly correlated with the actual behavior under consideration. Our confidence here lies with the fact that strong emotional areas were not under measurement in this study. A further assumption which must be made is that the amount of response error is uniformly distributed over the independent variables being considered. The authors are confident that these assumptions have been adequately met and that the data have provided an accurate measurement of the relationships under consideration.

TABLE 4

ACCIDENTS AND VIOLATIONS BY AGE AND RESPONSE CATEGORY

Age at Beginning of Driver Record Period	Violations								Accidents							
	Total Sample		Respondents		Non-Respondents		Non-Recipients		Total Sample		Respondents		Non-Respondents		Non-Recipients	
	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.
All Ages	0.422	10,250	0.386	6,664	0.517	2,955	0.366	631	0.125	10,250	0.126	6,664	0.131	2,955	0.090	631
16 years (0-2) months	0.371	426	0.343	327	0.489	92	0.143	7	0.141	426	0.148	327	0.120	92	0.143	7
16 years (3-5) months	0.324	633	0.281	467	0.479	142	0.250	24	0.136	633	0.133	467	0.134	142	0.208	24
16 years (6-8) months	0.386	630	0.338	423	0.511	186	0.238	21	0.106	630	0.109	423	0.102	186	0.095	21
16 years (9-11) months	0.382	663	0.304	451	0.560	184	0.464	28	0.136	663	0.135	451	0.152	184	0.036	28
17 years (0-2) months	0.352	628	0.335	430	0.367	166	0.500	32	0.134	628	0.140	430	0.127	166	0.094	32
17 years (3-5) months	0.392	719	0.373	466	0.437	213	0.375	40	0.125	719	0.120	466	0.146	213	0.075	40
17 years (6-8) months	0.458	773	0.443	508	0.489	229	0.472	36	0.138	773	0.144	508	0.114	229	0.222	36
17 years (9-11) months	0.463	790	0.406	498	0.590	239	0.434	53	0.149	790	0.131	498	0.197	239	0.113	53
18 years (0-2) months	0.423	826	0.380	518	0.534	253	0.309	55	0.136	826	0.139	518	0.134	253	0.109	55
18 years (3-5) months	0.526	823	0.442	525	0.720	243	0.473	55	0.115	823	0.112	525	0.132	243	0.073	55
18 years (6-8) months	0.469	823	0.425	543	0.596	223	0.386	57	0.109	823	0.099	543	0.139	223	0.088	57
18 years (9-11) months	0.427	827	0.439	503	0.420	257	0.358	67	0.116	827	0.113	503	0.125	257	0.104	67
19 years (0-2) months	0.426	813	0.421	489	0.486	249	0.253	75	0.123	813	0.137	489	0.120	249	0.040	75
19 years (3-5) months	0.435	876	0.417	516	0.498	279	0.333	81	0.099	876	0.114	516	0.090	279	0.037	81

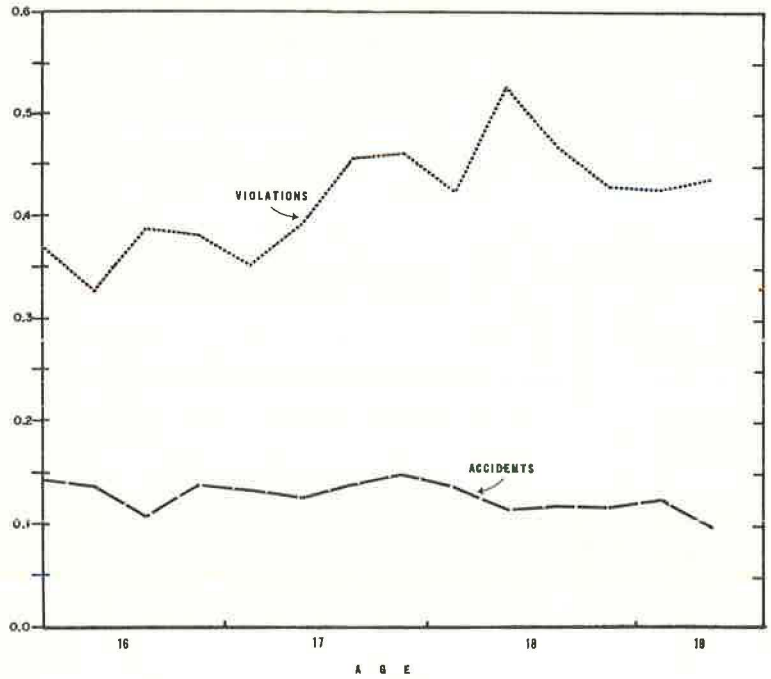

Figure 4. Average (mean) number of violations and accidents by age (1-yr record).

RESULTS

Age in Relation to Absolute and Relative Risk Potential

Are there any differences in the conviction and accident frequency among the various ages comprising the teen-age group? We have referred to such an index as absolute risk because the sole criterion is the frequency of certain types of events on each subject's driving record, regardless of the existence of significant exposure differences. The authors feel this absolute risk factor is the most relevant criterion for evaluating the present licensing age procedures inasmuch as it involves an evaluation of the risk which a given age group represents to the public. For example, if one age group is having twice as many accidents as another then that group represents twice the hazard or risk to the public, regardless of whether that group drives twice as many miles as the other.

Shown in Figure 4 and Table 5 are the average (mean) number of accidents and violations by sex for the various age groups comprising the study. For purposes of precision, the ages 16 years zero months through 19 years 5 months have been broken down into 14 three-month age groupings.

Statistical tests performed on the data indicated that accident frequency for both males and females is unrelated to age [Males: $r = -0.015$ $P > 0.05$; Females: $r = 0.006$ $P > 0.05$]. There is however, a significant relationship between violation frequency and age for both males and females. Analysis of the direction of the relationship indicates that as age increases, violations increase [Males: $r = 0.076$ $P < 0.05$; Females: $r = 0.055$ $P < 0.05$].

From this consideration alone, there is no evidence to support the assumption that 16-17-year-old drivers constitute a greater risk to the public than do drivers in their older teens. This, incidentally, is consistent with the conclusions of the previously mentioned study.

Do the age groups differ with respect to their violation and accident rates when the effects due to miles driven are controlled? This question is more closely related to

TABLE 5

ACCIDENTS AND VIOLATIONS BY AGE AND SEX

Age at Beginning of Driver Record Period	Males			Females		
	No.	Accidents per Person	Violations per Person	No.	Accidents per Person	Violations per Person
All ages	3,878	0.162	0.541	2,786	0.075	0.169
16 years (0-2) months	201	0.199	0.478	126	0.063	0.127
16 years (3-5) months	291	0.165	0.375	176	0.080	0.125
16 years (6-8) months	256	0.156	0.449	167	0.036	0.168
16 years (9-11) months	282	0.174	0.401	169	0.071	0.142
17 years (0-2) months	249	0.181	0.462	181	0.083	0.160
17 years (3-5) months	276	0.159	0.533	190	0.063	0.142
17 years (6-8) months	299	0.167	0.652	209	0.110	0.144
17 years (9-11) months	282	0.163	0.560	216	0.088	0.204
18 years (0-2) months	304	0.184	0.559	214	0.075	0.126
18 years (3-5) months	293	0.147	0.587	232	0.069	0.259
18 years (6-8) months	309	0.117	0.631	234	0.077	0.154
18 years (9-11) months	284	0.148	0.620	219	0.068	0.205
19 years (0-2) months	268	0.175	0.627	221	0.090	0.172
19 years (3-5) months	284	0.151	0.595	232	0.069	0.198

TABLE 6

MILES DRIVEN IN 1963 BY AGE AND ACCIDENT RATE[a]

Age at Beginning of Driver Record Period	Total Sample			Males			Females		
	Average* Miles Driven	Miles per Accident	Accidents per 100,000 Mi	Average* Miles Driven	Miles per Accident	Accidents per 100,000 Mi	Average* Miles Driven	Miles per Accident	Accidents per 100,000 Mi
All ages	7,548	59,905	1.78	9,557	58,994	1.78	4,643	61,907	1.77
16 years (0-2) months	4,668	31,541	3.46	5,685	28,568	3.74	2,916	46,286	2.52
16 years (3-5) months	4,637	34,865	3.00	5,343	32,382	3.19	3,422	42,775	2.49
16 years (6-8) months	5,571	51,110	2.07	7,165	45,929	2.27	2,989	83,028	1.32
16 years (9-11) months	6,178	45,763	2.35	7,647	43,948	2.40	3,632	51,155	2.15
17 years (0-2) months	6,629	47,350	2.25	8,345	46,105	2.26	4,114	49,566	2.24
17 years (3-5) months	7,159	59,658	1.77	8,872	55,799	1.87	4,578	72,667	1.49
17 years (6-8) months	7,156	49,694	2.10	9,568	57,293	1.79	3,506	31,873	3.40
17 years (9-11) months	8,327	63,565	1.68	10,822	66,393	1.56	4,828	54,864	2.03
18 years (0-2) months	8,160	58,705	1.79	10,322	56,098	1.86	5,004	66,720	1.60
18 years (4-5) months	9,107	81,313	1.32	11,594	78,871	1.35	5,941	86,101	1.25
18 years (6-8) months	9,027	91,182	1.17	11,498	98,274	1.05	5,597	72,688	1.50
18 years (9-11) months	8,991	79,566	1.39	11,865	80,169	1.37	5,230	76,912	1.45
19 years (0-2) months	8,910	65,036	1.63	11,870	67,829	1.55	5,213	57,922	1.87
19 years (3-5) months	9,127	80,061	1.31	11,714	77,576	1.35	5,944	86,145	1.22

[a]Based on 6,244 respondents.
*Arithmetic means.

TABLE 7

MILES DRIVEN IN 1963 BY AGE AND VIOLATION RATE[a]

Age at Beginning of Driver Record Period	Total Sample			Males			Females		
	Average* Miles Driven	Miles per Violation	Violations per 100,000 Mi	Average* Miles Driven	Miles per Violation	Violations per 100,000 Mi	Average* Miles Driven	Miles per Violation	Violations per 100,000 Mi
All ages	7,548	18,389	5.44	9,557	16,863	5.93	4,643	25,173	3.97
16 years (0-2) months	4,668	12,379	8.08	5,685	11,132	8.98	2,916	19,863	5.04
16 years (3-5) months	4,637	15,785	6.34	5,343	13,823	7.23	3,422	25,509	3.92
16 years (6-8) months	5,571	15,504	6.45	7,165	15,328	6.52	2.989	16,229	6.16
16 years (9-11) months	6,178	18,986	5.27	7,647	18,069	5.53	3,632	23,304	4.29
17 years (0-2) months	6,629	18,507	5.40	8,345	17,343	5.77	4,114	23,124	4.32
17 years (3-5) months	7,159	18,143	5.51	8,872	15,995	6.25	4,578	29,841	3.35
17 years (6-8) months	7,156	15,425	6.48	9,568	14,328	6.98	3,506	22,553	4.43
17 years (9-11) months	8,327	19,209	5.21	10,822	18,630	5.37	4,828	21,286	4.70
18 years (0-2) months	8,160	20,380	4.91	10,322	17,730	5.64	5,004	37,067	2.70
18 years (3-5) months	9,107	19,275	5.19	11,594	18,537	5.39	5,941	21,388	4.68
18 years (6-8) months	9,027	19,968	5.01	11,498	17,513	5.71	5,597	33,269	3.01
18 years (9-11) months	8,991	18,591	5.38	11,865	17,461	5.73	5,230	23,013	4.35
19 years (0-2) months	8,910	10,938	5.02	11,870	18,088	5.53	5,213	28,121	3.56
19 years (3-5) months	9,127	20,929	4.78	11,714	18,853	5.30	5,944	28,557	3.50

[a]Based on 6,244 respondents.

*Arithmetic means.

TABLE 8

ACCIDENTS AND VIOLATIONS PER 100,000 MILES BY MILES DRIVEN IN 1963

Miles Driven During 1963	Males		Females	
	Accidents per 100,000 Mi	Violations per 100,000 Mi	Accidents per 100,000 Mi	Violations per 100,000 Mi
Under 1,500	15.71	43.29	7.29	12.29
1,500-2,999	6.82	18.27	3.18	7.82
3,000-4,499	2.92	10.05	1.73	4.08
4,500-5,999	2.62	8.98	1.35	3.06
6,000-7,499	2.21	7.02	1.27	3.25
7,500-8,999	1.87	7.15	0.95	2.38
9,000-10,499	1.60	5.77	1.13	2.93
10,500-11,999	2.13	5.79	1.34	2.23
12,000-13,499	1.74	4.91	1.17	2.82
13,500-14,999	1.85	5.28	1.65	2.49
15,000-16,499	1.11	3.75	1.12	2.25
16,500-17,999	1.01	4.05	0.65	1.94
18,000-19,499	1.12	3.43	1.34	3.12
19,500-20,999	1.05	3.95	0.57	2.66
Over 20,999	0.84	3.39	1.21	2.14

the performance factor than was the previous question, but is further removed from the absolute accident or violation probabilities that each age group represents.

Table 6 shows the effect of a single variable, "total miles in year," on the relationship between accidents and age. Even a cursory glance at this table indicates that younger teen-aged drivers have a higher accident rate per mile driven. Younger teen-agers also tend to have a slightly higher violation rate per mile driven than do older teen-age drivers (Table 7).

Most of the relationship found here is not due to age alone, but is a result of the fact that those individuals who drove less during 1963 had a higher accident and violation rate per mile driven (Table 8). This could be due to a number of factors which are related to annual mileage such as additional exposure variables, skill, experience, and inaccurate responses to the questionnaire. Because younger drivers as an age group drove less than older teen-agers (Fig. 5), this factor is a primary contributor to their poorer driver record per mile driven.

A stratification procedure was employed to remove the aforementioned effect, and statistical analysis of the data through correlational techniques and analysis of variance procedures was employed. The results of this mileage-controlled analysis can be summarized as follows:

1. Although the difference between the age groups is not as dramatic as indicated by the previous ratios, younger teen-age males still have a higher accident rate than their older counterparts [Males: R Age Accidents · Mileage = -0.039 $P < 0.05$].
2. No significant relationship between age and accidents was revealed for females [Females: R Age Accidents · Mileage = -0.019 $P > 0.05$].
3. No significant relationship between age and violations was noted for either males or females [Males: R Age Violations · Mileage = 0.027 $P > 0.05$; Females: R Age Violations · Mileage = 0.028 $P > 0.05$].

From these results alone, it can be seen that the controlling of even one exposure variable can have dramatic effects. The possibility, however, that other exposure variables (type, time, and place of driving) also influence the results cannot be dismissed. Thus, before a final decision can be made regarding the relative risk of these age groups, it will be necessary to hold constant some additional exposure variables.

Is the age-driver record relationship obtained above affected by taking into account the effects of additional exposure variables? The present study included several measures of exposure in addition to miles driven per year. These variables were miles

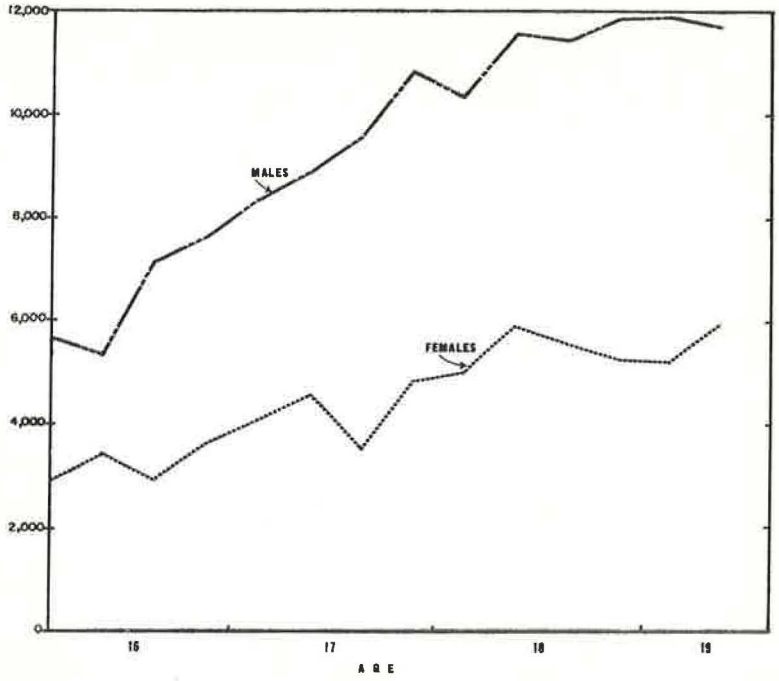

Figure 5. Average (mean) number of miles driven per year by age.

driven at night, miles driven on freeways and expressways, total hours per week, and total miles per week. Before a final conclusion can be formulated as to the relationship between age and driving record, with variations due to exposure controlled, it is necessary that the effects of these variables be removed. In order to do so, the authors resorted to the use of a multi-variate analysis technique (multiple regression analysis).

The first step in such an analysis is to determine the interrelationships (correlations) between all of the variables under consideration (Tables 9, 10). The multiple regression analysis then allows one to determine which of the exposure variables contributes uniquely to predictions of driver records, and results in a determination of the relationship between driver record and age with the effects of the exposure variables controlled.

In Table 11 are the findings with respect to age and the exposure variables. An S indicates that the variable made a significantly unique contribution while NS indicates that the variable did not make a significantly unique contribution.

In some instances certain mathematical assumptions underlying the use of correlational and regression analysis have been violated (linearity, normality, homoscedasticity, and continuity). The basic effect of such violations is to render probability levels approximate rather than exact.

The exposure variables total hours per week and total miles per week were found to make significantly unique contributions above and beyond the contribution of total miles in 1963; however, for both sexes, the findings concerning age are identical to those cited earlier when only one exposure variable was controlled. Age was found to be significantly related to male accident frequencies alone. Our multiple regression runs also showed (Tables 12 to 15) that, within the age groups under consideration here, exposure was a more important factor than age in accident prediction.

Age Driving Performance and Associated Factors

The third question raised in the introductory section of this report relates to the importance of inexperience, immaturity and parental control as factors in determining the driver records of teen-agers.

TABLE 9

SIMPLE CORRELATION COEFFICIENTS (MALES)[a]

	Criterion Variables		Miles per Week	Hours per Week	Total Miles in Year	Total Miles in Life	Age	Months License in Force	Parental Regulation
	Accidents	Violations							
Accidents	—								
Violations	0.146*	—							
Miles per week	0.089*	0.186*	—						
Hours per week	0.085*	0.149*	0.324*	—					
Total miles in year	0.096*	0.200*	0.647*	0.304*	—				
Total miles in life	0.045*	0.145*	0.371*	0.209*	0.505*	—			
Age	-0.014	0.076*	0.234*	0.084*	0.249*	0.246*	—		
Months license in force	-0.005	0.069*	0.247*	0.063*	0.253*	0.248*	0.797*	—	
Parental regulation	-0.011	0.001	-0.216*	-0.097*	0.196*	0.132*	-0.305*	-0.292*	—

[a]Based on 3,385 subjects.

*Correlations over ± 0.037 are significant beyond the 0.05 level.

TABLE 10

SIMPLE CORRELATION COEFFICIENTS (FEMALES)[a]

	Criterion Variables		Miles per Week	Hours per Week	Total Miles in Year	Total Miles in Life	Age	Months License in Force	Parental Regulation
	Accidents	Violations							
Accidents	—								
Violations	0.155*	—							
Miles per week	0.108*	0.149*	—						
Hours per week	0.044*	0.077*	0.248*	—					
Total miles in year	0.142*	0.160*	0.632*	0.203*	—				
Total miles in life	0.059*	0.122*	0.461*	0.156*	0.586*	—			
Age	0.006	0.055*	0.186*	0.018	0.174*	0.264*	—		
Months license in force	-0.030	0.067*	0.131*	-0.012	0.142*	0.260*	0.726*	—	
Parental regulation	-0.027	-0.014	-0.145*	-0.054*	-0.176*	-0.176*	-0.287*	-0.249*	—

[a]Based on 2,255 subjects.

*Correlations over ± 0.037 are significant beyond the 0.05 level.

TABLE 11

RESULTS OF MULTIPLE REGRESSION-AGE AND ALL EXPOSURE VARIABLES

Predictor Variables	Accidents		Violations	
	Males	Females	Males	Females
Age	S	NS	NS	NS
Total miles in 1963	S	S	S	S
Total hours per week	S	NS	S	NS[a]
Total miles per week	NS	NS	S	S
Miles driven at night	NS	NS	NS	NS
Miles on freeways and expressways	NS	NS	NS	NS

[a]Approaches significance.

TABLE 12

ACCIDENT PREDICTION WITH ALL VARIABLES (MALES)

Predictor Variables	Regression Coefficient	F	Probability
Constant term	1.8236×10^{-1}	27.413	$P < 0.001$
Total hours per week	1.7480×10^{-3}	11.910	$P < 0.001$
Total miles in 1963	3.5868×10^{-6}	22.423	$P < 0.001$
Age[a]	-1.4096×10^{-3}	5.283	$P < 0.05$

[a]Age equals number of months of age in excess of 14 years.
Note: R = 0.119

TABLE 13

ACCIDENT PREDICTION WITH ALL VARIABLES (FEMALES)

Predictor Variables	Regression Coefficient	F	Probability
Constant term	7.8669×10^{-2}	24.274	$P < 0.001$
Total miles in 1963	8.1128×10^{-6}	50.144	$P < 0.001$
Months license in force	-1.3070×10^{-3}	6.010	$P < 0.05$

Note: R = 0.151

TABLE 14

VIOLATION PREDICTION WITH ALL VARIABLES (MALES)

Predictor Variables	Regression Coefficient	F	Probability
Constant term	8.0779×10^{-2}	0.927	$P > 0.25$
Total miles per week	5.0231×10^{-6}	12.766	$P < 0.001$
Total hours per week	5.3571×10^{-3}	22.765	$P < 0.001$
Total miles in 1963	9.4942×10^{-6}	18.986	$P < 0.001$
Total miles in life	6.6062×10^{-7}	5.424	$P < 0.05$
Parental regulations	5.0003×10^{-2}	12.477	$P < 0.01$
Age[a]	2.5045×10^{-3}	3.182	$P < 0.1$

[a]Age equals number of months of age in excess of 14 years.
Note: R = 0.240

TABLE 15

VIOLATION PREDICTION WITH ALL VARIABLES (FEMALES)

Predictor Variables	Regression Coefficient	F	Probability
Constant term	2.8863×10^{-2}	0.992	$P > 0.25$
Total miles per week	3.7306×10^{-6}	6.297	$P < 0.05$
Total hours per week	1.6406×10^{-3}	3.338	$P < 0.1$
Total miles in 1963	9.7320×10^{-6}	14.675	$P < 0.001$
Months license in force	1.9469×10^{-3}	4.450	$P < 0.05$

Note: R = 0.181

TABLE 16

RESULTS OF MULTIPLE REGRESSION—ALL VARIABLES

Predictor Variables	Accidents		Violations	
	Males	Females	Males	Females
Age	S	NS	NS[a]	NS
Total miles in 1963	S	S	S	S
Total hours per week	S	NS	S	NS[a]
Total miles per week	NS	NS	S	S
Months license in force	NS	S	NS	S
Miles in life	NS	NS	S	NS
Parental regulation	NS	NS	S	NS

[a]Approaches significance.

Two variables were used in an attempt to measure the effect of driving experience on driving record: total miles driven in life and months license was in force. It was hypothesized that those individuals who had driven less in their life and who had possessed a driver license for a shorter period of time would be the less experienced drivers. (One must remember that the entire study group was limited to drivers with a minimum of one year driving experience at the time of coding and that, therefore, the effects of less than one year's experience could not be assessed.)

Immaturity could not be assessed directly from the information obtained in the questionnaire; consequently, an indirect assessment of this factor was made by controlling all available variables which are related to age but which were not considered to be immaturity factors. Any relationship between age and driving record which remained was then attributed to immaturity. Such a definition, of course, ties this concept directly to chronological age and results in a variable which encompasses somewhat more than the concept of psychological immaturity.

Parental regulation was measured by determining the number of ways (indicated by questionnaire responses) that each subject's driving behavior had been regulated by his parents. Since it has been suggested that increased parental control could result in younger teen-agers driving more carefully, it was hypothesized that this factor would be related to both age and driving record.

In order to evaluate the effects of the three aforementioned factors, it was necessary to again resort to a multiple regression analysis. In this analysis exposure, experience, age, and parental regulations were included. The results (Table 16) indicate that the same exposure variables continue to be predictors of violations and accidents. The significant exposure variables will be listed but not discussed.

Presented are the variables which were found to make a statistically significant contribution in accounting for the accident and violation frequencies of either males, females, or both. For males, an experience variable, miles in life, makes a unique contribution to our ability to predict violations, and the direction of the relationship is a positive one. That is, as experience increases, violation frequency also increases. This variable, however, was unrelated to accidents. For females, months license in force, also an experience variable, is significantly related to both accidents and violations. Here the direction of the relationship with respect to experience and violations is positive, in that increased experience is associated with increased violation frequency. The relationship between accidents and experience is in the opposite direction; as experience increases, accident frequency decreases.

One would speculate from these findings that greater experience results in increased confidence, which in turn results in a subsequent relaxation of compliance to traffic laws. This violation tendency does not necessarily result in a positive relationship between accidents and experience because the tendency for increased violations to produce a comparable increase in accidents is offset by an increase in driving skill.

Immaturity (defined in terms of the remaining age effect) appears as a significant factor in accidents for males, with less mature (younger) teen-age males having more accidents. This factor also approaches significance in our attempt to predict violations, but with the tendency being for more mature (older) teen-age drivers to have more violations. One possible explanation of this apparent contradiction is that younger drivers are more concerned with obeying traffic laws but lack the psychological maturity necessary for proper defensive driving. For females immaturity (age) was not found to be relevant to either accidents or violations.

Parental regulation was related only to violation frequency for males, and the direction of the relationship was such that increased regulation was associated with increased violation frequency. One should not confuse the cause and effect relationship, however, since it is highly probably that increased violations caused increased parental control rather than the converse.

The Influence of Driver Training On Accident and Violation Rates

In this section, an attempt will be made to answer two basic questions:

1. Do drivers who have taken behind-the-wheel driver training have significantly better subsequent driving records than those who have not taken such training?
2. To what extent can subsequent driver record differences be attributed to the effects of driver training?

The task of evaluating the effects of driver training on accident and violation rates is a difficult one. To adequately determine the effect of this type of instruction on subsequent driving behavior, it would be necessary to use a random assignment technique—randomly assigning subjects to a driver training course and a control group for later comparison. To our knowledge, no such controlled experimentation has been done. Instead, comparisons have been made between the driver records of subjects who have volunteered to take driver training classes with those who have not. In general, it has been shown that individuals who are volunteers have different characteristics than those who are not volunteers. In the case of driver training, a number of characteristics have been found to differentiate volunteers for driver training classes from non-volunteers; in some cases, these same characteristics are related to driving performance (1). For example, the New York Department of Motor Vehicles has established that whether a person takes a driver education class or not (in New York) is related to his scholastic standing and, furthermore, that scholastic standing is related to accident and violation records (3). It has also been suggested that because of socioeconomic and exposure differences, individuals who attend schools which do not offer driver training may have poorer driver records than individuals who attend schools which do offer such a course. It has been shown, for example, that drivers from lower socioeconomic backgrounds are more frequently negligent drivers than those with higher socioeconomic backgrounds (2).

TABLE 17

HIGH SCHOOL DRIVER TRAINING BY VIOLATIONS AND ACCIDENTS

Driver Training Status	Males			Females		
	No.	Average Violations (mean)	Average Accidents (mean)	No.	Average Violations (mean)	Average Accidents (mean)
Total	3,878	0.541	0.162	2,786	0.169	0.075
School offered driver training class	3,198	0.522	0.157	2,296	0.164	0.076
Did take and pass	2,514	0.498	0.158	1,795	0.154	0.076
Did not take	684	0.611	0.154	501	0.202	0.074
School did not offer driver training class	447	0.642	0.186	337	0.199	0.080
Status undetermined	233	0.601	0.185	153	0.183	0.059

To support the view that driver training is effective in reducing accident rates, it has often been pointed out that some insurance companies give rate reductions to teen-agers who have taken a behind-the-wheel course. This does not necessarily provide evidence in support of the effectiveness of driver training. If teen-agers that have completed a driver training course actually do have a superior driving record, it is possible that the difference is as much due to their personal characteristics as to the effectiveness of the course.

When the DMV driver questionnaire was designed, it was decided to include questions which would identify whether or not the subjects had taken driver education and training. It was hoped that the information gathered would aid attempts to evaluate behind-the-wheel training in general. Due to the previously mentioned selection factor (volunteer bias), it was realized at the outset that a completely definitive result could not be obtained.

In Table 17 and Figures 6 and 7, the driving records of the individuals who took and passed the driver training course (trained) are compared with those who attended a school which offered driver training but did not take the course, and those individuals who did not attend a school which offered driver training. These last two groups will be referred to, collectively, as untrained drivers. The difference with regard to violations is statistically significant in favor of the trained group [F (violations) = 6.64 $P < 0.01$]. This is consistent with findings from other studies, although the difference is not as marked as reported by some investigators (5, 6).

Data released by the California State Department of Education indicate that 63.5 percent of California high school students received driver training in the 1963-1964 school year. Our sample data match this figure almost exactly and provide rather convincing evidence for the validity and representativeness of the sample in this respect.

As for accidents [F (accidents) = 0.64 $P > 0.50$], it can be seen from Table 17 and Figure 7 that the performance of the groups is similar. The differences which do exist are not statistically significant. In fact, the two largest components—"did take" and "did not take"—are almost identical. This is indeed a surprising finding. Previous research has shown that subjects who take driver training have personality characteristics and socioeconomic backgrounds which are related to safe driving habits, so it would seem that any subsequent comparison, if anything, should favor the driver training group, if only because of these initial personality and cultural differences (4).

Before coming to a final evaluation of driver training effectiveness, it will first be necessary to examine some possible sources of bias which may have introduced distortions into the data. These possible biases can be categorized as follows:

1. Exposure differences between the trained and untrained groups.
2. Age differences between trained and untrained groups.

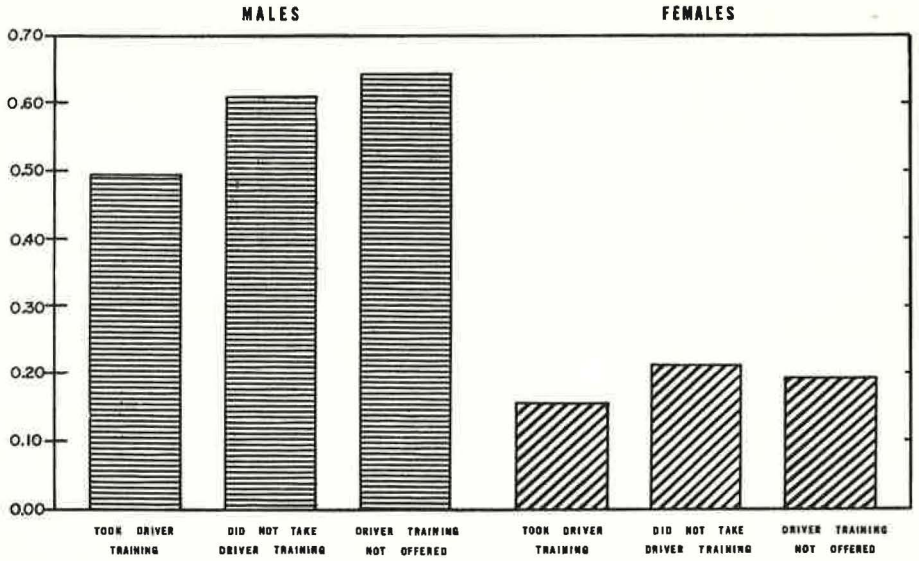

Figure 6. Average (mean) number of violations for trained and untrained drivers by sex (1-yr record).

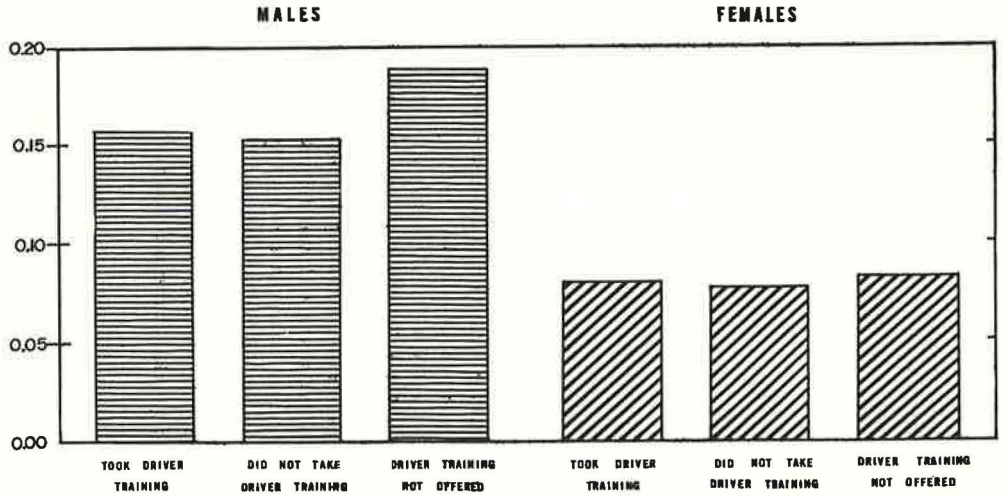

Figure 7. Average (mean) number of accidents for trained and untrained drivers by sex (1-yr record).

TABLE 18

ANNUAL MILEAGE—1963 BY DRIVER TRAINING STATUS

Driver Training Status	Mean Annual Mileage, 1963	
	Males	Females
Took and passed	9,489	4,596
Did not take	10,751	4,394
Could not take	10,641	4,971

3. Indeterminancy as to when driver training occurred in relation to the driving records of the trained groups. (For the 16-year-old group, there is a possibility that some of the drivers comprising the trained group had their driver training during or after the recorded "subsequent" driving record. If so, the distinction between the trained and untrained group might have been blurred and any effectiveness spuriously diminished.)

4. Differential response bias between the trained and untrained groups (i.e., the possibility that limiting the study to respondents favored one group more than the other).

In order to determine whether any mileage differences existed between the trained and untrained groups, the distribution of each group by sex with regard to annual mileage was determined (Table 18) and the respective averages computed for comparison. If the trained group had driven a significantly greater number of miles, any failure to find a lower accident frequency for the trained group could possibly be explained by the greater exposure of this group.

Statistical tests of significance indicated that the trained males actually drove significantly fewer miles than did the untrained males [t (took vs didn't take) = 9.06 $P < 0.001$; t (took vs couldn't take) = 2.42 $P < 0.01$]. For females, the small differences in mean miles driven are not statistically significant [t (took vs didn't take) = 0.68 $P > 0.40$; t (took vs couldn't take) = 1.08 $P > 0.20$]. Thus, if anything, the trained male group should have been favored in any driving record comparison and the trained females unaffected. This fact renders the superior violation record of the trained males as somewhat uncertain. On the other hand, the failure to find an accident reduction for the trained group becomes even more conclusive.

To test for the possible effects of an age bias between the trained and untrained groups, an analysis of variance procedure was employed in order to determine whether the comparative accident frequencies were similar at all age levels. In effect, such a procedure allows one to measure the effectiveness and stability of a treatment (e.g., driver training) at various levels (e.g., age) and to determine what variables are exerting significant effects on the data. The effect of training was constant at all age levels [F (age by training) = 0.857 $P > 0.25$]. Consequently, there is no reason to suspect that the previous findings with regard to accidents and driver training were contaminated by an age bias.

This same procedure also answers our third possibility of distortion—temporal indeterminancy. Since the effectiveness (or ineffectiveness) of training was constant at all ages, there is no reason to suspect that the occurrence of driver training for some of the younger drivers during or after the recorded driving record interval biased the outcome against the trained group. Had such a bias resulted, one would expect the older teen-age drivers to have done relatively better than their younger counterparts, but such was not the case.

As to the fourth possible source of bias, the reader is referred to our earlier finding concerning the overall response bias. It will be recalled that the respondents and nonrespondents were almost identical with respect to accident frequency (Mean = 0.126 and 0.131, respectively).

Since this indicated no significant bias to begin with, it is doubtful the data could have been distorted by limiting the samples to respondents.

After considering all the facts available from this study, the authors can find no evidence that, on a statewide basis, behind-the-wheel driver training is effective in reducing the frequency of accidents. (It was not possible, incidentally, to analyze any differences between ages or training groups as they may relate to accident severity.)

Due to the aforementioned exposure and violation bias which would tend to favor the trained group, the significance of the violation reduction becomes somewhat more uncertain. We therefore cannot determine from this study whether driver training, per se, results in a reduction in violation frequency.

The authors wish to emphasize that the present study has dealt with driver training as a whole, on a statewide basis. It is entirely possible that some effective programs do exist within the system, but are too insignificant in number to have appreciably affected the overall statewide accident average of the trained group.

TABLE 19

RESULTS OF STATISTICAL TESTS BY SEX

Variables Controlled	Accidents		Violations	
	Males	Females	Males	Females
Uncontrolled for mileage	Age not significant	Age not significant	Age significant[b]	Age significant[b]
Controlled for mileage variable (e.g., total miles in 1963)	Age significant[a]	Age not significant	Age not significant	Age not significant
Controlled for all mileage variables with significant predictor variables listed	Age significant[a] Total hours per week[b] Total miles in 1963[b]	Age not significant Total miles in 1963[b]	Age not significant Total miles in 1963[b] Total hours per week[b] Total miles per week[b]	Age not significant Total miles in 1963[b] Total miles per week[b] Total hours per week approaches significance[b]
Controlled for mileage and other factors related to age with significant predictor variables listed	Age not significant[a] Total hours per week[b] Total miles in 1963[b]	Age not significant Total miles in 1963[b] Months license in force[a]	Age approaches significance[b] Total hours per week[b] Total miles in 1963[b] Total miles per week[b] Parental regulation[b] Total miles in life[b]	Age not significant Total miles in 1963[b] Total miles per week[b] Months license in force[b] Total hours per week approaches significance[b]

[a]Negative.

[b]Positive.

Note: A positive relationship indicates that as the variable increases in value the criterion variable (accidents or violations) increases. A negative relationship indicates that as the variable increases in value the criterion variable decreases in value.

Future research in this area should be oriented toward determining which (if any) of the present programs are effective. In any event, the research effort described herein should not be considered an end in itself, but rather a beginning to the scientific development and evaluation of driver training programs in this state.

SUMMARY

In terms of driver record alone (uncontrolled for mileage differences), statistical analysis of the data indicated accident frequency for both teen-age males and females is unrelated to age. Violation frequency for both males and females, however, increases as age increases.

In order to adequately control the effects of differences in exposure between age groups and to determine the relationship between relative risk and age, it was necessary to resort to a multiple regression analysis (Table 19). This analysis established: (a) exposure was a more important factor than age in determining accident and violation rates and (b) age was related only to male accident rates, with older males having fewer accidents.

To determine the effects of inexperience, immaturity (as measured by age) and parental control on accident and violation records, it again was necessary to resort to a multiple regression analysis.

For males, in addition to two exposure variables which were found to be positively related to accidents, age was found to be a predictor of accidents, with older males having fewer accidents. From this result, it was concluded that some intrinsic components of age (e.g., immaturity) were factors in the accident frequency of the younger male teen-aged driver.

Male violation frequencies were found to be related to three exposure variables, miles in life (experience) and parental regulations. More experienced drivers and more regulated drivers had more violations. It was concluded that regulations came as a result of violations rather than the converse. Age (immaturity) approached significance, and the direction of the relationship was a positive or increasing one. Some possible explanations of these findings were offered previously.

For females one exposure variable and an experience variable (months license in force) were found to be significantly related to accidents, with more experienced drivers having fewer accidents. Three exposure variables and the experience variable (months license in force) were found to be significantly related to violations—the more experienced female drivers having more violations. Parental regulations and age (immaturity) made no contribution to accident or violation records for females.

In terms of absolute risk, the authors can find no evidence to support a raise in the minimum licensing age in California. In terms of relative risk, however, there is some evidence, for males, that younger drivers are more predisposed to accidents than drivers in their older teens. Any final decision concerning a raise in licensing age must be based upon the relative merits of these two methods of comparison.

The sample of teen-aged drivers was broken into three groups (did take, didn't take and couldn't take) on the basis of their answer to the questionnaire item regarding the completion of a behind-the-wheel driver training course. When the three groups were compared, the trained group had fewer violations, but no significant differences were found between the trained and untrained groups on accidents. Although it is entirely possible that some programs in certain individual school districts are effective, this finding raises serious questions about the general effectiveness of statewide driver training in reducing accidents.

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