THE EFFECT OF LOWER LEGAL DRINKING AGES ON YOUTH CRASH INVOLVEMENT

FINAL SUMMARY REPORT

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INTRODUCTION

Following the repeal of prohibition state laws relating to the minimum legal age for the purchase, possession, and consumption of alcoholic beverages remained virtually unchanged for almost 40 years. After federal voting rights were bestowed upon 18 year olds in 1971, over 20 states changed their public policy to give 18 year olds full adult rights, including the purchase and use of alcoholic beverages. Michigan, Vermont, and Maine were among the first states to take this step. The present research effort was designed to investigate the impact of the lower legal drinking ages on the alcohol-related highway crash experience of the affected young driving populations.

The specific research questions in this legal impact study were:

(1) Did the alcohol-related crash experience change following legislation which lowered the legal drinking ages to 18?

(2) If a change is found in accident rates which is statistically significant, is that change causally related to the legal change?

(3) Are there plausible rival hypotheses which would challenge a causal relationship between the legal change and resulting changes in accident rates, and to what extent can these be controlled by design or analysis?

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DESIGN

In order to address adequately these questions a design was developed which approximated an experimental condition. Two control groups and an experimental group were identified on the basis of:

(1) Legal posture regarding the legal drinking age;
(2) Geographic distribution;
(3) Data availability; and
(4) Demographic and social characteristics.

New York and Louisana are the only states having long-term 18-year-old legal drinking ages, and this alone merited their study. Pennsylvania and Texas were selected as long-term 21-year-old control states. Because Vermont, Maine, and Michigan all lowered existing legal drinking ages to 18 within the same six month period, all three were selected as experimental jurisdictions. Three subsets of Michigan were also included in the design as experimental jurisdictions, including Washtenaw County, Oakland County, and Wayne County; all fatal crashes in Michigan were also analyzed.

Accident records were transformed for all 11 analytical jurisdictions in such a way as to make each driver involvement in a crash the basic unit of analysis. Therefore, each involved vehicle and driver were included along with all pertinent descriptive variables of the associated accident. The sampling fractions and number of driver involvements in the resultant analytical files varied according to data availability and size. The files are presented in detail in Table 1.

DATA DEFINITIONS AND ANALYSES

After a thorough investigation of the operational definitions of alcohol involvement in crashes among the seven states it was found that this variable, as found in available statistics from police reports, is inconsistent between states and often within the same state over time. As examples,

TABLE 1. DATA - FULL DESIGN

Year of File	Jurisdiction	Number of Records in Original File	Number of Cases in Analytic Vehicle File	Census Sample Fraction (if any)	Time Period Covered	Missing Data and Notations
1968	Michigan Statewide 01	413,281[1]	45,461	15%	1/1-12/31/68	"HBD" variable form change effective 1/1/71. Property damage definition changed from $150 to $200 on
1969	Michigan Statewide 01	449,215	49,465	15%	1/1-12/31/69	
1970	Michigan Statewide 01	472,165	52,369	15%	1/1-12/31/70	
1971	Michigan Statewide 01	577,609	63,537	15%	1/1-12/31/71	
1972	Michigan Statewide 01	855,612	91,240	15%	1/1-12/31/72	
1973	Michigan Statewide 01	544,537	57,743	15%	1/1-07/31/73	
1968	Washtenaw County, Michigan 02	7,495	11,351	Census	1/1-12/31/68	Property damage changed from $150 to $200 on
1969	Washtenaw County, Michigan 02	7,911	12,540	Census	1/1-12/31/69	
1970	Washtenaw County, Michigan 02	8,327	12,598	Census	1/1-12/31/70	
1971	Washtenaw County, Michigan 02	8,744	13,448	Census	1/1-12/31/71	
1972	Washtenaw County, Michigan 02	9,160	13,887	Census	1/1-12/31/72	
1971	Wayne County, Michigan 03	-------[2]	3,005	15%	1/1-12/31/71	Not including the city of Detroit. Property damage changed from $150 to $200 on
1972	Wayne County, Michigan 03	-------	5,113	15%	1/1-12/31/72	
1973	Wayne County, Michigan 03	-------	3,442	15%	1/1-07/31/73	
1968	Oakland County, Michigan 04	25,387	44,926	Census	1/1-12/31/68	Property damage definition changed from $150 to $200 on
1969	Oakland County, Michigan 04	29,265	51,798	Census	1/1-12/31/69	
1970	Oakland County, Michigan 04	29,650	52,994	Census	1/1-12/31/70	
1971	Oakland County, Michigan 04	29,362	52,652	Census	1/1-12/31/71	
1972	Oakland County, Michigan 04	34,262	60,900	Census	1/1-12/31/72	
1968	Michigan Fatal Accidents 05	1,987	3,057	Census	1/1-12/31/68	
1969	Michigan Fatal Accidents 05	2,154	3,265	Census	1/1-12/31/69	
1970	Michigan Fatal Accidents 05	1,863	2,815	Census	1/1-12/31/70	
1971	Michigan Fatal Accidents 05	1,889	3,289	Census	1/1-12/31/71	
1972	Michigan Fatal Accidents 05	1,997	3,453	Census	1/1-12/31/72	

[1]In Michigan there is a variable number of records per accident. In each accident a record for the accident plus a separate record for each injury and each driver-vehicle is built into the master file. Therefore, there is no apparent correspondence between the number of records in the original file and the number of cases in the vehicle analytic file. Michigan master files include between two and twelve individual records per accident.

[2]Wayne County data were subsetted from the Michigan Statewide Vehicle File.

TABLE 1. DATA - DESIGN (cont'd)

Year of File	Jurisdiction	Number of Records in Original File	Number of Cases in Analytic Vehicle File	Census Sample Fraction (if any)	Time Period Covered	Missing Data and Notations
1970	Maine 06	27,113	45,299	Census	1/1-12/31/70	Property damage changed from $100 to $200 on September 23, 1971.
1971	Maine 06	26,695	45,216	Census	1/1-12/31/71	
1972	Maine 06	24,952	41,201	Census	1/1-12/31/72	
1971	Louisiana 07	11,874	22,644	10%	1/1-12/31/71	Original data a 10% sample including first and second involved drivers. Property definition damage changed, 1972.
1972	Louisiana 07	13,051	25,184	10%	1/1-12/31/72	
1973	Louisiana 07	7,975	15,295	10%	1/1-07/31/73	
1971	Vermont 08	16,561 (approx)	27,657	Census	1/1-12/31/71	
1972	Vermont 08	16,944 (approx)	27,958	Census	1/1-12/31/72	
1969	Texas 09	18,837	32,224	5%	1/1-12/31/69	HBD variable not reported after 1970.
1970	Texas 09	19,392	33,204	5%	1/1-12/31/70	
1971	Texas 09	19,088	33,140	5%	1/1-12/31/71	
1972	Texas 09	21,000	36,505	5%	1/1-12/31/72	
1968	Pennsylvania 10	279,663	24,851	5%	1/1-12/31/68	Property damage definition changed from $150 to $200 in 1972. All except Fatals missing in 1970.
1969	Pennsylvania 10	292,192	25,868	5%	1/1-12/31/69	
1970	Pennsylvania 10	1,966	2,866	5%	1/1-12/31/70	
1971	Pennsylvania 10	301,374	20,911	5%	1/1-12/31/71	
1972	Pennsylvania 10	277,556	24,198	5%	1/1-12/31/72	
1968	New York 11	50,820 (approx)	86,053	5%	1/1-12/31/68	Year identifier miscoded in 1968 (grouped with 1969). Property damage definition changed from $150 to $200 on
1969	New York 11					
1970	New York 11	25,310 (approx)	42,281	5%	1/1-12/31/70	
1971	New York 11	21,780 (approx)	38,328	5%	1/1-12/31/71	
1972	New York 11	22,990 (approx)	39,377	5%	1/1-12/31/72	

reported alcohol involvement in Texas during 1969 and 1970 was defined as a violation of driving while intoxicated - a most conservative measure. Reported alcohol involvement was not available in the Texas data for 1971 and 1972. In Pennsylvania reported alcohol involvement was one of many "contributing circumstances" and was found to be infrequently reported. In Michigan the operational format of the "had been drinking" question in standard accident investigation forms was changed in 1971 which made incomparable any reported "had been drinking" statistics between and after the form change.

Therefore, it was necessary to identify an objective measure of alcohol involvement for analysis before and after the effective dates of the new legal drinking age. The alternative, surrogate, measure needed to be valid and reliable for all populations in the design.

Through a process of multiple analysis of variance for two jurisdictions, Oakland County, Michigan 1972 and Texas, 1970, we found that single vehicle accidents, occurring between 9:00PM and 6:00AM with male drivers, are between 53% and 63% alcohol-related. Thus the surrogate consists of the subset of all accidents which meet the requirements of three objective and reliably reported parameters - time, sex of driver, and number of involved vehicles. Hereafter this alternative measure of alcohol involvement will be referred to as the three-factor surrogate; it is equally reliable and valid for young and old drivers and for all jurisdictions in the design. It overcomes the difficulties of non-comparability of reported alcohol involvement both between and within jurisdictions over the 1968 to 1973 period.

Another research problem was the selection of a statistical procedure which both controls for plausible research hypotheses inherent in time-series measurements and provides a level of statistical confidence in conclusions derived from the analyses.*

*Unlike sample statistics, time-series data are characterized by dependencies between adjacent time points. No assumptions of measurement independence can be made with time ordered measures which invalidates the use of tests which are appropriate for sample statistics.

The Box and Tiao (1965) autoregressive time-series "t" statistical procedure was selected as the optimal test for our purposes.*

The Box and Tiao test requires that data be free of expected values associated with regular cyclic or seasonal effects and linear trend. These components of time-ordered accident records can also be interpreted as rival explanations to the effect of the lower legal drinking age. The data were decomposed and expected seasonal and linear effects were removed, resulting in second-level residual (irregular) measures for analysis. Long-term cycles were not identified in the available data. A further confounding effect, that of age-specific crash population growth, was controlled by computing age-specific rates** of the three-factor surrogate both for young drivers affected by the lower legal drinking ages and comparison groups of older drivers. The age-specific rates are regarded as third-level residuals. The process of controlling for trend, seasonal, and age-specific population growth factors resulted in data for analysis of crash involvements which are relatively free of confounding effects. Other confounding factors are controlled through state selection and variable selection.

RESULTS

The analyses were performed in two steps which were designed to:

*Box, G.E.P. and Tiao, G.C. "A Change in Level of a Non-Stationary Time Series". Biometrika, 52(1), 1965, pp.181-192.

**Age specific rates are defined as the subset of a population (or sample) which meets a specific set of criteria, divided by the total size of the population. The 18 to 20 year old three-factor surrogate age-specific rate is:

$$\frac{\text{18 to 20 Frequency of Driver Involvements Meeting Three-Factor Surrogate Criteria}}{\text{18 to 20 Total Crash Frequency}}$$

for all files except Maine, in which the rate was computed with different age groups. The rates were computed for each monthly time interval.

(1) Test the statistical significance of changes in magnitude of alcohol-related crash frequencies and rates of young and old drivers; and

(2) Investigate the age-specific alcohol-related crash frequency distributions of young drivers before and after the effective dates of new legal drinking ages in the experimental states.

The results of the first analytical step are summarized in Table 2. The variables used in the analyses include:

Total 18-20 crash frequency
Total 21-45 crash frequency
Reported alcohol involvement 18-20 year old frequency
Reported alcohol involvement 21-45 year old frequency
3-Factor surrogate 18-20 year old frequency
3-factor surrogate 21-45 year old frequency
3-factor surrogate 18-20 year old age-specific rate
3-factor surrogate 21-45 year old age-specific rate
Total crash frequency
Total reported alcohol involvement frequency
Total 3-factor surrogate frequency

The test statistic ($t_{\hat{\delta}}$) is the Box and Tiao autoregressive statistic and can be interpreted as having the Student t distribution. Analyses of reported alcohol involvement were included in most jurisdictions in order to make the present study comparable to other investigations based on reported official state statistics.

In Michigan, with the exception of Wayne County (excluding Detroit), there is strong evidence that non-fatal, alcohol-related crashes of the 18 to 20 year old group increased at a highly significant level after the legal drinking age was lowered. There was no increase in alcohol-related crashes among the older comparison group which supports a causal relationship between an external influence on the 18 to 20 year olds which did not operate on the 21 to 45 year old group. We feel that this influence was the lower legal drinking age.

TABLE 2. $t_\zeta^{\hat{}}$ - FULL DESIGN

Jurisdiction	18-20 Total	21-45 Total	18-20 HBD	21-45 HBD	18-20 3FS	21-45 3FS	18-20 3FS Rate	21-45 3FS Rate	Total Crash	Total HBD	Total 3FS
Michigan Statewide											
n_1=48	2.8104	1.2053	3.2941	1.6130	2.3663	1.1365	1.6444	-.064314	1.5622	2.5551	2.6685
n_2=19	ρ<.0025	n.s.	ρ<.0007	n.s.	ρ<.0091	n.s.	ρ<.05005	n.s.	n.s.	ρ<.0053	.0038
Washtenaw County											
n_1=48	.28458	-.07635	3.5533	-.57737	2.1028	-1.1996	3.7331	-.93616	.57677	.44908	-.007768
n_2=12	n.s.	n.s.	ρ<.001	n.s.	ρ≤.0166	n.s.	ρ<.0001	n.s.	n.s.	n.s.	n.s.
Wayne County											
n_1=12	1.4202	2.4708	1.3105	.81655	.41349	.66427	-.124928	-.46344	2.3790	1.5639	1.1600
n_2=19	n.s.	ρ<.0068	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	ρ<.0087	n.s.	n.s.
Oakland County											
n_1=48	.98778	1.6589	3.247	-.50654	3.6966	-.4867	2.2037	-.14816	.24544	2.2048	3.7150
n_2=12	n.s.	ρ<.0485	ρ<.001	n.s.	ρ<.001	n.s.	ρ<.0139	n.s.	n.s.	ρ<.0122	.001
Michigan Fatals											
n_1=48	2.3451	-.50753	1.6616	.17364	1.5363	1.2118	-.86595	-2.4675	.99107	.21655	1.007
n_2=12	ρ<.0094	n.s.	ρ<.0485	n.s.	n.s.	n.s.	n.s.	ρ<.0068	n.s.	n.s.	n.s.
Maine Statewide											
n_1=29	.93723	-.12188	2.2975	.72298	1.4629	.38170	.13237	.069132	-.02384	1.1121	.89265
n_2=7	n.s.	n.s.	ρ<.0110	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Vermont Statewide											
n_1=12	-.5189	-.78658	.9779	-1.0598	.62321	1.1747	.22366	-1.2872	-.22393	-.0661	.96742
n_2=12	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Pennsylvania Statewide											
n_1=48	.04781	2.0769	--------	--------	1.4044	.62337	1.9994	1.7808	2.4319	--------	1.6609
n_2=12	n.s.	ρ<.0192	--------	--------	n.s.	n.s.	ρ<.0233	ρ<.0375	ρ<.0075	--------	n.s.
Texas Statewide											
n_1=36	1.3915	1.9399	--------	--------	.7540	.3284	-.4467	-1.2862	2.2031	--------	1.11327
n_2=12	n.s.	ρ<.0262	--------	--------	n.s.	n.s.	n.s.	n.s.	ρ<.0136	--------	n.s.
Louisiana Statewide											
n_1=12	-.31131	-.3861	-1.2678	-1.2527	-1.2762	-1.5341	-.19558	-.98393	.6370	-.21318	-1.4566
n_2=19	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
New York Statewide											
$f_{n_2=12}^{n_1=24^*}$	.85158	-.30631	-.20152	.055005	-.11957	1.1225	.05368	1.7415	-.50045	-.44225	1.0401
$r_{n_2=12}^{n_1=36}$	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	ρ<.0409	n.s.	n.s.	n.s.

[1]Statistic: Autoregressive Time-Series "t" statistic Box and Tiao, 1965.
One tailed significance tests of shift in level after the legal drinking age was lowered in Michigan and Vermont.
[2]Impact point, except for Maine, is January 1, 1972. June 1, 1972 used for Maine.

In Maine reported alcohol-involvement increased for the 18 to 19 year olds and remained stable for the 20 to 44 year old group. The legal drinking age changed from 21 to 20 in 1969 which might have softened the impact of the June 1972 change. Although the young driver three-factor surrogate frequency increased, statistical significance of the shift at the .05 level was not attained. We believe that if the short (seven month) "after" period were longer, statistical significance would have been reached.

No shift in magnitude was found for any crash frequency or rate in Vermont following the lower legal drinking age. No evidence was found in any control state that the 18 to 20 year old alcohol-related crash experience increased except in Pennsylvania where the older group experience increased as well. On the basis of these analyses we are confident that in Michigan and probably in Maine alcohol-related crashes increased beyond any normally expected level after the legal drinking ages were changed. We are confident that these changes were causally related to the legal changes.

The second step of the analysis plan was to investigate the age-specific alcohol-related crash frequency distributions of young drivers in the various jurisdictions. The purposes for this descriptive analysis were:

(1) To attempt to determine why no change was identified in Vermont;

(2) To examine the patterns of change in Michigan and Maine; and

(3) To form a basis of prediction for the probable effect of lower legal drinking ages in Texas and Pennsylvania.

The three-factor surrogate and reported alcohol involvement frequency distributions of young drivers before and after the lower legal drinking ages were determined and plotted for all jurisdictions; and an example is shown in Figure 1 for Oakland County Michigan. A basically bimodal distribution characterized

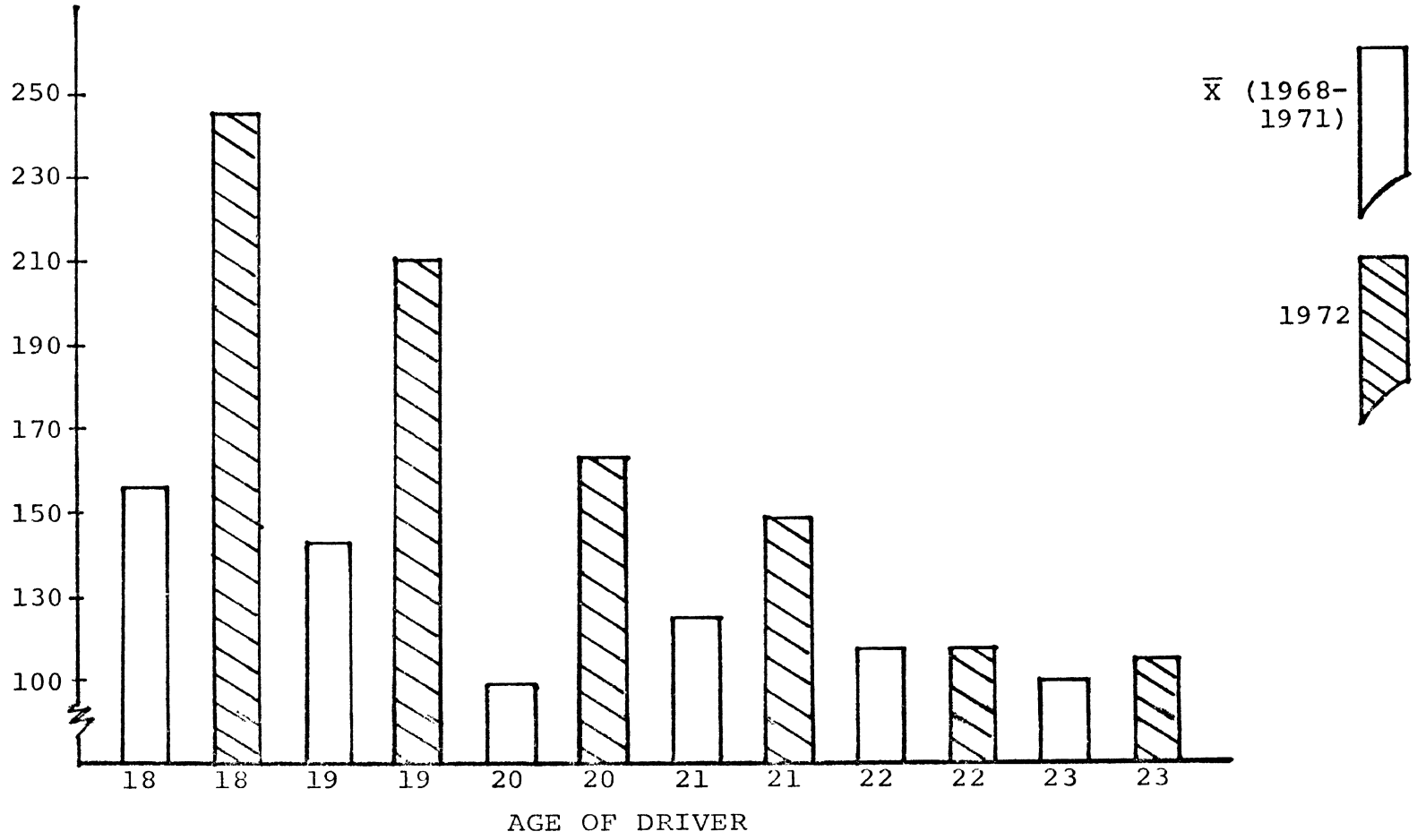

FIGURE 1. OAKLAND COUNTY THREE FACTOR SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

the Michigan jurisdictions before the legal change and a skewed distribution followed the change. In these counties the character of the problem underwent considerable change.

In Maine, the distributon patterns of alcohol-related crashes reversed after the legal change. The bimodal pattern (before the change) found in Michigan is also present in the Maine three-factor surrogate distributions which supports our belief that the increase after the new law was real.

In Vermont, New York and Louisiana a skewed distribution was dominant both before and after the change. In Texas a fairly skewed distribution was found for the three-factor surrogate, however, a bimodal pattern characterized that measure in Pennsylvania.

There is no evidence of any increase in the 18 to 20 year old alcohol-related crash experience in 1972 in Vermont as a result of the lower legal drinking age. It is possible that the single year of "before" data available were inadequate to measure changes based on a long-term comparison. Another speculative explanation is that for the 1971-72 period a federally funded Alcohol Safety Action Project operated successfully throughout the state. A third possibility is that the small Vermont population is within a cultural and social diffusion sphere of influence with New York State where the 18 year old legal drinking age has been in effect since 1934.

DISCUSSION

The effect of the lower legal drinking age is related to a number of characteristics of any specific jurisdiction. When faced with the task of predicting the consequence of a lower legal drinking age on youth crash rates, the following characteristics should be considered.

(1) The density and relative size of the affected population. In Michigan, Washtenaw County has the highest 18 to 20 year old population density and the largest 18 to 20 year old population in relation to other age groups. Washtenaw

County experienced the greatest changes in alcohol-related crashes among the affected populations in the experimental design.

(2) Jurisdictional proximity of population base to a long-term 18 year old drinking state. No change was seen in Vermont and the "before" age specific distributions of alcohol-related crashes resembled those of New York. Maine and Michigan were more distant from states with lower legal drinking ages than other states in the design.

(3) If the age specific alcohol-related crash distribution is skewed with highest frequencies among 18 to 20 year old drivers, before the legal drinking age is lowered, then no change would be expected after the law is changed. If the "before" distribution is bimodal, then the 18 to 20 year old group is expected to become dominant in the distribution after the legal change.

(4) Closely associated with the density and relative magnitude of the 18 to 20 year old population, the enforcement of alcohol beverage control laws regarding sales to minors is expected to be more rigid in jurisdictions with large young populations - such as Washtenaw County. Areas of rigid enforcement are expected to experience a greater change under a lower legal drinking age than areas of less strict legal control.

On the basis of these considerations and with most weight given to the age-specific distributions of the three-factor surrogate frequencies, it is predicted that Pennsylvania would experience a change in alcohol-related crashes much like Michigan under a lower legal drinking age. Texas, on the other hand, is not predicted to experience a reaction as great as Michigan or Pennsylvania because the frequency distribution of alcohol-related crashes among young drivers has resembled a long-term 18 year old state for the 1969 to 1972 period.