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Age, Exposure, and Alcohol Involvement in Night Crashes

William L. Carlson

This study compared driving and crash patterns of young (age 16 to 25) drivers. The use of random samples of the driving population is presented as an alternative exposure measurement technique. The high occurrence of young drivers in night, single-vehicle crashes was found to be related to exposure, with two exceptions; drivers aged 16 to 18 are overinvolved in nonalcohol-related crashes and drivers aged 18 to 21 are overinvolved in alcohol-related crashes. These overinvolvements are consistent with the assumption of a learning-to-drive and a learning-to-drink-and-drive model of crash occurrence. Once these learning periods have passed, the high percentage of crash involvement for drivers aged 19 to 25 corresponds to high driving exposure. The use of relative exposure is presented as a useful device for determining overinvolvement in crashes.

Previous studies have established that persons who have traffic crashes are more likely to have other life problems as well (Tillman & Hobbs, 1949). In addition, 18 to 20 year old drivers with the highest numbers of driving convictions have fathers with more driving convictions, perform academically below their potential, and tend to have more nontraffic contacts with the law (Carlson & Klein, 1970). In the case of young drivers, it has been suggested (Klein, 1968) that their high crash involvement may be due to increased exposure at hazardous times and places and/or a learning effect rather than inherently worse driving ability.

Are crashes involving young drivers due to unusual exposure or to driving characteristics that contribute to crash occurrence (e.g., immaturity, poor judgment, failure to perceive problems, speed, etc.)? This question is of great importance to those attempting to design countermeasures to alleviate the high losses from young drivers' crashes. If the problem is "poor" driving, then developing high quality driver training programs seems a reasonable solution. This approach might be valid in spite of the lack of crash reduction from present driver education programs. If the large number of crashes results from either a learning effect[1] or excessive driving, however, the problem must be approached differently. Pure learning effects will be difficult to overcome by training and probably can only be reduced by making the driving task simpler (providing a greater margin for error without crash occurrence). Excess crashes resulting from excess exposure are most directly reduced by modifying automobile usage patterns.

A previous analysis (Carlson, 1971) of 2.4 million crashes from the National Accident Summary provides some interesting insights into the young driver problem. That study indicated that drivers under age 25 were involved in 42% of nighttime (7:00 p.m. to 7:00 a.m.) crashes but in only 32% of daytime crashes. Each vehicle or pedestrian in a crash contributed a unit of involvement. Data for the National Accident Summary file were collect-

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[1] Learning effect refers to the accumulation of road experience during the period following initial licensing.

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ed from 26 states, for 1969, by the National Highway Traffic Safety Administration.

A number of authors have stated the importance of including exposure in comparisons of crashes between groups. Generally accepted measures of exposure are not easy to obtain, however. The most widely used measure is to convert gasoline sales tax accumulations to an estimate of mileage for a particular geographic region. This measure leaves unanswered questions of an appropriate conversion factor (miles per gallon of gasoline) and of exposure variations among different driving conditions. At this point, it is useful to review previous efforts at establishing exposure measures.

A nationwide personal interview survey of drivers was conducted in order to define differences in exposure by miles driven among various driver, vehicle, and environment combinations (Carroll, Carlson, McDole, & Smith, 1970). Table 1 compares the mileage and crash involvement of various age groups. Drivers in the 26 to 40 age range drove more miles than did drivers 25 and below. But, drivers 16 to 25 had more crashes per driver and more crashes per mile than did older drivers. Mileage and crash estimates for that study were both self-reported, based upon driver memory. Under those conditions, it was not reasonable to partition a particular driver's mileage and crashes into, for example, day and night components.

Another approach—induced exposure—measures relative exposure by driver involvement in nonculpable crashes (Haight, 1970). Carlson (1970) presents an application of this general approach that resulted from an extension of work by Hall (1970). A nonculpable crash was defined as a crash in which the other driver received a police summons and the driver of interest did not. The conclusion from that analysis was that drivers aged 16 to 20 are overinvolved in culpable crashes. For drivers above age 35, involvement in nonculpable crashes—and hence exposure—decreased compared to a consistent level of nonculpable crash involvement for ages 16 to 35. These results are, of course, restricted by the problems of culpability assignment.

Pelz and Schuman (1971) developed a dummy variable regression model—using data from 3,000 personal interviews obtained from a probability sample of suburban drivers—to explain the contribution of various factors to crash involvement. This sophisticated approach explained that portion of the variance in self-reported crashes resulting from exposure. Their method is based upon the assumption that a portion of the crashes incurred by a particular age group are due to exposure and the remainder are due to unexplained factors. That portion that is due to exposure can be "predicted" by a dummy variable regression

TABLE 1
MILES DRIVEN AND CRASHES FOR VARIOUS DRIVER AGE GROUPS

AGE GROUP	N	NATURAL LOG OF MILES DRIVEN 30 DAYS		MILES DRIVEN 30 DAYS		MEAN SELF-REPORTED CRASHES, LAST 3 YEARS	CRASH RATE PER 1,000,000 MILES
		Mean	Standard deviation	Mean	Standard deviation		
16-20	441	5.941	1.409	796	1146	0.720	25.1
21-25	899	6.058	1.675	1007	1497	0.496	13.7
26-30	822	6.266	1.498	1125	1588	0.364	9.0
31-35	713	6.317	1.441	1136	1501	0.310	7.6
36-40	665	6.362	1.424	1263	1939	0.237	5.2
41-45	706	6.273	1.347	1022	1245	0.202	5.5
46-50	641	6.252	1.417	1054	1400	0.246	6.5
51-60	947	6.155	1.464	966	1315	0.182	5.2
61-70	533	5.804	1.570	706	897	0.173	6.8
70 +	151	5.189	1.554	402	570	0.236	16.3
Total	6518	6.151	1.499	1010	1435	0.310	8.5

Note.—Result of F test for dependency between the age group and the natural logarithm of estimated miles driven: $F(9,6508) = 15.533$, $\alpha < .01$.

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AGE	N	ACC
16	335	
17	242	
18	212	
19	160	
20	157	
21	172	
22	174	
23	132	
24	86	
Total	1670	

[a]Expected accidents were comp

model of the following f

$Y = f(X_1, X_2,$

Where

Y —predicted number
resulting from exposure
X_1—self-reported milea
X_2—number of days dr
X_3—number of hours d
X_4—number of short t
X_5—number of long tr
X_6—percent of driving
X_7—percent of driving
X_8—percent of drivin
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Residual crashes (resulti
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[2]The model was actually fitt
Classification Analysis (MCA)
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TABLE 2
COMPARISON OF AVERAGE AND RESIDUAL CRASHES PER DRIVER USING THE RESULTS OF PELZ AND SCHUMAN

AGE	N	(1) ACCIDENTS PER DRIVER	(2) ACCIDENTS PER DRIVER MINUS EXPECTED ACCIDENTS PER DRIVER[a]	(3) ACCIDENTS PER DRIVER MINUS AVERAGE ACCIDENTS PER DRIVER
16	335	.19	0.00	−0.11
17	242	.27	0.00	−0.03
18	212	.45	0.13	0.15
19	160	.46	0.10	0.16
20	157	.34	0.01	0.04
21	172	.27	−0.06	−0.03
22	174	.33	−0.02	0.03
23	132	.21	−0.18	−0.09
24	86	.29	−0.04	−0.01
Total	1670	.30		

[a]Expected accidents were computed using the Pelz-Schuman exposure correction regression model.

model of the following form[2]:

$$Y = f(X_1, X_2, \ldots, X_8)$$

Where

Y —predicted number of crashes per driver resulting from exposure

X_1—self-reported mileage
X_2—number of days driving per week
X_3—number of hours driving per week
X_4—number of short trips last month
X_5—number of long trips last year
X_6—percent of driving done during daytime
X_7—percent of driving on super highways
X_8—percent of driving on other types of roads

Residual crashes (resulting from unexplained sources) were computed as follows:

$$\text{Residual crashes} = \text{Observed crashes} - \text{Predicted crashes}$$

The residual crashes or deviations from the model were then plotted against age. The residual crashes per driver for 18 and 19 year olds had the highest deviation above the predicted crash rate given their exposure. Thus, 18 and 19 year olds had the highest crash rates even after a correction was made for exposure.

The regression model that was used explained 5% of the total variability. This low value for explained variability may not be critical if the model contributes to an understanding of exposure and crash involvement. Examination of Table 2, which presents the Pelz and Schuman data, raises some questions, however. Column 2, which contains the residual crash rates, provides the basis for their conclusion that 18 and 19 year old drivers are overinvolved in crashes after correcting for exposure. If they had used Column 3,[3] however, which merely subtracts the average crashes per driver, they would probably have reached the same conclusion. Thus, either exposure has very little effect on crashes or the Pelz and Schuman approach does not adequately measure the effect of exposure.

METHOD

This study uses several sources of data to provide measures of the total population, the night driving population, and the night crashing population in a medium-sized midwestern county. Of particular interest are alcohol use and driver age among these populations.

The study methodology is simple and straight-forward. Frequency distributions of driver age are compared for crash-involved and noncrash-involved subpopulations in the

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[2] The model was actually fitted by using the Multiple Classification Analysis (MCA) program developed by the Survey Research Center.

[3] The numbers presented in Column 3 are equal to observed crashes minus average crashes for all drivers in the sample. Thus we have a naive, unsophisticated exposure prediction model that merely defines exposure as the average number of crashes.

county driving population. Comparison between crash and noncrash subpopulations indicates which age groups are over- or under-involved in crashes, and under what conditions this involvement occurs.

Drivers who had a single-vehicle crash were included in a crash subpopulation. Drivers for the noncrash subpopulation were randomly selected by an interview team. If both of these processes are random, then the age distributions in each subpopulation should be the same, within the range of sampling error. Differences that are larger than could be attributed to chance indicate that particular age groups are over- or under-involved in crashes. Conversely, lack of such differences indicates that particular levels of crash involvement are consistent with exposure.

The data sources for this study are:

1. A random sample of 748 night drivers in Washtenaw County was interviewed and tested for alcohol using a Breathalyzer (Carlson, Chapman, Clark, Filkins, & Wolfe, 1971). The sample was obtained by stationing a survey team at randomly selected locations along the county roads. A cooperating police officer stopped drivers chosen at random from the traffic passing these locations. Of the drivers selected in this manner, 87.5% agreed to participate. The target population was driver trips made between the hours of 7:00 p.m. and 3:00 a.m. The occurrence of various subgroups in the sample thus provides a measure of their relative exposure, assuming that each trip is a unit of exposure. Drinking drivers were defined as those who had a Blood Alcohol Concentration (BAC) greater than or equal to 0.02%.

2. Crash data for Washtenaw County from January 1968 to June 1971 were obtained from files maintained by the Highway Safety Research Institute. These files contain all crashes investigated by law enforcement departments in the county. In order to minimize the problems of assigning culpability, the data were restricted to single-vehicle crashes that occurred between 7:00 p.m. and 3:00 a.m. (the same hours that the random driver sample was interviewed). Police officers' subjective estimates were used as the basis for alcohol involvement in crashes. Although this measure has been shown to underestimate alcohol involvement in fatal crashes (Filkins, Clark, Rosenblatt, Carlson, Kerlan, & Manson, 1970), I am not aware of comparable results for nonfatal crashes. The assumption in this study is that any bias affects all types of crashes uniformly.[4]

TABLE 3
PROBABILITY DISTRIBUTION OF WASHTENAW COUNTY GROUPS BY AGE

AGE GROUP	POPULATION OVER AGE 15 (1970 CENSUS)	LICENSED DRIVERS	NIGHT DRIVERS WEIGHTED BY TRAFFIC VOLUME			NIGHT SINGLE-VEHICLE CRASH DRIVERS	
			All	BAC≥0.02	BAC≥0.05	All	Alcohol-related
16-17	0.042	0.041	0.047	0.002	0.000	0.089	0.035
18-20	0.165	0.082	0.176	0.074	0.017	0.202	0.139
21-24	0.171	0.165	0.256	0.246	0.245	0.228	0.234
25-29	0.126	0.171	0.162	0.261	0.241	0.152	0.212
30-34	0.082	0.112	0.069	0.049	0.026	0.087	0.119
35-44	0.135	0.167	0.147	0.214	0.263	0.125	0.132
45-54	0.119	0.135	0.090	0.111	0.115	0.074	0.079
55-64	0.081	0.085	0.040	0.043	0.093	0.032	0.041
65 +	0.079	0.042	0.013	0.000	0.000	0.011	0.009
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Number used for estimate	170,987	17,989	748	140	76	2,356	777

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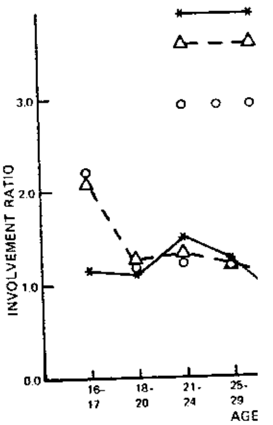

Using these data, tl were tested:

1. Drivers of variou cle crashes at night amount of driving at

2. Drivers of vario cle alcohol-related cr tion to their driving

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RESULTS

Table 3 presents th the subgroups used i expect to find a simi for census and for There are two notal The 18 to 20 age gro

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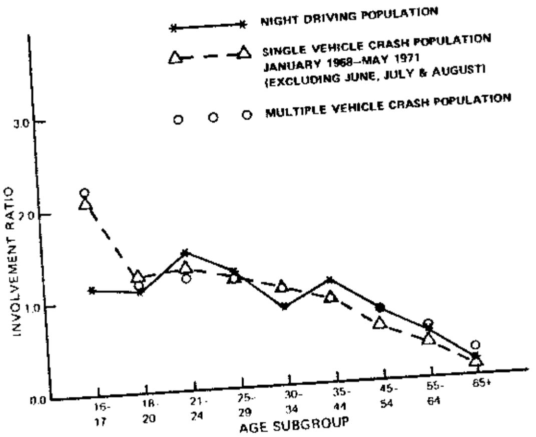
[5] Of the June, July, and A to 19 year old drivers wh the rest of the year in 23.1% of the crashes ov year olds.

FIGURE 1
COMPARISON OF INVOLVEMENT IN NIGHT DRIVING AND CRASH POPULATIONS RELATIVE TO TOTAL POPULATION



Using these data, the following hypotheses were tested:

1. Drivers of various ages have single-vehicle crashes at night in proportion to their amount of driving at night.
2. Drivers of various ages have single-vehicle alcohol-related crashes at night in proportion to their driving after drinking at night.
3. Drivers under age 21 drive after drinking in the same proportion as drivers over age 21.

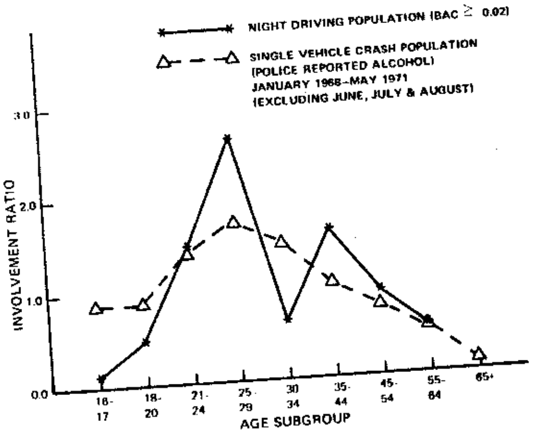
RESULTS

Table 3 presents the distributions by age for the subgroups used in this study. One would expect to find a similarity in age distribution for census and for driver registration data. There are two notable differences, however. The 18 to 20 age group makes up 16.5% of the census population aged 16 and over and only 8.2% of the registered driver population. This probably results from the large number of university students in the Washtenaw County population. Another difference occurs in the 25 to 34 age group—20.8% of the population and 28.3% of the licensed drivers. This may result from the large number of graduate students who establish short-term (two to four years) residences in the community.

Young drivers (21 and below) in this population tended to be either high school or college students. The summer driving population could therefore be different as a result of a number of young persons being absent from the county. Conversely, young drivers might have fewer responsibilities during the summer and do more driving for recreational reasons. In fact, drivers 16 to 19 were involved in a larger proportion of single-vehicle night crashes during the months of June, July, and August than during other months.[5] Therefore, I excluded the June, July, and August crash data when making comparisons by age for the crash versus noncrash populations.

Another important assumption is made in this analysis. The roadside survey took place over a four-week time period, whereas the crash population was drawn from a three-year period. I assumed, therefore, that the distribution of drivers by age did not change over this period. (Changes in total traffic volume would not affect the results; only a change in the dis-

FIGURE 2
COMPARISON OF INVOLVEMENT IN NIGHT DRINKING-DRIVING AND ALCOHOL-RELATED SINGLE-VEHICLE CRASH POPULATIONS RELATIVE TO TOTAL POPULATION



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[4] This could be objected to on the grounds that younger, less experienced drinkers might be more frequently identified as having been drinking. However, we might argue that the characteristics observed by the police officer—incoherent speech, inability to perform simple physical tasks, aggressive behavior, etc.—might be more closely related to crash involvement than is the BAC. In a previous study (Carlson, 1972), a comparison was made between subjective estimates (by nonpolice interviewers) of alcohol use and Breathalyzer readings for randomly selected drivers. The conclusion was that errors were made in both directions so that the proportion of drinking drivers in the group was estimated reasonably accurately.

[5] Of the June, July, and August crashes, 25.2% involved 16 to 19 year old drivers whereas 22.5% of the crashes during the rest of the year involved 16 to 19 year olds. Thus, 23.1% of the crashes over the full year involved 16 to 19 year olds.

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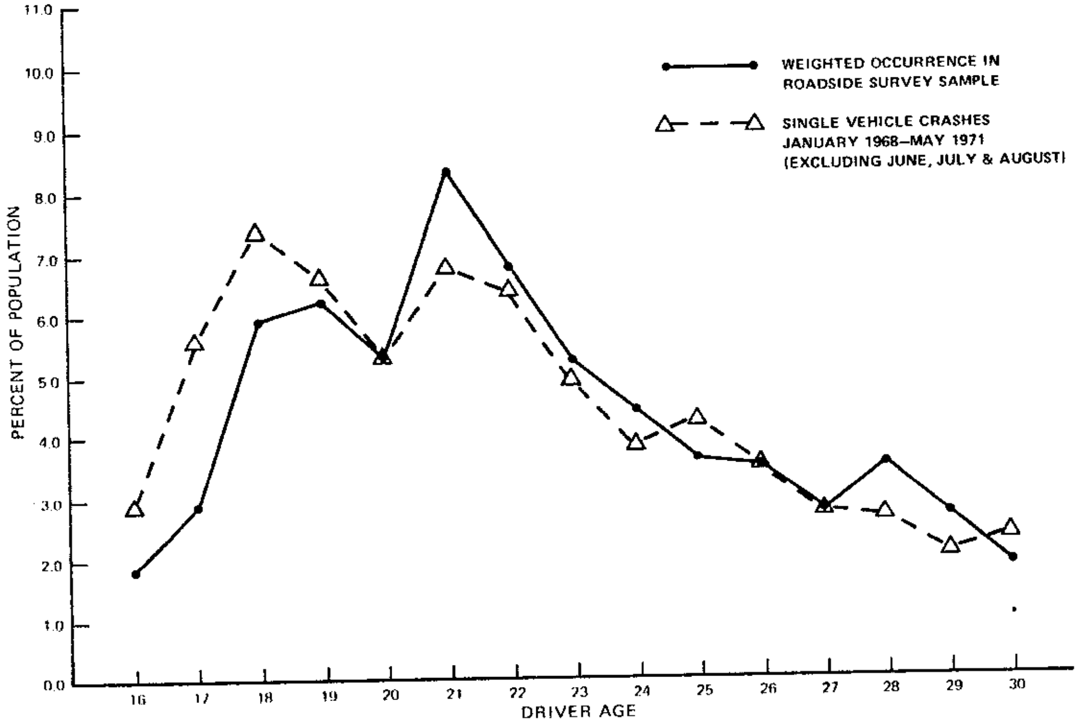
FIGURE 3
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
SINGLE-VEHICLE CRASHES AND IN NONCRASH POPULATION



tribution of drivers by age would have done so.)

Figures 1 and 2 compare the involvement in night driving and night single-vehicle crashes for various driver age groups. Figure 1 presents relative exposure and relative crash involvement by age group.[6]

Thus, if all age groups were equally likely to be driving at night, the "exposure" graph would be a horizontal line at the 1.0 involvement level. Similarly, if all age groups were equally likely to be involved in night single-vehicle crashes, the "crash" graph would be horizontal. Since neither line is, in fact, horizontal, it is apparent that both exposure and crashes are related to age. Drivers under age 21 and aged 25 to 44 drive to much the same extent at night. Drivers 21 to 24 drive at night more than any other age subgroup, and exposure decreases steadily above age 44. With the exception of ages 16 and 17, nighttime single-vehicle crash involvement is consistent with nighttime exposure. For example, drivers 21 to 25 had 22% of the night single-vehicle crashes and did 26% of the night driving. Only 16 and 17 year olds are greatly overinvolved in night single-vehicle crashes compared to exposure, perhaps because of the learning effect. Drivers involved in multiple-vehicle crashes follow the same pattern (Figure 1).[7]

Figure 2 presents a similar analysis for drinking nighttime drivers. The exposure subgroup is derived by dividing the percentage of drivers in a given age group with a Blood Alcohol Concentration (BAC) of 0.02% or greater by the percentage of the County population in that age group (Table 3).[8] The crash group likewise is computed by dividing alcohol-related crash percentage by County population

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[6] Relative exposure was computed by dividing the percentage of all night drivers in a given age group by the percentage of the County population in that age group. Relative crash involvement was computed by dividing the percentage of all night crash drivers in a given age group by the percentage of the County population in that age group. Table 3 data were used in both computations.

[7] Culpable and nonculpable drivers are not separated in the multiple-vehicle data.

[8] Similar results occur when a cutoff of 0.05% BAC is used.

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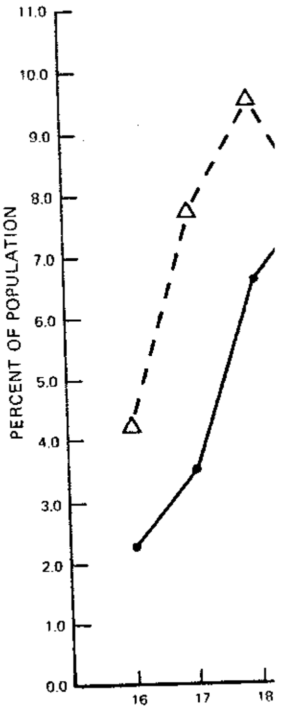

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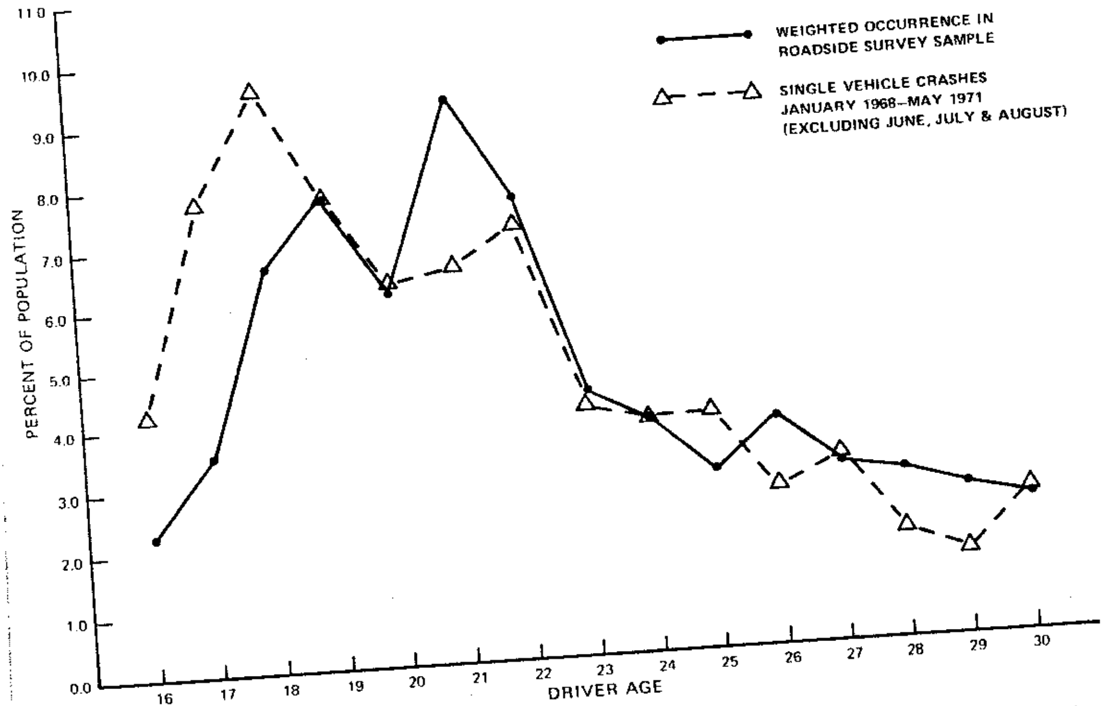
FIGURE 4
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
SINGLE-VEHICLE CRASHES AND IN NONCRASH POPULATION, NONALCOHOL-RELATED



percentage for each age group (Table 3). Alcohol-related crashes were defined as single-vehicle crashes in which the police officer indicated that the driver had been drinking. Figure 2 shows that alcohol-related driving increases through age 29 and decreases for the 30 to 34 age group. Alcohol crash involvement peaks with the 25 to 29 age group and then decreases. Drivers aged 16 to 17 drink very little but have a high involvement in alcohol-related crashes, again suggesting a learning problem. On the other hand, drivers aged 25 to 29 and 35 to 44 have fewer alcohol-related crashes than would be expected from their high level of exposure. This might be explained by more experience with both drinking and driving.

Once these broad age group comparisons had been made, I examined individual age differences in detail, concentrating on ages 16 to 25. Fortunately, the random sample of night drivers was large enough to permit statistical significance tests. Comparison of the injury versus noninjury single-vehicle crashes during this time period showed that drivers 25 and below were involved in 54% of the noninjury crashes and 59% of the injury crashes.

Kolmogorov-Smirnov statistical tests were performed on the data shown in Figures 3 through 10 to determine the probability of the observed differences being due to chance. Figure 3 presents the age distribution for the driving population and for a sample of the driving population.[9] As shown, the proportion of drivers aged 16 to 18 in the crash population (0.159) is larger than the proportion of drivers in the exposure population for the same age group (0.107). The probability is less than .05 (as determined by the K-S test) that a difference of 0.052 could have occurred if the crash and noncrash population have the same distribution by age. This supports the belief that a learning effect is responsible for the difference, since Michigan drivers are licensed at age 16. Also notable is that ages 18 and 21 have the

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[9] In the figures that follow, only the lower portion of the age range is shown, since the distributions do not differ at the higher ages. All significance tests are based upon the entire age range.

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FIGURE 5
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
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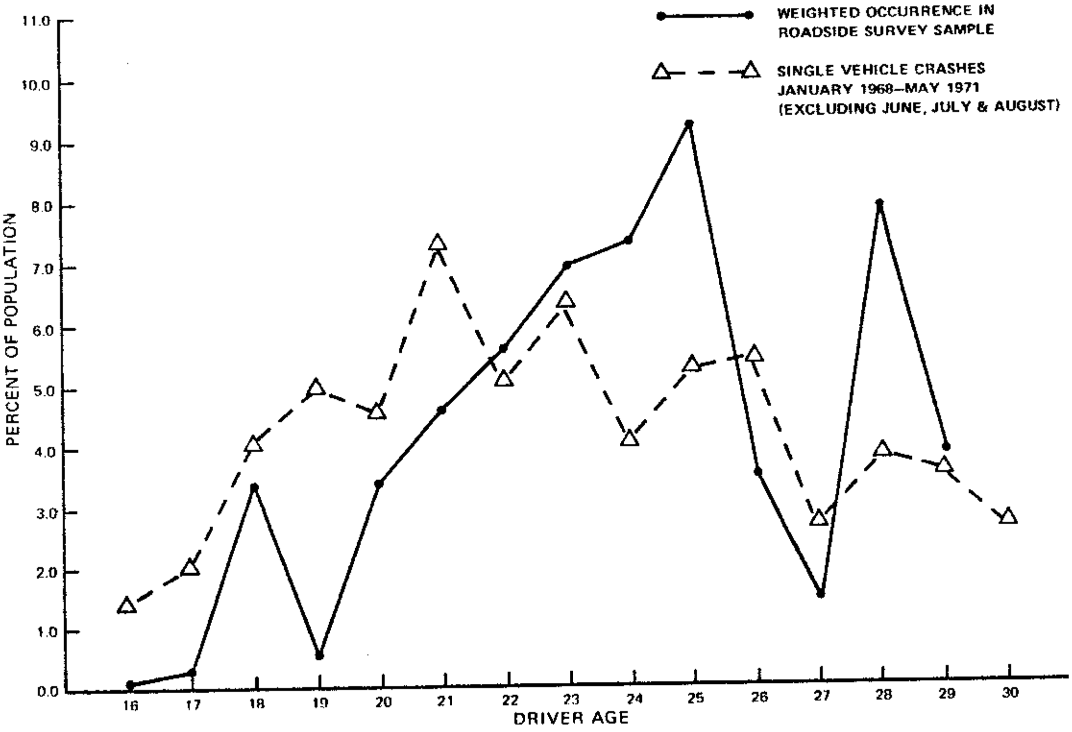

highest occurrence in nighttime single-vehicle crashes. The lower crash occurrence for 20 year old drivers corresponds to a lower occurrence in the driving population. This double peak also occurs in the age distribution of Michigan drivers involved in 1968 and 1969 fatal crashes (O'Day, 1970). O'Day found that the 18 year old peak was associated with nonalcohol reported fatal crashes while the 21 year old peak was associated with drivers reported to be using alcohol.

Since alcohol has previously been found to have a greater effect on young drivers (Carlson, 1972), the drinking and nondrinking crash and noncrash populations were analyzed separately. Alcohol-related crashes were identified by the investigating police officer and thus could be underreported. The drinking driver subpopulation is represented by the sample of drivers ($N = 140$) who had a measured BAC of 0.02%. The nondrinking subpopulation consists of drivers with a BAC of 0.00%. Drivers with a BAC of 0.01% and drivers for whom the police could not determine whether they had been drinking were excluded from these analyses.

Using the logic applied to Figure 3, Figure 4 indicates that nondrinking drivers aged 16 to 18 are significantly overinvolved in single-vehicle crashes compared to the exposure population ($\alpha < .01$). Peak crash involvement occurs at age 18 and decreases steadily from that point.

Figure 5 presents a somewhat different picture. Alcohol-related crashes exceed alcohol-related driving until age 21, with the peak occurrence at age 21. The observed difference has a probability of less than .05 of occurring purely by chance. In addition, alcohol use shows a steady increase through age 25. The double peak in crash occurrence (18 and 21) observed in Figure 3 has thus been partitioned into alcohol- and nonalcohol-related crashes, supporting the conclusion of O'Day. Further, both of these crash peaks follow increases in relative driving exposure. This is again consistent with the hypothesis that specific components of the crash overinvolvement by driv-

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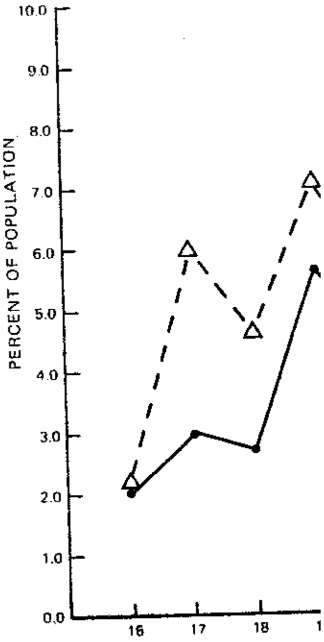

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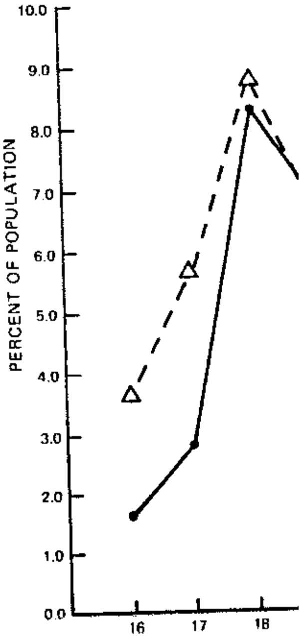

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FIGURE 6
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
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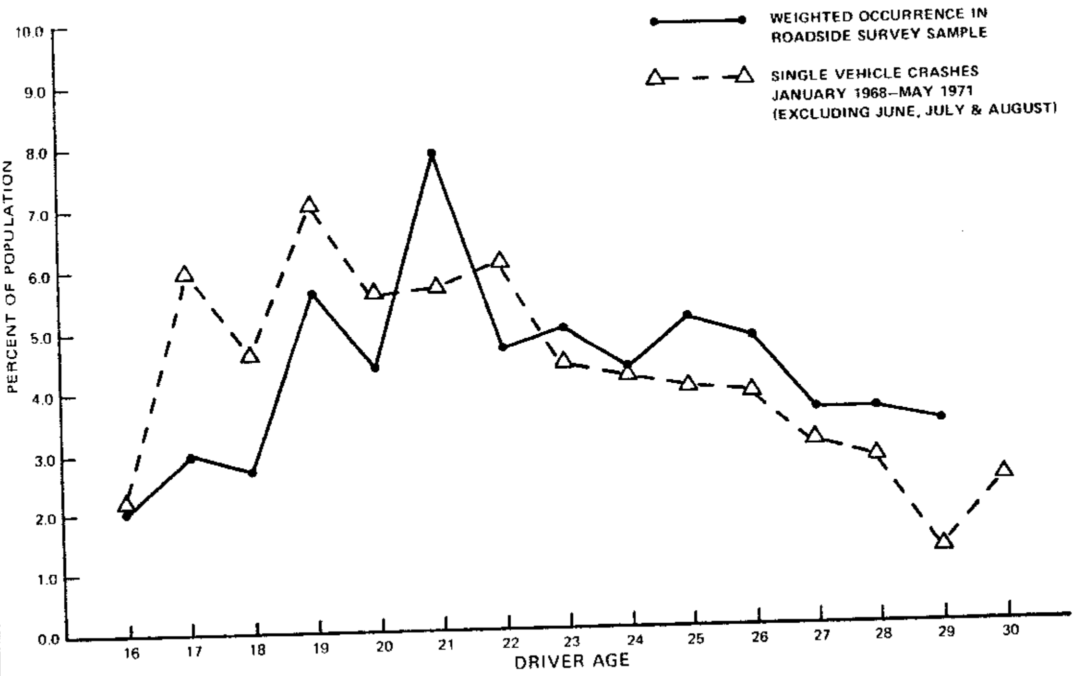

FIGURE 7
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
SINGLE-VEHICLE CRASHES AND IN NONCRASH POPULATION, WEEKEND ONLY

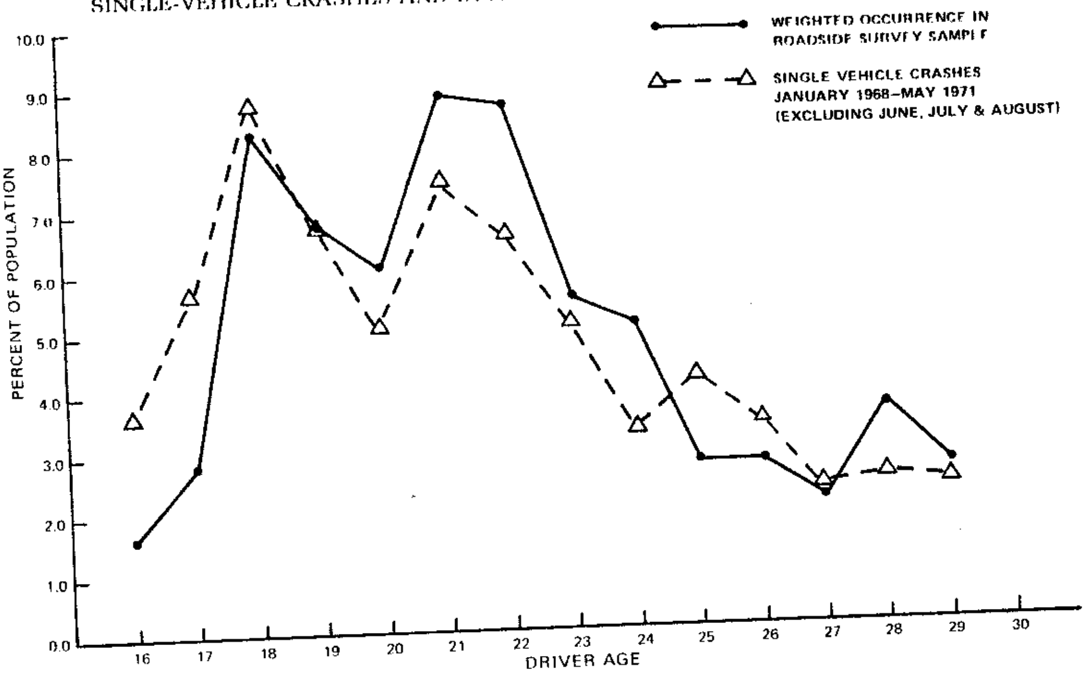

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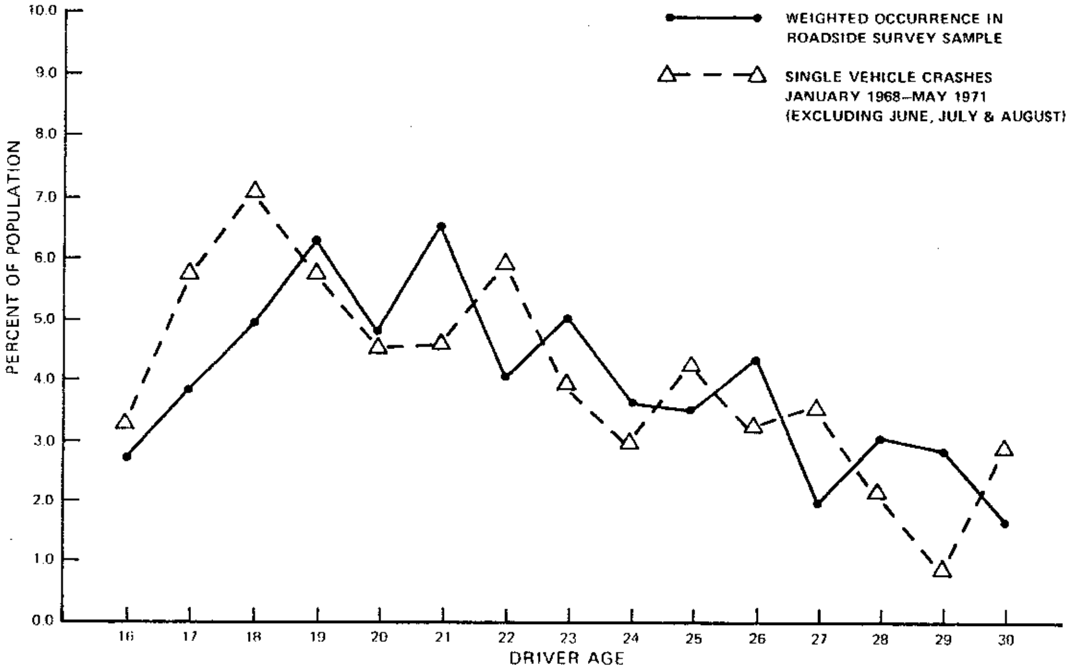
FIGURE 8
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
SINGLE-VEHICLE CRASHES AND IN NONCRASH POPULATION, 7:00 P.M. TO 9:30 P.M.



ers under 25 result from a learning-to-drive period followed by a learning-to-drink-and-drive period.

Figures 6 and 7, which compare weekday and weekend crash and driving involvement, suggest some differences in the time of crash occurrence for drivers of various ages. Drivers through age 20 are overrepresented in weekday single-vehicle crashes, but overrepresentation occurs only up to age 18 for weekend drivers. Drivers through age 24 drive more frequently on weekend nights compared to weekday nights, however. The weekday crash versus exposure pattern appears to resemble the alcohol-related crash pattern shown in Figure 4.

Comparisons of crashes and driving for three nighttime periods (7:00-9:30, 9:31-12:00, 12:01-4:00) are shown in Figures 8, 9, and 10. Drivers 16 to 18 are again overrepresented in crashes during all three time periods, although the only statistically significant difference occurred for the 9:31-12:00 period. Other differences observed in these graphs provide the seeds for interesting speculation, but without making additional assumptions about the data, these differences can not be attributed to anything but chance.

DISCUSSION

This study has two important results. The first is a different method for assessing exposure, that is, using driving trips as the basic unit. Most other studies have used mileage or some function of mileage, because of the assumed capability to measure miles driven and in spite of the shortcomings of mileage as a measure of exposure. If driving is defined as a series of decision and action tasks, then there will be some error due to differences in trip length when trips are used as a measure of exposure. But, if all trips made during a particular time period on a particular set of roads involve a similar number of "important" tasks, this error is, of course, minimized. Similarly, if each mile driven involves the same number of tasks, errors due to different driving environments are minimized.

In this study, a particular time period and road network were used to draw a sample of all driver trips. Based on the results of the study,

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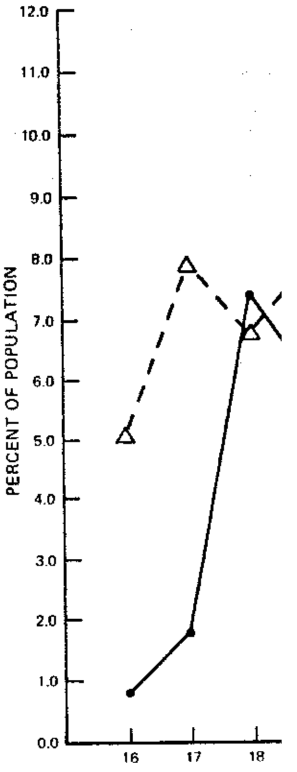

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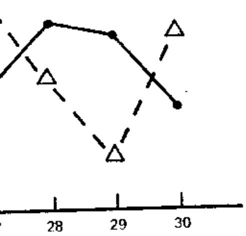

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extension of this method of trip sampling to other time periods and road networks is recommended. This extension should include vehicle and environment stratifying variables. Further study of alternate exposure methods is also needed.

The second result concerns the reasons for the high crash involvement of drivers in the 16 to 25 age group. These young drivers face two learning situations: first, learning to drive and then, a few years later, learning to drive after drinking. The result is crash involvement larger than can be attributed to exposure. Once these learning periods have passed, however, young drivers continue to have larger numbers of crashes than would be expected from their representation in the population. With the exception of these two learning periods, however, the high crash involvement of drivers 16 to 25 corresponds to a high degree of night driving. For example, Figure 3 shows that drivers at each age level from 18 to 25 are found more often in the night driving population than drivers at the age levels above 25. Thus, a major portion of young drivers' high night crash involvement corresponds to high night driving involvement. Since most of this night driving is done for recreational purposes, a relationship between youths' life style and the results of this study is likely. Such a relationship has been suggested by others (Klein, 1968).

Any countermeasures designed to reduce young drivers' crash involvement must therefore include changing automobile use patterns. Merely improving driving skill or attempting to modify "attitude" appears promising only if these qualities can be improved to a level where younger drivers will have fewer crashes—relative to exposure—than do older drivers, who drive less and crash less at night.

This argument raises some fundamental questions about the multiple goals of the highway transportation system (Baker, 1971). The

FIGURE 9
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
SINGLE-VEHICLE CRASHES AND IN NONCRASH POPULATION, 9:31 P.M. TO MIDNIGHT

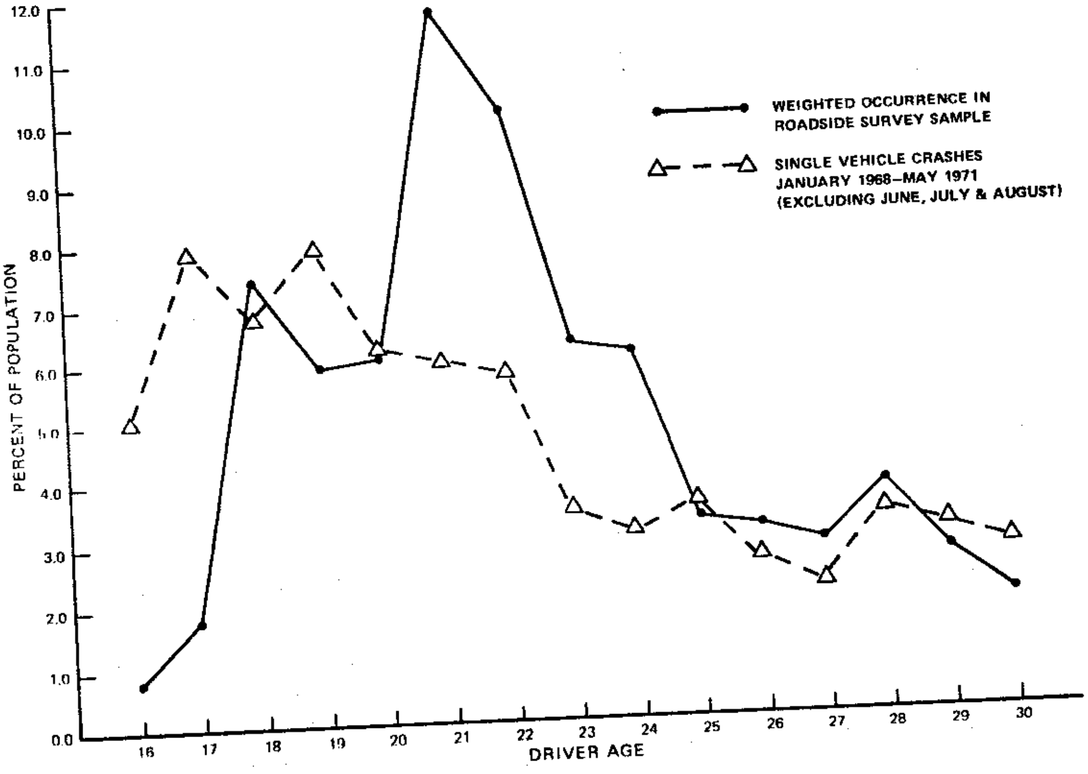

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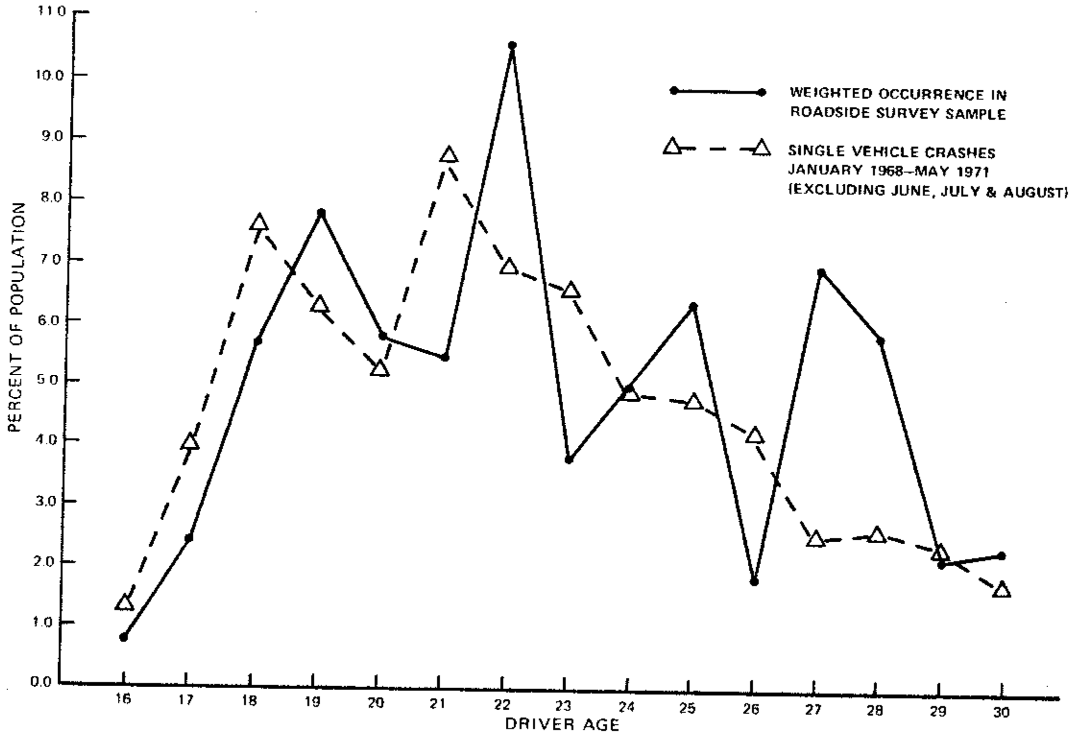
FIGURE 10
DISTRIBUTION OF WASHTENAW COUNTY DRIVERS IN
SINGLE-VEHICLE CRASHES AND IN NONCRASH POPULATION, 12:01 A.M. TO 4:00 A.M.



use of the automobile to attain the nighttime mobility desired by young drivers is quite apparent from this study. The cost in terms of crashes is equally apparent. There are undoubtedly other social costs in terms of alternate uses for the skills and time required to acquire and use an automobile, but these are beyond the scope of this study.

In order to reduce the crash "costs" resulting from these automobile use patterns, it will probably be necessary to reduce nighttime driving. Legal restriction, of course, limits freedom. Education concerning the costs of such driving activity might be a rational approach and might result in a modification of recreational automobile use. It would at least provide an awareness of the costs of pursuing this activity. As long as driving remains an important recreational activity for young drivers, however, and as long as other recreational activities can only be reached by using the automobile, the young driver crash problem will be difficult, if not impossible, to change.

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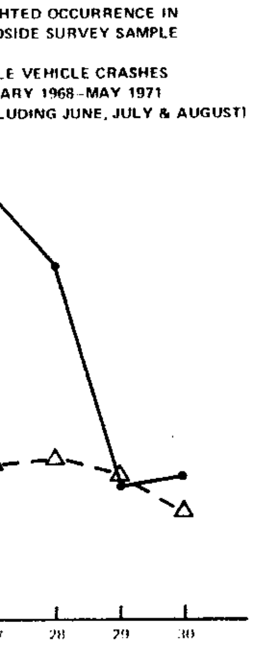

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