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THE EFFECT OF LOWER LEGAL DRINKING AGE ON YOUTH CRASH INVOLVEMENT

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16. Abstract Several states recently lowered the legal drinking age to 18. The objectives of the present study were: 1) To determine if alcohol-related crashes increased among legally affected populations in three study states, 2) to determine, if changes occurred, whether a causal relationship exists between the crash experience changes and the legal changes. Seven states were studied in a multiple-time-series quasi-experimental design. Through controlled time-series analyses it was found that statistically and socially significant increases in alcohol-related crashes resulted in Michigan and Maine following the lower legal drinking age. A surrogate measure for alcohol-related crash frequencies was used, in that official police data were found t be inadequate for comparative analyses between the seven jurisdictions or over time periods. Analyses of age-specific alcohol-related crash frequency distributions provided support and explanation for the results of the time-series analyses, and provided a basis for prediction regarding the potential effect of lower legal drinking ages on youth crash involvement. Recommendations for action and research are provided.

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1.0 INTRODUCTION AND SUMMARY

Following the repeal of Prohibition, state laws regulating the minimum legal age for the purchase and consumption of alcoholic beverages remained virtually unchanged for almost 40 years. After a Constitutional Amendment in July 1971 permitted 18-year-olds to vote in federal elections, legislation was passed in over 20 states to lower the legal drinking age. Although the general trend was to bring full adult rights into conformity with the 18-year-old age of majority, six states lowered the legal drinking age from 20 to 19.

The present study investigated the impact of the lower legal drinking age on the alcohol-related highway crash experience of affected young driving populations in Maine, Michigan, and Vermont. The specific research questions in this legal impact study were:

(1) Did the alcohol-related crash experience change in the three study states which lowered the legal drinking age to 18?

(2) If changes occurred in alcohol-related crash experiences in the three study states, were those changes causally related to the legal change?

Opposing viewpoints of expected and reported consequences of the lower drinking ages on highway safety emerged during the legislative processes preceding the new laws and after the effective dates. In Michigan, for example, resistance to an 18-year-old legal drinking age came from law enforcement officials and organizations concerned with alcohol-related social problems.[1-9] Following the legal change in Michigan the same sources have contended that alcohol-related crashes of young drivers have increased dramatically.

Proponents of the new law included the organized alcoholic beverage industry, many liberal political groups, and segments of the academic community interested in alcohol-related behavior. These groups have challenged the validity

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[1] Commission on Alcohol Problems, State of Minnesota. "Reduction of Drinking Ages Increases Young DWI Arrests." (NEWSRELEASE) Hennepin County Alcohol Safety Action Project, August 8, 1973, 3pp.

[2] Commission on Alcohol Problems, State of Minnesota. "More Young DWI's." ASAP FOCUS, Hennepin County Alcohol Safety Action Project, August 1973, p.1.

[3] R.L. Hammond. "Legal Drinking at 18 or 21 - Does It Make Any Difference?" Journal of Alcohol and Drug Education, Vol. 18, No. 3, pp.9-13, Spring 1973.

[4] B.D. Bowen and M.R. Kagay. Report to the White House Conference on Youth: The Impact of Lowering the Age of Majority to 18, June 1973. White House Conference on Youth, Washington, D.C. 63pp.

[5] Safety and Traffic Division, State of Michigan Department of State Police. "Motor Vehicle Accident Experience of Drivers 18 to 20 Years of Age and of All Other Drivers in Michigan - First Quarter of 1971, 1972, 1973." Mimeo, August 1973.

[6] Michigan Council on Alcohol Problems. "Liquor Lobbyist's Dual Role Uncovered - Conflict of Interest Charged in Hearing." Focus, Vol. 6, No. 2, pp.1-2, Summer 1973.

[7] Michigan Council on Alcohol Problems, Report No. 35 (On Effects of Lower Age of Majority Law and Traffic Safety.) Micap Recap, August 14, 1973. 2pp.

[8] Michigan Council on Alcohol Problems. "It's All in How You Figure the Percentage - Homicides or Teen Driving Accidents." Focus, Vol. 6, No. 4, p.2, Winter 1973.

[9] D.A. Works. "Statement on 18 Year Old Drinking." Journal of Alcohol and Drug Education, Vol. 18, No. 3, p.14, Spring 1973.

of reported increases in alcohol-related crash statistics as being artifactual, rather than actual evidence of extensive behavioral changes among the 18- to 20-year-old drivers involved in crashes.[10-14]

The impact of the lower legal drinking age on highway safety has continued to be an unresolved issue. Long-term data have not been available and controlled investigations have not been conducted. The majority of state officials questioned in a governmental survey reported that accident statistics show little evidence of changes which could be attributed to the lower legal drinking ages. Officials in Michigan and Rhode Island, however, claimed that accidents among young people have increased since the legal changes became effective.[15,16]

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[10] Bowen and Kagay, op.cit, 1973.

[11] Distilled Spirits Council of the United States, Inc., Licensed Beverage Industries. "Public Attitudes Changing: Minimum Age Law." New York, New York, No. 326, p.1, June-July 1973.

[12] Michigan Licensed Beverage Association (Correspondence to Chairman, Governor's Task Force on Drinking Driver Problems.) Critical Review of Effect of Age of Majority on Michigan Traffic Statistics, July 2, 1973, 9pp.

[13] R. Zylman. "When It is Legal to Drink at 18: What Should We Expect." Journal of Traffic Safety Education, pp.9-10, June 1973.

[14] R. Zylman. "When It Became Legal to Drink at 18 in Michigan: What Happened?" Journal of Traffic Safety Education, April 1974, pp.15-16.

[15] Distilled Spirits Council of the United States, Inc., Licensed Beverage Industries. "Survey of Minimum Age Law Experience on Drinking/Driving." New York, New York, News Letter, No. 330, pp.1 & 3, December 1973.

[16] National Clearinghouse for Alcohol Information of the National Institute on Alcohol Abuse and Alcoholism. "24 States Drop Drinking Age in 3-Year Period." Alcohol and Health Notes, pp.1 & 5, Rockville, Maryland, October 1973.

Evidence from individual states which lowered the legal drinking age has largely consisted of relatively informal observations of accident data with no design or analytic control for alternative explanations. For a variety of reasons, the direct information on drinking and driving among young people is confounded by factors other than the change in drinking laws. It has been suggested that police officers became more attentive to reporting alcohol involvement in crash investigations with young drivers after the legal change in Michigan, a practice which allegedly has created artifactual statistical increases. Changes in accident reporting forms and procedures have resulted in questionable validity of before and after comparisons based on recorded alcohol involvement data. Reporting systems have grown in comprehensiveness during the same time period which raises other questions about the validity of before and after comparisons.

Therefore, particular attention has been given to the problems of research design, measurement, and analytic technique in the present investigation. Attempts have been made to define and measure quantities which indicate true changes in the alcohol-related crash experience of specific populations and which are independent of the kinds of operational variations which have been suggested above. A quasi-experimental design has been used which included three states--Maine, Michigan, and Vermont--which recently lowered the legal drinking age to 18 as an experimental group. Two control groups were included. New York and Louisiana were studied as long-term 18-year-old drinking states and Texas and Pennsylvania represented long-term 21-year-old drinking states. An objective, empirically-derived surrogate measure of alcohol-related crash frequencies was used in comparative time-series analyses. The methodology applied and detailed in the present work is viewed as an important element in the report, both in appreciating the conclusions and in facilitating analyses of other states which have lowered their legal drinking ages.

Findings

In Michigan, and also in two of its counties studied separately, alcohol-related crashes among 18- to 20-year-old drivers increased after the lower legal drinking age became effective. The increases are statistically significant and of magnitudes large enough to be considered socially significant. The effect of the lower legal drinking age appears to be directly related to the relative proportion of the 18- to 20-year-old population in the jurisdiction under consideration. Increases in alcohol-related crashes were accompanied by alterations in the age-specific crash frequency distributions of young drivers. After the legal change the 18- and 19-year-old drivers became more involved than drivers in other age groups. No significant increases in alcohol-related crashes occurred among older drivers.

The results of analyses of Maine data were similar to those of Michigan. The legal situation in Maine affords somewhat less confidence in the conclusions than in Michigan in that the legal drinking age changed from 21 to 20 in 1969, and then from 20 to 18 in June 1972.

No significant increases in alcohol-related crash experience were identified in Vermont for either young or old drivers. In addition to an absence of change in magnitude, the age-specific frequency distribution of alcohol-related crashes of young drivers did not change following the lowering of the legal drinking age.

Increases which could be attributed to an influence affecting only the 18- to 20-year-old driving population were not found in any of the four control states.

It is suggested that Vermont experienced no legal impact following the legal change because the pattern of the age-specific alcohol-related crash frequencies was like an 18-year-old age-of-majority state before the legal change. In Pennsylvania the distribution was similar to those in Maine and Michigan before 18-year-old drinking ages became legal in those states. It is suggested that Pennyslvania would experience a legal impact like Michigan and Maine with an 18-year-old legal drinking age.

Texas, where the legal drinking age was changed from 21- to 18-year-old in August 1973, was characterized until 1972 by an alcohol-related frequency distribution similar to Louisiana and other 18-year-old states. This situation is analogous to Vermont in 1972. No legal impact is predicted for Texas.

An "end state" of alcohol-related crash frequency distributions of young drivers is proposed stating that maximum alcohol-related crash frequencies will be found among 18- or 19-year-old drivers when the minimum legal drinking age is 18-years-old. Under the "end state" no major resurgent age-specific-frequency would be of a comparable magnitude for other (older) age groups. States with 21-year-old drinking ages, that do not have this "end state" condition, are predicted to undergo a change if the legal drinking age is lowered to 18-years-old. The change is predicted to result in the "end state" condition characteristic of New York and Louisiana, with long-term 18-year-old drinking ages, as well as Michigan and Maine after the legal drinking age became 18-years-old.

2.0 METHODOLOGY

A data analytic approach, using a multiple time-series quasi-experimental analysis of available accident data, was selected to address the research questions of interest. The overall experimental situation first had to be assessed and a suitable design selected to study the legal impact phenomenon under consideration. An appropriate statistical model and companion statistical procedures applicable to the experimental design were chosen. Implementing the design consisted of selecting appropriate study jurisdictions, identifying appropriate variables from available accident data, and processing these data in conformance with the requirements of the statistical model.

These steps are subsequently discussed in some depth to reveal both the strengths and weaknesses of the methodology. Several important research issues are developed more fully in appropriate appendices.

2.1 THE EXPERIMENTAL SITUATION

Ideally, investigations of the effects of a change and causal inferences regarding that change can best be accomplished in a controlled experiment. Such an experiment, on the model of the natural science laboratory, exercises control over the population potentially being affected by an experimental variable in such a way as to eliminate all confounding factors which might also affect the population. A second ingredient in the pure experimental design is the inclusion of one or more control groups which are identical to the experimental group except for presence of the change-producing, experimental variable. The best experimental procedures randomly assign individual subjects to control or experimental groups. In that valid assumptions about the comparability of groups can be made in a controlled experiment, causal inferences relating the experimental variable to observed changes in the experimental group can also be made. Replications of such a controlled experiment strengthen the causal interpretation but do not alter the basic validity of causal inferences of the first experiment performed.

The present research is obviously not compatible with a pure controlled experimental design. An investigation of lower legal drinking ages is a legal impact study in which the effects of a specific legal change on a social system are assessed. It is not possible to assign legal conditions randomly to naturally existing populations, nor is it possible to control which state populations are exposed to a new law and which are not. In addition, no control is possible over the effective date of a new law or what specific administrative changes accompany a new law. The problem, then, is to apply a research strategy to the real-world, non-laboratory environment of highway accident phenomena occurring in jurisdictions with previously prescribed legal conditions and with an intact social structure.

2.2 QUASI-EXPERIMENTAL DESIGNS

Campbell and Stanley have set forth a classification of research strategies known as quasi-experimental designs which help to circumvent some of these inherent problems.[17,18]

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[17] D.T. Campbell and J.C. Stanley. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally, 1966.

[18] D.T. Campbell. "Reforms as Experiments." American Psychologist, Vol. 24:409-29, 1969;
D.T. Campbell and H.L. Ross. "The Connecticut Crackdown on Speeding: Time Series Data in Quasi-Experimental Analysis." Law & Society Review, Vol. 3:33-53, 1968;
J.Stanley (ed). Improving Experimental Design and Statistical Analysis. Seventh Annual Phi Delta Kappa Symposium on Educational Research. "Administrative Experimentation, Institutional Records, and Nonreactive Measures." D.T. Campbell, Chicago: Rand McNally & Co., 1967, pp.257-91.

Lempert (1966) adopted these to legal impact studies.[19] The development of the quasi-experimental, or "almost experimental", design was intended to assist investigators faced with the desire for causal interpretation in real-world circumstances, including the effects of legal changes. This section presents, in general terms, an overview of important issues of quasi-experimental research designs and the analytical strategy selected to study the effects of lower legal drinking ages. Definitions and notation follow that of Campbell and Stanley.

2.2.1 RESEARCH DESIGN ISSUES. Fundamental to the development of a sound research design is the delineation of conceptual benchmarks that provide a basis of design evaluation. Three such conceptual topics are of particular importance: plausible rival hypotheses, and the extent to which these are controlled; internal design validity; and external design validity.

A plausible <u>rival hypothesis</u> represents a possibility that an event or combination of events, long-term phenomena, or characteristics of a population might explain an observed change rather than the experimental variation being investigated. Optimally, the full range of plausible rival hypotheses is controlled in a laboratory situation, and it is this level of control that a social investigator is compelled to approximate. Rival hypotheses come in a variety of forms from the obvious and dramatic to the more subtle and easily overlooked. Factors which define plausible rival hypotheses jeopardize the validity of conclusions drawn from empirical investigations.

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[19] R. Lempert. "Strategies of Research Design in the Legal Impact Study." Law & Society Review, pp.111-32, November 1966.

Design validity, logically preceding validity of interpretation, can be classified into two distinct forms: internal validity and external validity. Internal validity is the basic minimum without which any experiment is uninterpretable; without it, no confident conclusions can be made regarding the relationship of observed effects and experimental changes. Without internal validity, external validity is not tenable.

Regarding the internal validity of legal impact research in the highway safety area, six classes of extraneous variables warrant attention. If not controlled, such sources of variation might confound the effects of a legal change. These variable classes are:

(1) History, the specific events influencing the population between the first and last observation of the experimental period. Examples in this situation are specific changes in laws other than the age of majority; changes in administrative procedures; short-term economic and social dynamics and extraneous stimuli, including potential effects of age-of-majority related mass media messages; and the effects of such stimuli both on the newly enfranchized 18 - 20-year-old drinking-driving population and the legal-enforcement-administrative groups, including police.

(2) Maturation, processes acting on the affected populations as a normal function of the passage of time. Long-term economic, demographic, and social trends constitute the basic components of such gradual effects. Specifically, the linear trends of relative affluence, population growth, total alcohol beverage consumption, age-specific population growth rates, vehicle population growth, increase of personal vehicle ownership or accessibility, and long-term trends of roadway improvement, taken as a whole, contribute to the explanation of changes in highway safety over a period of time.

(3) Instrumentation, in which changes in the operational measurement of variables are altered. An example, as will be seen subsequently, is a change in the recording of reported alcohol involvement in crashes that occurred in Michigan during the period under study.

(4) Statistical regression, in which high outcomes or frequencies tend to be followed by lower outcomes and vice versa. Accident data exhibit diurnal weekly, seasonal, and long-range cyclic characteristics in which peaks in time-series measurements are invariably followed by troughs.

(5) Selection of experimental and control groups, if uncontrolled, introduce biases which are large or small depending upon the total comparability of the groups. In the present case it is obvious that no one state is like another in all respects. However, by matching to the extent possible certain geographic, economic, and demographic characteristics, and keeping potential biases in mind during the process of interpretation, a functional control of selection biases can be attained.

(6) Any of the above sources of alternative explanation can act interactively and create a plausible rival hypothesis unlike each acting independently. Frequently selection, maturation, and history have been found to have interactive effects.

Lempert[20] emphasized another extraneous variable of specific concern in legal impact studies. When two or more experimental jurisdictions are included in an investigation of a specific legal change, the effective date of the legal change must be comparable or exactly the same. While several states have lowered the legal drinking age in recent years, only Michigan and Vermont laws became effective on or about January 1, 1972. Vermont's law became effective on December 31, 1971. Maine's new age-of-majority law became

[20] Lempert, op.cit., p.118.

effective in the first half of that year. These facts precluded the inclusion of other states on the basis of the effective date of new age-of-majority legislation. If other jurisdictions with different effective dates were included, a variety of uncertainties based on previously defined extraneous variables would be present in the design. The desire for accurate interpretation in this case predetermined the state selection process.

2.2.2 THE MULTIPLE TIME-SERIES QUASI-EXPERIMENTAL DESIGN. The availability of the "running record" in the form of representative accident data over a reasonable time period provided the opportunity of implementing what Campbell and Stanley defined as the multiple time-series quasi-experimental design. Lempert defended this design as the "design _par excellence_ for legal impact theory experimentation".[21]

The design is basically a series of comparable, consistent measurements at regular time intervals taken on two or more populations interrupted by a social or legal dynamic in one or more of the populations. The appeal of this design, when coupled with appropriate statistical analyses, is its ability to achieve maximal control over plausible rival hypotheses as expressed by the defined classes of extraneous variables.

The design can be represented in the abstract with the following formulation:

	t_1	t_9	t_{16}
Group 1	0000000	X	00000000

Group 2	0000000		00000000

[21] Lempert, _op.cit._, p.130.

where:

0 = an observation, or measurement, taken at equal time intervals, $t_1, t_2, \ldots, t_{16}$.

X = an experimental variable introduced to Group 1, the experimental group, at time point t_9.

--- indicates that group assignment was prescribed by circumstance, and not according to random selection methods.

With this design, comparisons are made between the affected "experimental" population and the unaffected "control" population on parameters of interest. The comparisons become more internally valid the larger the number of time-ordered measurements and the greater the equivalence of measurements before and after the introduction of the social dynamic or experimental variable. The design increases in external validity, or generalizability, with increased representativeness of demographic, geographic, and other pertinent characteristics among the measured populations.

2.3 IMPLEMENTATION OF THE TIME-SERIES DESIGN

Implementation of the quasi-experimental design outlined abstractly above consisted of several interrelated steps, including selection of states and investigation of data availability, identification and selection of variables, and data processing.

2.3.1 SELECTION OF STUDY STATES. As mentioned earlier, the state selection process for the present research was largely prescribed by historical events regarding the legal structures of the states from which to choose.

Three uncomplicated legal classes exist in the United States regarding the minimum legal drinking age: long-term 18-year-old; long-term 21-year-old; and transitional, in which the minimum age has been changed from 21 to 18, or 20 to 19 as in Maine. More complicated classes include those states with mixed legal structures by age of majority, e.g., 19-year-old, or beverage-specific combinations such as low alcohol content beer, wine and beer but not spirits, and other unique categories. States with complex legal structures regarding the legal drinking age, especially beverage-specific combinations, were eliminated because of the confounding effects on analysis and interpretation introduced by these mixed structures.

Only New York and Louisiana have long established 18-year-old legal drinking ages. New York's law became effective in 1934 and Louisiana's in 1948. The desire for as much external validity as possible led to the inclusion of at least two states in each of the three legally defined groups, and therefore both New York and Louisiana necessarily were selected. New York data were available for the full 1968-72 time period, and Louisiana data were available in digital form for the January 1971 to July 1973 period.

Michigan and Vermont are the only states which, for practical purposes, lowered the legal drinking age from 21 to 18 in the first half of 1972. Michigan's "Age of Majority Act of 1971"[22] and Vermont's Public Act Number 90, 1971 became effective December 31, 1971.[23,24] Maine's law

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[22]Michigan State Legislature. Age of Majority Act of 1971. Michigan Public Acts 1971 - No. 79. Lansing, Michigan: State of Michigan, 1971, pp.142-43.

[23]Vermont State Legislature. Public Acts, 1971. No. 90. Montpelier, Vermont, 1971.

[24]For purposes of analysis, January 1, 1972 was used as the effective date in the present research.

lowered the legal drinking age from 20 to 18 effective June 9, 1972.[25,26] The time-scale of the study dictated the choice of these states, rather than others that subsequently passed similar legislation, to include as many data points in the "after" time-series as possible.

Michigan data were available for the January 1968-July 1973 time period; however, not all reporting jurisdictions throughout the state were included until 1971. Specifically, the 1968 data excluded thirty-two of the largest Michigan cities and included only eleven. Most of these jurisdictions were represented in 1971 and later; however, Detroit was not completely represented until 1972. In order to avoid seriously incorrect inferences from analyses of a changing data base, the least common set of reporting jurisdictions which comprised the file in 1968 were used exclusively for the full time period. The statewide Michigan file, therefore, is primarily non-urban and represents about 55% of the total Michigan crash experience.

As a means of offsetting the non-representativeness of statewide Michigan data, files available at HSRI were utilized. Oakland County, Michigan 1968-72; Washtenaw County, Michigan 1968-72; Michigan Fatal Accidents, 1968-72; and Wayne County, Michigan (excluding Detroit) 1971-July 1973 were built into the design as independent jurisdictional data files. These data have been subjected to analyses identical to the other statewide data files. Utilization of the auxiliary data bases compensated for the largely non-urban statewide data in Michigan. Additionally, the specific analyses of Washtenaw, Oakland, Wayne and Michigan Fatal

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[25] Maine State Legislature. Maine Public Acts, 1972, Chapter 598. "An Act to Grant Adult Rights to Persons Eighteen Years of Age." Augusta, Maine, 1972, pp.49-50.

[26] For purposes of analysis, June 1, 1972 was used as the effective date in the present research.

Accidents provided further insight into the largest state in the study which lowered the legal drinking age.

Washtenaw County, which includes both Eastern Michigan University and The University of Michigan, has an unusually high proportion of 18- to 20-year-old residents and a youth-oriented social atmosphere much unlike the rest of Michigan. Oakland County, also in southeastern Michigan, is densely populated with major residential and industrial regions. Wayne County, surrounding the City of Detroit, is highly urbanized. A specific analysis of fatal accidents should serve to qualify the conclusions of a change in the level of the various parameters in terms of the most severe category of vehicle crash.

Vermont data were available only for the years 1971 and 1972. These data were secured from the State of Vermont Department of Motor Vehicles. Maine, the third transitional state, is represented by 1970, 1971, and 1972 data which were provided by the State of Maine Department of Transportation.

The selection of states in the long-term 21-year-old drinking category afforded the greatest latitude. However, the desire to match states as closely as possible on geographic, demographic, and economic parameters and issues of data availability resulted in the inclusion of Texas and Pennsylvania.

Texas, an approximate geographic match to Louisiana, was included using statewide data available at HSRI for the 1969-72 period. The Commonwealth of Pennsylvania Department of Transportation provided 1968-72 data; except for fatal accidents, however, no data were available for 1970. The missing data were filled-in by generating linear regression estimates of selected variables for the 1968-71 period.[27]

[27] The 1968-71 period was used in computing regression estimates of the 1970 parameters because, if a societal effect produced changes in 1972 in the experimental states, this would be confounded if comparison data were estimated from 1972 frequencies in Pennsylvania.

Pennsylvania is an exceptionally good match for Michigan and New York on geographic, demographic, and economic parameters.

2.3.2 ANALYTIC CRASH FILES. The states selected for study and the years for which accident data were obtained and analyzed are shown in Figure 2.1.

Accident data in digital form were available for each of the seven study states and the three Michigan counties, but the yearly coverage prior to 1972 is seen to be uneven. 1968 was selected as the first year for which data would be retrieved, thereby assuring an adequate number of monthly data points in the "before" time-series.

Accident files from the larger states were systematically sampled to create analytic files of manageable size, and the sampling fractions chosen were large enough to assure adequate representativeness of the sample. The Louisiana Highway Safety Commission provided a 10% systematic sample of data files starting with January 1971, and the New York Department of Motor Vehicles provided a 5% sample of accident files for the 1968-72 period.

The original crash files were copied and supplied to HSRI for Maine, Michigan, Pennsylvania, and Vermont. All Maine and Vermont accidents were retained for analysis, but a 15% sample of Michigan accidents and a 5% sample of Pennsylvania were used. Wayne County data, complete only from January 1971-July 1973, were taken from the 15% Michigan sample, but all of the Oakland and Washtenaw County data were available for a full five-year period. The original data were in the form of sequential archives of accident records. Each record contained numerous data elements of each involved vehicle and driver in a particular accident. In order to deal with multiple-vehicle cases the analytic files were built with individual drivers and vehicles as unique case determinants. Therefore, a single-vehicle crash representing one driver and one vehicle in the

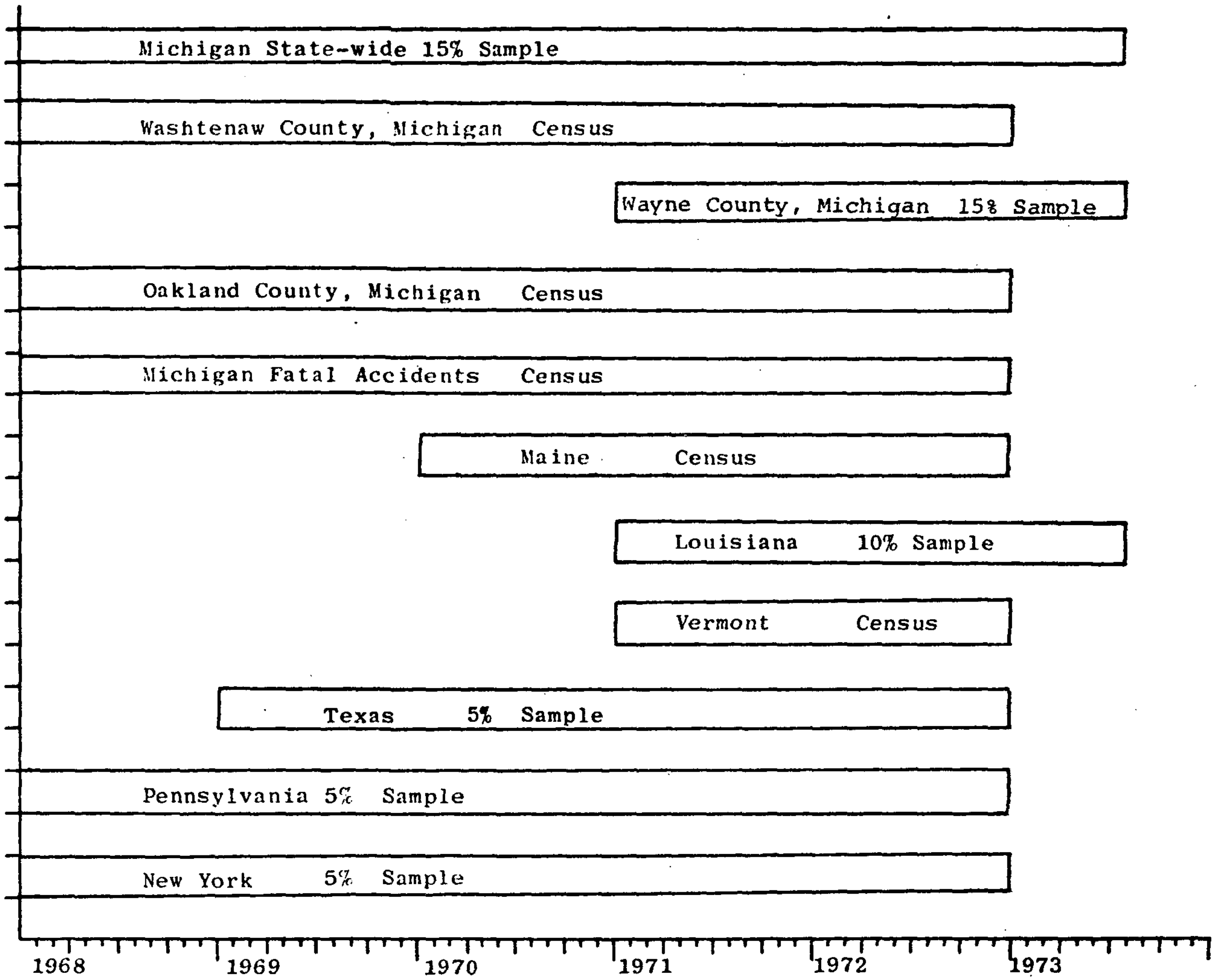


FIGURE 2.1. FULL QUASI-EXPERIMENTAL DESIGN WITH RANGE OF JURISDICTION DATA AND FILE COMPOSITION

original data produced one driver and one vehicle in the analytic (vehicle) files. On the other hand, a two-vehicle crash listing both vehicles and drivers in one record in the original data produced two separate driver involvements in the analytic files. In other words, a case is defined as one driver-vehicle involvement in a crash. Vehicle files were prepared for each jurisdiction and included the first two drivers in each original accident record. Identical sets of crash parameters were associated with each of the first two drivers involved in the same crash.

Table 2.1 presents a complete summary of data files included in this research. The table includes total numbers of records of master files which were used to generate vehicle files. Also noted are appropriate sampling fractions, coverage periods, and peculiarities of each file.

2.3.3 SELECTION OF ANALYTIC VARIABLES. A time-series analysis requires that the independent variable, time be structured into equally-spaced regular intervals.[28] An individual month has been taken as the basic time unit and various monthly total measures of crash experience constitute the basic analytical units. The Michigan statewide data, for instance, have a total of 67 monthly intervals, with 48 in the n_1 "before" series from January 1968 to December 1971, and 19 monthly intervals from January 1972 to July 1973 in the n_2 "after" series. Monthly measures were also aggregated into yearly measures and into "before" and "after" measures in various analyses.

All dependent variables used in subsequent analysis originated from routine reports of crashes occurring in the ten jurisdictions under study. Generally investigating police officers fill out an accident report form, and the forms are compiled in a central registry within each state.

[28] M.G. Kendall. Time-Series. New York: Hafner Press, 1973, pp.7.

TABLE 2.1. FULL QUASI-EXPERIMENTAL DESIGN FILE DESCRIPTIONS

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. Source: State of Maine Department of Transportation
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 1st & 2nd involved drivers. Property definition damage change, 1972. Source Louisiana Highway Safety Commission
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	Source: State of Vermont Department of Motor Vehicles
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 coded after 1970. Source: HSRI*
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. Source: Commonwealth of Pennsylvania Department of Transportation
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 in 1970. Source: New York State Department of Motor Vehicles
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	

*HBD - Had Been Drinking

2.1. FULL QUASI-EXPERIMENTAL DESIGN DESCRIPTIONS

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 effect effective 1/1/71. Source: State of Michigan Department of State Police.
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	Source: HSRI
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.
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	Source: HSRI
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	Source: HSRI
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.

New York data, however, also include self-reported accident data submitted by crash-involved motorists.

All states' accident report forms include some kind of provision for recording whether the investing police officer believes that the driver had been drinking prior to the crash. This dependent variable is clearly important in the present study and it has been used extensively. However, reported alcohol-involvement is known to be subject to a number of defects which render it unsuitable as the sole measure of alcohol-related crashes. Appendix A contains detailed information about various problems with the reported alcohol-involvement variable that were found among the states under study. It should not be inferred, however, that this variable is useless. In states which have been attentive to the issue, such as Michigan, the reported alcohol-involvement variable remains the best single estimate of the proportion of alcohol-related crashes, particularly in non-fatal crashes where objective chemical tests of drivers' blood alcohol concentrations are made infrequently. The reader is cautioned to interpret the subsequent findings about this variable carefully and in view of the Appendix A discussion.

Because of the known problems with the reported alcohol-involvement variable, considerable emphasis was placed on the development of a surrogate measure for alcohol-involvement. The surrogate measure, described more fully in Appendix B, consists of the frequency of that subset of all crashes involving a single vehicle driven by a male driver and occurring between 9:00PM and 6:00AM. Various replicated analyses indicated that between 53% and 63% of these three-factor-surrogate crashes are consistently alcohol-related. Thus, the surrogate can be used as a reliable indicator of alcohol-related crashes across jurisdictions and also within jurisdictions over time, thereby overcoming many of the defects inherent in the reported alcohol-involvement variable. A major strength of the surrogate is that its three components are all reliably-reported, objective data elements free from judgments and biases on the part of crash investigators. It is true, of course, that there does not exist a one-to-one correlation between three-factor-surrogate crashes and reported alcohol-related crashes. However, the three-factor-surrogate is consistently related to alcohol-involvement, objective, and equally valid for young and old drivers. These qualities provide a measure with great utility for monitoring changes in alcohol-related crash experience occurring within a jurisdiction over a several year period, and for comparing across jurisdictions.

The two measures of a jurisdiction's alcohol-related crash experience described above were supplemented by the total monthly crash experience of that jurisdiction, irrespective of alcohol involvement. Together with the inclusion of age-of-driver data for each crash this permitted the computation of age-specific rates of alcohol-related crashes. These age-specific rates are the frequency of alcohol-related crashes (as measured either by reported alcohol-involvement or by the three-factor surrogate) in a given age group divided by the frequency of all crashes for the same age group occurring within the period under consideration. Their utility is discussed in the methodological summary section.

These selection processes resulted in the following 11 basic measures of each jurisdiction's crash experience:

Total 18-20 year-old crash experience[29]

Total 21-45 year-old crash experience

Total crash experience, all ages

[29] In Maine, the age stratifications were 18-19 and 20-44 years-old.

18-20 year-old HBD crash experience[30]
21-45 year-old HBD crash experience
Total HBD crash experience, all ages

18-20 year-old three-factor-surrogate crash experience
21-45 year-old three-factor-surrogate crash experience
Total year-old three-factor-surrogate crash experience, all ages

18-20 age-specific three-factor-surrogate rate
21-45 age-specific three-factor-surrogate rate

Data on these 11 measures were subjected to identical time-series analyses for all jurisdictions as described subsequently.

2.4 PROCESSING AND ANALYSIS OF DATA

The objectives of the study were to determine whether changes occurred in the alcohol-related crash experience of young drivers following reduction of legal drinking ages to 18 in the transitional states, and to determine whether any resultant changes were causally related to the reduced legal drinking age. The primary procedure for accomplishing the first objective consisted of forming time-series of the frequency measures of reported alcohol-related crash experience and of the three-factor-surrogate rate among the affected population in the transitional states and examining these series for shifts in their level from the before period to the after period.[31] The second objective was accomplished primarily by forming similar time-series on the same measures

[30] HBD denotes "had been drinking", the reported alcohol involvement variable, for all jurisdictions. Appendix A discusses the meaning of this variable for each jurisdiction.

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

for non-affected adults in the transitional states and for both youthful and adult drivers in the four control states and then comparing the results of the several time-series analyses. The flow of this process for each time-series is depicted in Figure 2.2.

Additional insight into the nature of the resulting changes was gained by plotting age-specific frequency histograms of three-factor-surrogate crash annual mean values of young drivers before and after the legal drinking ages were changed.

2.4.1 FORMATION AND DECOMPOSITION OF TIME-SERIES. The literature frequently frames a time-series in the context of an additive model consisting of four components:[32]

$$Y = S + C + T + I$$

where

Y is the series;

S are seasonal, cyclic components;

C are non-seasonal, cyclic components;

T is the trend, or long-term movement;

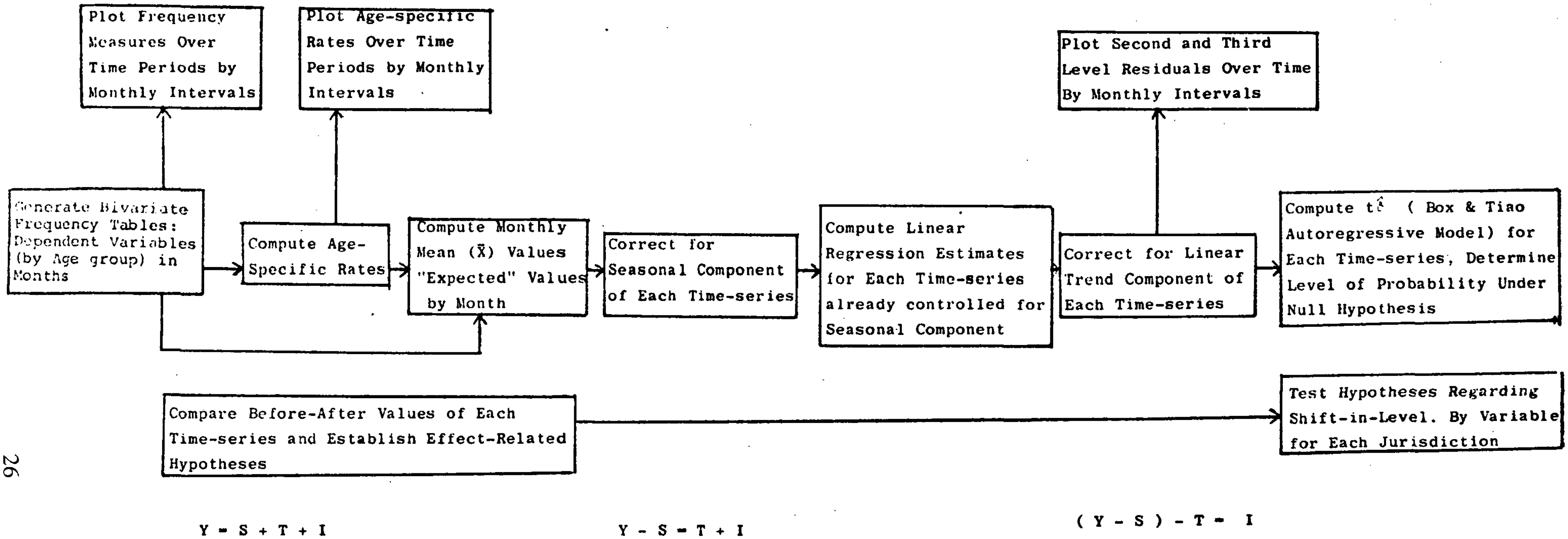
I are residual, irregular, or random effects not a part of the other components.

The irregular, residual components are of central concern here. If the other three components are absent or can be removed, then the effects of other unexplained variations, including those due to a change in the legal drinking age, would appear as a shift δ in the I component of the several time-series under consideration.

It can be seen from Figure 2.2 that monthly measures of crash experience were first generated to form the time-series for subsequent analysis.[33] Each time-series was then plotted

[32] M.G. Kendall, op.cit., p.16.

[33] Ross, et al., (1970) standardized 28-day, 29-day, and 30-day monthly accident data to 31-day months. That level of precision was considered unnecessary in this study.



Components and Decomposition of Time-series Data:

Y= Series, S= Seasonal Component
T= Trend Component, I= Irregular Component

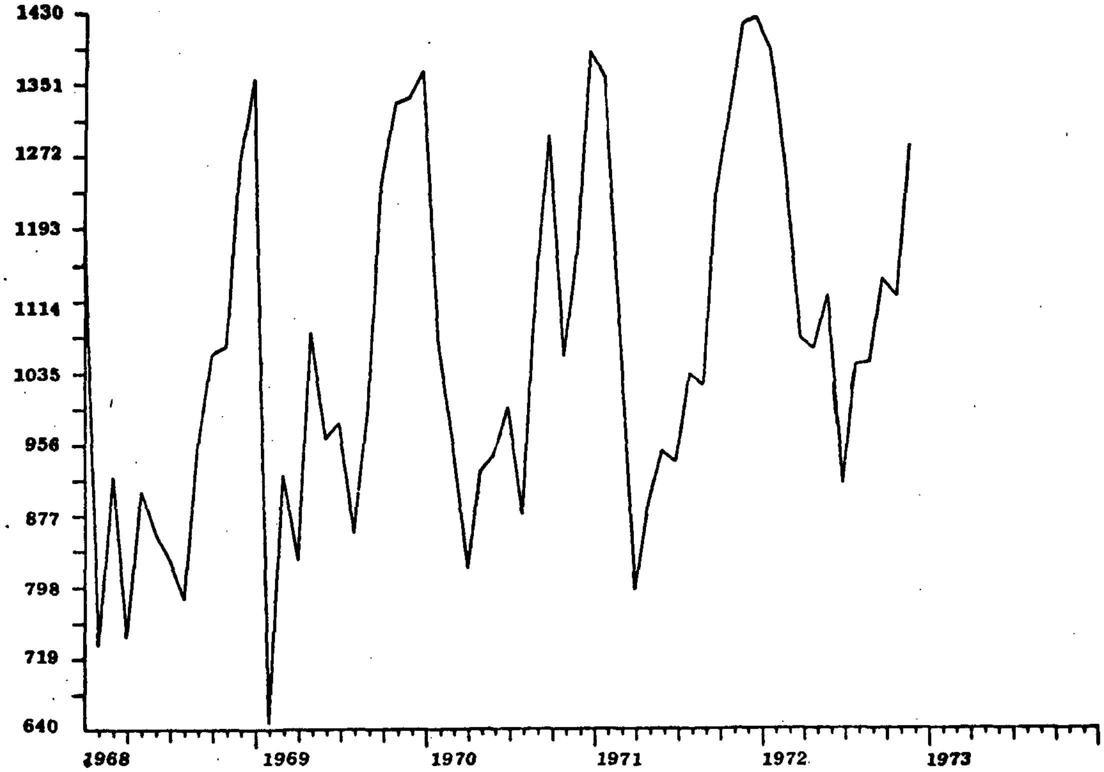
FIGURE 2.2. ANALYSIS FLOW CHART

and examined for the presence of S, C, or T components. Examples of plotted time-series frequencies demonstrating strong trend and seasonal components are shown in Figure 2.3. No C-type cyclical components were identified in time-series of the pertinent crash data, but seasonal (S) and trend (T) components are readily apparent from Figure 2.3. Therefore the time-series residuals were conceptualized as consisting of the difference between the raw series and its S and T components: $I = Y - S - T$.

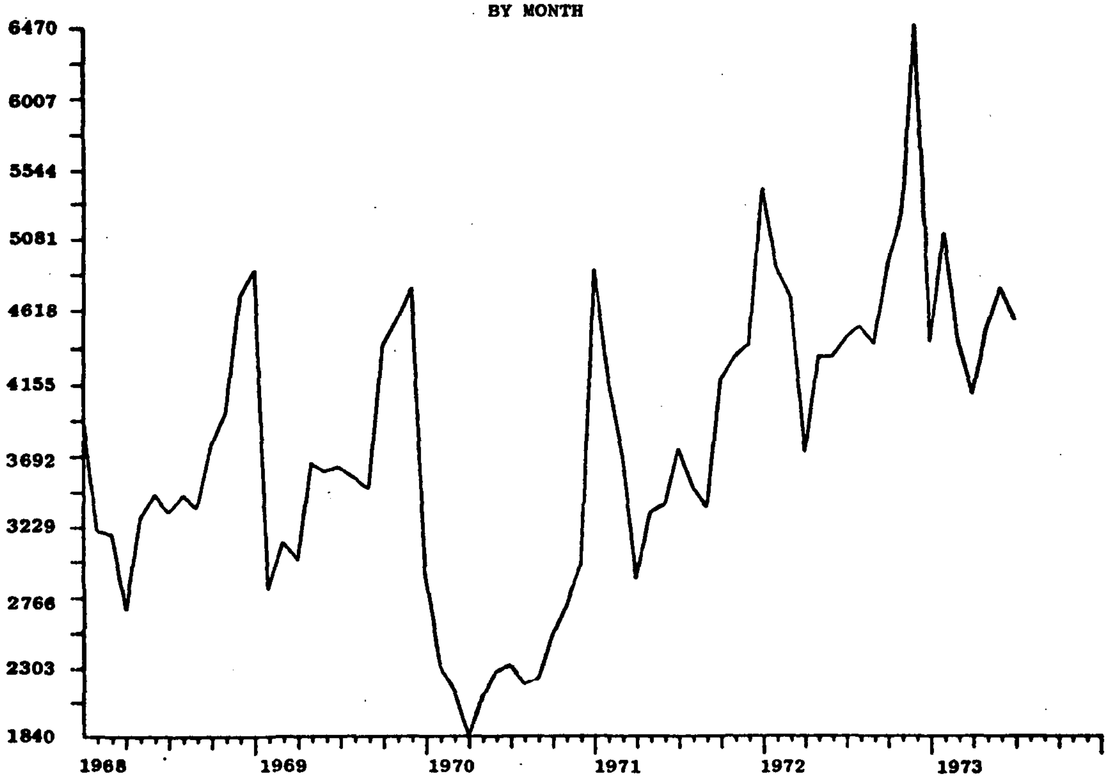
The appropriate statistical procedures subsequently applied require that the time-series be free from systematic trends or cycles and have mean values equal to zero. Therefore seasonal decomposition was accomplished by computing the twelve monthly means of any given dependent variable for all like months, e.g., all Januarys, in the series and then subtracting the appropriate mean values from each monthly observation of like months. The expected, seasonally cyclic variation in each series was thus removed.

Data corrected for seasonal effects then were submitted to linear regression analysis. The least squares plots of all observations in the series were computed and residuals about the line were saved. In this way the trend component of the series was removed, and the residuals define the irregular component I in the general time-series model with zero mean values. Because both seasonal and trend components have been removed, the resultant irregular data points are called a second-order residual. These residuals were then segregated into n_1 pre-intervention observations and n_2 post-intervention observations and the test statistic t^{δ} was computed for each of eleven variables for each of eleven analytic jurisdictions.

2.4.2 STATISTICAL PROCEDURES. Two statistical models, the autoregressive model and the integrated moving average



TOTAL DRIVER-CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN
BY MONTH



TOTAL DRIVER-CRASH INVOLVEMENTS IN MICHIGAN (STATEWIDE FILE)
BY MONTH

FIGURE 2.3. EXAMPLES OF TREND AND SEASONALITY IN TIME-SERIES DATA

model, are candidates for determining a change in level of a non-stationary time-series. Both rely on the Student t-distribution for determination of statistical significance of differences between the before and after levels of a time-series. The essential difference between the two lies in the way in which observations in the before and after series are weighted in computing the test statistic. Observations in the autoregressive model are uniformly weighted, irrespective of their proximity to the intervention point. In the integrated moving average model, the data points closer in time to the intervention point are weighted more heavily than those further removed; the weights decay exponentially as a function of the length of the time-series, and the degree of interdependence of the observations in the time-series. These models are discussed in the fundamental paper by Box and Tiao (1965).[34]

In contrast to other investigations[35,36], in which the integrated moving average model was used in analyzing legal impacts, the autoregressive model was chosen for this study. The Connecticut crackdown on speeding in 1956 (Glass, 1968) and the revision of the German divorce laws in 1900 (Glass, et al., 1971) clearly attempted to restrict behavior patterns considered undesirable. In contrast, lower legal drinking ages, rather than being more restrictive, are permissive in that a new part of the population is legally permitted to

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[34] G.E.P. Box and G.C. Tiao, op.cit., 1965, p.181-192.

[35] G.V. Glass. "Analysis of Data on the Connecticut Speeding Crackdown as a Time-Series Quasi-Experiment." Law & Society Review, Vol. 3, August 1968, pp.55-76.

[36] G.V. Glass, G.C. Tiao, and T.O. Maguire. "The 1900 Revision of German Divorce Laws." Law & Society Review, Vol. 5, May 1971, pp.539-62.

purchase and consume beverage alcohol. A reasonable presumption is that restrictive practices are more likely to result in immediate compliance, if they are to be effective at all, than permissive legislation which does not require that a population change its behavior at all. The current nationwide reduction to a 55 m.p.h. speed limit, and popularly reported compliance with it, is a case in point.

Newly enfranchized drinkers were in a different situation. Except for those who had been drinking (illegally) and subsequently driving before the law changed, the new drinkers had to go through a several-step process before changed behavior patterns would appear in crash statistics. In effect they first had to learn to drink, and they had to establish new drinking patterns of some regularity. Further, those who would become exposed to alcohol-related crashes had to couple increased consumption with subsequent driving in sufficient frequency that alcohol-related crashes, which are rare events among drinking drivers, would have adequate opportunity to occur in a probabilistic sense. In short, a complex maturation process resulting in different drinking and driving patterns was almost certainly at work, and there is every reason to suppose that several months, and perhaps even much longer, would be required before the situation stabilized. It was concluded, therefore, that observations near the end of the rather short "after" series should be weighted as heavily as those closer to the date of the new legal drinking age and that the autoregressive statistical model was the proper choice in this application.

The computer program developed by Maguire and Glass (1967)[37] applicable to the Box-Tiao model was available within the University's School of Public Health, Department of

[37] T.O. Maguire and G.V. Glass. "A Program for the Analysis of Certain Time-Series Quasi-Experiments." Educational and Psychological Measurement, 1967, Vol. 27, pp. 743-750.

Biostatistics. The program was modified to fit the University's computing equipment and to use uniform weighting of before and after data points. The modified program was used to compute $t\hat{\delta}$, the autoregressive t statistic associated with the estimated change in level, $\hat{\delta}$, of the series.[38]

2.5 SUMMARY AND DISCUSSION OF METHODOLOGY

The multiple interrupted time-series quasi-experimental design was selected as the most appropriate means of addressing the purposes of this research. Operationalization of the design included state selection, identification of appropriate dependent and independent variables, and statistical procedures. Sources of extraneous variation that introduce hypotheses which challenge a causal association between any observed changes in alcohol-related crash experience among the legally affected, crash-involved populations have been defined and addressed. The design has been executed in order to impose controls over as many extraneous variables as possible.

Specifically six plausible rival hypotheses, which are sources of design invalidity, have been controlled in the present study, as summarized in Table 2.2.

As a consequence of the state selection process which completes a three-group, eleven-jurisdiction multiple time-series design, the extraneous variables of selection and

[38] In the autoregressive model the value of $t\hat{\delta}$, and estimates of a shift in level following an intervention, depend upon the value of the lag-1 autocorrelation of the time-series (Rho). In the present case, the full range of possible lag-1 autocorrelations and associated $t\hat{\delta}$ values were computed. The maximum likelihood estimate of the lag-1 autocorrelation (Rho-estimate) was calculated and its associated $t\hat{\delta}$ value was determined by identifying the $t\hat{\delta}$ associated with an equivalent value of Rho. Intervals around the $t\hat{\delta}$ values were examined and statistical confidence in the interpretations was found to be consistent. Appendix C contains a detailed explanation of the mathematical model.

TABLE 2.2. COMPONENTS OF DESIGN OPERATIONALIZATION AND CONTROL OF PLAUSIBLE RIVAL HYPOTHESES (X INDICATES CONTROL EFFECTED BY OPERATIONAL STAGE)

Plausible Rival Hypotheses	Operational Component		
	State Selection	Variable Identification	Statistical Procedures
History	X	X	
Maturation		X	X
Instrumentation		X	
Statistical Regression			X
Selection	X	X	X
Comparability of Legal Change Effective Date	X		

history have been partially controlled. Interstate economic and social changes which have taken place during the five-year period were experienced in both Northern and Southern states, in both rural and industrial areas, and among densely and sparsely populated regions. Development and improvement of interstate highway systems was common to the states selected, although more pronounced in some than others. Geographic peculiarities of the three northern transitional states are found as well in New York and Pennsylvania.

With the inclusion of two Southern states with quite different seasonal and geographic characteristics, the external validity of an inference has been strengthened. An historical threat to the validity of the design at this stage is uncontrolled, this being the incomplete data bases for Vermont, Maine, and Louisiana; it is not possible to state with precision what changes in the eventual interpretation would be made if full five-year periods were available for these jurisdictions. The selection of distinct subsets of

Michigan as jurisdictions for analysis is expected to add strength to the external validity of the design by increasing the heterogeneity of the comparison groups without affecting the comparability of these groups.

Campbell and Ross (1968)[39], in an analysis of the 1955 Connecticut crackdown on speeding, observed that when a legal or social change occurs in one state, the effects of that change have a potential effect in neighboring states. The authors termed this threat to validity the process of diffusion, and there is a possibility of diffusion between several states in the current design (Maine, Vermont, New York, Pennsylvania). However, control states located at significant distances (Texas and Louisiana) and an isolated experimental state (Michigan) should provide reasonable control for the problem.

A result of variable identification was to effect partial control over four threats to design validity. Interaction of selection and instrumentation represents non-comparability of the reported alcohol involvement variable between the different state jurisdictions. The surrogate for reported alcohol involvement provides an alternative dependent variable which has effected a control over the inconsistency of the reported statistics within and between jurisdictions. The surrogate also controls for historical events in Michigan and Texas--administrative changes in the crash investigation form in Michigan and absence of reported alcohol involvement in the Texas data. The surrogate variable has the additional quality of being valid across jurisdictions in the design which augments the external validity of the investigation.

The computation of age-specific rates effected a partial control over the extraneous variable maturation, as defined earlier. Age-specific determinants of positive or negative

[39] Campbell and Ross (1968), op.cit., p.46.

trends which are primarily a function of the age-specific total crash experience are "smoothed" with the utilization of rates, although more general social, economic, and other determinants of general, linear trend remain to be controlled by other statistical procedures.

A final component of the operationalization of the quasi-experimental design, statistical procedures, dealt both with the underlying additive model of the time-series analysis and the need to control for extraneous variables of selection, statistical regression, and maturation. Seasonality is different among the seven states in the design, particularly between the five Northern states and the two southern states. The selection biases imposed by seasonal differences have been controlled by the removal of expected monthly values that were isolated through time-series decomposition. Similarly, maturation (linear trend) was controlled through the removal of time-ordered expected values identified through linear regression analyses. Statistical regression is best expressed as the interaction of seasonal cycles and linear trend. In that long-term cycles were not identified in the data, regression effects have been controlled.

The inclusion of comparison groups within the three transitional states and in other states provided a basis for causal inference to the lower legal drinking ages in Maine, Michigan, and Vermont. By imposing design and statistical controls on the time-series data, the direction of any changes can be interpreted.

The Box and Tiao (1965) autoregressive technique to determine the statistical significance of shifts in level of critical dependent variables was selected. The conceptual and statistical reasons for the selection of this statistical procedure were discussed earlier and are discussed in greater detail in Appendix C. The statistical model requires that inputed data be free of regular cyclic and trend components. Thus, in the process of imposing controls over plausible rival hypotheses the criteria for statistical testing were largely met. In addition, the input data (residuals) are required to have zero-mean values. Washtenaw County, Michigan statistics are presented in Table 2.3 as an example of the degree to which the zero-mean assumption has been met through the statistical procedures. Overall, the range of the residuals of the eleven dependent variables for eleven jurisdictions was $\pm$ 1.0 X 10^{-9} to $\pm$ 1.0 X 10^{-18}. A full set of time-series plots for eleven analytic variables in Washtenaw County is presented in Appendix D. These figures demonstrate the adequacy of the statistical procedures regarding the control of trend and seasonal components.

TABLE 2.3. DESCRIPTIVE MEASURES OF ELEVEN DEPENDENT VARIABLES WASHTENAW COUNTY, MICHIGAN 1968-1972
n=60 MONTHLY OBSERVATIONS

	Frequency (Raw Data)				Level 2. Residual Controlled for Seasonal and Linear Trend Components			
Variable	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
18-20 Total Experience	158.450	32.338	100.000	225.000	$-.11369\text{X}10^{-13}$	17.8800	-35.798	36.643
21-45 Total Experience	563.500	117.930	312.000	790.000	$-.50922\text{X}10^{-14}$	61.8600	-214.160	175.620
18-20 Had Been Drinking	11.017	4.890	2.000	25.000	$-.15728\text{X}10^{-14}$	3.9790	-7.467	10.933
21-45 Had Been Drinking	60.883	12.153	35.000	89.000	$-.20724\text{X}10^{-15}$	8.8900	-23.260	28.960
18-20 Three Factor Surrogate	8.400	3.376	3.000	17.000	$-.65133\text{X}10^{-15}$	3.0160	-6.293	6.306
21-45 Three Factor Surrogate	25.550	6.940	11.000	43.000	$-.12953\text{X}10^{-15}$	6.1551	-14.866	13.637
Total Overall Crash Experience	1063.100	197.390	647.000	1426.000	$-.2783\text{X}10^{-14}$	106.1000	-326.120	288.890
Total Overall Had Been Drinking Experience	92.470	14.810	62.000	126.000	$-.32196\text{X}10^{-15}$	10.7320	-27.284	30.449
Total Overall Three Factor Surrogate Experience	40.850	9.690	21.000	68.000	$-.62913\text{X}10^{-16}$	8.3270	-20.091	18.291
	Age Specific Rates - Level 1. Residual Controlled for Age Specific Population Growth				Age Specific Rates - Level 3. Residual Controlled for Growth, Seasonal and Linear Trend Components			
18-20 Three Factor Surrogate	.05295	.01893	.02222	.10345	$-.10119\text{X}10^{-17}$	.01844	-.03152	.05244
21-45 Three Factor Surrogate	.04659	.01358	.02056	.08558	$.40621\text{X}10^{-17}$	.01134	-.03131	.03168

TABLE 3.1. TIME-SERIES ANALYSIS OF SHIFT IN LEVEL OF CRASH-RELATED DEPENDENT VARIABLES MICHIGAN JURISDICTIONS

Variable Name	Michigan Statewide $t\hat{\delta}$	$n_1=48$ $n_2=19$ ρ level	Washtenaw County $t\hat{\delta}$	$n_1=48$ $n_2=12$ ρ level	Oakland County $t\hat{\delta}$	$n_1=48$ $n_2=12$ ρ level	Wayne County $t\hat{\delta}$	$n_1=12$ $n_2=19$ ρ level	Fatals Statewide $t\hat{\delta}$	$n_1=48$ $n_2=12$ ρ level
18-20 Total Crash Experience - Frequency	2.8104	$\rho<.0025$	.28458	n.s.	.48778	n.s.	1.4202	n.s.	2.3451	$\rho<.0094$
21-45 Total Crash Experience - Frequency	1.2053	n.s.	-.07365	n.s.	1.6589	$\rho<.0485$	2.4708	$\rho<.0068$	-.50753	n.s.
18-20 Reported Had Been Drinking - Frequency	3.2941	$\rho<.0007$	3.5533	$\rho<.001$	3.247	$\rho<.001$	1.3105	n.s.	1.6616	$\rho<.0485$
21-45 Reported Had Been Drinking - Frequency	1.6130	n.s.	-.57737	n.s.	-.5065	n.s.	.8166	n.s.	.17364	n.s.
18-20 Three Factor Surrogate - Frequency	2.3663	$\rho<.0091$	2.1028	$\rho<.0166$	3.6966	$\rho<.001$	.4135	n.s.	1.5363	n.s.
21-45 Three Factor Surrogate - Frequency	1.1365	n.s.	-1.1946	n.s.	-.4867	n.s.	.66427	n.s.	1.2118	n.s.
18-20 Three Factor Surrogate Age Specific Rate	1.6444	$\rho<.05005$	3.7331	$\rho<.0001$	2.2037	$\rho<.0139$	-.2493	n.s.	-.86595	n.s.
21-45 Three Factor Surrogate Age Specific Rate	-.06431	n.s.	-.93616	n.s.	-.14816	n.s.	-.4634	n.s.	-2.4675	$\rho<.0068$
Total Overall Crash Experience - Frequency	1.5622	n.s.	-.57677	n.s.	.24544	n.s.	2.3790	$\rho<.0087$	.9911	n.s.
Total Overall Reported Had Been Drinking - Frequency	2.5551	$\rho<.005$	.4491	n.s.	2.2048	$\rho<.0122$	1.5639	n.s.	.21655	n.s.
Total Overall Three Factor Surrogate - Frequency	2.6685	$\rho<.004$	-.00777	n.s.	3.7150	$\rho<.001$	1.1600	n.s.	1.007	n.s.

Statistic: Autoregressive Time-Series "t" statistic ($t\hat{\delta}$) Box and Tiao, 1965.
One tailed significance tests, of shift in level of time series after the legal drinking age was lowered, effective 1/1/72.

County the level did shift in a positive direction, however, the statistical significance of the shift did not reach the .05 probability level. The 18- to 20-year-old three-factor-surrogate frequency and age-specific rate shifted significantly in Washtenaw and Oakland Counties and in the State-wide file. Non-significant, positive shifts were measured for the three-factor-surrogate frequency and rate for 18- to 20-year-old driver involvements in Wayne County and in the Fatal File.

Of the three alcohol-related dependent variables for 21- to 45-year-old driver involvements in five Michigan data files, only once did the age-specific three-factor-surrogate rate shift at or above the .05 significance level; in the Fatal File the value of this variable decreased. It is clear that there was no increase in alcohol-related crash involvement in these jurisdictions among the 21- to 45-year-old groups. In the Statewide, Washtenaw, and Oakland files where consistent and highly significant increases were measured among the 18- to 20-year-old groups for the three critical alcohol-involvement variables, the 21- to 45-year-old groups experienced non-significant shifts in the negative direction.

Among the remaining variables there is no clear pattern, regarding shifts in level, between jurisdictions. The overall experience of total crashes shifted significantly in only Wayne County. Overall reported alcohol involvement and three-factor-surrogate shifts were found in the Statewide and Oakland files with non-significant changes elsewhere.

From these results it is clear, except for Wayne County, that the critical 18- to 20-year-old variables shifted positively after the legal drinking age was lowered to 18-years-old. These files represent a full range of crash types and severity. Among fatal accidents, reported alcohol involvement for the 18- to 20-year-old group shifted significantly along with total crash involvement for the age group. The three-factor-surrogate frequency shifted positively, however, statistical significance was not attained and the age-specific-rate for the surrogate was negative. For fatal crash involvements, then, it appears that the increase in alcohol-related crashes was more a function of total crash involvement for the 18- to 20-year-old group and increased alcohol-involvement reporting, than anything else, including a measurable shift related to the legal change. This interpretation will receive further attention in Section 3.2.

The clearest demonstrations of a shift in alcohol-related crashes following the legal change are in Oakland and Washtenaw Counties where reported and surrogate measures of alcohol involvement shifted dramatically while non-alcohol-related crash involvements for the 21- to 45-year-old groups remained unchanged.

Maine and Vermont. Table 3.2 presents the $t\hat{\delta}$ values for time-series analyses of Maine and Vermont data. In Maine reported alcohol involvement for the affected 18- to 19-year-old drivers shifted significantly while the three-factor-surrogate frequency and age-specific rate for this group failed to shift at a statistically significant level. No 20- to 44-year-old group measure shifted at a statistically significant level and the $t\hat{\delta}$ values for the older group were consistently smaller than those for the 18- and 19-year-old drivers. The short, seven-month post-intervention period in Maine could have affected the value of $t\hat{\delta}$ for the three-factor-surrogate frequency for the young drivers. However, the small value of the 18- to 19-year-old three-factor-surrogate rate suggests that the frequency increase was likely related to increased total age-specific crash involvement.

TABLE 3.2. TIME-SERIES ANALYSIS OF SHIFT IN LEVEL OF CRASH-RELATED DEPENDENT VARIABLES, MAINE AND VERMONT

Variable Name	Maine Statewide $t\hat{\delta}$	$n_1=29$ $n_2=7$ ρ level	Vermont Statewide $t\hat{\delta}$	$n_1=12$ $n_2=12$ ρ level
18-19 or 18-20 Total Crash Experience - Frequency	.43723	n.s.	-.5189	n.s.
20-44 or 21-45 Total Crash Experience - Frequency	-.12188	n.s.	-.78658	n.s.
18-19 or 18-20 Reported Had Been Drinking - Frequency	2.2995	$\rho<.0110$	.9779	n.s.
20-44 or 21-45 Reported Had Been Drinking - Frequency	.72298	n.s.	-1.0598	n.s.
18-19 or 18-20 Three Factor Surrogate - Frequency	1.4629	n.s.	.62321	n.s.
20-44 or 21-45 Three Factor Surrogate - Frequency	.3817	n.s.	1.1747	n.s.
18-19 or 18-20 Three Factor Surrogate Age Specific Rate	.13237	n.s.	.22366	n.s.
20-44 or 21-45 Three Factor Surrogate Age Sepcific Rate	.06913	n.s.	-1.2872	n.s.
Total Overall Crash Experience - Frequency	-.02384	n.s.	-.22393	n.s.
Total Overall Reported Had Been Drinking - Frequency	1.1121	n.s.	-.0661	n.s.
Total Overall Three Factor Surrogate - Frequency	.89265	n.s.	.96742	n.s.

18-19 and 20-44 age brackets in Maine.
18-20 and 21-45 age brackets in Vermont.
Statistic: Autoregressive Time-Series "t" statistic ($t\hat{\delta}$) Box and Tiao, 1965.
One tailed significance tests of shift in level of time-series after the legal drinking age was lowered.

TABLE 3.3. TIME-SERIES ANALYSIS OF SHIFT IN LEVEL OF CRASH-RELATED DEPENDENT VARIABLES, PENNSYLVANIA AND TEXAS

Variable Name	Pennsylvania Statewide $t\hat{\delta}$	$n_1=48$ $n_2=12$ ρ level	Texas Statewide $t\hat{\delta}$	$n_1=36$ $n_2=12$ ρ level
18-20 Total Crash Experience - Frequency	.04781	n.s.	1.3915	n.s.
21-45 Total Crash Experience - Frequency	2.0769	$\rho<.0192$	1.9399	$\rho<.0262$
18-20 Reported Had Been Drinking - Frequency	-------	-------	------	-------
21-45 Reported Had Been Drinking - Frequency	-------	-------	------	-------
18-20 Three Factor Surrogate - Frequency	1.4044	n.s.	.7540	n.s.
21-45 Three Factor Surrogate - Frequency	.62337	n.s.	.3284	n.s.
18-20 Three Factor Surrogate Age Specific Rate	1.9994	$\rho<.0233$	-.4467	n.s.
21-45 Three Factor Surrogate Age Specific Rate	1.7808	$\rho<.0375$	-1.2862	n.s.
Total Overall Crash Experience - Frequency	2.4319	$\rho<.0075$	2.2031	$\rho<.0136$
Total Overall Reported Had Been Drinking - Frequency	------	-------	------	-------
Total Overall Three Factor Surrogate - Frequency	1.6609	n.s.	1.11327	n.s.

Statistic: Autoregressive Time-Series "t" statistic ($t\hat{\delta}$) Box and Tiao, 1965.
One tailed significance tests of shift in level after the legal drinking age was lowered in Michigan and Vermont.

New York and Louisiana. Time-series analysis results for the two long-term 18-year-old drinking states are presented in Table 3.4. Louisiana appears to have had the best post-intervention period (1972 to July, 1973) crash experience of the seven states in the design. Ten of eleven analytic variables shifted slightly downward with small $t\hat{\delta}$ values.

In New York, only the 21- to 45-year-old three-factor-surrogate age-specific rate shifted significantly in 1972. All 18- to 20-year-old measures are remarkably stable in New York with values of $t\hat{\delta}$ ranging from -.306 to +.055. Most measures of New York's crash experience are stable within the limits of statistical confidence.

The long-term 18-year-old drinking states, like the two 21-year-old control states, exhibited no evidence of any sudden change in alcohol-related crash frequencies or rates for young drivers that could be attributed to an external influence that became effective in 1972.

The Full Quasi-Experimental Design. Table 3.5 summarizes the time-series anslyses of eleven analytic variables for all eleven files. It is apparent that the 1972 Michigan alcohol-related crash experience for young drivers was worse than for any other state in the design. The two statewide files in Michigan are marked by significant positive shifts for the total 18- to 20-year-old frequencies. None of the other six states experienced such a change.

Reported alcohol involvement for young drivers in five of seven experimental group files showed highly significant, positive increases after the legal drinking ages were lowered. None of the eleven jurisdictions experienced a significant shift in reported alcohol involvement among the older driver comparison groups.

Three-factor-surrogate frequencies shifted significantly in three Michigan jurisdictions for the young drivers after

TABLE 3.4. TIME-SERIES ANALYSIS OF SHIFT IN LEVEL OF CRASH-RELATED DEPENDENT VARIABLES, LOUISIANA AND NEW YORK

Variable Name	Louisiana Statewide $t\hat{\delta}$	$n_1=12$ $n_2=19$ ρ level	New York Statewide $t\hat{\delta}$	$n_1=24$, $n_2=12$ }Frequency $n_1=36$, $n_2=12$ }Rates ρ level
18-20 Total Crash Experience - Frequency	-.31131	n.s.	.85158	n.s.
21-45 Total Crash Experience - Frequency	-.3861	n.s.	-.30631	n.s.
18-20 Reported Had Been Drinking - Frequency	-1.2678	n.s.	-.20152	n.s.
21-45 Reported Had Been Drinking - Frequency	-1.2527	n.s.	.05501	n.s.
18-20 Three Factor Surrogate - Frequency	-1.2762	n.s.	-.11957	n.s.
21-45 Three Factor Surrogate - Frequency	-1.5341	n.s.	1.1225	n.s.
18-20 Three Factor Surrogate Age Specific Rate	-.19558	n.s.	.05368	n.s.
21-45 Three Factor Surrogate Age Specific Rate	-.98393	n.s.	1.7415	$\rho<.0409$
Total Overall Crash Experience - Frequency	.63703	n.s.	-.50045	n.s.
Total Overall Reported Had Been Drinking - Frequency	-.21318	n.s.	-.44225	n.s.
Total Overall Three Factor Surrogate - Frequency	-1.4566	n.s.	1.0401	n.s.

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.

TABLE 3.5. TIME-SERIES ANALYSIS OF SHIFT IN LEVEL OF CRASH-RELATED DEPENDENT VARIABLES FULL ELEVEN JURISDICTION QUASI-EXPERIMENTAL DESIGN[1,2]

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
$n_2=19$	$p<.0025$	n.s.	$p<.0007$	n.s.	$p<.0091$	n.s.	$p<.05005$	n.s.	n.s.	$p<.0053$	$p<.0038$
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.	$p<.001$	n.s.	$p\leq.0166$	n.s.	$p<.0001$	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.	$p<.0068$	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	$p<.0087$	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.	$p<.0485$	$p<.001$	n.s.	$p<.001$	n.s.	$p<.0139$	n.s.	n.s.	$p<.0122$	.001
Michigan Fatals											
$n_1=48$	2.3451	-.50753	1.6616	.17364	1.5363	1.2118	-.86595	-2.4675	.99107	.21655	1.007
$n_2=12$	$p<.0094$	n.s.	$p<.0485$	n.s.	n.s.	n.s.	n.s.	$p<.0068$	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.	$p<.0110$	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.	$p<.0192$	--------	--------	n.s.	n.s.	$p<.0233$	$p<.0375$	$p<.0075$	--------	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.	$p<.0262$	--------	--------	n.s.	n.s.	n.s.	n.s.	$p<.0136$	--------	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{$n_1=24$*; $n_2=12$}	.85158	-.30631	-.20152	.055005	-.11957	1.1225	.05368	1.7415	-.50045	-.44225	1.0401
r{$n_1=36$; $n_2=12$}	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	$p<.0409$	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.

the lower legal drinking age became effective. Analyses of the surrogate frequencies in Vermont suggest that no change occurred. In Maine and for Fatal crashes in Michigan, the $t\hat{\delta}$ values are positive and approaching significance at the .05 probability level. Three-factor-surrogate frequency measures of 21- to 45-year-old drivers did not shift significantly in any of the eleven analytic files.

In Wayne County, Michigan it will be recalled that only 1971, 1972 and seven months of 1973 data were available for analysis. Figure 3.1 shows the frequency plots of 21- to 45-year-old and 18- to 20-year-old three-factor-surrogate driver involvements in Wayne County for the time periods available. It is clear that for both young and old drivers a general linear increase in crash involvement was present. The linear, trend, component is stronger in the plot of 18- to 20-year-old involvements than for the older drivers. The strong linear component in the 18- to 20-year-old plot is present in 1972 and absent during that year for the 21- to 45-year-old drivers. It is possible to speculate at this juncture that the time-series decomposition, and specifically the removal of the linear trend component, is primarily responsible for the small $t\hat{\delta}$ value computed for the 18- to 20-year-old three-factor-surrogate frequency. There are a variety of speculative explanations for the Wayne County time-series analysis results, of which none can be tested adequately. It is possible that if the linear 1971 increase for the 18- to 20-year-olds was in anticipation of the forthcoming lower legal drinking age, then, the model imposed on the data in the present analysis has produced a type II interpretive error; by rejecting a hypothesis of change related to the new law when one, indeed, was present. On the other hand, if the 1971 increase was related to unknown reporting system growth, or behavioral factors that were unrelated to the new law, then the present analysis has properly

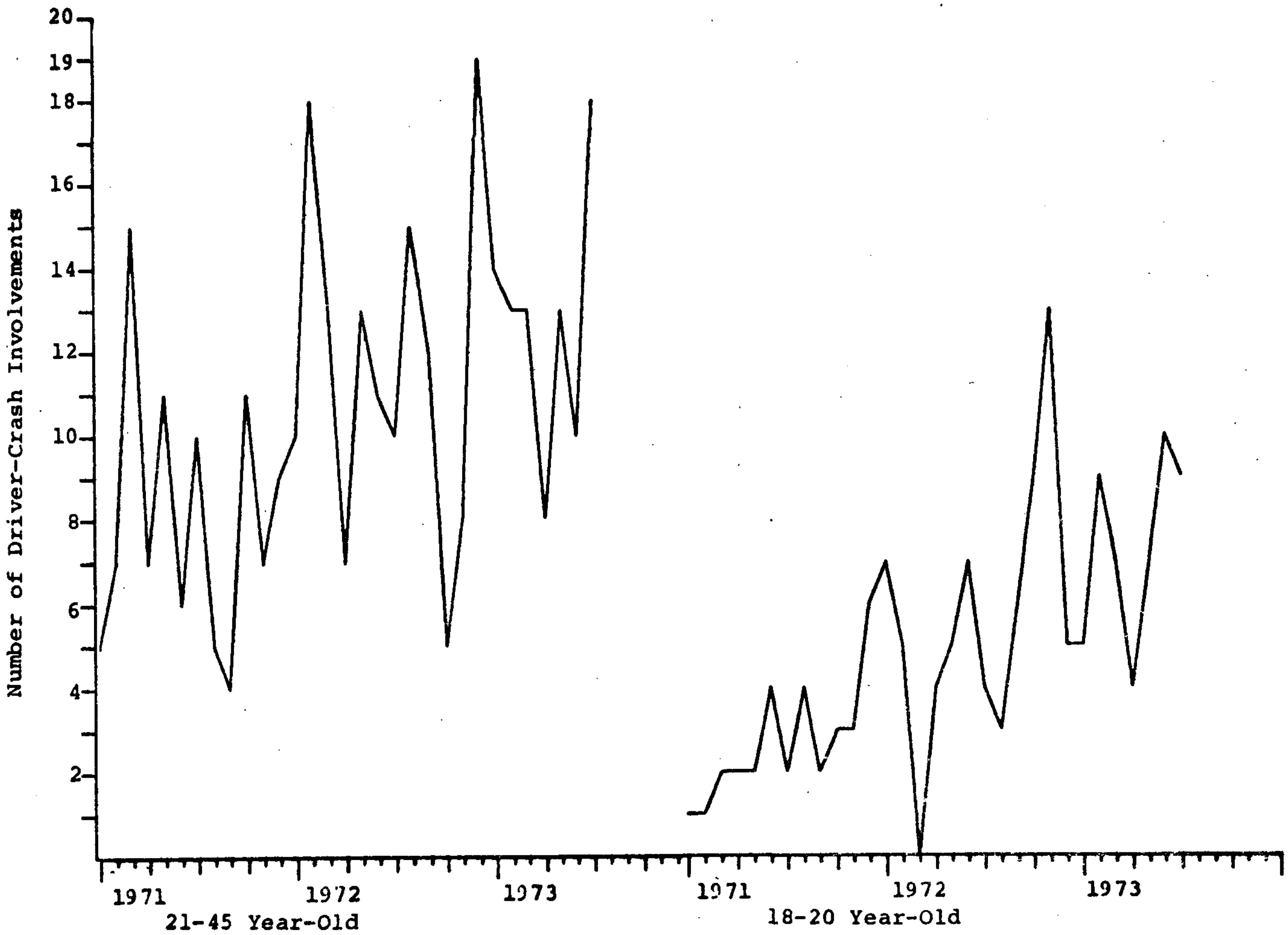

FIGURE 3.1. THREE-FACTOR-SURROGATE DRIVER-CRASH INVOLVEMENTS IN 15% SAMPLE OF NON-DETROIT, WAYNE COUNTY, MICHIGAN BY MONTH

controlled for plausible rival hypotheses. The interpretation of Wayne County will continue in Section 3.3.

Age-specific three-factor-surrogate rates for the affected young drivers shifted significantly in three Michigan jurisdictions. The age-specific-rates, the most conservative measures of alcohol-involvement, did not exhibit evidence of any change in the other four experimental files - including Maine and Vermont. No age-specific surrogate rate for older drivers increased significantly in Michigan, Maine, or Vermont. In no control state did the 18- to 20-year-old age-specific surrogate rate increase in the absence of an increase among the older drivers. Thus, when the rate for young drivers did increase in an experimental jurisdiction, the increase was unlikely to be related to a societal influence that also affected other age groups.

In two experimental files, Michigan Fatal and Maine, the 18- to 20-year-old three-factor-surrogate frequencies shifted significantly at the .07 probability level. In that the age-specific rates associated with these frequencies did not shift, it might be concluded that the frequency increases can be explained as a function of total age-specific crash increases. Two problems arise in this explanation, however, which require further investigation. First, Fatal accidents are known to have a higher probability of alcohol-involvement than crashes of other levels of severity. If the three-factor-surrogate is a conservative measure for all crashes, it becomes more conservative for fatal crashes. Secondly, in Maine the short post-intervention period did not cover a full annual cycle which puts into question the conclusiveness of the apparent discrepancy between reported alcohol-involvement and the three-factor-surrogate for young drivers.

3.2 RELATIONSHIPS OF $t\hat{\delta}$ STATISTICS AND PERCENTAGE OF CHANGES BETWEEN EXPECTED FREQUENCIES AND SECOND-LEVEL RESIDUALS FOR AGE-SPECIFIC FREQUENCIES

Table 3.6 displays the values of $t\hat{\delta}$, the unexpected residual frequencies, and the percentage of difference between the actual (observed) and the residual frequencies in the post-intervention period. The table refers to six experimental group files and six frequency measures. The percentage values were computed according to the equation:

$$\hat{\%}_f = \frac{\delta}{(f_a - \delta)} \text{ X } 100, \text{ where:}$$

$\hat{\delta}$ is the estimated second-level residual post-intervention frequency not explained by linear trend or seasonal cycles;

f_a is the total actual frequency in the post-intervention period;

$\hat{\%}_f$ is the percentage of f_a that is not more adequately explained by linear trend or seasonal cycles.

It can be seen from the table that there is no intuitive relationship between the size of the percentage difference in the post-intervention period and the value $t\hat{\delta}$. Herein lies the difference between statistical and social significance.

The 18- to 20-year-old observations in four Michigan files increased uniformly after the lower legal drinking age became effective. That the statistical test $t\hat{\delta}$ is conservative is readily apparent when it is considered that in the Michigan Fatal file, the 14.5% increase of 18- to 20-year-old three-factor-surrogate crashes was not statistically significant at the .05 level. If 19, unexpected, three-factor-surrogate fatalities for the 18- to 20-year-old drivers in the Michigan Fatal file (representing

TABLE 3.6. RELATIONSHIPS OF ($t\hat{\delta}$) STATISTICS AND PERCENTAGE OF CHANGE BETWEEN EXPECTED FREQUENCIES AND SECOND-LEVEL RESIDUALS FOR AGE-SPECIFIC FREQUENCIES

Jurisdiction	18-20 Total	21-45 Total	18-20 Reported Alcohol-Involvement	21-45 Reported Alcohol-Involvement	18-20 Three-Factor-Surrogate	21-45 Three-Factor Surrogate
Michigan (Statewide)						
$t\hat{\delta}$	2.8104*	1.2053	3.2941*	1.6130	2.3663*	1.1365
%	5.80%	0.81%	13.1%	2.97%	9.99%	1.64%
$\hat{\delta}$	684	296	226	184	135	53
Washtenaw County						
$t\hat{\delta}$	.28458	.07635	3.5533*	-.57737	2.1028*	-1.1996
%	1.58%	-0.03%	26.9%	1.59%	25.66%	-7.26%
$\hat{\delta}$	34	-2	46	12	29	-23
Oakland County						
$t\hat{\delta}$	.98778	1.6589*	3.247*	-.50654	3.6966*	-.4867
%	3.07%	3.25%	20.48%	5.47%	19.15%	4.97%
$\hat{\delta}$	273	934	206	234	99	63
Michigan Fatals						
$t\hat{\delta}$	2.3451*	-.50753	1.6616*	.17364	1.5363	1.2118
%	19.6%	-0.01%	16.57%	5.34%	14.5%	4.6%
$\hat{\delta}$	79	-11	28	34	19	17
Vermont						
$t\hat{\delta}$	-.5189	-.78658	.9779	-1.0598	.62321	1.1747
%	0.92%	0.20%	2.73%	1.14%	1.59%	0.75%
$\hat{\delta}$	37	28	8	12	7	8
Maine						
$t\hat{\delta}$	.93723	-.12188	2.2975*	.72298	1.4629	.38170
%	6.49%	-5.07%	29.14%	5.73%	16.42%	5.65%
$\hat{\delta}$	158	-621	67	74	44	55

55% of the state's crash experience) are "significant" enough to merit social concern, then the four Michigan files represented in Table 3.6 are consistent. The lower legal drinking age appears to have increased alcohol-related crashes for 18- to 20-year-olds in these Michigan data by about 18%, while unexpected total 18- to 20-year-old crashes increased by about 7%. In Oakland and Washtenaw Counties, where the greatest evidence is available supporting a large increase inalcohol-related crashes, unexpected total crashes for the 18- to 20-year-olds was lowest (about 2%).

In Maine 18- to 19-year-old drivers experienced an unexpected 16.42% increase in three-factor-surrogate crashes that did not reach the .05 level of statistical significance. Because the associated 44 crashes are of all levels of crash severity, from fatal to property damage, it is less certain that these crashes represent social significance. Also, a smaller proportion of these crashes were causally related to alcohol than was the case with the fatal crashes previously examined in Michigan. On the other hand, the magnitude of the percentage increase in Maine of the 18- to 19-year-old three-factor-surrogate frequency is within the range of observed, and statistically significant shifts of affected young drivers in four Michigan files. It is possible that the short, seven month post-intervention period has acted on the conservative significance testing methodologies in such a way as to produce a type II interpretive error. It is unlikely that, even with greatly increased police reporting activity, a 29.14% increase in reported alcohol-involved crashes would take place without a proportionate, real, increase in the frequency of three-factor-surrogate crashes.

Unlike the Michigan files displayed in Table 3.6 and in Maine, Vermont data offer no evidence of a statistically or socially significant increase in 18- to 20-year-old alcohol-related crashes.

In all cases in Michigan and Maine, as shown in Table 3.6, 21- to 45-year-old alcohol-related crash frequencies remained stable. The absence of concomitant increases in these measures supports a causal relationship between the legal changes that affected the young drivers and increased youth crash involvement. The absence of time-series statistical support of increases in youth alcohol-related crash frequencies in Vermont and Wayne County, Michigan remain to be further examined.

3.3 AGE-SPECIFIC THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS OF YOUNG DRIVER INVOLVEMENTS AND THE LOWER LEGAL DRINKING AGE

The present discussion departs from the primary time-series analytic focus of the research to address a different hypothesis. Among affected populations, did the lower legal drinking age cause a change in the age-specific frequency distributions of alcohol-related crashes among young drivers? To address the hypothesis that the legal change is accompanied by a distribution change, age-specific frequency distributions of three-factor-surrogate crashes were plotted by age for 18- to 23-year-old drivers.[40] Average, age-specific frequencies were plotted for mean time periods before and after the lower legal drinking ages became effective in experimental jurisdictions, and according to the Michigan and Vermont impact points in the control states.

A frequently reported bimodal distribution of alcohol-related crashes among young Michigan drivers is clearly seen in "before" distributions of the three-factor-surrogate in Figures 3.2 to 3.5.[41] These four Michigan jurisdictions demonstrate striking consistency in the age-specific

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[40] Beside the desire for parsimony, the 18- to 23-year-old age range was selected to provide a balanced 6-year age range of "young" drivers, given that the 18- to 20-year-old group has been focus of the time-series analyses, and is the most often affected by the lower legal drinking age. Peak frequencies for the three-factor-surrogate were found within the 18- to 23-year-old age range in all files.

[41] J. O'Day. "Drinking Involvement and Age of Young Drivers in Fatal Accidents." HIT LAB Reports, October 1970, pp.13-14.

D.C. Pelz, T.L. McDole and S.H. Schuman. "Drinking-Driving Behavior of Young Men in Relation to Accidents." Paper prepared for American Psychological Association Annual Meeting, New Orleans, Louisiana, September 1974.

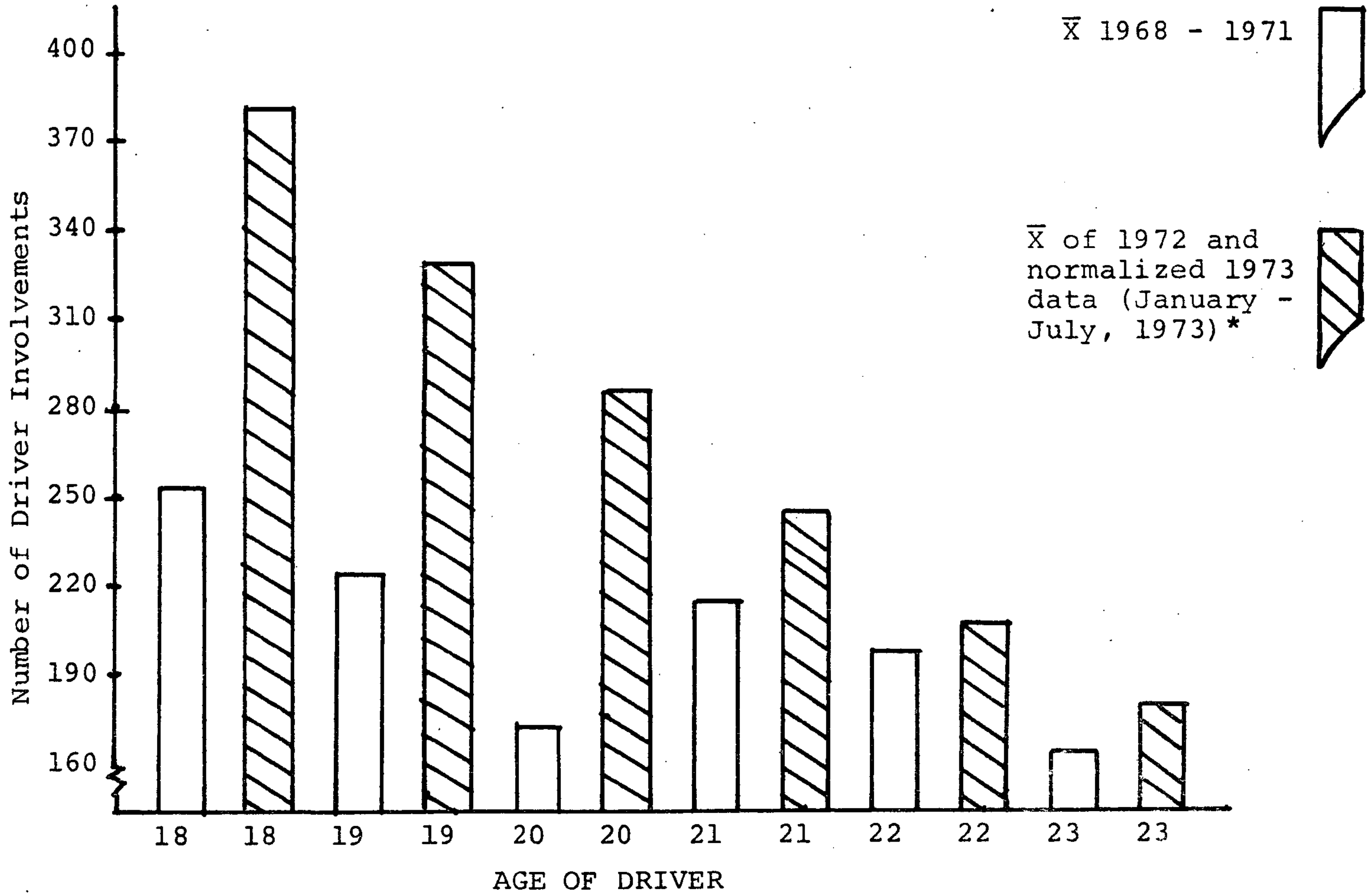

FIGURE 3.2. MICHIGAN STATEWIDE (15% SAMPLE) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

*[(1972 Frequencies) + (January-July, 1973 Frequencies)]/1.583 years for each age stratum.

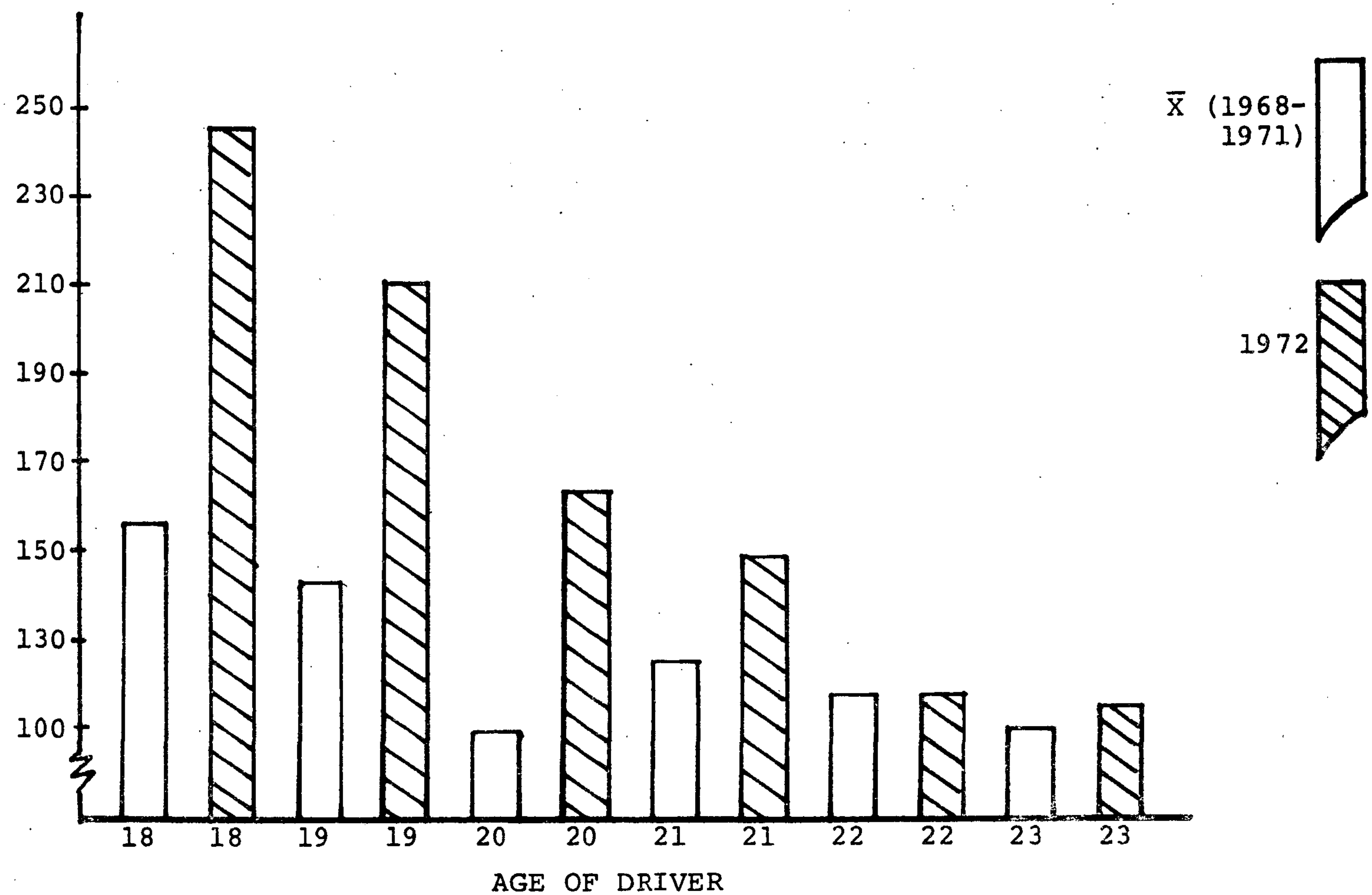

FIGURE 3.3. OAKLAND COUNTY THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

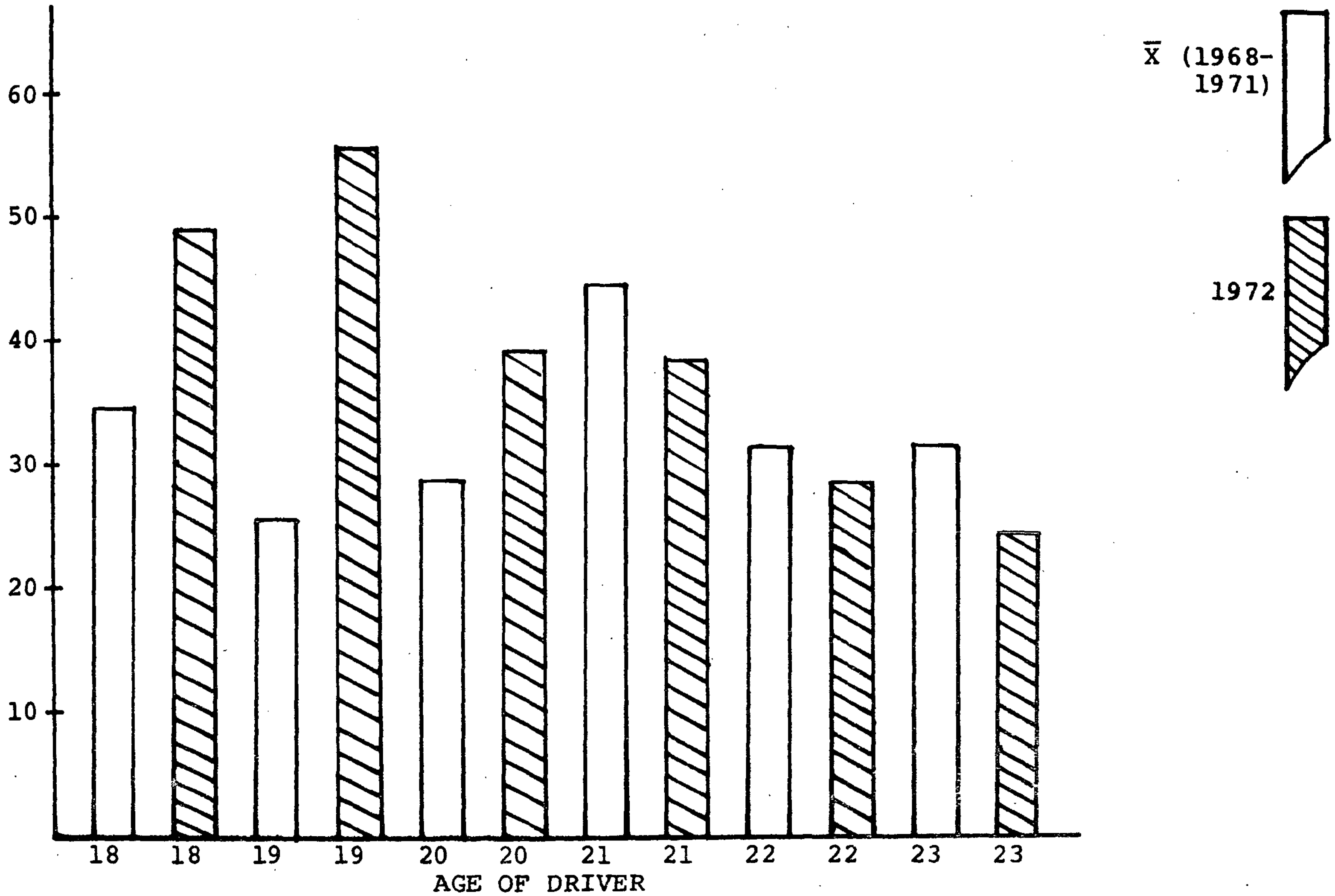

FIGURE 3.4. WASHTENAW COUNTY THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

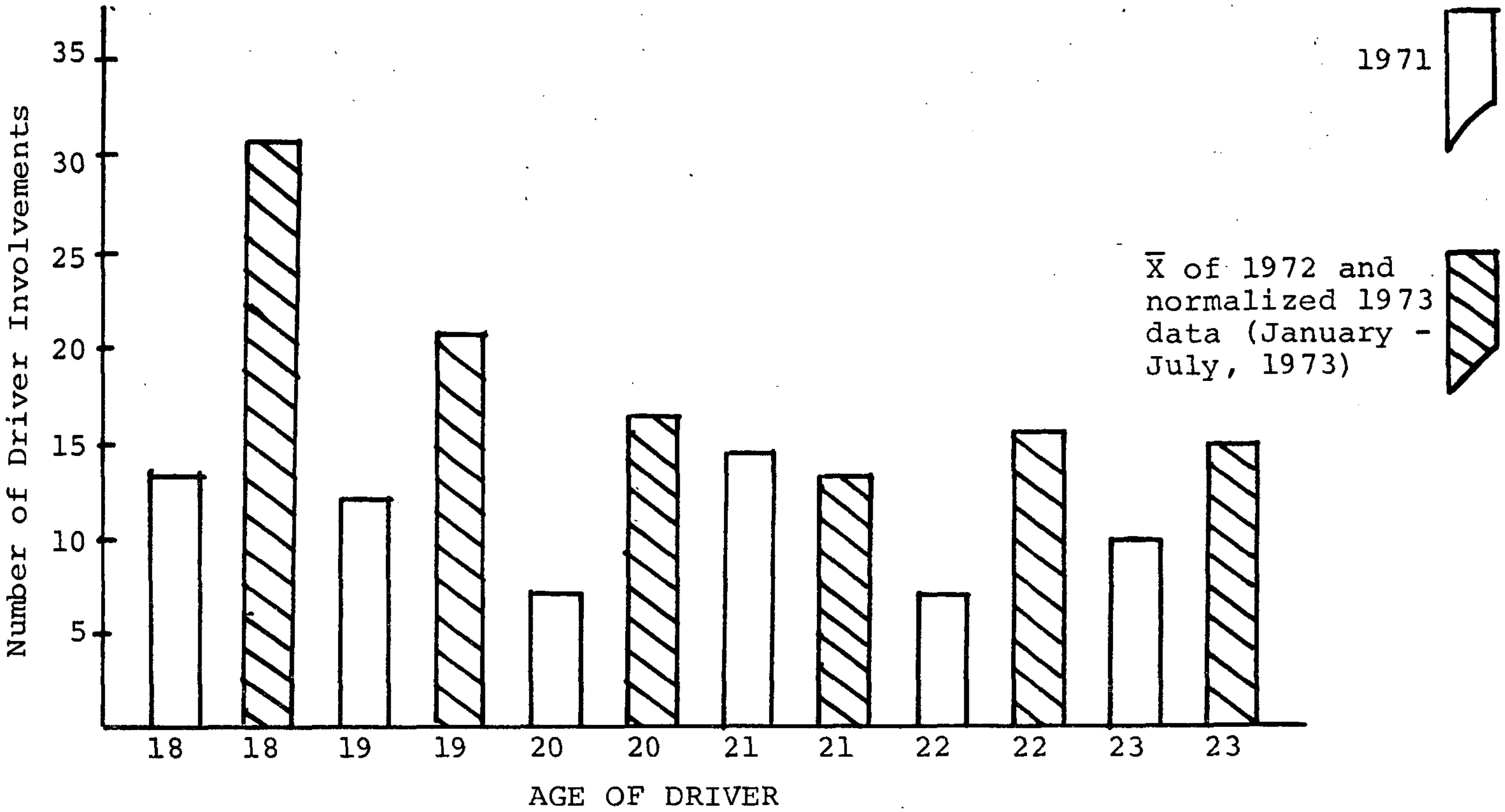

FIGURE 3.5. WAYNE COUNTY, MICHIGAN (15% SAMPLE, EXCLUDING DETROIT) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

frequency distributions when the legal drinking age in Michigan was 21-years-old. In the same four jurisdictions, the age-specific frequency distributions became skewed with maximum crash involvements among the 18-year-old or the 19-year-old drivers, after the legal drinking age was lowered to 18. O'Day (1970) predicted that the bimodal distribution, that had a long history in Michigan, would change under a lower legal drinking age; it appears that his prediction has been supported.

In Maine, Figure 3.6, the three-factor-surrogate distribution before the 18-year-old legal drinking age is much like the distributions found in Michigan. The general bimodal shape of the distribution changed after the effective date of the lower legal drinking age in exactly the same way as did the Michigan jurisdictions. After the legal change the distribution became sharply skewed with peak involvement at age 18.

Unlike Michigan and Maine distributions, Vermont data after the lower legal drinking age remained unchanged. The importance of the Vermont distribution is the fact that the shape of the distribution is skewed with peak involvement at age 18 - both before and after the lower legal drinking age (Figure 3.7). This is the age-specific frequency distribution pattern found in Michigan and in Maine <u>after</u> the legal drinking ages were lowered.

These distributions of crash involvements in states that lowered the legal drinking age support the hypothesis that the legal change had a uniform effect on youth crash involvements in Michigan, despite the lack of a statistically significant shift in the time-series analysis of the Wayne County experience. In addition, the speculation of a statistically significant shift in Maine, given a longer post-intervention period, is supported by the frequency distribution changes that paralleled the changes in Michigan jurisdictions.

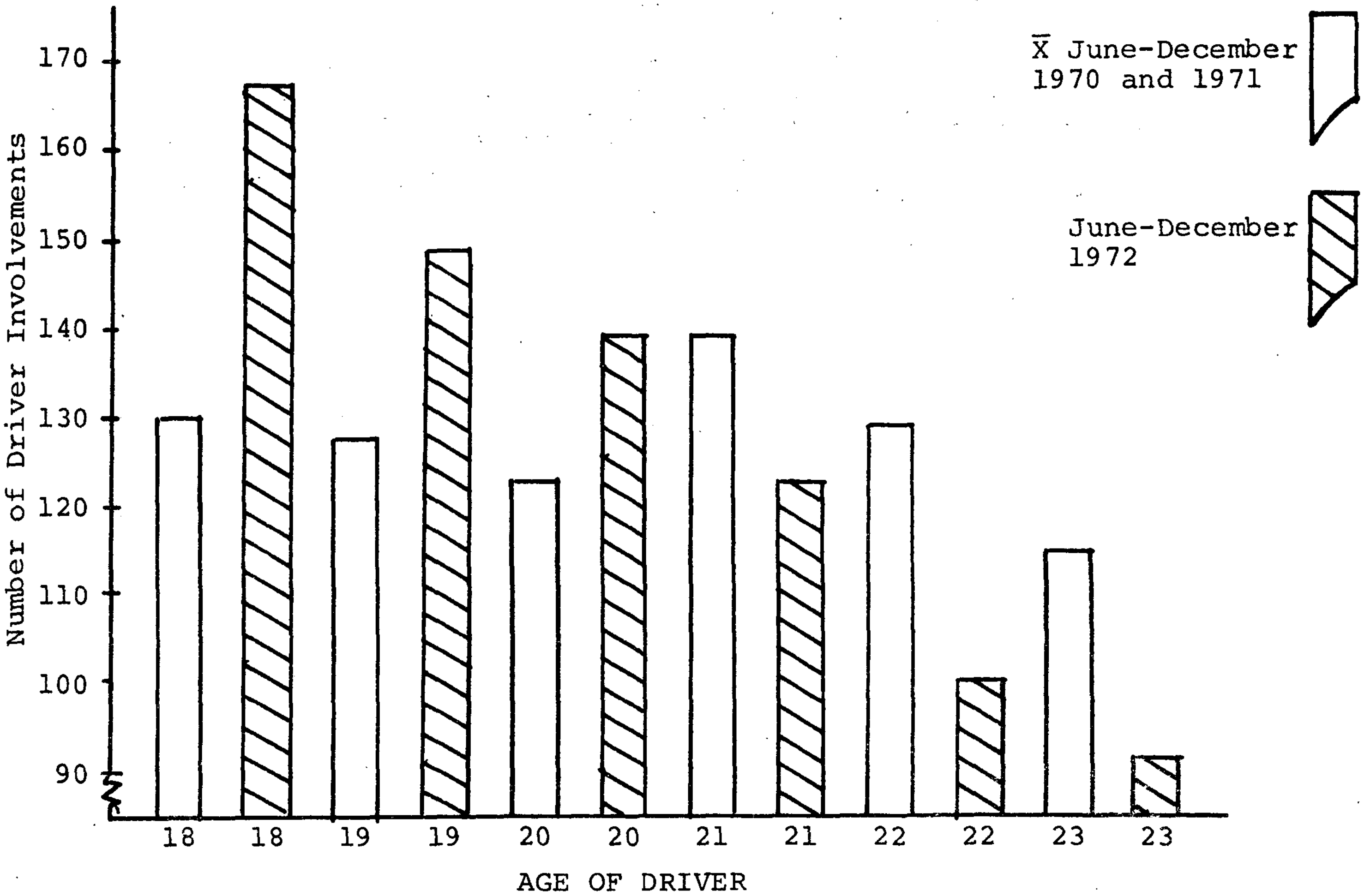

FIGURE 3.6. MAINE THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE*

*June-December used in order to avoid confounding related to Seasonal Effects.

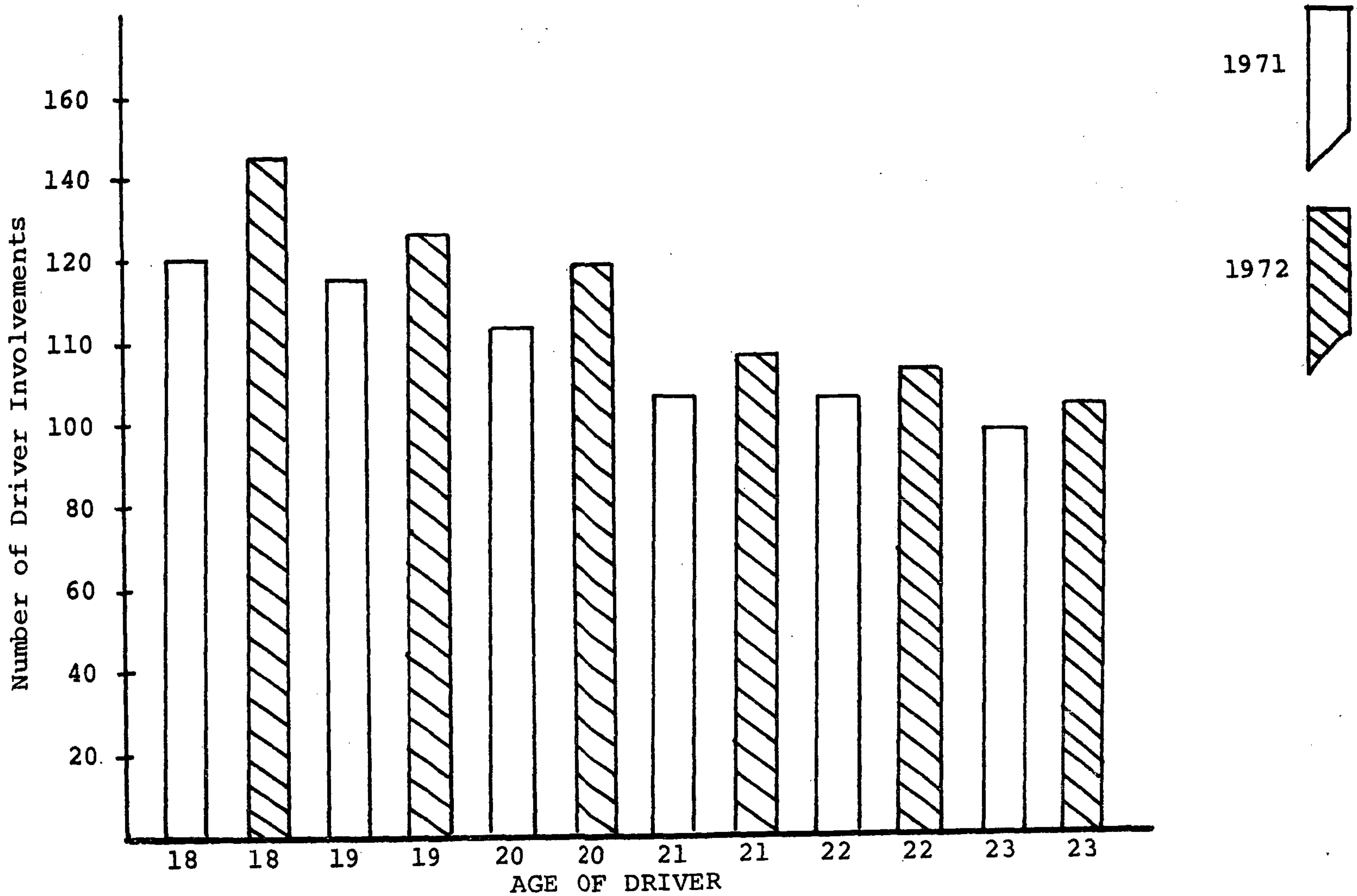

FIGURE 3.7. VERMONT THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND YEAR 1971 and 1972

The examinations of frequency distributions after the legal impacts in Michigan and Maine provide an explanation of why no statistically, or socially, significant crash increase was found in Vermont. It appears that the age-specific alcohol-related crash frequency distribution in Vermont was like Michigan and Maine <u>after</u> the 18-year-old drinking ages became effective in those states. In Vermont the 18-year-old drivers dominated the skewed age-specific frequency distribution <u>before</u> the legal change, which predetermined the distribution pattern expected on the basis of the Michigan and Maine experiences. How do these distributions compare with the long-term 18-year-old and 21-year-old control states in the design?

Figures 3.8 and 3.9 present the age-specific frequency distributions of three-factor-surrogate measures in Pennsylvania and Texas. In Pennsylvania the distributions are bimodal before and after 1972. The distributions closely resemble the Michigan jurisdictions and Maine when those states had 21-year-old legal drinking ages. In Texas, the 1972 distribution is bimodal, like Pennsylvania, Michigan, and Maine under a 21-year-old age of majority; however, the mean 1969-1971 distribution is skewed and similar to Washtenaw County, Michigan <u>after</u> the lower legal drinking age became effective. A four-year average would be unimodal with a 19-year-old peak frequency.

The age-specific three-factor-surrogate frequency distributions in New York and Louisiana, long-term 18-year-old drinkings states, are presented in Figures 3.10, 3.11, and 3.12. From 3.10 it is clear that the 18- to 20-year-old drivers in New York state dominate the distributions in both time periods and the distributions are skewed with peak involvement frequencies at age 18.

In Louisiana, 1971 and 1972 data were complete, while only the first seven months of 1973 were available. As can

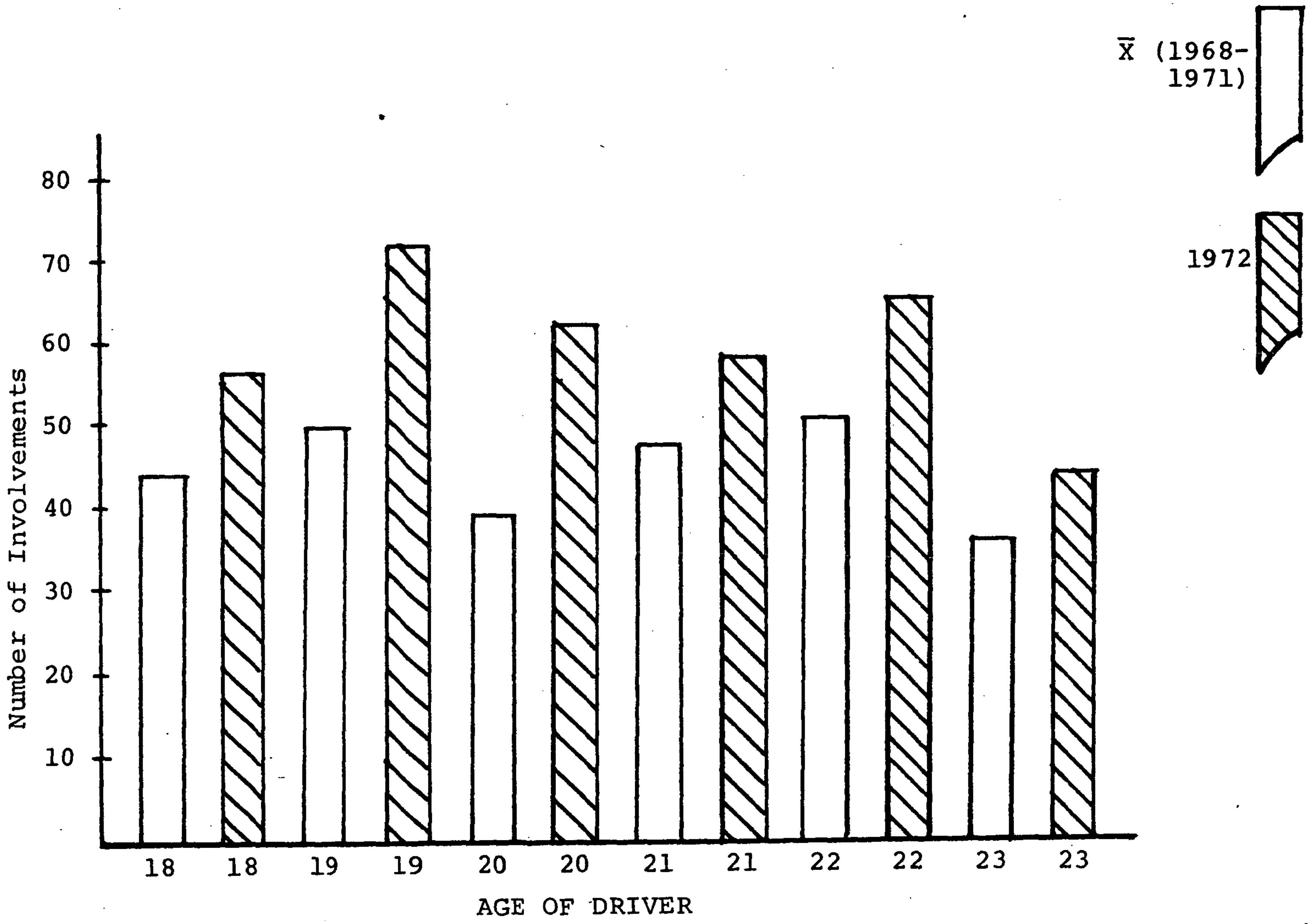

FIGURE 3.8. PENNSYLVANIA (5% SAMPLE) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE CHANGED IN MICHIGAN AND VERMONT (1972)

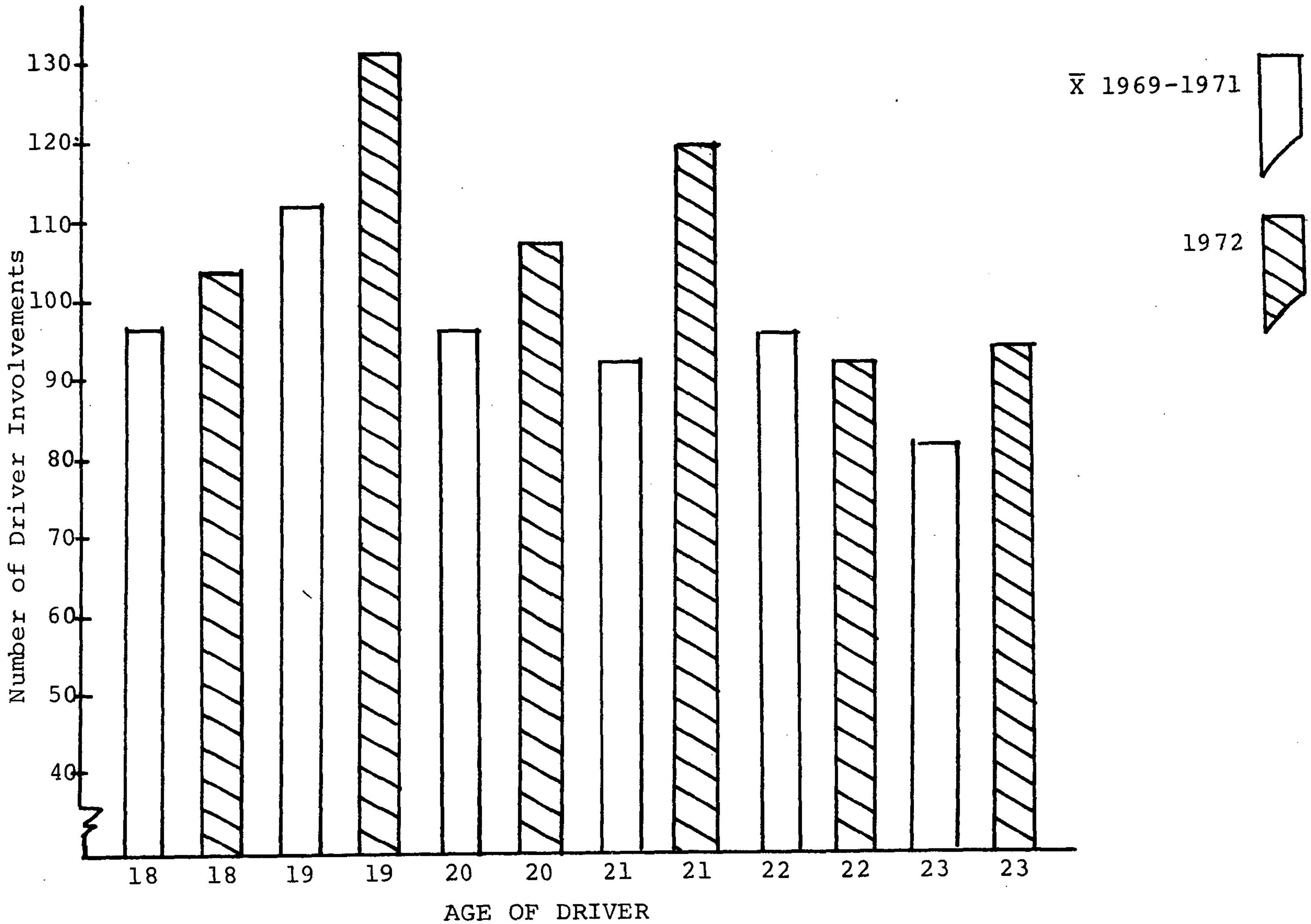

FIGURE 3.9. TEXAS (5% SAMPLE) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER THE LOWER LEGAL DRINKING AGES IN MICHIGAN AND VERMONT

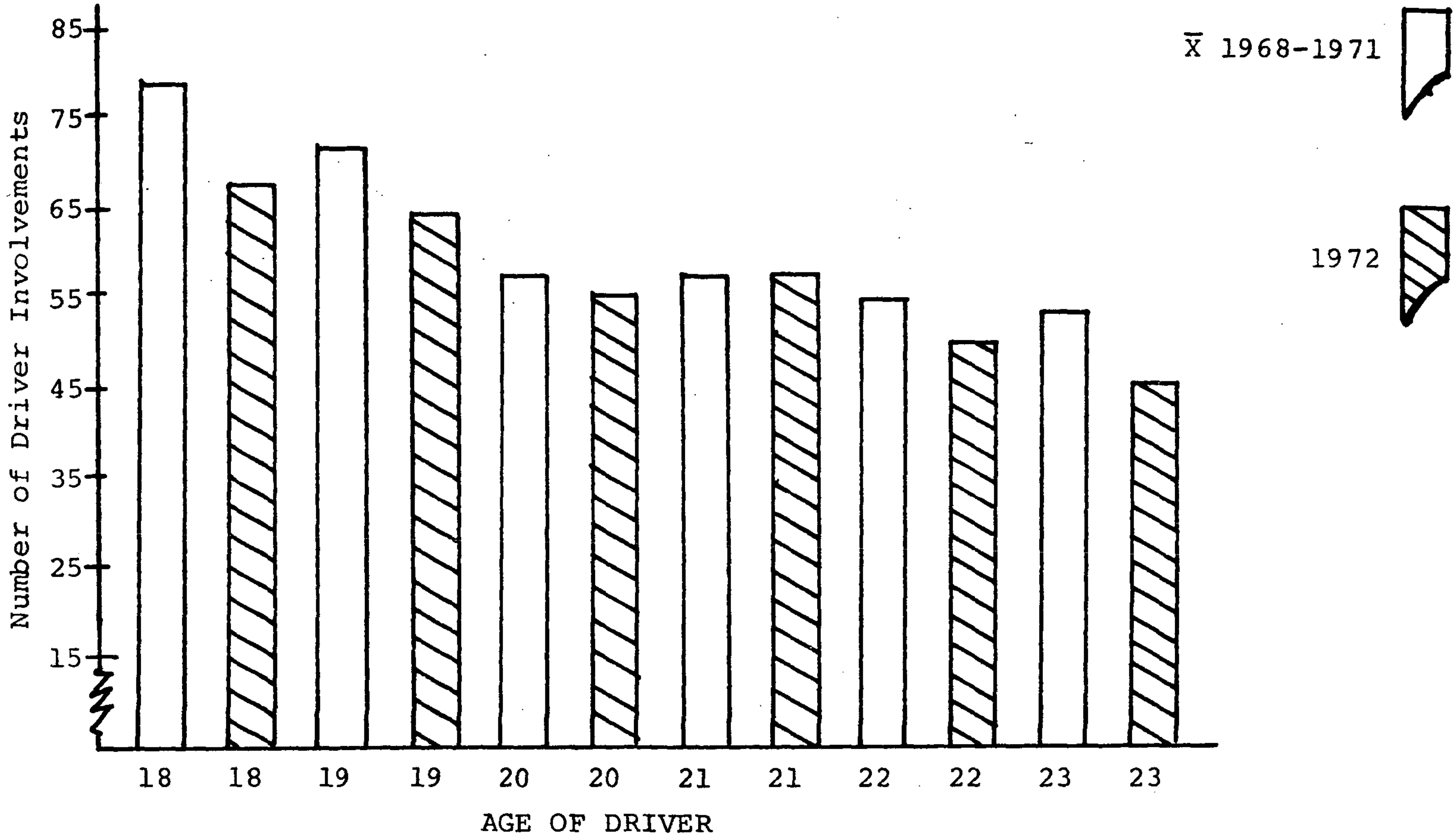

FIGURE 3.10. NEW YORK STATE (5% SAMPLE) THREE-FACTOR-SURROGATE AGE-SPECIFIC FREQUENCY DISTRIBUTIONS BY AGE OF DRIVER AND PERIOD BEFORE AND AFTER LEGAL DRINKING AGE CHANGES IN MICHIGAN AND VERMONT

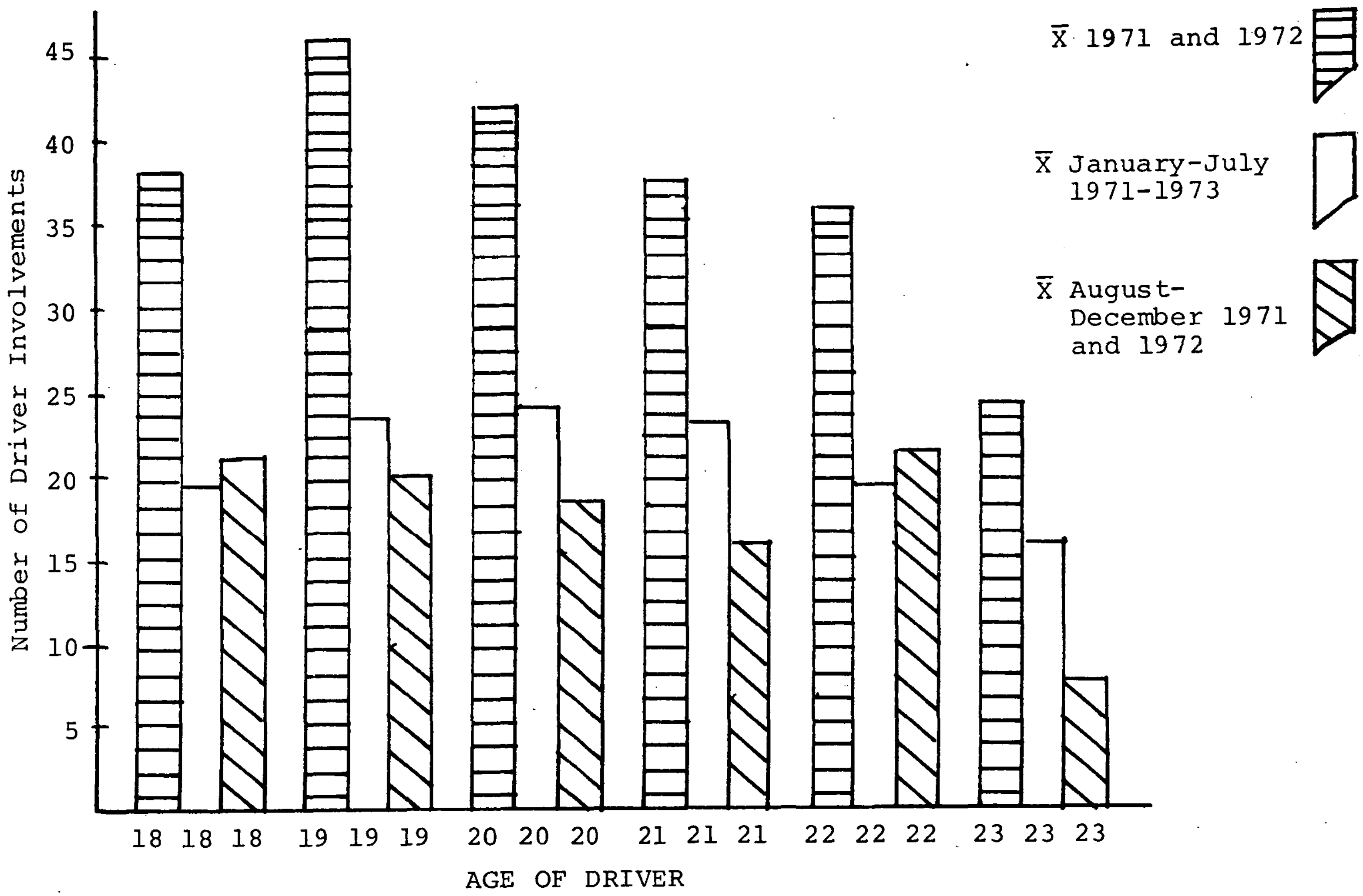

FIGURE 3.11. LOUISIANA (10% SAMPLE) THREE-FACTOR-SURROGATE AGE-SPECIFIC FREQUENCY DISTRIBUTIONS BY AGE OF DRIVER DEMONSTRATING SEASONAL DIFFERENCES

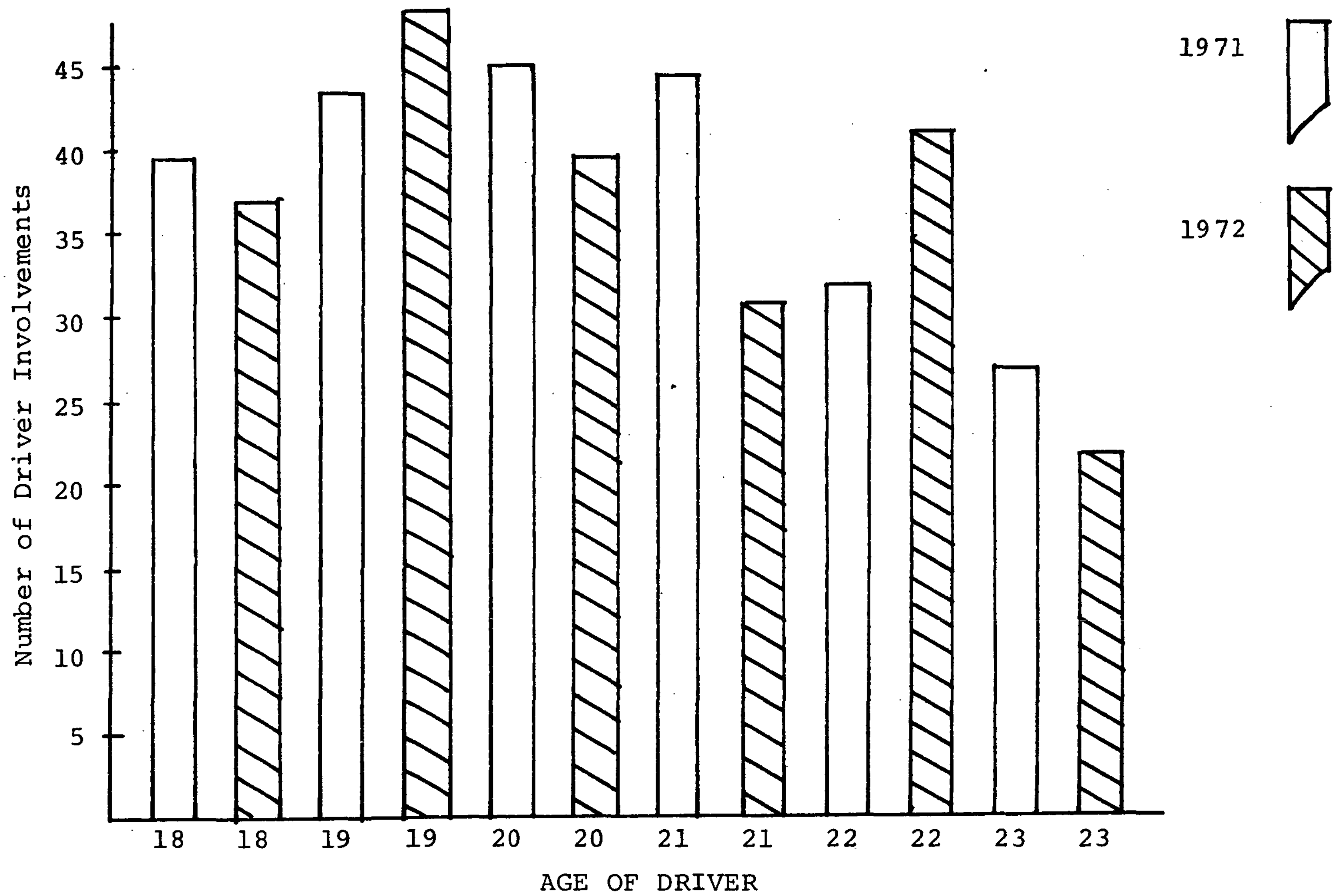

FIGURE 3.12. LOUISIANA (10% SAMPLE) THREE-FACTOR-SURROGATE AGE-SPECIFIC FREQUENCY DISTRIBUTIONS BY AGE OF DRIVER DEMONSTRATING ATYPICAL 22-YEAR-OLD FREQUENCY, ATTRIBUTED TO AUGUST-DECEMBER, 1972 22-YEAR-OLD EXPERIENCE

be seen in Figure 3.11 the mean age-specific frequencies for 1971 and 1972 demonstrate a sharply skewed distribution with peak involvements at age 19. In order to utilize all available data with adequate control for seasonal effects, January to July mean frequencies were computed for 1971 and 1973 (Figure 3.11). Similarly, mean frequencies are shown in the figure for August to December, 1971 and 1972. The January to July distribution is unimodal and 18- to 20-year-old involvements are dominant. An unexpected increase in 22-year-old involvements is seen in the August to December distribution that suggests either a regular seasonal shift to a bimodal distribution, or an atypical situation for a long-term 18-year-old drinking age state. The distributions in Figure 3.12 demonstrate that the unexpected 22-year-old frequency in Figure 3.11 is attributable to August to December, 1972; this is interpreted to be an atypical situation. The Louisiana age-specific frequency distributions, are considered to be skewed with peak involvements among 18- to 20-year-old drivers, as expected for a state with an 18-year-old legal drinking age.

A comparison of the distributions of the three quasi-experimental groups suggests that the two long-term 18-year-old states (New York and Louisiana); Michigan and Maine <u>after</u> the lowering of the legal drinking ages; and Vermont before <u>and</u> after 1972, are all characterized by skewed frequency distributions with peak crash involvements within the 18- to 20-year-old group. Michigan and Maine, before the lower legal drinking ages became effective, and Pennsylvania, a long-term 21-year-old state, are characterized by bimodal distributions with no clear dominance of the 18- to 20-year-old group.

Vermont shares a common border with New York state and the population concentration is close to New York. It is possible to speculate that Vermont was characterized by age-specific frequency distributions common to an 18-year-old state before the legal change because of a diffusion of drinking norms and practices from New York, perhaps in anticipation of the new law. Time-series data of longer duration would be necessary to substantiate a long-term frequency distribution similarity between New York and Vermont.

Texas is more like Louisiana than the experimental jurisdictions before the change in legal drinking ages, regarding the age-specific frequency distributions. The speculation of a diffusion of drinking norms and practices from Louisiana to Texas is not tenable because of the total size and population dispersion in Texas. It is valid, however, to speculate that drinking and driving-after-drinking practices in Texas, for whatever reasons, are more like long-term 18-year-old states than Michigan, Maine, or Pennsylvania with 21-year-old legal drinking ages. The mean distributions of Louisiana (1971-1972) and Texas (1969-1971) are virtually identical, which is suggestive of regional or cultural determinants.

The comparative analysis of age-specific frequency distributions of the three-factor-surrogate provides a potential means of predicting the outcome of lowering the legal drinking age. The Pennsylvania distributions closely resemble distributions in Michigan and Maine before the lower legal drinking ages became effective. It is predicted that, if the legal drinking age in Pennsylvania were to be lowered, then the consequence would be a change in the age-specific frequency distribution of alcohol-related crash involvements similar to the changes in Maine and Michigan. It is likely that the magnitude of the frequency increases in Pennsylvania would parallel the Michigan experience, on the basis of the socio-economic and demographic similarities of the two states. Based on the pre-existing similarities of the frequency distributions in Texas to jurisdictions with 18-year-old legal drinking ages, a legal impact of the magnitude or character identified in Michigan and Maine would not be expected. This prediction can be tested because the lower legal drinking age became effective in Texas in August, 1973. Just as Vermont experienced no change under a lower legal drinking age, Texas is not expected to experience sudden changes in the frequency or relative distribution of 18- to 20-year-old alcohol-related crash involvements.

4.0 DISCUSSION AND CONCLUSIONS

4.1 THE MEANING OF LEGAL IMPACTS OF LOWER LEGAL DRINKING AGES ON YOUTH CRASH INVOLVEMENT

Throughout this report the lower legal drinking ages in Michigan, Maine and Vermont have been conceptualized in terms of an experimental treatment in a quasi-experimental design. The meaning of this particular legal change needs to be taken into consideration before the research results can be adequately appreciated.

How much change in the drinking, driving-after-drinking, or alcohol-related crash experiences of young people could reasonably be expected as a consequence of a lower legal drinking age? If few young people acquired and consumed alcoholic beverages, by any means, before they reach the legal drinking age, and if monthly birth rates were approximately equal, then about seven times the normal number of people entered the alcoholic beverage consuming population in Michigan and Vermont in 1972.[42] If this was true, it might be expected that behavioral consequences, including alcohol-related-crashes, would increase many-fold for the affected population concurrently with the consuming population increase.

[42] The seven-fold incremental increase was determined by the following deductions. On the basis of mean annual time intervals, six months of new 21-year-olds normally enter the legally enfranchised drinking population in a normal year for a 21-year-old state. In Michigan and Vermont, this was the case until 1972. In 1972, however, 12 months of 21-year-old, 12 months of 20-year-olds, 12 months of 19-year-olds and 6 months of 18-year-olds technically entered the enfranchised drinking population. This represents an imprediate increment of about seven times the normal number of persons newly enfranchised to purchase and consume alcoholic beverages.

It is not true, however, that few young people drink, or that few young people drink and drive, before they reach the legal age of majority. The facts that many, indeed most, 18- to 20-year-olds drink occasionally, and many frequently drive after drinking prevents an accurate estimate of the effect of the lower legal drinking age by deductive means. In that the proportion of the total 8- to 20-year-old drinking and driving population that would normally become crash-involved as a result of drinking was unknown in any of the three experimental states, accurate a priori predictions of the effect of the lower legal drinking age were not possible. Therefore, it was necessary to conduct a retrospective investigation such as the present study to seek a meaningful answer to the question of a legal impact.

It has been demonstrated in the present research that in Michigan jurisdictions and in Maine the frequency of alcohol-related crashes and the age-specific frequency distributions were altered after the legal change. On the basis of no concomitant changes in long-term 18-year-old or long-term 21-year-old control states in the design, the changes in Michigan and Maine were attributable to the lower legal drinking age.

No impact was identified in Vermont, however, which has been explained in relation to the conditions existing in Vermont before the legal change. It has been suggested that for one reason or another Vermont 18- to 20-year-olds were involved in alcohol-related crashes in much the same ways as those in New York or other states with 18-year-old legal drinking ages. One explanation might be that the 21-year-old legal drinking age in Michigan and the 20-year-old legal drinking age in Maine were more effective in determining drinking patterns and associated behavioral consequences than the legal drinking age was in Vermont. This suggests that among some populations the legal drinking age and the enforcement of the laws are more effective than among other populations.

Still unknown, however, are several critical intervening variables. It remains unknown if age-specific consumption changed, if the places in which drinking occurs changed rather than the quantities consumed, or how much more after-drinking driving exposure resulted from the lower legal drinking ages. It is, in short, possible now to say with confidence what happened regarding alcohol-related crash experiences in Michigan, Maine, and Vermont, but the variables linking the legal condition to crash involvement remain in doubt.

At the same time as the legal drinking ages were being changed in Michigan and Vermont, Alcohol Safety Action Programs (ASAPs) were active in Washtenaw County, Michigan and throughout Vermont. Survey research findings before and after the lower legal drinking ages were changed provided some evidence that there was little change in drinking/driving behavior in Vermont while significant changes were taking place in Washtenaw County, Michigan.

In Vermont, 1971 roadside survey findings showed that 51% of the young males in the sample were "high risk drivers" based on reported drinking patterns and measured blood alcohol concentrations.

A high proportion of the young men was under 20-years-old. The authors of the 1971 survey noted that, "These data concerning the TAM (teenaged males) are even more striking when one realizes that, at the time of this baseline survey, the legal age for consumption of alcohol beverages in Vermont was 21 years. This must stand as a classic example, therefore of a law that was not effective."[43] A second

[43] Waller, J.A., Worden, J.K., and Maranville, I.W. Baseline Data for Public Education About Alcohol and Highway Safety in Vermont. CRASH Report I-1, February 1972, Waterbury, Vermont, pp.30-31.

survey in 1972 found that 55% of the young males was high risk drivers.[44] The difference between 51% and 55% in the two surveys is not likely to be significant if normal measurement error and other rival hypotheses are taken into consideration. These survey findings would lead one to expect little impact of a lower legal drinking age - a prediction supported by the findings of the present research.

In Washtenaw County, Michigan, on the other hand, two ASAP surveys of high school students in 1971 and 1973; two general public surveys in 1971 and 1973; and three (1971, 1972, and 1973) replicated blood alcohol concentration roadside surveys indicate that both drinking and drinking/driving patterns underwent significant change during the time that the legal drinking age was lowered.

The first high school survey was conducted in the Fall and Winter of 1970-71 and the second during the 1972-73 school year. The authors report that:

> "In comparing the results of the two surveys the most obvious findings is the widespread and increasing use of alcoholic beverages by high school students. In 1970 66% of the respondents said they would drink at least once or twice a year, while in 1972 76% of the respondents said they had drunk alcoholic beverages at least once in the previous year. In 1970 only 3% said they would drink three or more times a week, while in 1972 7% indicated that they drank about this frequently. In 1970 12% said their usual quantity was five or more drinks, while in 1972 20% said they usually drank that much. In 1970 31% said that their maximum was five or more drinks, while in 1972 40% said they had drunk six or more drinks at least once in the previous year. In 1970 43% reported that half or more of their "crowd" drank at least once a month, while in 1972 65% reported that half or more of their

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[44] Worden, J.K., Waller, J.A., Riley, T.J., and Flowers, L. Pre-campaign Data for Public Education About Alcohol and Highway Safety in Vermont. CRASH Report I-2, February 1973, Waterbury, Vermont, p.12.

> teenage friends drank at least occasionally ... In 1970 13% of the respondents (22% of the licensed drivers) said they had driven after drinking two or more drinks at least once in the previous three months, and in 1972 22% of the respondents (43% of the licensed drivers) said they had done this at least once in the previous year. Nineteen percent of the student licensed drivers admitted they had driven at least once after drinking "too much for safe driving", which is not a great deal less than the 28% of the general public licensed drivers who admitted to doing this in the 1973 survey".[45]

The general public surveys in Washtenaw County were conducted in the Spring of 1971 and in 1973. These were household surveys conducted for the Alcohol Safety Action Program. The authors stated that,

> "In regard to alcohol use a comparison of the two surveys shows a substantial increase from 1971 to 1973 in alcohol consumption in the county, an increase that is particularly marked among 18- to 20-year-olds but is also substantial in all age groups under 35. Along with this there is a smaller but still considerable increase in the reported extent of "driving after drinking too much", an increase found almost entirely in the 18-20 year old group."[46]

The replicated roadside surveys in Washtenaw County demonstrated that, based on blood alcohol concentrations, in 1971 8% of 18- to 20-year-old drivers were drinking. This proportion rose to 12% in 1972, and 16% in 1973. Over the same time period a decrease in drinking and driving was measured for older drivers. At the time of the surveys it was noted that,

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[45] Wolfe, A.C. and Chapman, M.M. 1971 and 1973 ASAP Surveys: Washtenaw County High School Students. Highway Safety Research Institute, The University of Michigan, Ann Arbor, UM-HSRI-AL-73-12, November 1973, pp.1-2.

[46] Wolfe, A.C. and Chapman, M.M. 1971 and 1973 ASAP Surveys: Washtenaw County General Public. Highway Safety Research Institute, The University of Michigan, Ann Arbor, UM-HSRI-AL-73-9, November 1973, p.1.

"One explanation for the differences in proportion between the 18- to 20-year-old age group and older drivers might be the change in Michigan's age of majority law which gave 18-year-olds the right to drink legally...Although hypotheses regarding the reason for the increase in 18- to 20-year-old drinking were not tested, the increase was related in time, to the legal change."[47]

The Washtenaw County ASAP survey results help explain the immediate and significant changes in the alcohol-related crash rates and frequencies after the lower legal drinking age became effective.

4.2 THE MAGNITUDE OF CHANGE

Through highly controlled time-series analyses, changes in the level of frequencies and age-specific rates of alcohol-related-crashes have been measured. Table 4.1 displays results of the time-series anslyses of the legal impact in seven experimental group files. The percent change in three-factor-surrogate frequency measures ($\%\hat{\delta}$) is the estimated increase in alcohol-related crashes among affected populations attributable to the legal change.[48] The values of statistical tests of a change in level of time-series measurements ($t\hat{\delta}$) are displayed for frequency measures and associated age-specific rates.[49] The age-specific rates were based on monthly observations of three-factor-surrogate frequencies divided by total age-specific crash frequencies.

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[47] Clark, C.D., Compton, M.J., Douglass, R.L., and Filkins, L.D. Washtenaw County 1971, 1972 and 1973 BAC Roadside Surveys. Highway Safety Research Institute, The University of Michigan, Ann Arbor, UM-HSRI-AL-73-6, August 1973,p.14.

[48] $\hat{\delta}$=actual observed frequencies minus expected frequencies determined through time-series analysis.

[49] $t\hat{\delta}$ values are used to determine the probability that $\%\hat{\delta}$ values were not due to random effects.

TABLE 4.1. CHANGES IN THREE-FACTOR-SURROGATE CRASHES AMONG LEGALLY-AFFECTED YOUNG DRIVERS IN MICHIGAN, MAINE, AND VERMONT

Jurisdiction/File	$\%\hat{\delta}$	Frequency $t\hat{\delta}$*	Age-Specific Rate $t\hat{\delta}$*
Michigan (statewide)	9.99%	2.366**	1.644**
Washtenaw County	25.66%	2.103**	3.733**
Oakland County	19.15%	3.697**	2.204**
Wayne County	1.47%	.414***	-.249
Michigan Fatals	14.50%	1.536***	-.866
Maine	16.42%	1.463***	.132
Vermont	1.59%	.623	.224

*Box and Tiao (1965) autoregressive time-series "t" statistic values.

**Statistically significant at or above .05 level.

***Other evidence supports frequency changes in these files of social importance.

From Table 4.1 it is clear that three patterns of response to the legal change emerged from the present analysis. The patterns are based on the degree of association between frequency $t\hat{\delta}$ values and age-specific rate $t\hat{\delta}$ values. Michigan (statewide), Washtenaw County, Michigan, and Oakland County, Michigan all had statistically significant positive increases in frequency and rate measures. There is reason to believe that these jurisdictions experienced an effect of the lower legal drinking age above the level established by a four year pre-intervention time-series.

Wayne County, Michigan data and fatal Michigan crashes were characterized by small non-significant positive frequency $t\hat{\delta}$ values and non-significant negative age-specific rate $t\hat{\delta}$ values. The interpretation of these relationships is that these jurisdictions experienced a reaction to the lower legal drinking age below the expected level.

In both Maine and Vermont the magnitude and sign relationships of the frequency and rate $t\hat{\delta}$ values suggests that the percent $\hat{\delta}$ change, after the legal drinking age changed, was within the limits of expectation. In Maine and Vermont there is no evidence that the proportion of the total crash population related to alcohol increased at a faster rate than all other crash types. This appears to be true in addition to other evidence that Maine experienced reaction of importance to the legal change and Vermont did not.[50]

These interpretations suggest that legally-affected young Michigan drinking drivers, except those in non-Detroit, Wayne County and those involved in fatal crashes, overreacted to the lower legal drinking age. The degree of over-involvement as seen in three Michigan jurisdictions was not apparent in either Maine or Vermont.

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[50] Based on age-specific three-factor-surrogate crash frequency distributions of Maine data.

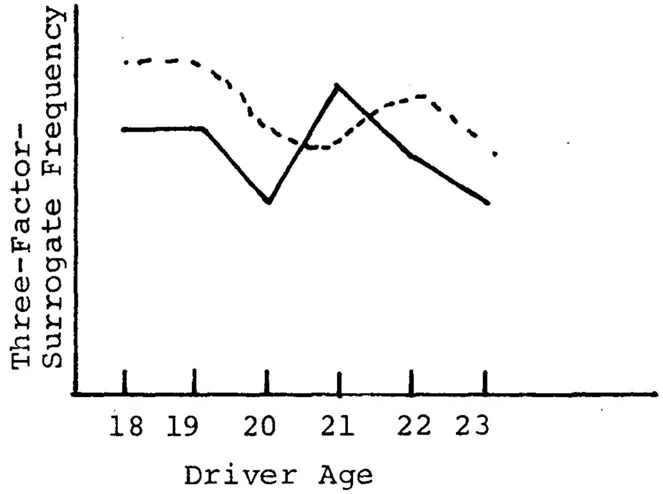
4.3 THE PATTERNS OF CHANGE

In all Michigan data and in Maine, for all levels of crash severity, the age-specific frequency distributions of 18- to 23-year-old driver involvements in three-factor-surrogate (alcohol-related) crashes changed after the lower legal drinking ages became effective. These changes did not proceed the legal changes, but took place immediately after the legal changes.

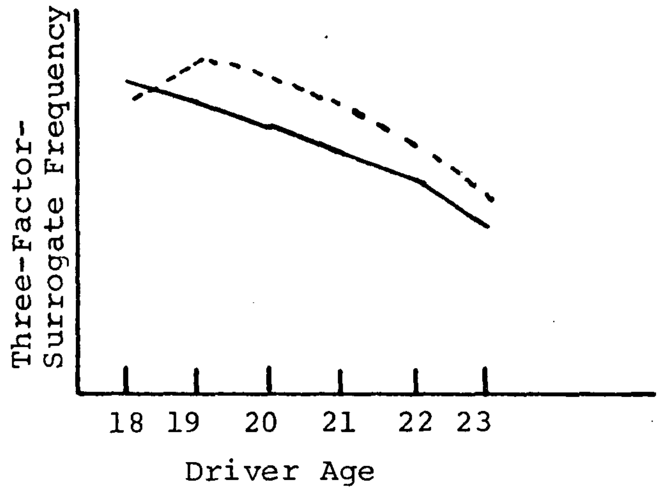
Figure 4.1 presents generalized bimodal and skewed distributions that were characteristic of the three-factor-surrogate crash data examined in this study. The figure lists jurisdictions by time period for which the generalized distribution patterns apply. The analyses show that of the jurisdictions where a demonstrable frequency increase could be measured, the age-specific frequency distribution patterns also changed.

The skewed distribution of alcohol-related crashes with peak involvement among 18- to 19-year-old drivers appears to be an "end state" common to states with 18-year-old minimum drinking ages. If a state has this characteristic prior to a lowering of the legal drinking age, as in Vermont, then no legal impact will result following the legal change. If a state has a bimodal frequency distribution of alcohol-related crashes however, the lower legal drinking age is expected to increase the frequency of alcohol-related crashes among affected age groups and alter the frequency distribution to a skewed pattern. These findings are consistent among the seven states in this study.

On the basis of these observations, Pennsylvania would be expected to experience an increase in the frequency of alcohol-related crashes among 18- to 20-year-old drivers if the legal drinking age there would be lowered to 18. Texas, the other 21-year-old control state, is not expected to



Generalized Bimodal Distributions



Generalized Skewed Distributions

Representative Jurisdictions

Generalized Bimodal Distributions	Generalized Skewed Distributions
Michigan (statewide) 1968-1971[1]	Michigan (statewide) 1972-1973[3]
Oakland County, Michigan 1968-1971[1]	Oakland County, Michigan 1972[3]
Washtenaw County, Michigan 1968-1971[1]	Washtenaw County, Michigan 1972[3]
Wayne County (non-Detroit), Michigan 1971[1]	Wayne County, Michigan 1972-1973[3]
Maine 1970-1971[2]	Maine 1972[3]
Pennsylvania 1968-1972[1]	Vermont 1971-1972[1,3]
	Louisiana 1971-1973[3]
	Texas 1969-1972[1]
	New York State 1968-1972[3]

[1]Legal Drinking Age: 21-years-old

[2]Legal Drinking Age: 20-years-old

[3]Legal Drinking Age: 18-years-old

FIGURE 4.1. GENERALIZED AGE-SPECIFIC THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS AND REPRESENTATIVE JURISDICTIONS IN THE QUASI-EXPERIMENTAL DESIGN

experience a significant impact following the legal change (August 1973) in that the frequency distribution pattern of alcohol-related crashes was similar to long-term 18-year-old states before the legal change.

It is evident from the analyses discussed above that the effect of the lower legal drinking age on alcohol-related crash involvement of youth is not simply stated. The design and statistical techniques applied in this research have provided the basis for conservative and highly confident assessments of the stability or change in crash frequencies and rates in the course of time-series observations. Although, as Glass noted, the time-series analytic procedures used here are blind to the underlying causes of such alterations,[51] the statistical procedures in combination with state selection, variable identification and other components of the research methodology, support a causal relationship between frequency, age-specific rate, and frequency distribution changes of alcohol-related crashes and the lower legal drinking ages in Michigan and in Maine.

Survey research findings have provided support to the conclusions of change in Washtenaw County, Michigan, and the absence change in Vermont following legal changes in these jurisdictions. The analysis of age-specific-frequency distribution patterns appears to provide a basis for prediction regarding the potential impact of lower legal drinking ages on youth crash involvement.

[51] Glass, op.cit., 1968, p.76.

4.4 RECOMMENDATIONS

The following recommendations for action and research are based on the findings and conclusions of the present investigation.

Action

(1) Reporting procedures and practices regarding alcohol-involvement in crash investigations should be improved. Operational formats similar to the forced-response category now found in Michigan should become standard in other states.

(2) States now considering the enactment of a lower legal drinking age should investigate the age-specific three-factor-surrogate (alcohol-related) crash frequency distributions of young drivers and determine if an impact of the new law is to be expected.

(3) States that expect to lower the legal drinking age and expect a legal impact should plan and implement countermeasures specific to the legally affected age groups of drivers.

(4) States that expect a legal impact might consider lowering the legal drinking age to 18-years-olds in a stepwise fashion, beginning with 20-year-olds, in order to lessen the abrupt changes found in Michigan's experience.

Research

(1) The methodology detailed in the present research should be replicated in analyses of other states in transition between legal drinking ages.

(2) Additional research is highly desirable regarding drinking and driving-after-drinking behavior of youth before and after changes in legal drinking ages.

(3) The stability and generalizability of the three-factor-surrogate as a measure of alcohol-related crashes should be tested in many more populations than was possible in the present research.

(4) The legal impact of the 18-year-old minimum drinking age on under-aged drivers should be investigated, with particular attention to 14- to 17-year-old drivers.

(5) The duration of effects in Michigan and Maine should be followed and measured to determine if the lower legal drinking ages produced permanent or temporary changes in those states.

(6) The long-term alcohol-related crash experience of cohorts of young drivers should be investigated over several years. It is possible that the overall crash experience of these groups will decrease, increase or remain unchanged over time as a consequence of the 18-year-old minimum drinking age.

(7) Levels of enforcement of the alcohol beverage control laws, including the legal drinking age, should be researched. The present research offers evidence that enforcement of the legal age laws is different between states. Research that is specific to this question is greatly needed.

(8) Examination of critical intervening variables is highly desirable in order to more fully understand changes in Michigan and Maine. It is important to determine if consumption levels actually increased among the 18- to 20-year-old populations after the age of majority became 18. If consumption did not change dramatically, then the social environment of the drinking practices should be investigated for changes associated with the lower legal drinking age.

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APPENDIX A

THE OPERATIONAL MEANING OF REPORTED ALCOHOL INVOLVEMENT IN OFFICIAL STATE ACCIDENT DATA

THE OPERATIONAL MEANING OF REPORTED ALCOHOL INVOLVEMENT IN OFFICIAL STATE ACCIDENT DATA

A.1 REPORTED ALCOHOL INVOLVEMENT

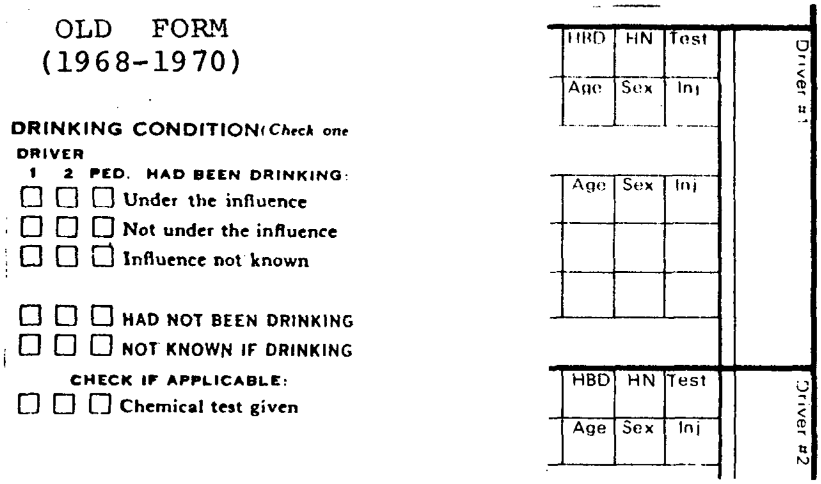
Each of the seven states' accident data included in the quasi-experimental design contained a measure of alcohol involvement. The operational forms and meanings of the official data, however, were characterized by a wide range of definitions which by no means could be taken to refer to the same category of event. In all states except Michigan and Texas the operational formats of alcohol-involvement questions remained constant during the present period of investigation.

This appendix will detail the operational formats and meanings of reported alcohol involvement during the study period in the seven states under investigation. The inconsistencies between jurisdictions and over time required the development of a more satisfactory surrogate dependent variable for analysis (see Appendix B).

A.2 MICHIGAN

The official Michigan accident report form contained a separate section for documenting alcohol involvement during the 1968-1973 time period. However, extensive revisions in 1971 created an operational incompatability with the earlier version. The old and new operational forms are shown in Figure A.1.

It can be seen that the old form includes three possibilities for an affirmative response to the question of drinking by a crash-involved driver, an option for a negative response, including an opportunity to defer the issue with a valid "Influence Not Known" code. The new form is a forced-response question in which uncertainties become missing data rather than separate valid responses. Both


OLD FORM
(1968-1970)

DRINKING CONDITION (Check one
DRIVER
1 2 PED. HAD BEEN DRINKING:
☐ ☐ ☐ Under the influence
☐ ☐ ☐ Not under the influence
☐ ☐ ☐ Influence not known

☐ ☐ ☐ HAD NOT BEEN DRINKING
☐ ☐ ☐ NOT KNOWN IF DRINKING
CHECK IF APPLICABLE:
☐ ☐ ☐ Chemical test given

NEW FORM
(1971-1973)

FIGURE A.1. MICHIGAN ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

forms provide a means of recording chemical tests from which levels of intoxication are determined.[52] In the new form all affirmative options of the old form are collapsed into a single affirmative response option.

The absence of a valid "Unknown" code in the new form was intended to force crash investigators to address the question of alcohol involvement. It is likely that reporting of alcohol involvement with the new form has been affected with proportionally more of the previously documented "Influence Unknown" responses becoming "HBD" (Had Been Drinking) in the new form, than either missing data or "HN" (Had Not Been Drinking).

All three affirmative options of the old form were collapsed into a single affirmative response for the 1968-1973 time-series analyses in the present study. The negative response codes "Had Not Been Drinking" were unchanged between data

52 A further confounding influence is the fact that chemical testing capabilities within police agencies were changing during the period of study.