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Alcohol-related Accidents and DUIL Arrests in Michigan: 1978-1980

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16. Abstract

Thirteen years (1968-1980) of Michigan accident data and 3 years (1978-1980) of DUIL arrest data were analyzed to assess the impact of first lowering the minimum legal drinking age from 21 to 18 on January 1, 1972 and subsequently raising it back to 21 on December 23, 1978. Both HBD (Had Been Drinking) rates and, for later years, frequencies were used.

The results clearly show that the minimum legal drinking age influences drinking-driving patterns among the affected age group. Alcohol-related accidents increased among 18- to 20-year-old drivers when the legal drinking age was reduced to 18. In non-fatal accidents, both HBD rates and frequencies decreased for drivers aged 18-20 when the legal drinking age was raised. In fatal crashes, both HBD and HNBD frequencies decreased with the increase in the legal drinking age, resulting in no significant change in HBD rate. The affected age group was the only one showing such decreases. Other ages showed increases or no change in HBD frequencies.

Analysis of age cohorts confirmed these findings. Every cohort showed a marked increase in HBD rate when it could first drink legally. There was also a noticeable increase at age 18 among later cohorts, suggesting that a resdiual effect of the lower legal drinking age period persists.

The DUIL arrest data also strongly demonstrate the effect of the increased legal drinking age in 1979. All age groups except 18-20 had more arrests in 1979 than in 1978, while the 18-20 group concurrently had fewer arrests.

An analysis of the accident and arrest data shows that the variability in HBD accidents from county to county is primarily a function of population differences, but that fewer a-r accidents are associated with greater DUIL enforcement. DUIL enforcement indexes for all 83 counties are given for 1978-1980.

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SUMMARY

All accidents occurring in Michigan that were investigated by police agencies and reported on official forms were obtained for the thirteen years from 1968 through 1980. Two subsets of these data were formed, one a 20% sample of all accidents irrespective of accident severity, and the other a census of all fatal accidents. Driver involvements in these accidents, and involvements in alcohol-related accidents, were analyzed by age and by year of occurrence.

Arrest data for DUIL (Driving Under the Influence of Liquor) offenses were also obtained for 1978, 1979, and 1980. For 1978 and 1979, UD-31 breath test report forms were used for those cases in which the DUIL defendant provided a valid breath test, and these forms provided the date, place, and time of arrest, the age of the driver, and the driver's blood alcohol content. For 1980, essentially the same data elements were obtained from Breathalyzer test logs used by the Department of State Police in monitoring its breath-test program. For DUIL defendants who refused to take a breath test for determination of blood alcohol content, breath-test refusal data were obtained for 1978-1980 from the Michigan Department of State.

The accident and DUIL datasets were analyzed both separately and jointly for several purposes. Analysis of the accident data focused on driver involvements in alcohol-related accidents as determined by the HBD (Had Been Drinking) variable recorded on the police accident report form. The specific topics of concern were the changes that occurred among the affected age groups because of the lowered legal drinking age in 1972 and the increased legal drinking age in 1979. The DUIL arrest data were also used to examine the effects on drinking-driving patterns of the increased legal drinking age. Additionally, the effect of the warrantless arrest law (effective August, 1978) was analyzed using the DUIL dataset. For 1978 and 1979, elements of the two data sets were also combined to generate a DUIL enforcement index--the ratio of DUIL arrests to alcohol-related accidents--for the state as a whole, for each of the 83 counties, and for the 56 cities having population of 20,000 or greater. Additionally, regression analyses were performed to investigate the relationship between enforcement and alcohol-related accidents throughout the state.

Determination of the effects on traffic safety of the two changes that occurred in the legal drinking age requires careful analysis and attention to other changes which might alter reported alcohol-related accidents. During the past thirteen years three changes have occurred in reporting practices. From 1968 through 1971 there was a gradual growth in the completeness of the digital files for non-fatal accidents, from about 55% complete in 1968 to 100% complete in 1972 and subsequent years; fatal accidents, however, were complete from 1968 (and earlier) on. In 1971, the way in which alcohol involvement is recorded on the accident-report form was changed. In 1974 FARS (Fatal Accident Reporting System) was introduced, and this reduced the missing data on the HBD variable, with the result that an artifactual increase in the frequencies of alcohol-related accidents occurred. These early changes in reporting practices largely were accounted for by the analytical techniques employed, and the changes do not affect the data in the later years. In addition, there have been changes in the larger context which influence drinking patterns and driving patterns, both singly and in combination. One can cite the energy crisis of the mid-1970's and the recent economic downturn. These perturbations, of course, preclude simple before-after comparisons of only the affected age groups in the analytical and inferential work, but they cannot in any sense be used to dismiss the findings out of hand.

The combined results of the analytical work on the accident and DUIL datasets clearly and unequivocally demonstrate that the legal drinking age influences drinking-driving patterns among younger drivers. Drivers aged 18-20 in the 20% sample accident data had statistically significant increases in their involvement in alcohol-related accidents when the legal drinking age was reduced, and significant reductions when the legal drinking age was increased. In fatal accidents, these drivers had significant increases--in both HBD rates and frequencies--when the drinking age was reduced. The subsequent reduction in HBD rate found in the 20% sample data (when the age was increased) was not duplicated in the fatal data. However, a reduction in the frequencies of HBD involvements among the 18- to 20-year-old drivers did occur; the 5-year average (1974-1978) of 179 HBD involvements in fatal accidents decreased to an average of 162 in 1979-1980, a 9.7% reduction. This reduction occurred at the same time that all other drivers experienced an 11.9% increase in their fatal HBD involvements, from an average of 676 in the 1974-1978 period to 757 in 1979-1980.

Similar results hold in the 20% sample data. The 18- to 20-year-old drivers experienced an 18% decrease in HBD frequencies, from an average of 2168 per year in the 1974-1978 period to 1783 in 1979-1980. Other ages showed increases. All other ages combined increased 9% from an average of 8774 per year to an average of 9539 per year.

It should be noted that HBD frequencies and rates for 18- to 20-year-old drivers are still higher than they were prior to the lower legal drinking age law effective in 1972. Thus, while the increased legal drinking age has reduced the HBD rate for the 18-20 age group, the rate has not returned to its pre-1972 level.

HBD rates for several cohorts of drivers were also analyzed. (The cohorts of interest here, for example, are those drivers who were age 16 in 1976, age 17 in 1977, etc.) Without exception, the HBD rates for every cohort that could be analyzed increased sharply in the year in which the cohort was legally enfranchised to drink. This occurred whether the legal drinking age at the time of enfranchisement was 18 or 21. Further, the increases at the year the cohort could drink legally occurred in both the fatal dataset and in the 20% sample dataset. The later cohorts also show increases at age 18 as well as at age 21 (legal drinking). This suggests that the effect of the lower legal drinking-age law still persists to some extent.

Analysis of the DUIL arrest data also demonstrates clearly that the recently increased legal drinking age altered drinking-driving practices among the affected drivers. The 18-, 19-, and 20-year-old drivers, whether considered singly or as a group, consistently showed fewer arrests in 1979 than in 1978. Drivers of all other ages, specifically including those just slightly younger and older, experienced more arrests in 1979 than in 1978.

Analysis of the accident data revealed wide differences in HBD rates throughout the state. The proportion of alcohol-related accidents among the counties varies by more than 3:1, with 44% in Keweenaw County (the highest), to 12% in Kent and Ottawa Counties (the lowest). The DUIL enforcement index shows even wider variations, varying from 1.07 in Gladwin County to 0.06 in Benzie County, an 18:1 ratio. The widespread differences in both the proportion of HBD accidents and in the DUIL enforcement index need to be studied to understand why such differences exist and to determine what countermeasure implications hold.

1. INTRODUCTION

This is the final report of a project sponsored by Michigan's Office of Highway Safety Planning entitled "Drinking Driver Analysis." Results of the work conducted from April 1, 1979 - June 30, 1982 are presented.

The first interim report [1] dealt exclusively with analysis of nine years (1968-1976) of Michigan's fatal accident experience.[1] The second interim report [2] extended the work in several important respects. First, accidents for 1977-1979 were added to the database, so that twelve years of accident experience were available for analysis. Second, non-fatal accidents, in addition to fatal accidents, were analyzed. A 20% random sample of all Michigan accidents was used for this purpose. Third, DUIL (Driving Under the Influence of Liquor) arrest data were obtained for 1978 and 1979, and the results of analyzing those data were presented. Finally, exploratory research was undertaken in connection with the conception and formulation of a DUIL enforcement index, intended to assist policy makers and program planners in the efficient allocation of limited enforcement resources.

In the final year of the project, both fatal and sample data for 1980 were added to the accident database. Arrest data for another year, also 1980, were added to the DUIL database as well. Thus thirteen years of accident data--1968-1980--and three years of arrest data--1978-1980--became available and have been analyzed during the course of the project. The analytical work presented in the interim report is still valid, of course, since the data for 1968-1979 have not changed. In order to make this final report as complete and self-contained as possible, however, much of the work for those years is repeated here. Additional work focussing on 1980 is included and is integrated into the earlier analyses.

The general impetus for the present work remains the same as for much of the prior research: alcohol continues to be the factor most frequently cited as causing traffic accidents, and the strength of the association becomes stronger as accident severity increases. Increased knowledge about the phenomenon, and about arrest activity to deal with it, should eventually lead

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[1] Numbers in brackets [ ] refer to References at end of report.

to more effective countermeasures. The specific focus of the present work, and certainly a valid reason in itself for undertaking this study, is understanding the influence of the minimum legal drinking age on traffic safety.

The effect of the legal drinking age on traffic safety has been a topic of much attention and concern for the last decade, both in Michigan and elsewhere. In Michigan, the discussion has arisen primarily in the context of changes--and proposed changes--in the legal drinking age during the past few years. Before presenting analyses of the accident data (Section 2) and the DUIL arrest data (Section 3), a review of changes in the legal drinking age during the last decade is in order.

1.1 Changes in Michigan's Legal Drinking Age

Michigan's legal drinking age for all alcoholic beverages had been 21 since 1937 until it was reduced to 18, effective January 1, 1972. This reduction was consistent with a nationwide revision of the age of majority from 21 to 18 and with the Twenty-Sixth Amendment to the U.S. Constitution (approved July 5, 1971) establishing the voting age in all federal elections at 18. Michigan was one of some two dozen states that reduced its legal drinking age from 21 to 18 along with the age of majority package.[1]

The legal drinking age remained at 18 until 1978 when, by legislative action, it was increased to age 19 effective December 3, 1978.[2] This action was shortly superseded, however, by an amendment to the Michigan constitution. By popular initiative a proposition was placed on the ballot to amend the constitution to make age 21 the new legal drinking age. This proposition was approved by the electorate at the November 7, 1978 general election and became effective December 23, 1978.[3]

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[1] Act No. 79, Public Acts of 1971.

[2] Act No. 94, Public Acts of 1978.

[3] Of 5,230,345 registered voters in November, 1978, 2,818,086 (53.9%) cast valid votes on Proposition D. "Yes" votes, favoring the raised legal drinking age of 21, numbered 1,609,589, 57.1% of the votes cast. Source: Elections Division, Michigan Department of State.

Two other legal actions should be included in this brief review. In two different court cases (subsequently heard together), a group of individuals within the affected age group, their parents, and liquor licensees, challenged the constitutionality of the 1978 amendment. The cases were heard in the U.S. District Court, Eastern District of Michigan, Southern Division. The Honorable Ralph B. Guy, Jr., in his opinion dated December 22, 1978, concluded that the plaintiffs "... failed to carry their burden of proof ..." of unconstitutionality and therefore denied the request for injunctive relief to prohibit the amendment from taking effect.

Recently another attempt was made to amend the Michigan Constitution, this time lowering the legal drinking age from 21 to 19. The issue was placed before the electorate at the November 4, 1980 general election, in this instance by legislative action.[1] The voters again preferred the higher age of 21, with 61.6% favoring the higher age.[2]

1.2 Prior Research

The effect of the earlier decrease in Michigan's legal drinking age--from 21 to 18, effective January 1, 1972--has been particularly well analyzed and reported [3-6]. The research, which we consider to be thorough and in accord with modern design and analysis techniques, has produced consistent findings: the 1972 decrease in the legal drinking age from 21 to 18 resulted in an increase in alcohol-related accidents among the affected age group. Wagenaar and Douglass [7] and Wagenaar [8-10] have reported statistically significant reductions among 18- to 20-year-old drivers in non-fatal, alcohol-related accidents following the December, 1978 increase in the legal drinking age. The analysis in Section 2 supports these findings.

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[1] ENROLLED HOUSE JOINT RESOLUTION S, State of Michigan, 80th Legislature, Regular Session of 1980, Filed with the Secretary of State July 16, 1980.

[2] Registered voters in October, 1980 numbered 5,725,713. "Yes" plus "No" votes totalled 3,654,808, 63.8% of the eligible voters. "No" votes on this Proposition B, that is those favoring retention of the 21-year-old legal drinking age, totalled 2,250,873, 61.6% of the votes cast. Source: Elections Division, Michigan Department of State.

Nonetheless, there seems to exist considerable skepticism among public officials whether the legal drinking age influences drinking and driving behavior among younger drivers. Some of this may arise because the relevant research has not been circulated adequately or presented in the proper forums. Some of the apparent skepticism may merely reflect the fact that the findings are contrary to previously established and strongly held positions. There is also criticism--which we share only in part--of the use of the Had Been Drinking variable on accident reports and the research findings that can be inferred from it.

The latter criticism is not, of course, relevant to the analysis of DUIL arrests presented in Section 3. A DUIL arrest, which then generally leads to a breath test, is initiated by an officer at an accident or by observing an unsafe or illegal driving behavior. Consistently high blood alcohol concentrations usually are found. The average BAC of arrested and tested drivers in this dataset is above 0.17% W/V, and only 3.5% of these drivers are under the legally impaired limit of 0.08% W/V. These results strongly indicate that police officers are not making ill-advised or capricious arrests. DUIL arrests, therefore, provide an alternative measure of drunken driving to the HBD variable utilized in analyses of accidents in other studies.

2. FATAL AND 20% SAMPLE ACCIDENT DATA

In this section we analyze two sets of accident data. The first, denoted "fatals," is the set of all drivers involved in all fatal accidents in Michigan during the years 1968 through 1980. The second, denoted the "20% sample," is a twenty-percent sample of drivers involved in any police-reported accident in Michigan during these years. (The sample is a 20% systematic sample with a random start within each year of accident data.) Some of the early years of the 20% sample were subject to some under-reporting from some jurisdictions. This has been discussed previously [3]. The effect of this underreporting on the rates, however, has been small. In any event, the current emphasis is on changes in accident occurrence coincident with the recent law change. Both sets of these police-reported data are complete for the most recent years.

For each set of data, the age-specific rates of alcohol involvement of drivers have been analyzed. The rates--the ratio of Had Been Drinking drivers to Had Been Drinking plus Had Not Been Drinking drivers--are denoted HBD rates. For accidents occurring each year, these age-specific rates have been compared. The chi-squared test has been used to judge whether variability of HBD rates exceeds random variation. The overall chi-squared statistic has also been partitioned into components, each of which is associated with a comparison of particular years.

For easy reference, the partitions for the 1968-1979 analyses are numbered as shown in Figure 1. In the figure, the arrows above each number indicate the years that are compared by the partition denoted by that number. Table 1 lists all of the partitions by number. However, it may be worthwhile to highlight some of the more important partitions.

Partition 1 compares the average rate during the years 1968 to 1971 with the average rate from 1972 through 1979. This corresponds to the lowering of the legal drinking age from 21 to 18 on January 1, 1972. Partition 2 compares the average rate of HBD in the years 1976 through 1978 with the rate in 1979. This corresponds to the raising of the legal drinking age from 18 to 19 (on December 3, 1978) and from 19 to 21 (on December 23, 1978). There is an implicit assumption that the annual rates would not differ much if the last

Figure 1

Identification of Partitions by Years for Chi-squared Analysis

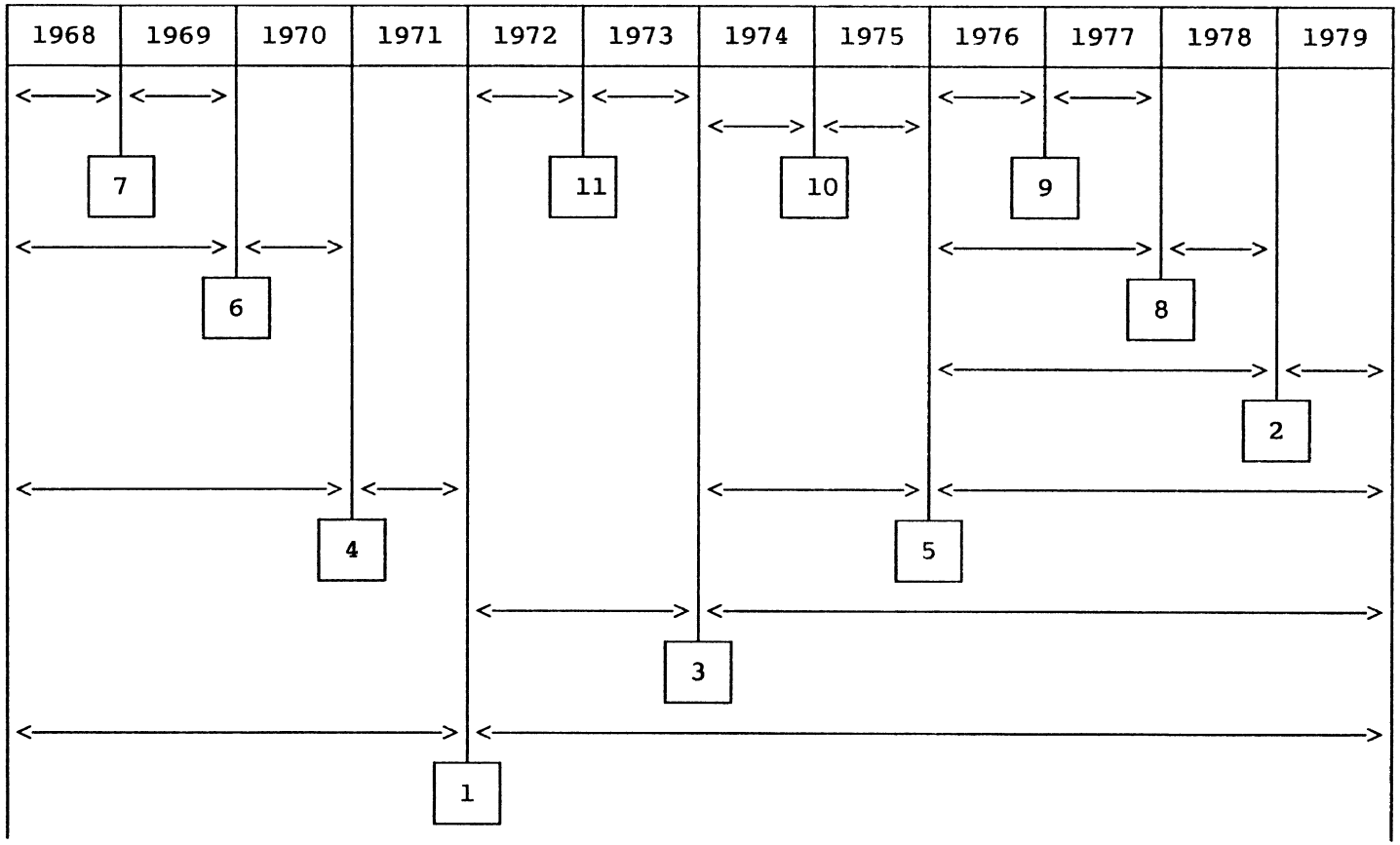

Table 1

List of Partitions

Partition Number	Years	Events or External Criteria
1	1968-1971 1972-1979	Corresponds to lowering of the legal drinking age
2	1976-1978 1979	Corresponds to raising the legal drinking age
3	1972-1973 1974-1979	Corresponds to FARS introduction, also an energy crisis and recession
4	1968-1970 1971	Corresponds to a change in reporting form
5	1974-1975 1976-1979	Compares the energy crisis with more recent years
6	1968-1969 1970	No external criteria
7	1968 1969	No external criteria
8	1976-1977 1978	No external criteria
9	1976 1977	No external criteria
10	1974 1975	No external criteria
11	1972 1973	No external criteria

few days of 1978 are treated as though the legal drinking age remained at 18. Partition 3 corresponds to the introduction of the FARS (Fatal Accident Reporting System) and compares the average HBD rate in 1972 and 1973 with that

during 1974-1979.[1] Partition 4, which compares the average HBD rate during 1968 through 1970 with the rate in 1971, corresponds to a change in the police accident data form. There are few other external criteria, although it is to be noted that the energy crisis and recession of 1974 corresponds with the introduction of FARS.

2.1 Analysis of the 1968-1979 Fatal Accident Data

Table 2 summarizes the significant partitions in the fatal data. In each case, the rates reported are HBD/(HBD+HNBD), where HNBD identifies the Had Not Been Drinking frequencies; these rates, therefore, exclude missing data on the HBD variable. Changes were judged significant at an age-group-wise 5% level, comparing the eleven partitions within a given age or age group. The partitioned chi-squared statistics were compared to 8.06 as the critical value for determining this group-wise significance rate, where the critical value was found using Bonferroni's method.

The most frequent significant partition was the partition that corresponds with the lowering of the legal drinking age in 1972. The HBD rates increased significantly at that time for ages 17, 18, 19, and 20, and for the groups 15-17, 18-20, 21-23, 24-26, 35-39, 45-49, and "All ages." This partition had the largest sample sizes. The next most frequent significant change occurred with the introduction of FARS in 1974. Ages 16, 19, 21, and groups 15-17, 18-20, 21-23, and "All ages" showed significant increases in the HBD rates corresponding to this partition. A few other partitions showed significant changes. There was a significant increase from 1972 to 1973 among the 26-year-old drivers and a significant increase from 1976-77 to 1978 for the 34-year-old drivers. The 18-20, 21-23, and 24-26 year-old groups showed a significant decrease in HBD rate from 1968-1969 to 1970, as did all ages combined. Finally, all ages combined showed a significant increase in the HBD rate comparing 1976-1978 with 1979. Thus, while non-significant changes occurred in the HBD rates for individual ages and for the three-year age groups, for all ages combined there was an increase in HBD rate among fatal

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[1]The missing-data rate on the HBD variable exceeded 20% for 1968-1970 and was about 11% for 1971-1973. Following the introduction of FARS, the missing-data rate dropped to 1.2% in 1974 and has fluctuated around 2% since. As reported in [1], there is evidence that drinking involvement is somewhat higher among missing cases than among reported cases.

Table 2

Summary of Significant Partitions: Fatal Data

Age Group	Partition	Change in HBD Rate
16	1972-1973 vs. 1974-1979	.1314 to .2455
17	1968-1971 vs. 1972-1979	.1569 to .2747
18	1968-1971 vs. 1972-1979	.2290 to .3959
19	1968-1971 vs. 1972-1979	.2680 to .4363
	1972-1973 vs. 1974-1979	.3452 to .4673
20	1968-1971 vs. 1972-1979	.2730 to .4333
21	1972-1973 vs. 1974-1979	.3302 to .5000
26	1972 vs. 1973	.2364 to .4933
34	1976-1977 vs. 1978	.2644 to .5091
35-39	1968-1971 vs. 1972-1979	.2807 to .3480
45-49	1968-1971 vs. 1972-1979	.2278 to .3108
15-17	1968-1971 vs. 1972-1979	.1454 to .2438
	1972-1973 vs. 1974-1979	.1723 to .2702
18-20	1968-1971 vs. 1972-1979	.2546 to .4214
	1968-1969 vs. 1970	.2838 to .1868
	1972-1973 vs. 1974-1975	.3476 to .4455
21-23	1968-1971 vs. 1972-1979	.3851 to .4521
	1968-1969 vs. 1970	.4346 to .3082
	1972-1973 vs. 1974-1979	.3595 to .4803
24-26	1968-1971 vs. 1972-1979	.3579 to .4179
	1968-1969 vs. 1970	.4273 to .2656
All ages	1968-1971 vs. 1972-1979	.2770 to .3437
	1968-1970 vs. 1970	.3054 to .2270
	1972-1973 vs. 1974-1979	.2997 to .3591
	1976-1978 vs. 1979	.3507 to .3886

drivers in 1979. This general pattern of increase may have obscured any decrease or lack of change in HBD rate in the 18- to 20-year-old drivers, who could no longer drink legally in 1979.

Table 3 gives the direction of changes for all partitions and all ages, with "*" denoting those that were statistically significant. There was a substantial reduction in missing data with the introduction of FARS in 1974. As reported in [1], this appears to have acted to increase the reported HBD rates. Some of the increases in HBD rates corresponding to the lowering of the legal drinking age may be due in part to the fact that the average HBD rate from 1968 to 1971 is compared with the average rate from 1972 on, and this latter rate is somewhat increased as a result of the reduction in missing data.

For this study the primary question is what happened to the HBD rates in 1979 when the legal drinking age was increased to 21. This corresponds to partition number two. As summarized in Table 3, all of the changes in HBD rates in the fatal data corresponding to partition 2 were non-significant, but most of the age groups showed increases in HBD rates in 1979. Over all ages the HBD rate increased significantly in 1979. Among drivers affected by the law change, the rate decreased only for the 18-year-old drivers. However, the HBD rate also decreased for 21-, 22-, and 25-year-olds among younger drivers, but all of these changes were non-significant.

It should be noted that although the HBD rates among the 18- to 20-year-old drivers involved in fatal crashes did not change much in 1979 relative to their earlier levels, the <u>frequency</u> of both HBD and HNBD involvements decreased. The frequency data for this age group, together with comparable data for other age groups, are given in Table 4.

It can be seen that the 15-17, 24-26, and "27 and older" groups all show the same general pattern. The 1979 HBD frequencies are higher than the earlier years, but the HNBD frequencies are lower. Significance at $p=0.05$ is achieved for the HNBD reductions among the two younger age groups and for the HBD increase among the 27 and older drivers.

The 18-20 and 21-23 groups differ from the three above and from each other as well. Among the 21-23 group the changes are small and non-significant. In contrast, the 18-20 drivers experienced a 10.5% reduction in

Table 3

Summary of Changes in Fatal HBD Rates

Age Group	Partition Number										
	1	2	3	4	5	6	7	8	9	10	11
0-15	+	+	+	+	-	0	0	+	+	+	+
16	+	+	+*	+	+	+	+	-	-	+	-
17	+*	+	+	-	+	-	+	+	+	+	-
18	+*	-	+	+	-	+	-	-	-	+	-
19	+*	+	+*	+	-	-	-	-	-	+	+
20	+*	+	+	-	+	-	+	+	-	-	+
21	+	-	+*	+	-	-	-	-	-	+	+
22	+	-	+	+	+	-	-	+	-	+	+
23	+	+	+	-	-	-	+	+	-	-	+
24	+	+	+	-	+	-	+	+	+	-	-
25	+	-	+	-	+	-	+	-	-	-	-
26	+	+	+	-	-	-	+	+	+	+	+
27	+	+	+	+	+	-	+	-	-	-	-
28	+	-	+	+	+	-	-	-	+	+	-
29	+	+	+	-	+	-	+	+	-	-	-
30	-	+	-	-	-	-	0	-	+	-	-
31	+	+	+	0	+	-	-	+	-	+	+
32	+	+	+	+	-	-	+	+	+	+	+
33	+	-	-	+	-	-	-	-	+	-	-
34	-	+	+	+	+	-	-	+	+	+	+*
35-39	+*	+	+	+	-	-	-	+	+	+	+
40-44	+	-	-	-	+	-	+	-	-	-	-
45-49	+*	-	+	-	+	-	-	-	-	+	+
50-54	+	+	+	+	-	-	-	-	+	-	+
55-59	-	0	-	+	+	-	+	0	+	+	+
60-64	-	+	-	+	-	-	+	-	-	+	+
65+	+	+	+	-	-	-	+	+	+	-	-
15-17	+*	+	+*	+	+	-	+	-	+	+	-
18-20	+*	+	+*	+	+	-*	+	+	-	+	+
21-23	+*	-	+*	+	-	-*	-	+	-	+	+
24-26	+*	+	+	-	+	-*	+	+	+	-	+
All	+*	+*	+*	+	+	-*	-	-	+	+	+

The "+" indicates that the rate increased in the latter period, "-" that the rate decreased, and "0" that the rates were the same to three decimals. The "*" denotes that the change was statistically significant at the row-wise simultaneous 5% level (chi-squared exceeded 8.07). Partitions are diagrammed in Figure 1 and listed in Table 1.

Table 4

HBD and HNBD Frequencies by Age Group
1974-1978 Mean and 1979

Age Group	Variable	1974-78 (Mean)	1979	% Change	*Signif.
15-17	HBD	49.2	55	+11.8	No
	HNBD	140.4	111	-20.9	Yes
18-20	HBD	178.8	160	-10.5	No
	HNBD	225.0	187	-16.9	Yes
21-23	HBD	144.8	142	-2.9	No
	HNBD	155.4	160	+3.0	No
24-26	HBD	98.6	106	+7.5	No
	HNBD	136.2	113	-17.0	Yes
27 and older	HBD	386.2	458	+18.6	Yes
	HNBD	912.4	878	-3.7	No
All excl. 18-20	HBD	678.8	761	+12.1	Yes
	HNBD	1344.4	1262	-6.0	Yes

*The statistical tests assume that the frequencies follow a Poisson distribution. Significance is indicated at p=0.05 (two-tailed test) using a normal approximation.

HBD frequencies in 1979 compared to the earlier years, and a 16.9% reduction in the HNBD frequencies. The HBD reduction is not significant at the 5% level, but the associated two-sided probability is 0.18, indicating that a reduction of this size is likely to occur by chance only about one in five times. As indicated in the table, the HNBD reduction is significant at the 5% level.

The last two entries in Table 4 provide the data for all drivers combined except for those aged 18-20. For this group a statistically significant increase in HBD involvements occurred in 1979, and a significant decrease

occurred in HNBD involvements. The HNBD change is in the same direction as for the 18-20 group, but the increase in HBD's is opposite to the reduction in HBD's for the 18-20 group.

Considered together, these findings indicate that the fatal accident experience of the 18- to 20-year-old drivers is consistent with a reduction in alcohol-related crashes associated with the increased legal drinking age in 1979. But it is also clear that other factors are operative which have reduced the HNBD experience as well. The concurrent reductions in both HBD and HNBD frequencies resulted in little change in the HBD rate of the affected age group in the first year of the higher legal drinking age. The trends noted here should be monitored for several years so that the steady-state effect of the law change can be established after the transient effects have dissipated.

2.2 Analysis of the 1968-1979 20% Sample Accident Data

The same approach to partitioning the chi-squared statistic into its eleven degrees of freedom was used on data from the 20% sample of all reported accidents. Some general features of these data differ from the fatal data. First of all, there are many more accidents than fatal accidents, so that the frequencies that these rates are based on are much larger, even when only a 20% sample is used rather than all of the accidents. Secondly, the HBD rates are much lower in the 20% sample data than they are in the fatal data. The HBD rates in the 20% sample are on the order of 10%, ranging roughly from 5% to 15%, whereas they ranged from about 20% to 45% for most groups in the fatal data.

Because of the much larger sample sizes, many more of the partitions were significant in the 20% data than were significant in the fatal data. Table 5 summarizes the directions of the changes corresponding to all the partitions and all of the age groups. The partition numbers are the same as for the fatal data and were presented in Table 1. Again, a "+" denotes an increase in the later years, a "-" denotes a decrease, and a "0" denotes that the rates were unchanged to three decimals. The significant changes are denoted by "*".

Table 6 summarizes all of the significant partitions, giving for each age group, the year groupings compared and the change in average HBD rate corresponding to that partition. While the significant partitions are too

Table 5

Summary of Changes in 20% Sample HBD Rates

Age Group	Partition Number										
	1	2	3	4	5	6	7	8	9	10	11
0-15	+	-	+	-	-	+	-	-	+	-	-
16	+*	-	+*	+	+	+	0	-	-	+	-
17	+*	-	+*	-	+	+	0	-	-	+*	+
18	+*	-*	+*	-	+	0	-	-	+	+	0
19	+*	-*	+*	-	+	-	+	-	-	+*	-
20	+*	-*	+*	-*	+	-	+	+	-	+*	+
21	-	+*	+*	-*	+	-*	-*	+	+	+	+
22	-*	+*	+*	-*	+	-*	0	-	-	+*	-
23	-	+	+*	-	+	-*	-	-	+	-	+
24	-*	+*	+*	-	+	-*	-	+	-	+	+
25	-*	+	+*	-	+	-*	+	0	+	+	+
26	-*	+	+	-	-	-*	+	0	+	+	-
27	-*	+	+*	-	+	-*	-	+	+	+	-
28	-*	+	+	-	-	-*	+	+	+	+	-
29	-*	+	+	-	-	-*	-	-	-	+	+
30	-*	+	+	-	-*	-	-	+	-	-	-
31	-*	+	+	-	-	-	+	+	-	-	-
32	-*	+*	+	-	-	-	-	-	+	-	-
33	-*	+	-	-	-	-	-	-	+	+	-
34	-	+	-	-	-*	-	-	0	-	-	-
35-39	-*	+	-*	-	-*	-*	+	-	-	-	-
40-44	-*	0	-*	-	-*	-*	+	-	-	0	-
45-49	-	+	-	-	-*	-*	+	-	-	+	+
50-54	-	0	-*	-	-*	-	-	-	-	0	0
55-59	-*	-	-	-	-	-	+	+	+	0	-
60-64	-	+	-	-	-	-	-	-	-	+	-
65+	-*	+	-	-	-	-	-	-	+	-	+
15-17	+*	-	+*	-	+	+	-	-*	-	+	+
18-20	+*	-*	+*	-	+	-	+	-	-	+*	+
21-23	-*	+*	+*	-*	+*	-*	-	-	+	+	+
24-26	-*	+*	+*	-*	+	-*	-	+	-	+	+
All	+	+*	+*	-*	-*	-*	-	-	-	+*	-

The "+" indicates that the rate increased in the latter period, "-" that the rate decreased, and "0" that the rates were the same to three decimals. The "*" denotes that the change was statistically significant at the row-wise simultaneous 5% level (chi-squared exceeded 8.07). Partitions are diagrammed in Figure 1 and listed in Table 1.

numerous to detail, certain common patterns occur. A significant increase in HBD rate occurred corresponding to the lowering of the legal drinking age for ages under 21 and only for those ages. This agrees with the findings from the fatal data. For many of the ages over 21, a significantly low HBD rate occurred in 1970.

The raising of the legal drinking age in 1979 corresponds to a significant drop in the HBD rate for ages 18, 19, 20, while a significant increase in the HBD rate occurred at this time for many of the older age groups, specifically, ages 21, 22, 24, 32, 21-23, 24-25, and all ages. Thus, when the legal drinking age was raised, significant reductions in the HBD rates for the 18-20 year old drivers were observed, while at the same time significant increases in the HBD rates were observed for the slightly older drivers. Various interpretations are possible. The fact that the HBD rate for 18- to 20-year-old drivers decreased significantly when the drinking age was raised, while the HBD rate for 21- to 26-year-old drivers increased, may mean that there was a general increase in HBD and that the observed reduction for young drivers was not as large as the real reduction. Another interpretation is that the effect of the law change was to reduce drinking and driving among the 18- to 20-year-old drivers, but to shift some of this to the next older drivers. Possibly a combination of the two or of some other causes occurred.

It is interesting to note that a reversed pattern occurs, corresponding to the lowering of the legal drinking age. At that time, HBD rates increased only for the young drivers, with significant increases for ages 16 to 20, while HBD rates for older drivers decreased. Significant decreases occurred in many of the older age groups. This suggests that the legal change may have affected both the 18-20 year old drivers and the slightly older ones, but changed their HBD rates in opposite directions.

The 20% sample data show rather different patterns than do the fatal data. Most of the fatal HBD rates corresponding to the partition at 1971 showed increases, but these were only significant in the young drivers, while the young drivers' rates increased and older drivers' HBD rates decreased in the 20% data. Considering changes in HBD rates in 1979, nearly all of the ages in the fatal data show increases, with older drivers showing significant increases and younger drivers non-significant increases. On the other hand,

Table 6

Summary of Significant Partitions: 20% Sample Data

Age Group	Partition	Change in HBD Rate
16	1968-1971 vs. 1972-1979	.0285 to .0406
	1972-1973 vs. 1974-1979	.0297 to .0442
17	1968-1971 vs. 1972-1979	.0372 to .0608
	1972-1973 vs. 1974-1979	.0500 to .0642
	1976 vs. 1977	.0545 to .0685
18	1968-1971 vs. 1972-1979	.0501 to .1113
	1972-1973 vs. 1974-1979	.0931 to .1174
	1976-1978 vs. 1979	.1259 to .0953
	1974 vs. 1975	.1025 to .1262
19	1968-1971 vs. 1972-1979	.0642 to .1184
	1972-1973 vs. 1974-1979	.0953 to .1258
	1976-1978 vs. 1979	.1326 to .1082
	1974 vs. 1975	.1086 to .1379
20	1968-1971 vs. 1972-1979	.0744 to .1228
	1968-1970 vs. 1971	.0808 to .0612
	1972-1973 vs. 1974-1979	.1060 to .1283
	1976-1978 vs. 1979	.1336 to .1192
	1974 vs. 1975	.1138 to .1337
21	1968-1970 vs. 1971	.1469 to .1110
	1968-1969 vs. 1970	.1623 to .1198
	1972-1973 vs. 1974-1979	.1000 to .1345
	1976-1978 vs. 1979	.1300 to .1559
22	1968-1971 vs. 1972-1979	.1385 to .1254
	1968-1970 vs. 1971	.1460 to .1203
	1968-1969 vs. 1970	.1591 to .1266
	1972-1973 vs. 1974-1979	.1060 to .1319
	1976-1978 vs. 1979	.1278 to .1553
	1976 vs. 1977	.1113 to .1377
23	1968-1969 vs. 1970	.1527 to .1202
	1972-1973 vs. 1974-1979	.1104 to .1295
24	1968-1971 vs. 1972-1979	.1298 to .1147
	1968-1969 vs. 1970	.1430 to .1122
	1972-1973 vs. 1974-1979	.1014 to .1190
	1976-1978 vs. 1979	.1158 to .1365

Table 6 - Continued
Summary of Significant Partitions: 20% Sample Data

Age Group	Partition	Change in HBD Rate
25	1968-1971 vs. 1972-1979	.1347 to .1169
	1968-1969 vs. 1970	.1543 to .1218
	1972-1973 vs. 1974-1979	.1062 to .1205
26	1968-1971 vs. 1972-1979	.1296 to .1136
	1968-1969 vs. 1970	.1502 to .1085
27	1968-1971 vs. 1972-1979	.1366 to .1137
	1968-1969 vs. 1970	.1596 to .1147
	1972-1973 vs. 1974-1979	.1017 to .1170
28	1968-1971 vs. 1972-1979	.1330 to .1162
	1968-1969 vs. 1970	.1532 to .1152
29	1968-1971 vs. 1972-1979	.1344 to .1142
	1968-1969 vs. 1970	.1530 to .1210
30	1968-1971 vs. 1972-1979	.1309 to .1114
	1974-1975 vs. 1976-1979	.1274 to .1069
31	1968-1971 vs. 1972-1979	.1353 to .1121
32	1968-1971 vs. 1972-1979	.1321 to .1145
	1976-1978 vs. 1979	.1070 to .1295
33	1968-1971 vs. 1972-1979	.1394 to .1173
34	1974-1975 vs. 1976-1979	.1287 to .1073
35-39	1968-1971 vs. 1972-1979	.1282 to .1146
	1968-1969 vs. 1970	.1378 to .1138
	1972-1973 vs. 1974-1979	.1212 to .1123
	1974-1975 vs. 1976-1979	.1220 to .1084
40-44	1968-1971 vs. 1972-1979	.1310 to .1120
	1968-1969 vs. 1970	.1459 to .1163
	1972-1973 vs. 1974-1979	.1211 to .1084
	1974-1975 vs. 1976-1979	.1217 to .1023
45-49	1968-1969 vs. 1970	.1308 to .0991
	1974-1975 vs. 1976-1979	.1143 to .1032
50-54	1972-1973 vs. 1974-1979	.1030 to .0939
	1974-1975 vs. 1976-1979	.1047 to .0889
55-59	1968-1971 vs. 1972-1979	.0969 to .0841
65-69	1968-1971 vs. 1972-1979	.0525 to .0425

Table 6 - Continued
Summary of Significant Partitions: 20% Sample Data

Age Group	Partition	Change in HBD Rate
15-17	1968-1971 vs. 1972-1979	.0339 to .0528
	1972-1973 vs. 1974-1979	.0418 to .0563
	1976-1977 vs. 1978	.0616 to .0535
18-20	1968-1971 vs. 1972-1979	.0615 to .1171
	1972-1973 vs. 1974-1979	.0976 to .1235
	1976-1978 vs. 1979	.1304 to .1069
	1974 vs. 1975	.1078 to .1323
21-23	1968-1971 vs. 1972-1979	.1359 to .1255
	1968-1970 vs. 1971	.1441 to .1173
	1968-1969 vs. 1970	.1586 to .1223
	1972-1973 vs. 1974-1979	.1052 to .1321
	1974-1975 vs. 1976-1979	.1263 to .1345
	1976-1978 vs. 1979	.1287 to .1518
24-26	1968-1971 vs. 1972-1979	.1313 to .1151
	1968-1970 vs. 1971	.1357 to .1219
	1968-1969 vs. 1970	.1491 to .1143
	1972-1973 vs. 1974-1979	.1044 to .1185
	1976-1978 vs. 1979	.1157 to .1298
	1974 vs. 1975	.1096 to .1240
All Ages	1968-1970 vs. 1971	.1065 to .0942
	1968-1969 vs. 1970	.1138 to .0946
	1972-1973 vs. 1974-1979	.0977 to .1049
	1974-1975 vs. 1976-1979	.1066 to .1042
	1976-1978 vs. 1979	.1032 to .1072
	1974 vs. 1975	.1031 to .1100

in the 20% sample data, significant decreases are observed for younger drivers, while most older ages show increases and the ages immediately older than 20 show significant increases.

Thus, in the 20% sample data, drivers in the age groups directly affected by the law change showed significant reductions in their HBD rate, while at the same time older drivers, particularly those only slightly older, showed significant increases in HBD rates. This finding argues that the change in HBD rates may have been caused by the law change. In the fatal data, a different pattern was observed. Only the 18-year-old drivers showed a

reduction in the HBD rate in 1979; the 19, 20, and slightly older drivers all showed significant increases in their HBD rates. All of these changes in the fatal data were non-significant, and so could be ascribed to chance.

2.3 Analysis of 1980 Accident Data

As mentioned in the introduction, this section updates the analysis by incorporating data from the 1980 accident experience. Both data for drivers involved in fatal crashes and data for drivers in all police-reported crashes are utilized. In the interests of brevity and conciseness, not all of the detailed analyses involving all of the single-age groups are presented. Instead, only the four 3-year age groups and the totals are given. In addition to the age-group analyses, the cohort work is presented as well as consideration of driver-involvement frequencies.

Inclusion of the 1980 accident data calls for a slight modification of the partitions described in Figure 1. In addition to those needed to include the 1980 data, there are now two additional comparisons of particular interest that cannot be included with the previous partitioning and still maintain orthogonality. These two new comparisons are: first, all years with 18 as the legal drinking age compared to all years with 21 as the legal drinking age, and second, a comparison of the years 1968-1971 with 1979-1980. This last compares the two periods having legal drinking at age 21 to see whether the current HBD rates have returned to their levels prior to the interim period when drinking was legal at age 18. In the interests of brevity, only the data from the four age groups 15-17, 18-20, 21-23, and 24-26 have been partitioned. Table 7 summarizes the significant partitions found in the fatal data. A similar summary of the significant partitions found in the 20% sample data appears in Table 8. The complete table of HBD rates for drivers in fatal crashes is presented in Table 11, and the comparable data for the 20% sample will be found in Table 12. The frequencies from which these rates were derived are given in Appendix ?, tables ?-?. The specific results for age groups are discussed individually below.

Ages 15-17: Drivers in Fatal Crashes. The overall chi-square statistic for this group was 60.36 with 12 degrees of freedom, highly significant. Partitioning showed three comparisons to be significant at the age-group-wise 5% significance level. There was a significant increase from the 1968-1971

Table 7

Summary of Significant Comparisons: Fatal Data

Age Group	Comparison	Change in HBD Rate
15-17	1968-1971 vs. 1972-1980	.150 to .253
	1972-1973 vs. 1974-1980	.172 to .280
	1974-1978 vs. 1979-1980	.260 to .340
	1968-1971 vs. 1979-1980	.150 to .340
18-20	1968-1971 vs. 1972-1980	.269 to .429
	1972-1973 vs. 1974-1980	.348 to .453
	1968-1971 vs. 1979-1980	.269 to .483
	1968-71,1979-80 vs. 1972-1978	.417 to .344
21-23	1972-1973 vs. 1974-1980	.360 to .489
	1968-1971 vs. 1979-1980	.429 to .505
24-26	1974-1978 vs. 1979-1980	.420 to .511
	1968-1971 vs. 1979-1980	.349 to .511
All Ages	1968-1971 vs. 1972-1980	.296 to .352
	1972-1973 vs. 1974-1980	.300 to .367
	1974-1978 vs. 1979-1980	.353 to .404
	1968-1971 vs. 1979-1980	.296 to .404

period to the 1972-1980 period (X^2=27.02, 1 d.f.). The HBD rate averaged 0.150 in the earlier of these periods and 0.253 in the later period. This division corresponds to the lowering of the legal drinking age in 1971. A second significant increase was noted in comparing 1972-1973 with 1974-1980. This corresponds to the introduction of FARS, and the HBD rate increased from 0.172 to 0.280 (X^2=20.5, 1 d.f.). A significant increase was also noted in comparing the rate for 1974-1978 to 1979-1980, corresponding to the raising of the legal drinking age to 21. The HBD rate increased from 0.260 to 0.340 in these most recent two years (X^2=8.75, 1 d.f.).

The two additional, non-orthogonal partitions involve comparing the earlier age-21 period with the current and all age-21 years with age-18 years. The comparison of the earlier age-21 period with the current period (1968-1971 compared to 1979-1980) resulted in a chi-square statistic of 42.93 with 1 degree of freedom, highly significant. The earlier period had an HBD rate of

Table 8

Summary of Significant Comparisons: Sample Data

Age Group	Comparison	Change in HBD Rate
15-17	1968-1971 vs. 1972-1980	.034 to .055
	1974-1978 vs. 1979-1980	.057 to .063
	1979 vs. 1980	.055 to .077
	1968-1971 vs. 1979-1980	.034 to .063
	1968-1971,1979,1980 vs. 1972-1978	.046 to .052
18-20	1968-1971 vs. 1972-1980	.062 to .119
	1972-1073 vs. 1974-1980	.098 to .125
	1974-1978 vs. 1979-1980	.127 to .118
	1979 vs. 1980	.107 to .133
	1974-1975 vs. 1976-1978	.120 to .130
	1974 vs. 1975	.108 to .132
	1968-1971 vs. 1979-1980	.062 to .118
	1968-71,1979-80 vs. 1972-1978	.072 to .119
21-23	1968-1971 vs. 1972-1980	.141 to .130
	1972-1973 vs. 1974-1980	.105 to .137
	1974-1978 vs. 1979-1980	.128 to .160
	1979 vs. 1980	.152 to .170
	1968-1970 vs. 1971	.152 to .117
	1968-1969 vs. 1970	.159 to .139
	1968-1971 vs. 1979-1980	.141 to .160
	1968-1971,1979,1980 vs. 1972-1978	.149 to .121
24-26	1968-1971 vs. 1972-1980	.137 to .119
	1968-1970 vs. 1971	.144 to .122
	1972-1973 vs. 1974-1980	.104 to .123
	1974-1978 vs. 1979-1980	.116 to .141
	1979 vs. 1980	.130 to .155
	1968-1971,1979,1980 vs.1972-1978	.139 to .113
All Ages	1968-1970 vs. 1971	.110 to .094
	1968-1969 vs. 1970	.114 to .104
	1972-1973 vs. 1974-1980	.098 to .107
	1974-1978 vs. 1979-1980	.104 to .114
	1979 vs. 1980	.107 to .122
	1974-1975 vs. 1976-1978	.107 to .103
	1974 vs. 1975	.103 to .110
	1968-1971 vs. 1979-1980	.105 to .114

0.150 compared with the HBD rate of 0.340 for the most recent two years. The HBD rates for 15-17 year old drivers involved in fatal crashes have not returned to the pre-lower-drinking-age levels. Comparing the time periods with drinking at age 18 to those with drinking at age 21 results in no significant differences in the HBD rates: 0.233 at 18 compared to 0.216 at age 21 (X^2=0.91, 1 d.f.). However, it is important to note the pattern of these rates in the three time periods. The rates were 0.150, 0.233, and 0.340, respectively, for the time periods 1968-1971, 1972-1978, and 1979-1980.

Ages 15-17: 20% Sample Data. The total chi-square statistic for this age group was 301.60 with 12 degrees of freedom, highly significant. The major comparisons of interest are the increase when the legal drinking age was lowered to 18. The HBD rate increased from 0.034 to 0.055 at that time. This increase was highly significant, with a chi-squared of 156.35 (1 degree of freedom). The second major comparison showed a significant increase in the HBD rate from 0.042 to 0.058 corresponding to the introduction of FARS in 1974. The associated chi-square statistic was 81.92 with 1 degree of freedom. There was also a significant increase in HBD rate corresponding to raising of the legal drinking age in 1979. The HBD rate increased from 0.057 to 0.062, with an associated chi-square of 9.92 (1 d.f.). In this comparison it is important to note that the HBD rates for 1979 and 1980 differed significantly. The 1979 rate was 0.055, while that for 1980 was 0.077 (X^2=12.13, 1 d.f.). Thus, the 1979 HBD rate was lower than the earlier rate, but the 1980 HBD rate was higher, with the average rate for the two years higher than previously.

Turning to the non-orthogonal comparisons, the HBD rate currently is significantly higher than that of the earlier period when the legal drinking age was 21. The previous period's HBD rate averaged 0.034, while the current HBD rate is 0.063 (X^2=167.44, 1 d.f.). Only a relatively small difference in the HBD rates for all of the legal-at-age-21 drinking period compared to the legal-at-age-18 drinking period exists. The HBD rates were 0.046 for the age 18 and 0.052 for the age-21 drinking period. However, again, the rates show a progressive increase for the three periods: 0.034, 0.046, and 0.063, respectively.

Ages 18-20: Drivers in Fatal Crashes. The total chi-square for this group was 141.54 with 12 degrees of freedom, highly significant. The comparisons of particular interest were the increase in HBD rate from 0.269 to

0.429 in 1972, when the legal drinking age was lowered to 18. This difference was highly significant, with an associated chi-square statistic of 98.17 with 1 degree of freedom. A second comparison of interest showed an increase in HBD rate from 0.348 to 0.453 in 1974, corresponding to the introduction of FARS. The corresponding chi-square was 27.91 with 1 degree of freedom. A third comparison of interest corresponded to raising of the legal drinking age to 21 in 1979. This comparison showed a non-significant change in the HBD rate from 0.443 to 0.483 (X^2=3.39).

Two other non-orthogonal comparisons are of interest. Comparing the earlier legal-drinking-at-21 period with the current, one finds that the HBD rate averaged 0.269 earlier compared with 0.483 currently. This is a highly significant difference (X^2=83.49). Overall, the HBD rate was higher when the legal drinking age was 18 than when it was 21 (0.344 versus 0.417), but this may be misleading since there is such a difference in HBD rates between the two periods with legal drinking at age 21. The average rates for the three periods corresponding to the legal drinking age of 21, of 18, and again of 21 were 0.269, 0.417, and 0.483, respectively. These last two are not significantly different.

Ages 18-20: 20% Sample Data. Turning to drivers in all crashes in this age group, the overall chi-square was 1337.04 with 12 degrees of freedom, highly significant. Summarizing the most important comparisons, one finds the following. A very large significant increase occurred with the lowering of the drinking age. The HBD rate increased from 0.062 to 0.119, with an associated chi-square of 992.60. Another substantial increase was noted corresponding to the introduction of FARS in 1974, when the rate increased from 0.098 to 0.125 (X^2=196.75). A significant decrease occurred when the legal drinking age was raised to 21 in 1979, from 0.127 to 0.118 (X^2=16.32). However, the 1980 HBD rate was significantly higher than that for 1979 (0.107 to 0.133, X^2=52.77).

The current period has a higher HBD rate than the former period with legal drinking at age 21. The former rate was 0.062 compared to the current 0.118 (X^2=548.36, 1 d.f). Overall, the HBD rate when drinking was legal at age 18 was higher than when drinking was legal at age 21, but it should be noted that little difference is found between the current rate and that at age 18. Overall, the rate for legal-drinking-at-age 21 was 0.072 and for age-18

legal drinking the rate was 0.119 (X^2=444.25). This is mainly the result of the historically lower rate. The HBD rates for the three time periods were 0.0624, 0.1185, and 0.1184, respectively. One extra decimal place has been presented to show the difference between the current HBD rate and that averaged over all the years with legal drinking at age 18. Clearly these last two rates do not differ either in the statistical sense or in the practical sense.

Ages 21-23: Drivers in Fatal Crashes. The overall chi-square statistic for this group was 45.74 with 12 degrees of freedom. The only significant comparison corresponded to the introduction of FARS. At that time the HBD rates increased significantly, from 0.360 to 0.489 (X^2=29.4). A non-significant increase (X^2=3.65) occurred when the legal drinking age was lowered. An even less significant change (from 0.482 to 0.505) occurred when the drinking age was raised.

Comparing the earlier legal-drinking-at-age-21 period with the current, one finds that the HBD rate currently is significantly higher. The rate was formerly 0.429, compared to the current 0.505 (X^2=9.37). The HBD rate during the period when the legal drinking age was 18 did not differ significantly from the average rate when it was 21 (0.450 at 18 compared to 0.455 at 21). The HBD rates for the three time periods in question were 0.429, 0.450, and 0.505, respectively.

Ages 21-23: 20% Sample Data. The overall chi-square statistic for this age group was 457.24 with 12 degrees of freedom, highly significant. Several individual comparisons were significant. The most important ones are summarized here. There was a lower HBD rate (0.141 to 0.130) when the legal drinking age was lowered to age 18 (X^2=23.96). The HBD rate increased from 0.105 to 0.137 at the time FARS was introduced (X^2=167.84). Another increase from 0.128 to 0.160 was observed when the legal drinking age was raised back to 21 (X^2=155.86).

The other non-orthogonal comparisons showed that the HBD rate is currently higher, 0.160 compared to 0.141, than it was in the earlier period when the legal drinking age was also 21 (X^2=41.79). Overall, the HBD rate was lower when the legal drinking age was 18 than when it was 21, 0.121 compared with 0.149 (X^2=226.72). The HBD rates for the three periods in question for

this age group were 0.141, 0.121, and 0.160, respectively. This group had a lower HBD rate when drinking was legal at age 18, even apart from the fact that HBD rates seem generally higher now.

Ages 24-26: Drivers in Fatal Crashes. For this age group, the overall chi-square statistic was 35.37 with 12 degrees of freedom. While four comparisons were significant at the comparison-wise 5% level, only the change corresponding to the increased legal drinking age was significant at the group-wise 5% significance level. This change was an increase from 0.420 to 0.511 in the HBD rate (X^2=11.42, 1 d.f.).

Considering the non-orthogonal comparisons, the HBD rate for the earlier period having 21 as the legal drinking age was lower than the current rate. The rates were 0.349 formerly compared to 0.511 currently (X^2=19.94, 1 d.f.). No significant difference was observed between the HBD rate for the combined age-21 period compared to the period when the legal drinking age was 18. The three HBD rates were 0.349, 0.421, and 0.511, respectively.

Ages 24-26: 20% Sample Data. The overall chi-square statistic for this age group was 244.35 with 12 degrees of freedom, highly significant. The comparisons of primary interest showed that the HBD rate decreased when the legal drinking age was lowered (from 0.137 to 0.119, X^2=47.23) and increased when FARS was introduced (from 0.104 to 0.123, X^2=49.40). A significant increase was also observed when the age was raised to 21. Then the HBD rate changed from 0.116 to 0.142 (X^2=81.58). The HBD rate in 1980 was significantly larger than that from 1979 (0.130 compared to 0.155, X^2=28.88).

The other comparisons of interest showed a non-significant difference between the earlier and current periods of legal-at-21 drinking. However, a substantially lower HBD rate was observed during the period when 18 was the legal drinking age, 0.113 compared to 0.139 (X^2=158.72). The average HBD rates for the three periods were 0.137, 0.113, and 0.141, respectively.

All the data show an increase in the HBD rate corresponding to the introduction of FARS. This appears to have resulted from more attention being given to completing the information on the drinking variable and to reducing the missing data. The HBD rate seems generally to have increased in 1980 over that of 1979. The older age groups show somewhat lower rates during the period when drinking was legal at age 18. The younger age groups--those ages

directly affected by the law and the three years younger--show marked increases in HBD rates when the legal drinking age was first lowered. Only small, if any, decreases in HBD rates have been noted among these groups when the legal drinking age was raised, however. It must be noted that the period when the legal drinking age was raised also has higher drinking rates among the older ages and among all drivers generally.

Analysis of Frequencies. The observed differences in the HBD rates can arise in a number of ways. The numerator--number of HBD drivers in crashes--can change, the denominator--number of HNBD drivers plus the number of HBD drivers--can change, or both can change. Changes in these frequencies will affect the HBD rates and will do so in a non-linear fashion. For the period 1974 to 1980, the frequency data are complete for both the fatal and the 20% sample data and have no known perturbations of the data collection system. Table 9 summarizes these frequencies in terms of average number of drivers in fatal crashes per year in the HBD and HNBD categories for the two time periods 1974-1978 and 1979-1980. This division corresponds to the time when the legal drinking age was again raised to 21. (Detailed frequencies are given in Tables A1-A4 of the Appendix.

Considering fatal crashes, one sees that all the age groups experienced decreases in the number of HNBD drivers, the larger part of the denominator of the HBD rate. These decreases were statistically significant in all but the 21-23 age group. All of the age groups except the 18-20 group, those directly affected by the law, showed increases in the number of HBD drivers in fatal crashes. These increases were significant for the 24-26, the 27+, and the "all but 18-20" groups. The 18-20 age group, in contrast, showed a non-significant decrease in the number of HBD drivers in fatal crashes.

The 20% sample data, displayed in Table 10, exhibit a similar pattern. All groups exhibited significant drops in the number of HNBD drivers in crashes. The 15-17 age group showed no change in the number of HBD drivers, and the 18-20 age group showed a significant decrease in the number of HBD drivers. The other ages showed significant increases in the number of HBD drivers. Thus, all age age groups had decreases in the number of HNBD drivers, both in the fatal and the 20% sample data, while only the 18-20 age group showed a significant decrease in the the number of HBD drivers. All other groups showed increases in the HBD frequencies or no change. This is

consistent with an effect of the law acting to reduce the drinking-driving problem in the affected age group--18-20--in the face of an increasing trend for more HBD drivers in the rest of the population.

Table 9

Fatal HBD and HNBD Frequencies by Age Group
1974-1978 Mean and 1979-1980 Mean

Age Group	Variable	1974-1978 (Mean)	1979-1980 (Mean)	%Change	*Sig.
15-17	HBD	49.2	54.5	+10.8	No
	HNBD	140.4	106	-24.5	Yes
18-20	HBD	178.8	161.5	-9.7	No
	HNBD	225	173	-23.1	Yes
21-23	HBD	144.8	154	+6.3	No
	HNBD	155.4	151	-2.8	No
24-26	HBD	98.6	121.5	+23.2	Yes
	HNBD	136.2	116.5	-14.5	Yes
27+	HBD	383.8	427.5	+11.4	Yes
	HNBD	907.4	807	-11.1	Yes
All except 18-20	HBD	676.4	757.2	+11.9	Yes
	HNBD	1339.4	1180.5	-11.9	Yes

*The statistical tests assume that the frequencies follow a Poisson distribution. Significance is indicated at p=0.05 (two-tailed test) using a normal approximation.

Summary of Age Group Partitioning

Among the fatal data, all age groups showed increases in the HBD rate over the three time periods 1968-1971, 1972-1978, and 1979-1980. These periods had legal drinking at age 21, then legal drinking at age 18, and then legal drinking at age 21 again. Two frequencies are used to calculate these rates: the frequency of HBD drivers and the frequency of HNBD drivers. The HNBD frequencies show decreases in all age groups when the legal drinking age was raised in 1979, while the HBD frequencies show increases in all ages

Table 10

20% Sample HBD and HNBD Frequencies by Age Group
1974-1978 Mean and 1979-1980 Mean

Age Group	Variable	1974-1978 (Mean)	1979-1980 (Mean)	%Change	*Sig.
15-17	HBD	540	539.5	-0.0	No
	HNBD	9007.8	8068.5	-11.4	Yes
18-20	HBD	2167.6	1782.5	-17.8	Yes
	HNBD	14,937.4	13,278.5	-11.1	Yes
21-23	HBD	1594.6	1945.5	+22.0	Yes
	HNBD	10,880.4	10,232.4	-6.0	Yes
24-26	HBD	1148	1368.5	+19.2	Yes
	HNBD	8741.6	8326.5	-4.7	Yes
27 and older	HBD	5491.4	5685.5	+3.5	Yes
	HNBD	50,528.4	48,254.5	-4.5	Yes
All except 18-20	HBD	8774	9539	+8.7	Yes
	HNBD	79,158.2	74,482.	-5.9	Yes

*The statistical tests assume that the frequencies follow a Poisson distribution. Significance is indicated at the P=0.05 (two-sided test) level using a normal approximation.

except the 18-20 age group. Thus there appears to be a population trend for both the frequency and rate of HBD drivers to increase in recent years, except for the 18-20 age group.

In the 20% sample of drivers in all crashes, the HBD rates for the three time periods in question differed by age group. Ages 15-17 showed a monotone increase. Ages 18-20 showed an increase in HBD when the drinking age was lowered, but no further change. The older ages--21-23, 24-26, and all ages combined--showed a decrease in HBD rates when the legal drinking age was 18, and an increase when it was raised again. The HNBD frequencies decreased for all ages, while the HBD frequencies increased for all ages except ages 15-20. The 18- to 20-year-old-drivers showed a decrease in HBD frequency, while the younger drivers showed no change. These data indicate an increase in HBD

drivers in the population, while there was a decrease in HNBD drivers. The exception to this trend was the 18-20 age group, which also showed a decrease in HBD drivers.

Together, the accident data support the conclusion that an increase in HBD drivers occurred in the population in the last two years, while a decrease in HBD drivers occurred for the 18- to 20-year-old age group. The general population of drivers experienced a decrease in the total number of accident involvements.

2.4 Analysis of Cohort HBD Rates

With data on individual age groups for 13 years, it is possible to define cohorts of drivers and follow their HBD rates over a number of years. This was introduced by Flora, Filkins, and Compton [1]. In the present study such cohorts may be followed in both the fatal data and the 20% sample of police-reported accidents.

In this investigation, we identify cohorts by the age of the driver in 1979, since the event of most interest--raising the legal drinking age--took place then. Thus, the focus is on the later data rather than the earlier data. The effects of lowering the drinking age in 1972, of introducing FARS in 1974, etc., were investigated in the fatal data in the earlier report [1].

For each cohort defined by the drivers' ages in 1979, the HBD rate was calculated for each year. These rates can be observed in Table 11 for the fatal data or in Table 12 for the 20% sample data by proceeding diagonally. As one adds one year to the date at the top of the table, one drops one row to add one year of age. The chi-squared statistic calculated for following a cohort for several years can be partitioned to investigate when significant changes in the HBD rates occurred.

The set of partitions varies with the cohort. For example, the cohort that was age 20 in 1979 could drink legally at ages 18-19 and 21, but not at age 20. This suggests a comparison of the HBD rates at ages 16 and 17, before they could drink legally, at ages 18 and 19, when they could drink legally and at ages 20 and 21, another legal drinking/non-legal drinking change. This

Table 11

HBD Rates of Drivers in the Michigan Fatal Files, 1968-1980

AGE	YEAR												
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1-15	-0-	-0-	-0-	.067	.048	.100	.273	.188	-0-	.133	.100	.222	.211
16	.043	.183	.170	.207	.141	.119	.172	.327	.284	.247	.171	.302	.261
17	.170	.189	.131	.155	.225	.200	.266	.294	.264	.312	.295	.356	.422
18	.218	.277	.172	.288	.351	.317	.395	.440	.447	.408	.395	.400	.495
19	.306	.291	.271	.280	.331	.361	.424	.522	.538	.421	.421	.479	.459
20	.313	.320	.260	.260	.318	.405	.453	.412	.454	.379	.516	.509	.560
21	.454	.367	.407	.417	.322	.340	.500	.598	.527	.448	.481	.474	.523
22	.475	.439	.472	.410	.360	.402	.433	.524	.528	.449	.541	.457	.500
23	.403	.469	.446	.372	.293	.449	.468	.443	.440	.412	.430	.479	.600
24	.444	.415	.404	.289	.370	.365	.433	.386	.360	.398	.417	.512	.607
25	.429	.463	.348	.348	.397	.392	.448	.373	.518	.462	.459	.471	.462
26	.358	.449	.333	.338	.236	.493	.408	.470	.295	.417	.434	.460	.533
27	.227	.469	.386	.358	.403	.345	.460	.362	.627	.402	.375	.457	.519
28	.345	.333	.333	.453	.455	.339	.302	.412	.529	.576	.469	.355	.473
29	.257	.478	.480	.308	.406	.241	.395	.349	.375	.370	.487	.562	.451
30	.440	.440	.364	.357	.464	.379	.412	.333	.313	.359	.302	.378	.448
31	.484	.345	.292	.320	.222	.300	.377	.400	.383	.318	.439	.519	.417
32	.326	.395	.289	.333	.326	.373	.353	.500	.318	.424	.367	.440	.451
33	.357	.250	.313	.292	.439	.404	.409	.366	.375	.396	.326	.341	.450
34	.462	.311	.394	.520	.243	.425	.233	.351	.233	.295	.509	.500	.533
35-39	.308	.290	.296	.310	.325	.364	.400	.410	.289	.300	.298	.398	.441
40-44	.327	.344	.370	.246	.324	.310	.297	.297	.338	.288	.310	.311	.319
45-49	.304	.230	.269	.173	.252	.262	.320	.330	.372	.331	.323	.340	.347
50-54	.300	.253	.269	.290	.224	.278	.270	.264	.271	.296	.203	.293	.330
55-59	.225	.265	.234	.301	.233	.245	.186	.244	.193	.240	.219	.218	.188
60-64	.203	.205	.138	.262	.212	.235	.220	.246	.173	.160	.099	.211	.205
65-98	.105	.110	.097	.077	.111	.088	.151	.060	.058	.092	.120	.142	.114
Unk.	-0-	-0-	-0-	.250	.333	-0-	-0-	.333	.455	.333	.333	.429	.500
15-17	.121	.173	.136	.166	.180	.163	.236	.293	.261	.270	.243	.331	.348
18-20	.270	.295	.230	.277	.334	.361	.421	.466	.481	.404	.450	.461	.506
21-23	.449	.420	.446	.400	.326	.394	.469	.515	.502	.436	.487	.470	.539
24-26	.411	.441	.362	.321	.346	.412	.429	.408	.401	.424	.436	.484	.533
All	.303	.307	.294	.281	.289	.310	.347	.369	.361	.339	.352	.389	.422

Table 12

HBD Rates of Drivers in the Michigan 20% Sample Files, 1968-1980

AGE	YEAR												
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1-15	.051	.041	.062	.022	.048	.039	.073	.052	.067	.073	.058	.044	.080
16	.027	.027	.031	.029	.030	.029	.038	.041	.054	.046	.041	.044	.055
17	.037	.037	.040	.036	.048	.052	.054	.068	.070	.068	.061	.063	.084
18	.052	.051	.054	.048	.093	.093	.102	.126	.126	.133	.119	.095	.116
19	.063	.066	.069	.063	.097	.094	.109	.138	.138	.128	.132	.108	.133
20	.084	.085	.080	.061	.102	.110	.114	.134	.134	.131	.136	.119	.153
21	.177	.147	.136	.111	.098	.102	.125	.135	.124	.135	.131	.156	.174
22	.159	.159	.145	.120	.108	.104	.111	.138	.136	.124	.124	.155	.168
23	.158	.148	.137	.121	.107	.114	.125	.123	.127	.132	.126	.143	.167
24	.152	.134	.126	.128	.096	.106	.107	.122	.115	.110	.123	.136	.158
25	.151	.158	.139	.119	.102	.111	.110	.125	.118	.121	.120	.128	.160
26	.148	.152	.122	.117	.109	.103	.112	.126	.110	.112	.112	.124	.146
27	.167	.153	.130	.126	.105	.098	.107	.113	.111	.116	.125	.128	.149
28	.145	.160	.130	.123	.113	.111	.119	.121	.103	.110	.121	.130	.141
29	.158	.148	.138	.122	.111	.114	.116	.119	.120	.110	.102	.124	.144
30	.147	.146	.150	.112	.110	.107	.129	.125	.105	.099	.106	.118	.134
31	.140	.160	.148	.120	.112	.108	.125	.112	.113	.101	.110	.116	.139
32	.163	.135	.141	.116	.119	.108	.119	.116	.106	.115	.101	.130	.131
33	.161	.144	.141	.134	.126	.111	.113	.126	.112	.120	.115	.117	.131
34	.163	.133	.127	.113	.126	.118	.135	.123	.110	.099	.104	.117	.127
35-39	.136	.139	.128	.127	.124	.118	.124	.120	.111	.105	.106	.112	.123
40-44	.144	.147	.132	.122	.124	.118	.122	.122	.112	.096	.099	.102	.118
45-49	.123	.138	.110	.113	.114	.116	.113	.115	.105	.104	.097	.108	.107
50-54	.112	.110	.111	.096	.103	.103	.104	.105	.093	.089	.084	.089	.099
55-59	.103	.108	.100	.091	.094	.087	.089	.089	.075	.081	.083	.077	.087
60-64	.087	.079	.078	.070	.076	.072	.068	.074	.070	.060	.056	.073	.077
65-98	.061	.056	.050	.048	.040	.046	.049	.045	.041	.041	.034	.045	.043
Unk.	.225	.220	.188	.068	.119	.152	.136	.104	.134	.115	.116	.116	.128
15-17	.034	.033	.037	.033	.041	.042	.048	.057	.063	.060	.053	.055	.072
18-20	.064	.065	.066	.057	.097	.098	.108	.132	.133	.130	.128	.107	.133
21-23	.166	.152	.139	.117	.104	.106	.120	.132	.129	.130	.127	.152	.170
24-26	.150	.148	.129	.122	.102	.107	.110	.124	.115	.114	.118	.130	.155
All	.115	.113	.104	.094	.098	.097	.103	.110	.105	.103	.102	.107	.122

example has 6 years of data, thus having an overall chi-squared statistic with 5 degrees of freedom. Other cohorts have more or fewer degrees of freedom and may have different partitions of interest.

Age 17 in 1979

This cohort exhibits, in Table 13, significant increases in HBD rate for both fatal (X^2=18.36, 2 d.f.) and 20% data (X^2=194.41, 2 d.f.). The fatal data show a 108% increase in HBD rate from age 16 to 17 and a 39% increase in rate from age 17 to age 18. Both changes are statistically significant. Comparable figures for the 20% sample data are 53% and 84%, both of which are significant increases. The 0.116 HBD rate at age 18 in the sample data is about one-fourth that of the fatal data.

Table 13

Cohort Analysis: Age 17 in 1979

Age	Data File	
	Fatal	20% Sample
16	.171	.041
17	.356	.063
18	.495	.116

Age 18 in 1979

The fatal HBD rates show a monotone trend increasing with age, with a large increase at age 18. The overall chi-squared is 12.14 with 3 d.f. Most of this is associated with the increase in HBD rate at age 18. The average HBD rate for the combined 16-17 ages is 0.276; this increased to 0.429 for the combined 18-19 ages. The chi-squared statistic associated with this change is 10.77 (p=0.0001). Neither the change from age 16 to 17 nor the change from age 18 to 19 was statistically significant. The chi-squared statistics associated with these are 0.48 and 0.89, respectively, both non-significant.

Likewise, the 20% sample data show a monotone trend increasing with age. This is a more even increase with age than that observed in the fatal data. The overall chi-squared is 258.78 with 3 d.f. Again, most of this is

associated with the increase from 16-17 to 18-19, average rates for which are 0.056 and 0.111, with an associated chi-squared of 205.28. Some evidence of an increase from age 16 to 17 exists (X^2=6.91, p<.05), and strong evidence for an increase from age 18 to 19 (X^2=46.58).

Thus, while this cohort could not drink legally at any time during the years covered by these data, there appears to be a pattern of a strong increase in HBD rates as these drivers attain the age of 18.

Table 14

Cohort Analysis: Age 18 in 1979

Age	Data File	
	Fatal	20% Sample
16	.247	.046
17	.295	.061
18	.400	.095
19	.459	.133

Age 19 in 1979

This cohort, shown in Table 15, is of special interest because it represents a cohort that could not drink legally at 16 or 17, could drink legally at 18 in 1978, then could no longer drink legally at 19 in 1979 or at 20 in 1980.

The two data sets exhibit a different pattern of HBD rates. The drivers in fatal crashes in this cohort showed a monotone increase in HBD rate, with a statistically significant overall chi-squared of 21.55, 4 d.f. Most of this is associated with the increase observed in comparing the 16- and 17-year-old drivers with the 18- to 20-year olds. The chi-squared for this comparison is 14.58, 1 d.f., p=0.0000, with an increase in HBD rate from 0.2994 to 0.4754. No other comparisons were significant at the 5% level. However, the increase in HBD rate from age 18 to 19-20 was large and approached the joint 5% significance level. The rate increased from 0.3953 to 0.5190 with X^2=5.24 compared to the joint critical level of 6.24.

Table 15

Cohort Analysis: Age 19 in 1979

Age	Data File	
	Fatal	20% Sample
16	.284	.054
17	.312	.068
*18	.395	.119
19	.479	.108
20	.560	.153

The "*" denotes legal drinking.

The 20% data show a different pattern. A large increase in HBD rate corresponds with age 18 in 1978, when these drivers were able to drink legally. This is followed by a slight decrease the next year, when they could no longer drink legally. However, there was a sharp increase in 1980, at age 20, even though drinking was not legal. The overall chi-squared was 303.31, 4 d.f. Most of this (244.30) is associated with the increase at age 18, from 0.0625 to 0.1234. However, a substantial amount is also associated with the increase from age 19 to 20 (0.1082 to 0.1529) with X^2=51.47. The difference from age 16 to 17 was not significant at the joint 5% level (X^2=4.77 compared to 6.63), and there was no significant difference in comparing age 18 to age 19-20 combined (0.1188 to 0.1267, X^2=2.77). Thus, while the fatal data show a monotone increase in HBD rate over this age range, the 20% sample data show a slight, non-significant drop with the increased legal drinking age. This drop was followed by a sharp increase.

Age 20 in 1979

This cohort also was able to drink legally (at ages 18 and 19), then had that privilege withdrawn at age 20, and could again drink legally at age 21. Table 16 shows that the HBD rate in the fatal data had a sharp increase at age 18, with continued increases in each subsequent year, particularly at age 20. The chi-squared for the entire table is 20.71, 5 d.f. In the partitioning, the 16-17 group had a much lower HBD rate (0.2839) than the 18-21 group (0.4596). This difference is highly significant (X^2=14.91, p=0.0001). No

other partition was significant. However, the differences in rates between the 18-19 and 20-21 groups approached significance. The rates are 0.4135 for the younger group and 0.5161 for the older group (X^2=5.17, 1 d.f., compared with the joint 5% critical value of 6.63).

Table 16

Cohort Analysis: Age 20 in 1979

Age	Data File	
	Fatal	20% Sample
16	.327	.041
17	.264	.070
*18	.408	.133
*19	.421	.132
20	.509	.119
*21	.523	.174

The "*" denotes legal drinking.

Turning to the 20% sample data, the HBD rate shows a big increase at age 18--nearly double--a decrease at age 20, when this group could not drink legally, and a substantial increase at age 21 when this group could again drink legally. The overall chi-squared is 470.53, 5 d.f. Of this, 384.37 was associated with the difference between the 16-17 group compared to the 18-21 group; the rates increased from 0.0586 to 0.1366. The increase from age 16 (0.0413) to age 17 (0.0696) was also significant (X^2=17.00, p=0.0000). The individual ages 18 and 19 had essentially the same HBD rates, but the combined 18-19 ages were lower than the 20-21 group, 0.1326 compared to 0.1424. This difference, however, was not significant at the joint 5% level (X^2=5.05 compared to the joint critical value of 6.63). X^2=5.05, p=0.02). There is also a substantial difference between the 20- and 21-year-old rates, with the latter being significantly higher (X^2=64.09, p=0.0000). Thus, the 20% data demonstrate a decrease in HBD for the one year when drinking for this cohort was not legal, followed by an increase when it again was legal. This is a distinctly different pattern from that seen in the fatal data.

Age 21 in 1979

This cohort became legally able to drink at age 18 in 1976 and did not have its drinking privilege interrupted thereafter. The HBD rates in Table 17 show sharp increases at age 18 when the cohort could first drink legally. Generally HBD rates are about the same beyond age 18, although ages 18-19 are somewhat lower than ages 20-22.

The fatal data have an overall chi-squared of 33.56. Most of this (27.33) occurs at the age of majority: from 0.2486 to 0.4679 for the average rates before and after age 18. The increase from age 16 to age 17 was not statistically significant (X^2=2.44). The increase from 1976-1977 (0.4329) to 1978-1980 (0.4987) was not significant (X^2=3.09, 0.10<p<0.05). None of the other partitions had a chi-squared exceeding one.

Table 17

Cohort Analysis: Age 21 in 1979

Age	Data File	
	Fatal	20% Sample
16	.172	.038
17	.294	.068
*18	.447	.126
*19	.421	.128
*20	.516	.136
*21	.474	.156
*22	.500	.168

The "*" denotes legal drinking.

The 20% sample data had monotone increasing HBD rates. The total chi-squared was 517.63, 6 d.f. The largest component is identified with the age of majority, with the average rate for ages 16-17 increasing from 0.0561 to 0.1400 for ages 18-22 (X^2=437.78). Age 16 and 17 differed (X^2=18.98). Ages 18-19 differed from ages 20-22, with average rates of 0.1270 and 0.1510 (X^2=36.52). Age 18 did not differ significantly from age 19 (X^2=0.04). Age 20 was significantly lower than ages 21-22 (0.1357 compared to 0.1612, X^2=21.15), while the difference between ages 21 and 22 was non-significant.

Age 22 in 1979

This cohort, first able to drink legally at age 18 as shown in Table 18, exhibits somewhat similar patterns in the fatal and sample HBD rates. Both datasets show a sharp increase at age 18 corresponding to legal drinking. Both show the highest HBD frequency at age 19 and the highest HBD rate at age 23. However, the fatal data show a sharp increase in HBD frequency between age 22 (43) and age 23 (57), whereas the comparable figures from the 20% sample are 717 at age 22 and 562 at age 23. In both datasets the frequency of Had Not Been Drinking Drivers is lower at age 22 in 1979 than at age 23 in 1980. This drop in the frequency of HNBD accidents and drivers in 1980, as noted earlier, is generally the reason that the HBD rates are higher in 1980.

The overall chi-squared for the fatal dataset is 58.33, 7 d.f., p=0.0000. As with most of the other cohorts, the majority of this (X^2=40.26, p=0.0000) is associated with attaining legal drinking status at age 18. The rate for the 18-23 group (0.478) is more than twice that of the 16-17 ages (0.219). The drop from the combined 18-19 ages (0.4910) to the 20-year-olds (0.3786) is not significant at the joint 5% level (X^2=4.82 compared to the critical value of 7.24), nor is the increase from 0.4711 for ages 21-22 to 0.6000 at age 23 (X^2=4.53 compared to 7.24). None of the other changes approached significance.

Table 18

Cohort Analysis: Age 22 in 1979

Age	Data File	
	Fatal	20% Sample
16	.119	.029
17	.266	.054
*18	.440	.126
*19	.538	.138
*20	.379	.131
*21	.481	.131
*22	.457	.155
*23	.600	.167

The "*" denotes legal drinking.

The 20% sample data showed an overall chi-squared statistic that was also highly significant (X^2=670.39, 7 d.f., p=0.0000). Partitioning this showed that the most significant change in HBD rates corresponded to the legal drinking age (X^2=603.50). However, the difference between ages 16 and 17 was also significant (X^2=13.53), as was the difference between ages 18-20 and ages 21-23 (X^2=19.98). Although the differences were not large, the comparisons between 21 and 22, and between 21-22 and 23, were also significant.

Age 23 in 1979

This cohort, shown in Table 19, is similar to the age-22-in-1979 cohort. Both the fatal and 20% sample datasets have peak frequencies of HBD drivers at age 19 (in 1975), but have peak HBD rates occurring at age 24 (in 1980). Again the fatal HBD frequency increased from 1979 to 1980, while the HNBD frequency decreased from 49 to 35. As with the previous cohort, the 20% sample dataset had decreases in both HBD and HNBD frequencies, the latter proportionally larger so that the HBD rate actually increased to its maximum of any of the ages shown.

The fatal data have an overall chi-squared of 72.96 (8 d.f.), highly significant. The usual pattern holds: most of the increase is associated with the change when the legal drinking age is attained. The 16-17 rate (0.1749) increased to 0.4856 for the 18-24 ages (X^2=58.78, p=0.0000).

Table 19

Cohort Analysis: Age 23 in 1979

Age	Data File	
	Fatal	20% Sample
16	.141	.031
17	.200	.052
*18	.395	.102
*19	.522	.138
*20	.454	.134
*21	.448	.135
*22	.541	.124
*23	.479	.143
*24	.607	.158

The "*" denotes legal drinking.

None of the other partitions was significant at the joint 5% level. The largest was for the difference in rates between 1974 and 1975 (or ages 18 and 19) (X^2=4.75 compared to the cohort-wise 5% critical value of 7.26).

In the 20% sample data the overall chi-squared test was highly significant (X^2=581.16, 7 d.f., p=0.000). Again most of the difference could be associated with the age of enfranchisement (X^2=512.67). However, four other partitions were also significant at the cohort-wise 5% level. There was a significant increase from age 16 to age 17 (X^2=9.97). A significant increase occurred in comparing ages 18 and 19 with the ages 20-23 (X^2=15.06). The HBD rate at age 19 was larger than at age 18 (X^2=35.37). Finally, the higher HBD rate in 1979 compared to 1978 (age 23 compared to age 22) was significant (X^2=7.92).

Age 24 in 1979

This cohort, as seen in Table 20, shows many of the same characteristics as the earlier cohorts, but it also has several dissimilarities. Both the highest frequency (59) and the highest HBD rate (0.5268) occur at age 21 in the fatal dataset. There was little change in either thereafter. In the 20% sample dataset, the peak frequency occurred at age 20, and the peak rate (0.1602) at age 25. As with nearly all of the other cohorts, the increase in HBD rate in the 20% sample data--this includes all crash-involved drivers irrespective of accident severity--in 1980 occurred largely because of a 26% drop in HNBD drivers. However, the frequency of HBD drivers did concurrently decrease 10% as well. In contrast, the HBD fatal frequency remained essentially constant, while the HNBD frequency increased from 42 in 1979 to 50 in 1980.

The fatal data had an overall highly significant chi-squared statistic (X^2=44.16, 9 d.f., p=0.0000). Most of the difference in HBD rates was associated with the increase in HBD rate at the time the cohort became legally able to drink (in 1973 at age 18, X^2=30.47).). One other partition was nearly significant, with the 21-24 group having a higher rate than the 18-20 group (1976-1979 vs. 1973-1975, X^2=7.30 compared to the joint 5% critical value of 7.51).

Table 20

Cohort Analysis: Age 24 in 1979

Age	Data File	
	Fatal	20% Sample
16	.207	.029
17	.225	.048
*18	.317	.093
*19	.424	.109
*20	.412	.134
*21	.527	.124
*22	.449	.124
*23	.430	.126
*24	.512	.136
*25	.462	.160

The "*" denotes legal drinking.

The 20% sample data show significant overall differences in HBD rates (X^2=503.52, 8 d.f., p=0.000). In addition, several of the partitions were significant at the cohort-wise 5% level. The largest differences occurred when comparing ages 16 and 17 to ages 18-23. The increase in HBD rate for the older ages was significant (X^2=417.05). In addition, the HBD rate increased significantly from 1973 to 1974 and 1975 (ages 18 compared to 19 and 20) (X^2=31.13); the rate for age 20 is also higher than for 19 (X^2=16.33). There was also a significant increase in HBD rate for ages 21-24 compared to ages 18-20. (X^2=27.05). Finally, the increase in 1979 compared to 1978 was nearly significant (X^2=7.29 compared to the critical value of 7.51).

Summary of Cohort Analysis Results

Previous work (Flora, Filkins, and Compton [1]) involving cohort analysis showed that each cohort had a sharp increase in HBD rate when that cohort attained the legal drinking age, whether the age was 18, 19, 20, or 21. The present data concentrate on cohorts that became legally able to drink at age 18. The four youngest cohorts are somewhat different in that the two youngest are not yet old enough to drink legally and the next two had their drinking privileges interrupted. The current data generally show HBD rates increasing with age up to a maximum at age 20 or 21 or so and remaining relatively

constant thereafter. In addition, these data show a noticeably large increase at age 18 corresponding to the legal drinking age. The increase at age 18 was significant in all cohorts, even those who could not drink legally at that age.

Two cohorts had their drinking privileges interrupted. Those who were 19 in 1979 had been able to drink legally at age 18 and had this privilege removed in 1979-1980 at ages 19-20. The drivers in fatal crashes in this cohort showed increasing HBD rates, while the drivers in all accidents (the 20% sample data) showed a drop in HBD rates when the legal drinking age was raised. However, their rate increased in 1980 when they were 20. The other cohort--aged 20 in 1979--that had had drinking privileges interrupted also showed a small drop in the 20% sample HBD rate. This was followed by a substantial increase in 1980 when, at age 21, they could again drink legally. The HBD rates for the drivers involved in fatal crashes showed a monotone increasing trend with age.

2.5 Summary of Accident Data Analyses

In general all age groups showed an increasing trend over time in their HBD rates. The rate was generally lower in the 1968-1971 period (earlier legal drinking at age 21), markedly higher in the 1972-1978 period (legal drinking at age 18), and somewhat higher in the most recent, 1979-1980 period (legal drinking at age 21 again). The increase during the middle period was most noticeable for the drivers under 21. During the last two years, with legal drinking at 21, the frequency of HBD drivers increased for all age groups except for the 18- to 20-year-old drivers. This occurred both for drivers in fatal crashes and for drivers in any police-reported crash. On the other hand, the frequency of HNBD drivers decreased for all age groups. The result of these changes was a general increase in HBD rates across all ages, but smaller increases in the 18-20 age group than in the general population. Thus, while involvement in accidents has decreased in the 1979-1980 period, the role of alcohol in accidents has increased for all age groups except those directly affected by the increased legal drinking age.

Viewing the data from the cohort perspective, earlier work [1] showed that each cohort had a sharp increase in HBD rate when they were first able to drink legally. Current analysis of later cohorts shows a substantial increase

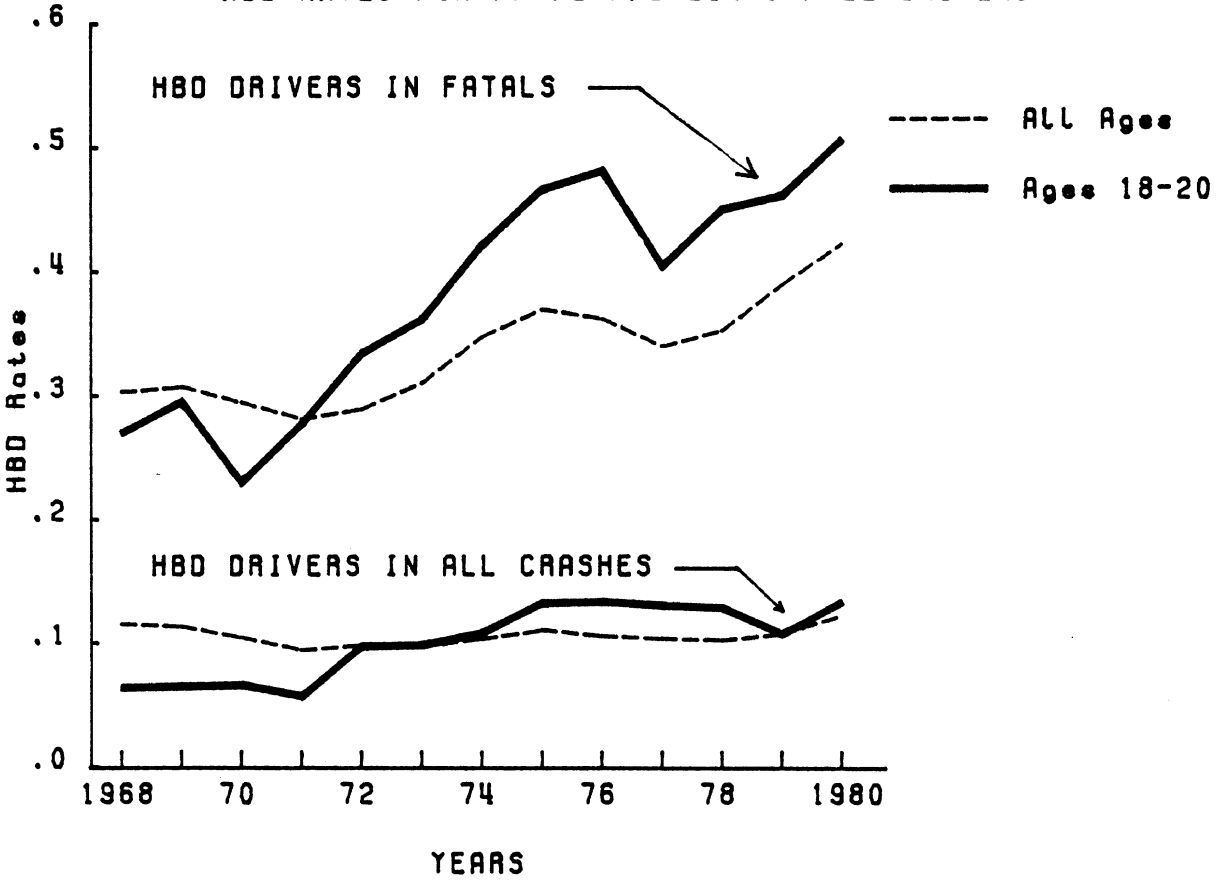
in HBD rates occurring at age 18, even though this was no longer the legal drinking age. Apparently some effect of the lower legal drinking age still persists. The HBD rates generally increase until age 21 or so, after which they remain relatively constant for several years before beginning a gradual decrease. Two cohorts had their legal drinking privileges interrupted. Drivers from these cohorts involved in fatal crashes exhibited continued increases in HBD rates, although the HBD frequencies dropped when legal drinking was interrupted. The 20% sample data showed slight drops in HBD rates when drinking privileges were interrupted, followed by increases when drinking became legal again.

The HBD rate for the 18-20 age group of drivers in fatal crashes is plotted in Figure 2, along with the rate for all drivers for comparison. The figure shows that the HBD rates were lower for the 18-20 age group than for all drivers until the drinking age was lowered. Since then, the rates for this age group have been higher than for all drivers; the plot of their rates is roughly parallel to that of the all-drivers curve, being about 7 or 8 percentage points higher (e.g. 50% vs. 42% in 1980).

HBD rates for drivers in all crashes (based on the 20% sample) are also presented in Figure 2 for the same two sets of drivers. The figure shows that HBD rates for 18- to 20-year-old drivers were below those for the general population until 1972, when the legal drinking age was lowered. The rates were virtually identical with the general population from 1972 through 1974, were noticeably higher from 1975 through 1978, and have returned to about the general population rates for the last two years (1979-1980) when drinking was legal at age 21.

FIGURE 2

HBD RATES FOR FATAL AND 20% SAMPLE DRIVERS



3. BREATH TEST AND IMPLIED CONSENT REFUSAL DATA

Michigan's breath-testing program began in the fall of 1967 as a result of the "implied consent" legislation.[1] This legislation provided that motorists were deemed to have given their consent to a chemical test of blood, breath, urine, or other bodily substance for the purpose of determining blood alcohol content if they had been arrested for driving under the influence or driving while impaired by intoxicating liquor. The legislation also provided that a motorist had the option of refusing a test altogether or demanding that only a breath test be given.

As a result of this legislation, and with financial support from the U.S. Department of Transportation, an extensive network of Breathalyzer test instruments was established throughout the state by the Michigan Department of State Police. The Safety and Traffic Division (now the Traffic Services Division) of the Department also formalized the procedures for conducting breath tests and for recording their results through use of a BREATHALYZER TEST REPORT (BTR).

Until 1980, standard operating procedures called for the completion of a BTR, in duplicate, each time a breath test was given. On many occasions, however, a BTR was filled out even if a drunk-driving defendant refused to take a breath test. This could happen, for example, if the defendant refused to take the breath test after the testing officer had prepared and calibrated his instrument. The BTR in this case might then be annotated with the fact of the refusal and the form mingled with the test forms for which the test was offered and accepted.[2]

The Michigan Department of State Police and the City of Detroit Police Department also used ALCOHOLIC INFLUENCE REPORT forms (AIR's) with drunk-driving arrests. These forms, although not the same for the two departments,

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[1] PA 253, State of Michigan, 74th Legislature, Regular Session of 1967, Enrolled House Bill No. 2038.

[2] The refusal information recorded on the BTR had no official standing. A different form--Officer's Sworn Report of Refusal to Submit to Chemical Test (DI93)--was forwarded to the Driver Improvement Division, Michigan Department of State, and formed the basis for official administrative sanctions against the refuser's driving license. This practice is still followed.

contained much of the same information as the BTR's and additional information about the arrest as well. The AIR's were sometimes used alone and sometimes in conjunction with a BTR.

A copy of the BTR--usually xerographic or carbon, but occasionally filled in by hand--and the AIR, if applicable, were subsequently forwarded to the Traffic Services Division of the Department of State Police. For 1979 and earlier years, the BTR's were tabulated and the data compiled into various reports used for administration of the breath-test program.

The BTR's and AIR's, after processing by the Traffic Services Division, were subsequently forwarded to the Michigan Department of State for its use in license appeal hearings. The forms were made available by MDOS to HSRI for data processing in this research program.

Starting in 1980, a revised version of the BREATHALYZER TEST LOG [Form UD-33] was used to record breath-test results. The logs--one for each instrument throughout the state--are collected monthly by the Traffic Services Division for administrative and statistical purposes. The change to use of the BTL for reporting purposes was motivated, in part, by the belief of headquarters personnel in the Traffic Services Division that not all of the BTR's were being forwarded to Lansing for processing. The UD-33 form was also revised at the time of this change so that the essential information recorded on the BTR's would also be recorded on the new log form. The complete set of 1980 UD-33 logs was made available to HSRI for entering the breath-test data into computer files.

3.1 Overview of BTR Data

In all, 65,576 cases were processed for 1978 and 1979. These cases comprised 61,417 different individuals, with the difference of the two (4159) accounted for by two or more arrests of the same persons. Of the total cases in the 1978-1979 file, 30,649 occurred during 1978 and 34,311 occurred during 1979. The balance--616 cases--either occurred in earlier years or had missing data on this item. The file contained over 4500 cases for which a breath test was refused. The resulting count of valid breath tests administered in connection with a drunk-driving offense was 27,528 in 1978 and 31,971 in 1979.

The BTL's processed for 1980 produced 41,119 cases, 41,009 of which were explicitly checked as having occurred during 1980. The OFFENSE variable on the form can be checked either "DUIL" or "Other," and the latter appeared 450 times; neither was checked in an additional 629 cases. Therefore these BTL data indicate that 39,930 breath tests were administered during 1980 as a result of a DUIL arrest.

The breath-test data for the three years, taken at face value and based on the number of valid breath tests, indicate that 16% more drunk-driving arrests occurred in 1979 than in 1978, and that 1980 arrests were up 25% over 1979. The 1979-1980 increase should be viewed with caution, however, in light of the fact that the 1979 frequencies were derived from individual Breathalyzer Test reports and the 1980 frequencies from the Breathalyzer Test logs. It is entirely possible, and indeed likely, that a considerable part of the 25% increase results from using two different data sources rather than strictly from a real increase in DUIL arrests. There are no independent arrest data currently available to the project staff to pursue this topic further, but a later analysis by county supports this possibility.

Drunk-driving arrests are still primarily a male phenomenon, with over 90% of them incurred by males. Females comprised 7.6% of 1978 arrestees, 8.5% of 1979 arrestees, and 9.4% of 1980 arrestees. A 1% increase per year in the percentage of female arrestees is not large, but it may indicate that long-term countermeasure efforts should be directed to both men and women rather than focusing primarily on men.

The average age of both the 1978 and 1979 arrestees is 33.3 years. About 2.2% were 17 years or younger, 51% were 30 years or younger, and 75% were 42 years or younger. About 1.7% of the defendants were 65 years or older. The 1980 data show a very slight shift toward younger drivers. The mean age decreased to 32.8 years, and the 1980 percentage of arrestees age 17 and under is 2.3%, 53.8% are age 30 or younger, and 77.6% are age 42 or younger. Issues related to age are discussed more fully in Section 3.4 dealing with the increase of Michigan's legal drinking age from 18 to 21 in late 1978.

Michigan residents accounted for 96.2% of the arrests in 1978-1979 and 96.4% in 1980. The neighboring jurisdictions of Illinois, Indiana, Ohio, Ontario, and Wisconsin together accounted for 2.5% in 1978-1979 and 2% in 1980, with the rest scattered among 51 other states and provinces.

The county in which the arrest occurred was determinable for 94% of the 1978-1979 cases. Of these, 52.8% took place in Macomb, Oakland, and Wayne counties. The next 13 most frequent counties (Bay, Berrien, Genesee, Ingham, Jackson, Kalamazoo, Kent, Livingston, Monroe, Ottawa, Saginaw, St. Clair, and Washtenaw), each with from 1%-4% of the total, together accounted for 26.7% of the arrests for which the location was determinable.

The 1980 situation is changed considerably in one important respect. The amount of missing data dropped sharply on the county-of-arrest variable, with the result that the county in which the arrest occurred was determined in 99% of the cases. The revised 1980 BTL provided a separate block for "Location of Arrest," with separate entries for "County No" and "City/Twp No." This is undoubtedly the reason for the increased reporting on this variable. One result, however, is that there are about 2,000 more cases in 1980 distributed among the counties in an unknown way. This condition, coupled with the likely increase in the number of reported arrests brought about by using the logs instead of the individual reports, makes it necessary to view changes from 1979 to 1980 with great care. It is certainly true, however, that the 1980 data present a more accurate picture of the county-by-county arrest experience than do the 1978 or 1979 data.

Wayne (22.6%), Macomb (12.3%), and Oakland (11.8%) again account for nearly half (46.6%) of the 1980 DUIL arrest experience. These three, together with the next 12 counties (Berrien, Calhoun, Genesee, Ingham, Jackson, Kalamazoo, Kent, Livingston, Monroe, Saginaw, St. Clair, and Washtenaw), account for three-fourths of all 1980 DUIL arrests.

Information about the pre-arrest event which triggered the DUIL arrest is available for all three years. Both forms provide boxes for checking whether an accident led to the arrest or some driving violation--speeding, for example, would be a legitimate reason for stopping a vehicle, although the specific fact of speeding would not be noted--preceded the arrest. An accident was checked as the triggering event in 17% of the cases during 1978-1979, a driving violation (without an accident) was checked in 79.9% of the arrests, and both boxes were checked on 1.3% of the BTR's. Little change was noted for 1980; the comparable figures are 17.4%, 81.7%, and 0.9%, respectively.

The BTR form also provided for recording the kind of offense for which the breath test was given. The DUIL offense accounted for 98.5% of the 1978-1979 arrests with DWI (Driving While Impaired) noted for only 0.2%. Drunk & Disorderly, Drunk Motor Law, other charges, and missing data accounted for the remainder. The BTL, however, provides only for a "DUIL" or "Other" charge. Of the 41,119 total cases originally processed for 1980, "DUIL" was checked in 97.0% of the cases, "Other" was checked in 1.1% of the cases, both were checked in 0.3% of the cases, and neither was checked for 1.6% of the cases. The "Other" and missing-data cases were subsequently eliminated for the analyses that follow.

The type of arresting department was determinable from the BTR in 93% of the 1978-1979 cases. Of these, the Michigan Department of State Police made 24% of the arrests, county sheriff departments made 15%, city police departments 54%, and other agencies, primarily township police departments, accounted for 7%. Additionally, the Department of Natural Resources used the breath test 45 times (0.07%), and there were 24 miscellaneous users, such as prisons checking the blood alcohol content of returning parolees.

The most notable difference for 1980, using the log instead of the individual reports, is that the arresting department was determinable in all but 0.3% of the cases. The Department of State Police again made 24% of the arrests, local police departments made 55.9% of the arrests, and county sheriff departments contributed 19.3% of the total.

There seems to be little doubt that use of the BTL, beginning in 1980, contributed to improved data-collection procedures for the breath-test results. There are no independent data available to assist in determining whether the large increase in numbers of arrests from 1979 to 1980 resulted from an increase in the actual number of arrests or from a more complete reporting of those that did occur. Apart from this uncertainty, however, the marked reduction in the amount of missing data on several of the variables is important. Although comparisons between 1979 and 1980 in the frequency of arrests are complicated considerably, the reduction in missing data will definitely contribute to a more accurate and usable data base in subsequent years.

3.2 Overview of Breath-Test Refusal Data

A DUIL defendant is legally entitled to refuse to take a breath test. The fact of the refusal is recorded and sworn to by the arresting officer, and the form is forwarded to the Department of State. The Department notifies the DUIL defendant that it has received official notice of refusal to take a chemical test and informs the defendant of his right to a License Appeal Board hearing regarding the arrest procedures. A second-level appeal through the courts is also possible if the defendant does not accept the LAB's conclusion. If the defendant does not appeal, or if neither of the appeals is successful, then the refusal information is recorded on the defendant's master driving record.

The Department of State searched their computer tapes containing master driving records for refusals occurring during 1978, 1979, and 1980. The refusal date, for each of one to ten refusals, together with the driver's sex and date of birth, were written into computer tape files for HSRI's use in the present program. The data contain a county code associated with each refusal, but the county is that of the driver's residence rather than the county in which the refusal occurred. Starting in July, 1981, the county code will indicate the county in which the arrest and refusal actually occurred.[1]

A total of 22,914 drivers had implied-consent refusals during the three-year period. The number of drivers having one or more refusals was 6,205 in 1978, 8,131 in 1979, and 8,578 in 1980. Thus a 31% increase occurred from 1978 to 1979 and a 5.5% increase from 1979 to 1980. The two-year increase from 1978 to 1980 is 38%, some 7% lower than the two-year increase of 45% noted from those cases in which a breath test was obtained.

Because of multiple refusals by the same driver, the number of refusals during the three-year period is 24,482, 6.8% higher than the number of refusers. Ninety-four percent of these drivers were found to have a single implied-consent refusal on their record. Drivers having two refusals numbered 1,188, or 5.2% of the total. One hundred forty-seven drivers (0.6%) had 3

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[1] Personal communication June 10, 1982 with J. Pixley, Michigan Department of State.

refusals, twenty-three drivers (0.1%) had 4 refusals, three drivers had 5 refusals, and one driver was found with 6 refusals. None had 7 or more refusals.

As with the breath-test data, the refusal data are predominantly male. Overall, 8.4% of the drivers were female, with 8.0% in 1978 and 1979 and 9.0% in 1980. Of the 21,552 drivers having just one refusal, 8.6% were female. Of the 1188 drivers having two refusals, 5.1% were female, and 4.8% of the 174 drivers with three refusals were female. None of the 32 drivers with four, five, or six refusals was female.

With respect to age, drivers with implied-consent refusals tend to be younger, but not markedly so, than DUIL defendants who accept a breath test. The average age of all drivers in the file, at the time of the first refusal, was 34.1 years.

From Table 21 it can be seen that drivers with a high number of refusals are somewhat older than drivers with fewer refusals. The drivers with one, two, or three refusals during 1978-1980 are about 34 years old, whereas those with three or more refusals are in their late 30's or early 40's.

Table 21

Average Age of Drivers at First Refusal by Number of Refusals: 1978-1980

Number Refusals	Drivers		
	Number	Average Age	Std. Dev.
1	21552	34.1	11.6
2	1188	33.6	10.6
3	147	33.9	10.4
4	23	38.0	10.2
5	3	42.7	13.3
6	1	40.0	

3.3 Effect of the Increased Legal Drinking Age

In the Introduction it was noted that Michigan raised its minimum legal drinking age from 18 to 21, effective December 13, 1978. These DUIL data, particularly those for 1978 and 1979, present an attractive alternative to the use of accident data only for assessing the effect of the increased legal drinking age. In the following analysis the data have been treated as if the change in legal drinking age were effective January 1, 1979. The effect is minor, of course, but it should be noted that the real differences in the DUIL arrest patterns of the 18- to 20-year-old drivers would be slightly greater than the differences reported here.

The emphasis in the following sections is on the change from 1978 to 1979 for two reasons. First, of course, is that those two years represent the immediately "before" and "after" years with respect to the most recent change in the legal drinking age. The second pertains to the observed increase in the frequency of DUIL arrests concurrent with the change in breath-test data forms beginning in 1980. As observed earlier, there are no independent means at hand for determining whether the increase resulted from an actual change in arrest frequencies or from just a change in reporting procedures. Therefore inferences drawn from the 1978 to 1979 changes are somewhat more reliable than those based on 1979 to 1980 changes, particularly those involving changes in frequency data. Age comparisons within the 1980 dataset, and those involving other variables as well, are valid.

3.3.1 Changes in DUIL Arrests: Age and Year Effects

The data to be presented in this section are highly persuasive that the increased legal drinking age definitely reduced the amount of drunk driving among the affected age group. It will be shown that the number of DUIL arrests, as measured by the BTR's, actually increased for all other ages from 1978 to 1979 but in fact decreased for the 18-20 age group. (The reason for part of the overall 1978-1979 increase is discussed in Section 3.4.)

Table 22 presents the 1978, 1979, and 1980 DUIL frequencies (for which a valid breath test was obtained) for 18- to 20-year-old drivers compared to all other drivers.[1] While drivers in all other age groups experienced a 20% increase in drunk-driving arrests from 1978 to 1979, drivers aged 18-20 experienced a 7% decrease during the same period.

Table 22

DUIL Arrests by Year
Age 18-20 vs. All Others

Age	Year			1978-1979 Change (%)	1979-1980 Change (%)
	1978	1979	1980		
18-20	4,049	3,757	4,836	-7.2	28.7
All others	23,302	28,058	34,750	20.4	23.9
TOTAL	27,351	31,815	39,586	16.3	24.4

Examination of the 3-year age groups adjacent to the affected age group is also useful. Table 23 presents, from the same datasets, DUIL arrests for the five 3-year groups from 15-29. Each of the other fourteen 3-year age groups from 30-71 exhibits the same pattern as drivers aged 15-17 and 21-29: 1979 DUIL arrests always exceed those for 1978.

Table 24 provides the same information for the fifteen single years from age 15-29. Here again it is seen that the 18-, 19-, and 20-year-old drivers had fewer DUIL arrests in 1979 than in 1978, and that all of the other single-year groups had more arrests in 1979 than in 1978. The increases range from 6.7% for the 17-year-olds to 42.0% for the 25-year-olds. Table 24 also shows that the highest frequency of any of the single-year groups during 1978 occurred for the 20-year-old drivers (1455 arrests). The peak shifted to the 21-year-old drivers in 1979, with 1624 arrests for these drivers; the 22-year-

[1] The missing-data rate on the age variable was low in all three years: 0.6% in 1978, 0.5% in 1979, and 0.9% in 1980.

Table 23

DUIL Arrests by Year
3-year Age Groups

Age	Year			1978-1979 Change (%)	1979-1980 Change (%)
	1978	1979	1980		
15-1 7	646	695	922	7.6	32.7
18 -20	4,049	3,757	4,836	-7.2	28.7
21-23	3,769	4,590	5,981	21.8	30.3
24-26	2,825	3,653	4,686	29.3	28.3
27-29	2,227	2,896	3,736	30.0	29.0

old drivers had about the same number and percentage increase over 1978 as the 21-year-old-drivers. Again in 1980 the 21-year-old drivers experienced the most arrests (2068), with the 22-year-old drivers running a close second.

3.3.2 Investigation of Two Alternative Explanations

The data presented above indicate strongly that the number of drunk drivers among 18- to 20-year-old drivers decreased from 1978 to 1979. The reduced legal drinking age is the most plausible reason for the observed reduction. Indeed, the authors do not know of any other social changes, changes in the traffic system, or changes in arrest procedures or processing of the associated data, that would result in fewer DUIL arrests among 18-,19-, and 20-year-old drivers while at the same time resulting in more DUIL arrests among other drivers. Nonetheless, it is certainly prudent to acknowledge the possibility that the observed reductions in the 18-20 age group might result from other changes in the system.

One potential explanation of the differential arrest experience for the 18-20 age group might be found in the willingness to accept a breath test. A very much higher proportion of 18- to 20-year-old DUIL arrestees refusing to take a breath test in 1979 compared to 1978 conceivably could account for the reduction among this age group's defendants who accepted the test.

Table 24

DUIL Arrests by Year
Single Years from Age 15 to Age 29

Age	Year			1978-1979 Change (%)	1979-1980 Change (%)
	1978	1979	1980		
15	4	5	13	25.	160.
16	122	135	222	10.7	64.4
17	520	555	685	6.7	23.4
18	1192	1131	1422	-5.1	25.7
19	1402	1259	1634	-10.2	29.8
20	1455	1367	1780	-6.0	30.2
21	1280	1624	2068	26.9	27.3
22	1306	1612	2020	23.4	25.3
23	1183	1354	1893	14.5	39.8
24	1050	1331	1709	26.8	28.4
25	873	1240	1517	42.0	22.3
26	902	1082	1460	20.0	34.9
27	805	1029	1307	27.8	27.0
28	755	960	1276	27.2	32.9
29	667	907	1153	36.0	27.1

In order to investigate this possibility, information about the refusals processed by the Department of State was used. Table 25 presents the number of drivers, by age, for whom a Chemical Test Refusal was recorded in 1978-1980.

It is seen that in 1979 there were 73 more 18- to 20-year-old drivers having a Chemical Test Refusal recorded on their driving record than in 1978, a 14.5% increase. Every other three-year age group, through ages 66-68, also experienced an increase, however. The increases are seen to be proportionately larger as well, excepting only the 51-53 group. The result is that the 18-20 group contained 8.1% of the refusing drivers in 1978 but only 7.1% in 1979. Thus our conjecture that a higher refusal rate in 1979 compared to 1978 might account for the reduced number of 18- to 20-year-old DUIL drivers noted in 1979 is not substantiated.

Table 25

Drivers with Implied Consent Refusals: 1978-1980

Age Groups	Year						1978-79 Change (%)
	1978		1979		1980		
	N	%	N	%	N	%	
13-17	67	1.1	112	1.4	97	1.1	67.2
18-20	502	8.1	575	7.1	602	7.0	14.5
21-23	641	10.3	973	12.0	1025	11.9	51.8
24-26	691	11.1	890	10.9	1030	12.0	28.8
27-29	686	11.1	889	10.9	1001	11.7	29.6
30-32	579	9.3	852	10.5	847	9.9	47.2
33-35	531	8.6	693	8.5	733	8.5	30.5
36-38	448	7.2	588	7.2	650	7.6	31.3
39-41	411	6.6	521	6.4	506	5.9	26.8
42-44	349	5.6	403	5.0	469	5.5	15.5
45-47	308	5.0	392	4.8	343	4.0	27.3
48-50	281	4.5	358	4.4	337	3.9	27.4
51-53	251	4.0	274	3.4	313	3.6	9.2
54-56	183	2.9	236	2.9	238	2.8	29.0
57-59	113	1.8	173	2.1	162	1.9	53.1
60-62	77	1.2	93	1.1	97	1.1	20.8
63-65	48	.8	59	.7	60	.7	22.9
66-68	18	.3	26	.3	35	.4	44.4
69-71	14	.2	11	.1	25	.3	-21.4
72-74	5	.1	9	.1	4	.0	80.0
75-77	2	.0	1	.0	2	.0	-50.0
78-84	-0-	-0-	3	.0	2	.0	-0-
TOTAL	6205	100.0	8131	100.0	8578	100.0	31.0

We are now in a position to combine the data for the arrested and tested drivers with those who were arrested but refused a chemical test. The combined data are given in Table 26. This table shows the total number of drivers who were arrested for DUIL in 1978 and 1979, and who either accepted a test or refused a test and did not successfully appeal. (The earlier tables present the number of arrests experienced by drivers in various age groups, whereas Table 26 gives the number of drivers who have had one or more arrests.)

Table 26

Total DUIL Drivers - 1978 and 1979

Age Group	Year		Yearly Change (%)
	1978	1979	
13-17	706	789	11.8
18-20	4412	4035	-8.5
21-23	4283	5156	20.4
24-26	3423	4248	24.1
27-29	2817	3561	26.4
30-32	2455	3207	30.6
33-35	2148	2494	16.1
36-38	1881	2299	22.2
39-41	1729	1981	14.6
42-44	1540	1666	8.2
45-47	1466	1600	9.1
48-50	1457	1520	4.3
51-53	1258	1324	5.2
54-56	1039	1119	7.7
57-59	715	853	19.3
60-62	493	561	13.8
63-65	367	385	4.9
66-68	185	211	14.1
69-71	104	116	11.5
72-74	67	61	-9.0
75-77	19	32	68.4
78-84	12	22	83.3
TOTAL	32576	37240	14.3

As expected, the same pattern is evident for the drivers, now including those who refused to take a breath test, as was evident for the arrests. In total, 1979 arrestees (including the 18-20 age group) exceed 1978 arrestees by 14.3%. Excluding the 18- 20-year-old drivers from the totals shows that 17.9% more drivers of all other ages experienced arrests after the legal drinking age was increased, while at the same time the affected 18- to 20-year-old drivers experienced an 8.5% reduction. Of perhaps more significance is the fact that the other three-year age groups closest in age to the affected group--the 13-17, 21-23, and so on--concurrently had more arrested drivers in

1979 than in 1978. From these data it is now clear that a differentially higher refusal rate in 1978 than in 1979 among the 18-20 group did not account for the lower arrest experience in 1979.

Another potential explanation of the differential DUIL arrest experience for the 18-20 group--although far more speculative--is that police officers have not dealt consistently with this group over the past few years. An inconsistency might have existed in either of two forms.

One possibility is that police officers were relatively more lenient with 18- to 20-year-old drunk drivers in 1979 than in 1978 because that group had just lost its legal drinking privileges. Such a practice might have reflected a general feeling among police officers that the legal drinking age should not have been increased for this group of young adults. Another possibility is that officers were more zealous with this group in the 1972-1978 period because they felt that 18- to 20-year-old drivers should not have been permitted to drink legally starting in 1972, and they were making a special effort to get that message across. If such were the case, then the increase in legal drinking age to 21 in December, 1978, might have then been followed by a more relaxed attitude on their part starting in 1979.

Either of these possibilities would suggest, if true, that some officers might have arrested only the very drunk drivers and would not have charged marginally drunk 18- to 20-year-old drivers during 1979. Under this assumption, there might be some shift, from 1978 to 1979, in the BAC distribution for the affected age group. It would be further speculated that the shift would cause the average BAC of 1979 arrestees to be higher than the average for 1978. A higher percentage of arrested drivers would also be found in the higher BAC ranges.

The first of these possible changes was not observed in this dataset. The average BAC for the 18-20 age group in 1978 was 0.1478% W/V. For 1979 it was 0.1473% W/V, an insignificant change. A slight rise in average BAC to 0.1550% W/V was noted for this group in 1980. As can be seen in Table 27, however, the increased average BAC in 1980 is not limited to just this group but holds for all of the adjacent age groups as well.

The second possible change--a shift of drivers from lower to higher BAC ranges--can also be examined in Table 27. It gives the distribution (percentage) of drivers in the four youngest age groups for the three years in terms of the legally presumptive limits relevant to drunk-driving arrests. (Drivers testing at or below 0.07% W/V are presumed to be not under the influence, drivers testing 0.08 or 0.09 are presumed to be Driving While Impaired, and drivers at a BAC of 0.10 or higher are presumed to be Driving Under the Influence of Liquor. The 0.15 BAC is of historical interest in that formerly it was the presumptive limit for DUIL.)

Table 27

Percentage Distribution of Young Drivers by BAC and Year

Blood Alcohol Concentration	Age Group Year											
	14-17			18-20			21-23			24-26		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
0-7	9.7	9.0	5.9	6.9	6.3	4.8	5.3	5.3	4.3	4.2	4.2	4.0
8-9	6.9	7.6	6.1	5.2	5.8	3.5	4.1	4.2	2.9	3.0	2.7	2.8
10-14	39.8	38.2	40.0	33.3	33.1	30.1	28.8	28.3	26.2	24.3	24.7	21.4
15-33	43.5	45.2	48.1	54.7	54.8	61.6	61.8	62.2	66.6	68.4	68.3	71.8
Average	.135	.137	.141	.148	.147	.155	.158	.157	.163	.167	.166	.170

The table shows that there have been minimal shifts in the distribution of arrests by BAC from 1978 to 1979 for the 18- to 20-year-old drivers. The percentage of all arrests for this age group in the lowest range has decreased slightly from 6.9% in 1978 to 6.3% in 1979, but this is exactly offset by the 0.6% increase in the 0.08 - 0.09 range. There is a slight increase in the percentage of drivers in the highest BAC range for 1980. As with the increase in average BAC, however, this change is not unique for only the 18-20 group but holds for the adjacent age groups as well.

There are no obvious changes from 1978 to 1979 in DUIL arrest practices for younger drivers that can be inferred from this line of inquiry. The changes in BAC noted from 1979 to 1980 are slight and not specific to just the 18- to 20-year-old drivers. Thus no evidence of police favoritism or prejudice is apparent from this dataset.

This section has presented, in considerable detail, the DUIL arrest patterns for drivers of all ages during 1978 and 1979. The 18-, 19-, and 20-year-old drivers, whether considered singly or as a group, consistently show fewer arrests in 1979 than in 1978. Drivers of all other ages, specifically including those just slightly younger and older, experienced more arrests in 1979 than in 1978. Neither of two other possible explanations that were investigated was found to be supported by the data. The only reasonable conclusion consistent with these data is that the increased legal drinking age led to an immediate and substantial decrease in the number of 18- to 20-year-olds driving unsafely while under the influence of liquor.

3.4 Effect of Warrantless Arrest at Accident Scenes

Prior to August, 1978 the motor vehicle and criminal codes did not specifically provide for DUIL arrests of drunk drivers at accident scenes. The applicable sections of these codes were amended in 1978 (P.A. 1978, No. 384 and No. 391) to enable officers to arrest drunk drivers at accident scenes without a warrant. The perceived gap in the arrest powers of officers for handling accident-involved drunk drivers is indicated in the legislative analysis of one of the bills:[1]

> Although under present law police officers are authorized to make warrantless arrests for felonies which they have not personally witnessed, a person who commits a misdemeanor offense, including "driving under the influence of liquor", cannot be arrested without a warrant unless the offense was committed in the presence of a police officer. In the majority of automobile accidents involving intoxicated drivers, a police officer does not actually witness the accident and therefore cannot arrest the driver and conduct a Breathalyzer test under "implied consent" provisions of drivers' license issuance. Some persons believe that this is a serious flaw in the law which should be corrected to allow an officer to make an arrest if the officer has good reasons to believe that a person at the scene of an accident has been driving under the influence of liquor.

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[1] ANALYSIS - H.B. 4642 (2-13-78), House Legislative Analysis Section.

Also pertinent, among the arguments advanced for the bill, is the relationship to arrest for public intoxication:

> Public intoxication became decriminalized on January 15, 1978. As a result, an officer cannot arrest a drunken driver on a charge of "public intoxication" at the scene of an accident. Without House Bill 4492, police officers would have their hands completely tied at the scene of an accident involving a drunk driver.

Accordingly, the Michigan code of criminal procedure was revised to include the following, and the same language was inserted into the motor vehicle code:

Sec. 15 (1) A peace officer may, without a warrant, arrest a person in the following situations:

(h) When the peace officer has reasonable cause to believe that the person was, at the time of an accident, the driver of a motor vehicle involved in the accident and was driving the vehicle upon a public highway of this state while under the influence of intoxicating liquor.

This revision of the criminal code was effective July 27, 1978 and the associated motor vehicle code revision was effective August 1, 1978.

Breathalyzer test reports show whether the DUIL arrest was preceded by an accident, a driving violation, or both. The dataset covers 7 months before the law changed and 17 months after, and thus it lends itself to an examination of whether the warrantless arrest provision is fulfilling its intended purpose.

A sharp change in the pattern of preceding incidents, starting exactly in August, 1978, is seen from Table 28. The table gives, for the DUIL cases for which both a breath test was given and the preceding incident was identified, the arrests by month for 1978.

Starting in August, the frequency of DUIL arrests preceded by an accident just about doubled, increasing each month thereafter (excepting November), and peaked at 646 in December. The monthly percentage attributable to these cases averaged 8.5% in the first 7 months, with a low of 7.0% in April and a high of 9.3% in July. The percentage jumped to 16.9% in August and continued to increase each month thereafter (again except for November), reaching 21.6% in December. The 5-month, August-December average of 19.0% is more than double the comparable percentage in the 7-month, pre-law period.

Table 28

1978 DUIL Arrests by Month and Preceding Incident

Month	Preceding Incident			TOTAL
	Accident	Violation	Both	
January	124 8.6%	1291 89.9%	21 1.5%	1436 100%
February	145 8.4%	1564 90.6%	18 1.0%	1727 100%
March	205 8.4%	2214 90.4%	30 1.2%	2449 100%
April	170 7.0%	2214 91.6%	34 1.4%	2418 100%
May	175 9.1%	1720 89.5%	26 1.4%	1921 100%
June	163 8.7%	1682 90.1%	22 1.2%	1867 100%
July	193 9.3%	1867 89.5%	25 1.2%	2085 100%
JANUARY - JULY SUBTOTALS	1175 8.5%	12,552 90.3%	176 1.3%	13,903 100%
August	371 16.9%	1793 81.5%	37 1.7%	2201 100%
September	450 17.5%	2079 81.0%	39 1.5%	2568 100%
October	536 19.2%	2224 79.5%	36 1.3%	2796 100%
November	484 19.0%	2021 79.4%	41 1.6%	2546 100%
December	646 21.6%	2296 76.8%	46 1.5%	2988 100%
AUGUST - DECEMBER SUBTOTALS	2487 19.0%	10,413 79.5%	199 1.5%	13,099 100%

Table 29 shows the same data for the first 7 months of 1978 compared to the first 7 months of 1979. The frequency of arrests preceded by an accident increased 177.4% from 1978 to 1979, nearly triple. Arrests preceded by violations were up only 14.7% in the same period. The post-law period shows 18.2% of all arrests triggered by a preceding accident compared to 8.5% in the pre-law period.

Table 29

DUIL Arrests by Month and Preceding Incident
January - August

Month	Preceding Incident			TOTAL
	Accident	Violation	Both	
January-July, 1978	1175 8.5%	12,552 90.3%	176 1.3%	13,903 100%
January-July, 1979	3259 18.2%	14,393 80.5%	227 1.3%	17,879 100%
Frequency change	+2084	+1841	+51	+3976
Percentage change in frequencies	+177.4%	+14.7%	+29.0%	+28.6%

Data from these two tables speak for themselves. The frequency of arrests preceded by accidents sharply increased in August, 1978, exactly when the warrantless arrest provision went into effect. The percentage of DUIL arrests accounted for by this category doubled at the same time, and both of these shifts were sustained during the following months. Looking at the accident data during the same general time period, we find that the number of Had Been Drinking accidents and the number of HBD, accident-involved drivers actually decreased about 1% from 1978 to 1979.[1] Therefore the increased number of DUIL arrests triggered by an accident must have come, not from

[1] Had Been Drinking accidents numbered 58,636 in 1978 and 58,127 in 1979. HBD drivers numbered 61,723 and 60,834 for these years. Source: Michigan Traffic Accident Facts, 1978 and 1979, Michigan Department of State Police.

increased numbers of alcohol-related accidents, but from the way police were arresting drivers involved in those accidents. Clearly the warrantless arrest provision of the criminal and motor vehicle codes is serving its intended purpose.

4. RELATIONSHIPS BETWEEN HBD ACCIDENTS AND DUIL ARRESTS

Earlier sections of this report have dealt separately with drivers in HBD accidents (accidents in which the investigating officer(s) determined that at least one of the involved drivers Had Been Drinking prior to the accident) and DUIL arrests. In this section relationships between DUIL arrests and HBD accidents are considered for Michigan's 83 counties from two different perspectives.

The first of these is whether drunk-driving enforcement efforts reduce alcohol-related crashes. This topic is particularly important now, for Michigan and the whole country, because the mood and thrust of much of the effort to deal with the problem is more vigorous law enforcement and more severe administrative and judicial sanctions levied against convicted drunk drivers. The subject is complex, of course, and a thorough exposition of the topic is far beyond the scope of the present discussion. However, it is certainly worthwhile to use the HBD and DUIL datasets to the extent possible to investigate this question, and the results of a preliminary analysis are given in the first subsection.

The second subsection uses these same variables in the calculation of a DUIL enforcement index. This index is intended to assist policy-makers in assessing the intensity of law enforcement in each county relative to the extent of its alcohol-related crash problem.

4.1 Enforcement and Alcohol-Related Accidents

The number of DUIL arrests occurring within a jurisdiction--counties, in this instance--depends on a large number of factors, none of which are easily measured. The amount of drunk-driving that occurs, taking into account both the numbers of drunk drivers and the extent of their drunkenness, directly affects the probability of a DUIL arrest. The number of road patrol vehicles within a county and the amount of patrol time they accumulate (during the periods in which drunk-driving is concentrated) also influence the number of DUIL arrests. Attitudes of road-patrol officers also are important. If drunk-driving enforcement is given a low priority at the command and operational levels then fewer DUIL arrests will result with given amounts of

drunk-driving and road-patrol activity. Higher levels of all of the above factors should result in more DUIL arrests, although the functional relationship certainly remains unknown at the present.

On the other hand, some factors should tend to reduce the number of DUIL arrests for given levels of drunk-driving and enforcement activity. The area being patrolled is one of these. It is reasonable to presume that the probability of a DUIL is lower in a county of say, 1500 square miles with ten road patrols and given numbers of drunk-drivers on the road, than it is in a county of 1000 square miles with ten road patrols and the same number of drunk-drivers. The chance of a patrol officer encountering a drunk driver is surely lower in the former case, and the number of DUIL arrests should also be lower. Similarly, the number of road miles should influence the number of arrests within a county for given levels of the other variables. Doubling the number of road miles on which drunk-drivers could drive should also reduce the number of chance encounters between them and road patrols, and the probability of an arrest would be decreased.

Given the complexity of the situation, it is by no means obvious what measure(s) of law enforcement (both activity and policy) one would adopt even if completely free to do so. Certainly one good candidate of overall activity would be the frequency of DUIL arrests per year. It was noted in Section 3, however, that a DUIL arrest can be preceded either by an accident or by a driving violation as the triggering event which alerts the arresting officer. Since we are interested in examining the relationship between law enforcement and alcohol-related accidents, it makes sense to separate those DUIL's associated with an alcohol-related accident from those brought about by non-accident driving activities. Failing to do so would necessarily result in a built-in correlation between our dependent and independent variables in the subsequent analysis.

From a practical point of view road mileage within a county seems to be the best of the available measures. From Table 2-2 of MDOT's Annual Progress Report [11], "TOTAL" road miles have been used in the subsequent analysis. "TOTAL" miles consist of urban primary, urban local, rural primary, rural local, and rural trunk line road miles.

Measurement of the alcohol-related crash problem is somewhat more straightforward. The number of HBD accidents is the best indicator of the extent of the a-r crash problem within a county. As with DUIL arrests, this number will be strongly influenced by the amount of drunk driving occurring within a county. The amount of drunk driving will be related to a number of other non-independent, highly-correlated variables such as vehicle-miles traveled, number of inhabitants, number of licensed drivers, and number of registered vehicles. All of these are potentially useful, but none is completely satisfactory and all may be criticized on various counts. Population data, therefore, have been used subsequently both because of convenience and because the 1980 figures are readily available. A county's road mileage may also influence the number of accidents in that greater road mileage may be indicative of greater travel not accounted for by the population variable. A sparsely populated county through which two interstate highways run is an example of this situation.

In summary, the number of DUIL arrests preceded by a driving violation in 1980 will be used as a measure of law enforcement activity directed to the drinking-driver problem within a county, and it will be taken as the primary independent variable of interest. The number of HBD accidents in 1980 will be used as a measure of the extent of the problem, and it will appear in the analysis as the dependent variable. Population and road mileage for each county will also appear as independent variables because their presence is indicated on logical grounds.

4.1.1 Correlation Matrix

The general nature of the individual relationships between DUIL arrests, HBD accidents, and the two exposure variables is indicated in the correlation matrix between these variables.[1]

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[1] Analytical work has been carried out in the MIDAS (Michigan Interactive Data Analysis System) program in MTS. MIDAS was written and is maintained by the University's Statistical Research Laboratory.

Correlation Matrix CASES=CASE#:1-83

N= 83 DF= 81 $R_{\neg}$.0500= .2159 $R_{\neg}$.0100= .2813

VARIABLE				
7.TOTAL RM	1.0000			
10.P80/1000	.3847	1.0000		
82.HBD 80	.3963	.9988	1.0000	
202.INC80VIO	.3885	.9640	.9592	1.0000
	7.	10.	82.	202.
	TOTAL RM	P80/1000	HBD 80	INC80VIO

A central fact to be observed from the correlation matrix is that Variable 82 (frequency of 1980 HBD accidents) and Variable 202 (frequency of 1980 DUIL arrests preceded by a driving violation) are both highly correlated with Variable 10 (1980 population in thousands of inhabitants.) The V82-V10 correlation is 0.9988, and the V202-V10 correlation is 0.9640. This exceptionally high correlation between the two variables of primary interest and a county's population suggests that the two variables themselves will be highly correlated, and this turns out to be case as indicated by the correlation of 0.9592 between them. Clearly any county-by-county analysis of the relationship between DUIL enforcement and HBD accidents must take into account this fundamental relationship. Without controlling for correlation with a third variable--population, in this case--one can be led to an erroneous conclusion that increased drunk-driving enforcement results in more alcohol-related accidents.

The correlation matrix also shows significant correlation between population and road miles (Variable 7), 0.3847. This is to be expected in that the more populous counties usually have a larger road network servicing them.

4.1.2 Regression Results

There are a number of ways to analyze the kinds of available data available here. All involve searching for the simplest structure which adequately describes the data and which is consistent with independent

information about the situation being modeled. Regression analysis is one of the standard techniques readily available in MIDAS, the results from which are shown below.

```
<SELECT VAR=82,7,10,202 CASES=1-83>

Selection of Regression  CASES=CASE#:1-83


ANALYSIS AT STEP 3 FOR 82.HBD 80  N= 83 OUT OF 83

SOURCE                DF   SUM OF SQRS  MEAN SQUARE   F-STAT     SIGNIF

REGRESSION             3    .20298 +9    .67662 +8    12446.     0.
 ERROR                79    .42946 +6    5436.2
 TOTAL                82    .20341 +9

MULTIPLE R= .99894  R-SQR= .99789  SE= 73.731


     VARIABLE      PARTIAL  COEFFICIENT  STD ERROR   T-STAT     SIGNIF

     CONSTANT                -16.889      25.105     -.67273      .5031
    7.TOTAL RM       .29316   .58111 -1   .21322 -1   2.7254      .0079
   10.P80/1000       .98659   5.6955      .10599      53.734      .0000
  202.INC80VIO      -.30439  -.87973 -1   .30974 -1  -2.8402      .0057


REGRESSION OF 82.HBD 80 USING FORWARD SELECTION

STEP    R-SQR  STD ERROR  # VAR       VARIABLE          PARTIAL  SIGNIF

   1   .99750   79.196        1    10.P80/1000     IN   .99875  0.
   2   .99769   76.636        2   202.INC80VIO     IN  -.27419   .0127
   3   .99789   73.731        3     7.TOTAL RM     IN   .29316   .0079
```

Since the constant term is not significant, the (linear) relationship between the variables is given as:

$$V202 = 5.7V10 - 0.088V202 + 0.058V7$$

HBD Accidents = 5.7 times county population in thousands minus
0.088 times county DUIL's preceded by a violation plus
0.058 times county road miles.

4.1.3 Interpretation of Results

The analysis indicates that most of the county-by-county variability in 1980 alcohol-related accidents can be accounted for by a county's population, its drunk-driving enforcement (as measured by DUIL arrests preceded by a driving violation), and its road mileage. The signs of the coefficients indicate that HBD accidents increase with population and road mileage and decrease with DUIL arrests.

These results are in accord with our judgment about how the variables in question should influence alcohol-related accidents. For several reasons, however, it would be a flagrant error to make the quantum leap that concludes that if we arrest 1200 more drunk drivers we will necessarily eliminate 100 alcohol-related accidents.

Cross-sectional correlational models are not causal models, and they should not be interpreted as such. Further, regression analyses using the same variables as above have been made on various subsets of Michigan--all counties except the three largest, counties with less than 100,000 population, and the like--with varying results. In all cases the coefficients changed magnitude, and in some cases a variable that was significant with one subset was not significant with a different subset.

In addition, the use of the same variables in a somewhat different manner can produce slightly different results. For example, the number of HBD accidents per capita is a reasonable choice for the dependent variable. Regressions using this variable have different coefficients on the independent enforcement and road-mileage variables so that numerically different conclusions are possible.

Finally, the potential imperfections in the choice of DUIL's as a measure of drunk-driving enforcement should be recognized. For example, one can envision that, at some exceptionally high level of enforcement coupled with severe penalties upon conviction, there would be be very little drunk driving and hence few DUIL's. In such a situation the number of DUIL's, as used above, would clearly be a poor measure of enforcement activity.

A balanced viewpoint of these data is that the variability in alcohol-related accidents from county to county is primarily a function of population differences. After accounting for population differences, greater enforcement is associated with fewer alcohol-related accidents, while increased road mileage is associated with more accidents. The results are indicative of the kind of modeling that can be undertaken with the data. If several years of high quality accident and enforcement data become available then it should be possible to develop cost-benefit analyses to indicate the potential payoff of further enforcement efforts.

4.2 DUIL Enforcement Index

At the beginning of the project a DUIL enforcement index was conceived as an aid to further understanding of the alcohol-related crash problem and law enforcement efforts to deal with it. It was also thought that the index would assist policy makers and program planners in their efforts to plan countermeasure efforts and to allocate limited resources to competing traffic safety projects. The utility of this measure for its intended purposes has yet to be demonstrated.

The DUIL enforcement index is the ratio of a jurisdiction's DUIL arrest frequency, for some given time period, to its alcohol-related crash frequency during the same period. DUIL arrests for 1978 and 1979, as used here and in the preceding sections as well, include those for which the offense noted on the Breathalyzer Test Report was a DUIL (Driving Under the Influence of Liquor), DWI (Driving While Impaired), or DML (Drunk Motor Law). For 1980, arrest data were obtained from the Breathalyzer Test Logs; these logs do not differentiate between the three categories and simply record the occurrence of a DUIL arrest in the broad sense. Consequently, the 1980 data are not directly comparable to those for 1978 and 1979. This change almost surely resulted in an artifactual increase in the frequency of DUIL arrests. For all three years alcohol-related crash frequencies were obtained from the HBD (Had Been Drinking) variable recorded on the UD-10 Accident Report form.

The index was discussed at some length for 1978 and 1979 in the last interim report [2], and that discussion need not be repeated here. For all three years the DUIL arrest frequencies, accident frequencies (classified by HBD, HNBD, and NKID, Not Known if Drinking), and DUIL indexes are given in Tables 30-32 for the state as a whole and for each of its 83 counties.

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Table 30

1978 Accidents, DUIL's, and DUIL Index by County

County		Arrests	Accidents				DUIL Index
Name	#		HBD	HNBD	NKID	TOTAL	
Alcona	1	12	70	321	15	406	.171
Alger	2	13	104	287	9	400	.125
Allegan	3	222	506	2250	76	2832	.439
Alpena	4	89	254	847	45	1146	.350
Antrim	5	63	101	503	7	611	.624
Arenac	6	33	160	604	10	774	.206
Baraga	7	17	82	270	18	370	.207
Barry	8	84	225	1365	37	1627	.373
Bay	9	236	939	4104	163	5206	.251
Benzie	10	4	84	394	17	495	.048
Berrien	11	822	1209	6578	368	8155	.680
Branch	12	205	247	1514	55	1816	.830
Calhoun	13	288	909	5504	296	6709	.317
Cass	14	217	387	1734	52	2173	.561
Charlevoix	15	41	144	622	13	779	.285
Cheboygan	16	51	151	598	22	771	.338
Chippewa	17	59	275	854	74	1203	.215
Clare	18	74	223	1072	25	1320	.332
Clinton	19	210	329	1663	40	2032	.638
Crawford	20	63	88	478	24	590	.716
Delta	21	35	286	1439	92	1817	.122
Dickinson	22	47	196	816	46	1058	.240
Eaton	23	141	496	2547	71	3114	.284
Emmet	24	48	174	862	37	1073	.276
Genesee	25	941	3142	13663	751	17556	.299
Gladwin	26	118	110	616	18	744	1.073
Gogebic	27	54	154	620	40	814	.351
Grand Traverse	28	77	464	2558	72	3094	.166
Gratiot	29	63	240	1361	66	1667	.262
Hillsdale	30	79	250	1481	116	1847	.316
Houghton	31	94	286	1053	81	1420	.329
Huron	32	186	245	1003	38	1286	.759
Ingham	33	834	1706	11091	158	12955	.489
Ionia	34	50	355	1690	82	2127	.141
Iosco	35	68	238	1083	19	1340	.286
Iron	36	35	91	397	28	516	.385
Isabella	37	44	320	1661	38	2019	.137
Jackson	38	329	1123	5698	305	7126	.293
Kalamazoo	39	597	1204	8518	413	10135	.496
Kalkaska	40	102	94	442	12	548	1.085
Kent	41	786	2526	18371	551	21448	.311
Keweenaw	42	10	34	38	2	74	.294
Lake	43	11	88	358	4	450	.125
Lapeer	44	295	429	2073	54	2556	.688

Table 30 (continued)

1978 Accidents, DUIL's, and DUIL Index by County

County		Arrests	Accidents				DUIL Index
Name	#		HBD	HNBD	NKID	TOTAL	
Leelanau	45	26	76	311	23	410	.342
Lenawee	46	143	535	3586	177	4298	.267
Livingston	47	186	583	2759	98	3440	.319
Luce	48	50	58	206	13	277	.862
Mackinac	49	38	108	371	16	495	.352
Macomb	50	2460	3768	20290	1158	25216	.653
Manistee	51	24	202	795	58	1055	.119
Marquette	52	116	702	2502	227	3431	.165
Mason	53	24	228	1176	42	1446	.105
Mecosta	54	69	236	1419	37	1692	.292
Menominee	55	60	221	1015	75	1311	.271
Midland	56	77	493	2545	18	3056	.156
Missaukee	57	22	51	333	4	388	.431
Monroe	58	417	1046	3894	133	5073	.399
Montcalm	59	125	289	1744	41	2074	.433
Montmorency	60	9	50	326	9	385	.180
Muskegon	61	199	1008	5762	142	6912	.197
Newaygo	62	109	257	1218	35	1510	.424
Oakland	63	3392	6226	33778	1386	41390	.545
Oceana	64	36	146	612	23	781	.247
Ogemaw	65	76	142	715	9	866	.535
Ontonagon	66	15	66	231	12	309	.227
Osceola	67	21	108	739	25	872	.194
Oscoda	68	35	81	311	7	399	.432
Otsego	69	101	111	569	19	699	.910
Ottawa	70	300	602	4536	70	5208	.498
Presque Isle	71	15	77	454	10	541	.195
Roscommon	72	50	168	660	17	845	.298
Saginaw	73	352	1526	9235	166	10927	.231
St. Clair	74	279	1030	4168	321	5519	.271
St. Joseph	75	108	341	2137	100	2578	.317
Sanilac	76	162	233	1002	42	1277	.695
Schoolcraft	77	12	96	333	24	453	.125
Shiawassee	78	126	374	1819	83	2276	.337
Tuscola	79	149	388	1439	33	1860	.384
Van Buren	80	178	434	1827	101	2362	.410
Washtenaw	81	648	1466	8367	287	10120	.442
Wayne	82	7784	14204	73789	12027	100020	.548
Wexford	83	39	168	1019	36	1223	.232
STATE TOTALS	84	25879	58636	308993	21564	389193	.441

Table 31

1979 Accidents, DUIL's, and DUIL Index by County

County		Arrests	Accidents				DUIL
Name	#		HBD	HNBD	NKID	TOTAL	Index
Alcona	1	8	77	256	9	342	.104
Alger	2	12	91	256	11	358	.132
Allegan	3	235	449	2062	85	2596	.523
Alpena	4	101	264	798	25	1087	.383
Antrim	5	53	86	498	8	592	.616
Arenac	6	43	121	478	19	618	.355
Baraga	7	23	79	256	24	359	.291
Barry	8	87	249	1382	47	1678	.349
Bay	9	445	1003	3725	174	4902	.444
Benzie	10	7	102	363	17	482	.069
Berrien	11	970	1031	5878	370	7279	.941
Branch	12	224	229	1364	51	1644	.978
Calhoun	13	251	859	5088	272	6219	.292
Cass	14	234	366	1454	90	1910	.639
Charlevoix	15	42	141	663	8	812	.298
Cheboygan	16	14	153	610	28	791	.092
Chippewa	17	77	208	884	73	1165	.370
Clare	18	95	182	925	41	1148	.522
Clinton	19	244	329	1534	51	1914	.742
Crawford	20	60	86	398	20	504	.698
Delta	21	62	285	1365	72	1722	.218
Dickinson	22	82	185	909	40	1134	.443
Eaton	23	128	462	2350	65	2877	.277
Emmet	24	102	193	906	50	1149	.528
Genesee	25	1533	3211	12327	674	16212	.477
Gladwin	26	122	115	513	10	638	1.061
Gogebic	27	35	150	546	45	741	.233
Grand Traverse	28	73	411	2419	64	2894	.178
Gratiot	29	129	234	1283	80	1597	.551
Hillsdale	30	46	241	1274	100	1615	.191
Houghton	31	225	274	1058	86	1418	.821
Huron	32	165	220	876	30	1126	.750
Ingham	33	870	1648	9786	166	11600	.528
Ionia	34	96	375	1837	105	2317	.256
Iosco	35	133	239	890	26	1155	.556
Iron	36	66	93	422	35	550	.710
Isabella	37	50	295	1529	33	1857	.169
Jackson	38	374	1045	5243	285	6573	.358
Kalamazoo	39	817	1201	8121	487	9809	.680
Kalkaska	40	69	71	404	5	480	.972
Kent	41	895	2703	18713	1094	22510	.331
Keweenaw	42	12	36	47	3	86	.333
Lake	43	24	86	300	6	392	.279
Lapeer	44	237	394	1960	50	2404	.602

Table 31 (continued)

1979 Accidents, DUIL's, and DUIL Index by County

County		Arrests	Accidents				DUIL Index
Name	#		HBD	HNBD	NKID	TOTAL	
Leelanau	45	17	106	346	25	477	.160
Lenawee	46	203	519	2960	143	3622	.391
Livingston	47	520	591	2548	79	3218	.880
Luce	48	6	53	190	22	265	.113
Mackinac	49	23	92	442	22	556	.250
Macomb	50	3044	3775	18482	1094	23351	.806
Manistee	51	69	187	765	73	1025	.369
Marquette	52	84	633	2252	239	3124	.133
Mason	53	25	184	1057	48	1289	.136
Mecosta	54	52	233	1600	39	1872	.223
Menominee	55	73	207	963	75	1245	.353
Midland	56	94	433	2393	21	2847	.217
Missaukee	57	16	47	286	6	339	.340
Monroe	58	383	931	3146	108	4185	.411
Montcalm	59	111	274	1767	50	2091	.405
Montmorency	60	21	47	288	3	338	.447
Muskegon	61	284	1070	5519	141	6730	.265
Newaygo	62	146	249	1041	41	1331	.586
Oakland	63	3483	6282	32684	1362	40328	.554
Oceana	64	17	145	542	23	710	.117
Ogemaw	65	98	151	669	21	841	.649
Ontonagon	66	26	80	217	18	315	.325
Osceola	67	20	124	763	35	922	.161
Oscoda	68	29	69	303	6	378	.420
Otsego	69	52	98	556	22	676	.531
Ottawa	70	362	665	4675	59	5399	.544
Presque Isle	71	17	81	411	19	511	.210
Roscommon	72	21	147	572	22	741	.143
Saginaw	73	469	1658	8452	203	10313	.283
St. Clair	74	404	914	3781	340	5035	.442
St. Joseph	75	197	294	1637	97	2028	.670
Sanilac	76	136	225	968	31	1224	.604
Schoolcraft	77	5	72	259	10	341	.069
Shiawassee	78	65	346	1702	83	2131	.188
Tuscola	79	198	375	1418	32	1825	.528
Van Buren	80	315	417	1649	82	2148	.755
Washtenaw	81	752	1510	7485	262	9257	.498
Wayne	82	8542	14398	67496	11019	92913	.593
Wexford	83	29	173	1030	35	1238	.168
STATE TOTALS	84	29978	58127	287264	21044	366435	.516

Table 32

1980 Accidents, DUIL's, and DUIL Index by County

County		Arrests	Accidents				DUIL Index
Name	#		HBD	HNBD	NKID	TOTAL	
Alcona	1	23	63	235	6	304	.365
Alger	2	32	94	229	13	336	.340
Allegan	3	480	494	1862	88	2444	.972
Alpena	4	109	240	690	54	984	.454
Antrim	5	57	90	419	19	528	.633
Arenac	6	126	119	552	25	696	1.059
Baraga	7	19	65	225	31	321	.292
Barry	8	100	288	1275	69	1632	.347
Bay	9	527	923	2942	141	4006	.571
Benzie	10	109	88	327	5	420	1.239
Berrien	11	1241	965	4574	357	5896	1.286
Branch	12	271	204	1181	49	1434	1.328
Calhoun	13	754	802	4493	287	5582	.940
Cass	14	237	416	1302	78	1796	.570
Charlevoix	15	67	163	511	31	705	.411
Cheboygan	16	73	165	492	26	683	.442
Chippewa	17	118	243	666	67	976	.486
Clare	18	97	184	851	25	1060	.527
Clinton	19	238	317	1395	79	1791	.751
Crawford	20	102	65	377	47	489	1.569
Delta	21	74	243	1104	77	1424	.305
Dickinson	22	77	145	712	26	883	.531
Eaton	23	339	460	2022	73	2555	.737
Emmet	24	125	191	778	27	996	.654
Genesee	25	1435	2758	10029	721	13508	.520
Gladwin	26	76	106	518	32	656	.717
Gogebic	27	106	131	499	56	686	.809
Grand Traverse	28	125	458	2048	68	2574	.273
Gratiot	29	108	220	1018	42	1280	.491
Hillsdale	30	110	225	1150	109	1484	.489
Houghton	31	180	272	905	90	1267	.662
Huron	32	181	251	1006	30	1287	.721
Ingham	33	1179	1572	8263	194	10029	.750
Ionia	34	149	403	1559	107	2069	.370
Iosco	35	261	221	822	28	1071	1.181
Iron	36	73	98	370	52	520	.745
Isabella	37	92	305	1271	55	1631	.302
Jackson	38	656	1052	4486	271	5809	.624
Kalamazoo	39	975	1230	6913	440	8583	.793
Kalkaska	40	75	81	416	7	504	.926
Kent	41	1132	2614	13413	990	17017	.433
Keweenaw	42	18	19	41	3	63	.947
Lake	43	23	82	308	10	400	.280
Lapeer	44	415	372	1682	91	2145	1.116

Table 32 (continued)

1980 Accidents, DUIL's, and DUIL Index by County

County		Arrests	Accidents				DUIL Index
Name	#		HBD	HNBD	NKID	TOTAL	
Leelanau	45	64	108	312	24	444	.593
Lenawee	46	493	447	2433	188	3068	1.103
Livingston	47	545	519	2163	75	2757	1.050
Luce	48	47	52	180	20	252	.904
Mackinac	49	66	83	332	21	436	.795
Macomb	50	4853	3681	14898	1209	19788	1.318
Manistee	51	69	160	668	83	911	.431
Marquette	52	195	590	1682	210	2482	.331
Mason	53	37	197	907	44	1148	.188
Mecosta	54	137	221	1421	50	1692	.620
Menominee	55	71	239	837	85	1161	.297
Midland	56	112	399	1945	31	2375	.281
Missaukee	57	21	60	311	8	379	.350
Monroe	58	558	897	2767	113	3777	.622
Montcalm	59	149	250	1573	59	1882	.596
Montmorency	60	37	48	251	11	310	.771
Muskegon	61	255	968	4192	169	5329	.263
Newaygo	62	92	214	1066	39	1319	.430
Oakland	63	4658	5546	26988	1364	33898	.840
Oceana	64	62	141	543	40	724	.440
Ogemaw	65	148	156	565	28	749	.949
Ontonagon	66	25	71	223	26	320	.352
Osceola	67	49	103	709	34	846	.476
Oscoda	68	56	79	305	10	394	.709
Otsego	69	170	75	439	36	550	2.267
Ottawa	70	399	623	3596	62	4281	.640
Presque Isle	71	34	85	372	18	475	.400
Roscommon	72	93	128	549	35	712	.727
Saginaw	73	781	1561	6844	206	8611	.500
St. Clair	74	808	852	3205	430	4487	.948
St. Joseph	75	242	329	1512	82	1923	.736
Sanilac	76	177	202	945	52	1199	.876
Schoolcraft	77	29	64	254	6	324	.453
Shiawassee	78	322	351	1441	149	1941	.917
Tuscola	79	270	354	1250	50	1654	.763
Van Buren	80	533	431	1436	113	1980	1.237
Washtenaw	81	1131	1494	6307	281	8082	.757
Wayne	82	8932	12680	55877	11726	80283	.704
Wexford	83	64	193	871	62	1126	.332
STATE TOTALS	84	39548	54148	238100	22345	314593	.730

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APPENDIX

Frequencies of HBD and HNBD Drivers by Age
for
Fatal and 20% Sample Data
1968-1980

Table A1

Frequency of Had Been Drinking Drivers by Age: Fatal Data

AGE	YEARS												
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1-15	-0-	-0-	-0-	1	1	2	3	3	-0-	2	1	2	4
16	2	11	8	12	11	7	11	16	21	19	12	16	12
17	15	17	11	13	29	21	33	32	28	29	36	37	38
18	26	36	20	30	47	38	58	59	67	62	51	48	47
19	30	30	29	30	49	48	56	71	78	75	48	58	51
20	20	33	19	26	35	51	48	33	54	53	81	54	65
21	54	40	35	40	38	32	51	49	59	47	63	54	58
22	47	43	59	41	31	39	39	55	57	40	60	43	51
23	27	38	37	35	22	35	37	47	40	40	40	45	57
24	32	34	23	28	30	35	29	34	31	37	40	44	54
25	30	31	24	24	31	29	30	22	44	36	39	33	43
26	24	40	17	23	13	37	31	31	18	35	36	29	40
27	10	30	22	24	27	20	29	29	32	33	27	32	28
28	20	15	21	24	20	20	16	28	36	34	30	22	26
29	9	22	24	16	26	13	17	15	27	20	39	41	23
30	11	22	12	15	26	22	21	15	15	23	19	28	26
31	15	10	14	16	10	15	20	18	18	14	29	28	20
32	14	17	11	13	14	19	18	16	14	14	18	22	23
33	15	9	10	14	18	19	18	15	15	19	15	15	18
34	12	14	13	13	9	17	7	13	10	13	28	18	16
35-39	56	51	50	53	62	63	62	64	43	51	57	82	75
40-44	55	62	67	42	55	52	41	35	46	38	44	38	36
45-49	48	40	35	31	40	44	39	35	45	40	43	36	34
50-54	39	39	36	38	26	40	33	28	32	32	26	36	30
55-59	23	31	22	31	30	23	18	20	16	24	23	19	16
60-64	15	15	9	21	18	20	20	14	13	15	9	20	15
65-98	17	20	15	13	22	15	21	8	10	17	20	18	14
Unk.	-0-	-0-	-0-	1	1	-0-	-0-	2	5	3	2	3	2
15-17	17	28	19	26	41	30	47	51	49	50	49	55	54
18-20	76	99	68	86	131	137	162	163	199	190	180	160	163
21-23	128	121	131	116	91	106	127	151	156	127	163	142	166
24-26	86	105	64	75	74	101	90	87	93	108	115	106	137
Total	666	750	643	668	741	776	806	807	874	865	936	921	922

Table A2

Frequency of Had Not Been Drinking Drivers by Age: Fatal Data

AGE	YEARS												
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1-15	6	12	9	14	20	18	8	13	8	13	9	7	15
16	45	49	39	46	67	52	53	33	53	58	58	37	34
17	73	73	73	71	100	84	91	77	78	64	86	67	52
18	93	94	96	74	87	82	89	75	83	90	78	72	48
19	68	73	78	77	99	85	76	65	67	103	66	63	60
20	44	70	54	74	75	75	58	47	65	87	76	52	51
21	65	69	51	56	80	62	51	33	53	58	68	60	53
22	52	55	66	59	55	58	51	50	51	49	51	51	51
23	40	43	46	59	53	43	42	59	51	57	53	49	38
24	40	48	34	69	51	61	38	54	55	56	56	42	35
25	40	36	45	45	47	45	37	37	41	42	46	37	50
26	43	49	34	45	42	38	45	35	43	49	47	34	35
27	34	34	35	43	40	38	34	51	19	49	45	38	26
28	38	30	42	29	24	39	37	40	32	25	34	40	29
29	26	24	26	36	38	41	26	28	45	34	41	32	28
30	14	28	21	27	30	36	30	30	33	41	44	46	32
31	16	19	34	34	35	35	33	27	29	30	37	26	28
32	29	26	27	26	29	32	33	16	30	19	31	28	28
33	27	27	22	34	23	28	26	26	25	29	31	29	22
34	14	31	20	12	28	23	23	24	33	31	27	18	14
35-39	126	125	119	118	129	110	93	92	106	119	134	124	95
40-44	113	118	114	129	115	116	97	83	90	94	98	84	77
45-49	110	134	95	148	119	124	83	71	76	81	90	70	64
50-54	91	115	98	93	90	104	89	78	86	76	102	87	61
55-59	79	86	72	72	99	71	79	62	67	76	82	68	69
60-64	59	58	56	59	67	65	71	43	62	79	82	75	58
65-98	145	162	139	155	177	155	118	125	161	168	146	109	109
Unk.	-0-	3	2	3	2	4	5	4	6	6	4	4	2
15-17	124	134	121	131	187	154	152	123	139	135	153	111	101
18-20	205	237	228	225	261	242	223	187	215	280	220	187	159
21-23	157	167	163	174	188	163	144	142	155	164	172	160	142
24-26	123	133	113	159	140	144	120	126	139	147	149	113	120
Total	1530	1691	1547	1707	1821	1724	1516	1378	1548	1683	1722	1449	1264

Table A3

Frequency of Had Been Drinking Drivers by Age: 20% Sample Data

AGE	YEARS												
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1-15	7	6	9	5	14	13	21	15	19	24	19	12	20
16	51	56	71	81	108	110	131	145	199	178	167	168	173
17	106	116	130	152	253	277	278	358	382	389	375	347	359
18	163	184	195	213	580	585	589	734	807	853	829	579	545
19	170	191	215	255	536	519	555	721	818	776	843	616	599
20	176	200	195	210	513	533	513	618	703	710	769	612	613
21	432	353	331	357	455	434	488	563	581	659	689	764	663
22	284	392	360	357	441	439	412	503	558	539	587	717	607
23	258	260	326	349	414	428	432	418	477	529	538	578	562
24	228	200	214	343	346	366	341	397	420	427	478	520	485
25	221	228	227	249	346	360	314	358	389	420	443	456	467
26	189	236	183	220	286	323	306	345	337	367	398	417	392
27	201	204	211	222	251	230	286	304	325	327	395	387	379
28	156	192	174	236	273	243	240	302	288	309	363	378	334
29	158	162	175	198	272	248	222	229	334	296	291	322	330
30	138	141	170	174	236	240	246	230	218	272	302	318	286
31	119	164	164	166	220	213	239	209	221	209	287	295	284
32	150	126	147	150	223	194	206	218	200	223	218	320	260
33	140	134	128	167	222	196	177	210	218	241	226	219	255
34	135	122	115	137	204	172	200	186	195	199	215	215	199
35-39	563	603	575	704	972	841	802	783	807	817	904	926	856
40-44	607	646	611	709	938	794	716	685	678	590	630	619	592
45-49	446	554	471	610	837	776	670	665	627	626	579	582	462
50-54	344	356	390	423	645	617	559	565	538	524	503	482	441
55-59	249	289	282	330	471	412	376	370	354	384	409	361	335
60-64	153	152	162	179	270	243	213	229	240	217	210	255	222
65-98	167	168	168	200	216	245	231	220	224	233	203	244	206
Unk.	56	53	42	35	186	165	126	141	276	271	232	283	268
15-17	164	178	210	238	375	400	430	518	600	591	561	527	552
18-20	509	575	605	678	1629	1637	1657	2073	2328	2339	2441	1807	1758
21-23	974	1005	1017	1063	1310	1301	1332	1484	1616	1727	1814	2059	1832
24-26	638	664	624	812	978	1049	961	1100	1146	1214	1319	1393	1344
Total	6067	6488	6441	7431	10728	10216	9889	10721	11433	11609	12102	11992	11202

Table A4

Frequency of Had Not Been Drinking Drivers by Age: 20% Sample Data

AGE	YEARS												
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1-15	130	141	136	227	276	320	265	273	265	306	309	263	236
16	1830	2009	2186	2723	3437	3675	3354	3365	3482	3662	3889	3635	2954
17	2724	3003	3140	4036	5003	5073	4826	4872	5106	5332	5733	5144	3904
18	2992	3445	3415	4258	5650	5704	5160	5080	5576	5561	6148	5499	4142
19	2514	2692	2904	3791	4997	5016	4555	4509	5098	5309	5538	5075	3922
20	1913	2160	2230	3223	4511	4315	3996	4006	4524	4728	4899	4522	3396
21	2007	2044	2101	2860	4185	3815	3430	3611	4099	4226	4586	4138	3158
22	1502	2072	2124	2610	3628	3791	3290	3151	3537	3815	4140	3900	2995
23	1377	1498	2060	2532	3468	3317	3026	2976	3287	3481	3747	3465	2808
24	1273	1292	1479	2347	3240	3072	2844	2868	3221	3472	3424	3290	2576
25	1244	1217	1409	1846	3057	2887	2545	2510	2920	3045	3237	3112	2448
26	1091	1314	1321	1654	2327	2800	2418	2396	2721	2918	3169	2937	2290
27	1001	1132	1417	1534	2144	2106	2392	2395	2606	2501	2759	2626	2158
28	917	1006	1162	1683	2139	1938	1772	2192	2519	2498	2634	2529	2040
29	842	929	1096	1420	2185	1918	1700	1700	2445	2394	2565	2268	1958
30	801	824	967	1376	1918	2006	1657	1603	1867	2477	2554	2373	1860
31	733	858	944	1218	1747	1765	1678	1656	1728	1856	2325	2246	1762
32	771	810	893	1144	1649	1607	1523	1663	1690	1717	1942	2151	1723
33	732	794	778	1082	1544	1576	1384	1452	1735	1762	1746	1659	1695
34	694	796	792	1074	1414	1291	1284	1330	1578	1807	1843	1630	1369
35-39	3567	3730	3903	4858	6879	6262	5670	5739	6472	6933	7621	7377	6095
40-44	3596	3740	4033	5086	6621	5952	5163	4949	5377	5524	5743	5454	4412
45-49	3176	3472	3810	4790	6492	5935	5242	5103	5367	5408	5410	4800	3867
50-54	2721	2886	3112	3994	5631	5358	4792	4824	5229	5383	5463	4911	3993
55-59	2178	2393	2550	3316	4566	4315	3838	3803	4362	4379	4547	4345	3522
60-64	1608	1761	1903	2392	3292	3127	2921	2850	3182	3371	3524	3226	2647
65-98	2585	2827	3168	3934	5155	5041	4519	4626	5256	5408	5715	5159	4648
Unk.	193	188	181	476	1378	917	799	1216	1784	2082	1768	2152	1822
15-17	4684	5153	5462	6986	8716	9068	8445	8510	8853	9300	9931	9042	7095
18-20	7419	8297	8549	11272	15158	15035	13711	13595	15198	15598	16585	15096	11461
21-23	4886	5614	6285	8002	11281	10923	9746	9738	10923	11522	12473	11503	8962
24-26	3608	3823	4209	5847	8624	8759	7807	7774	8862	9435	9830	9339	7314
Total	46712	51033	55214	71484	98533	94899	86043	86718	97033	101355	106978	99886	80409