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THE EFFECT OF LOWER LEGAL DRINKING AGES 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 to 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]

[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 rival hypothesis 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.

[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

[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]

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[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

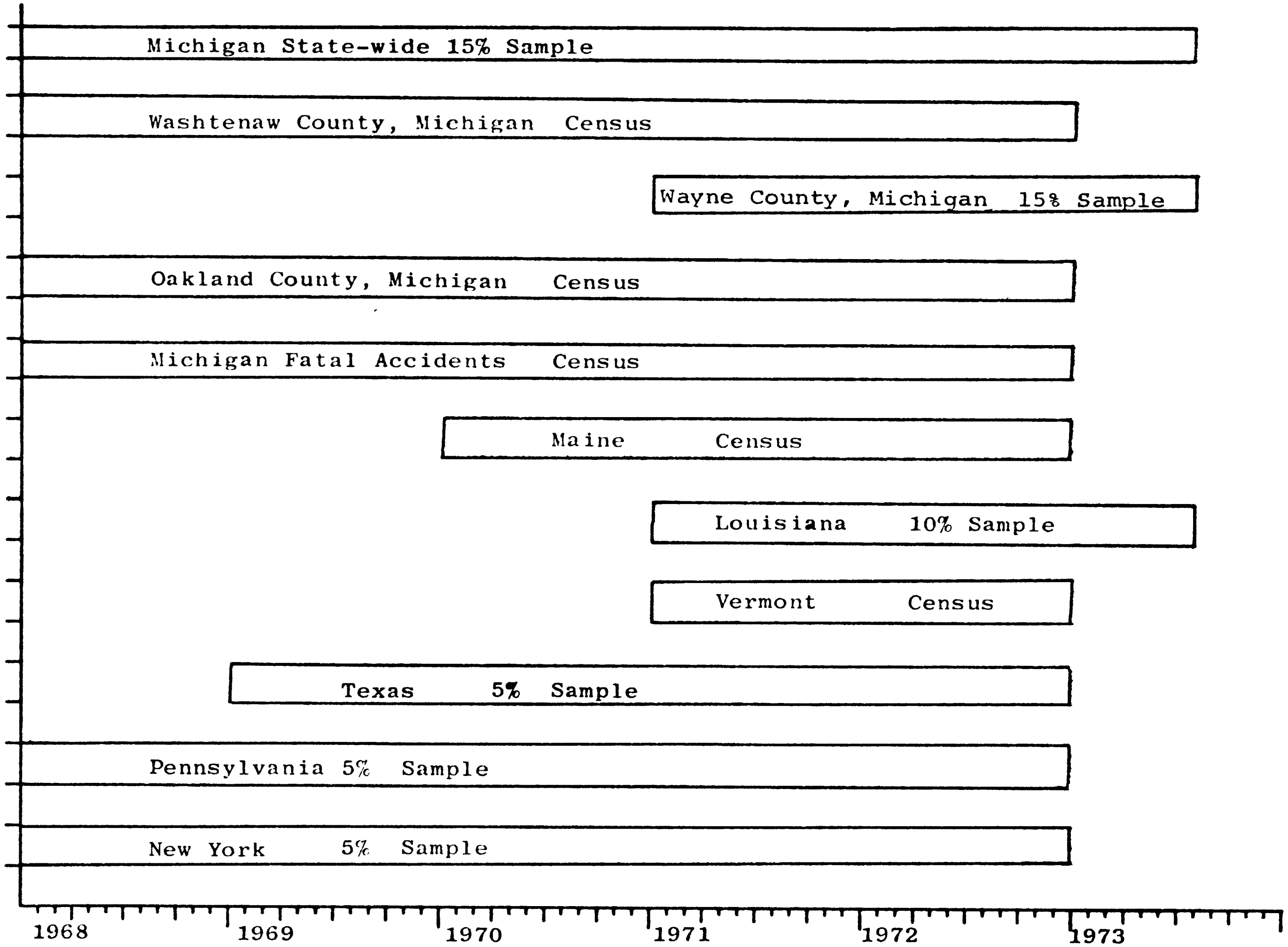


FIGURE 2.1. FULL QUASI-EXPERIMENTAL DESIGN WITH RANGE OF JURISDICTION DATA AND FILE COMPOSITION

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 invesating 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

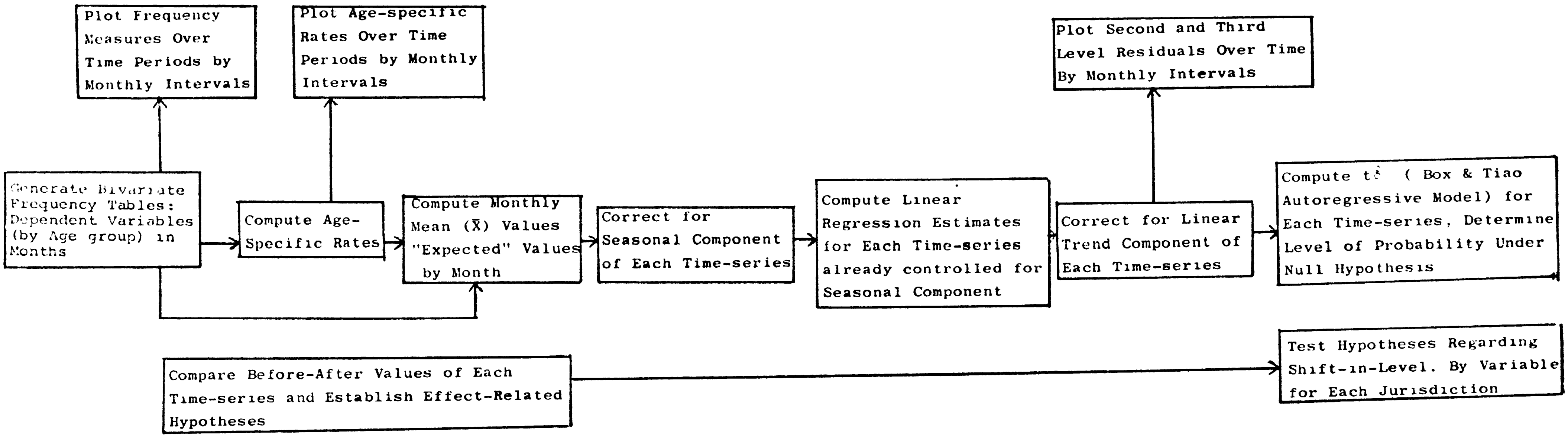
- Y is the series;
- S are seasonal, cyclic components;
- C are non-seasonal, cyclic components;
- T is the trend, or long-term movement;
- I are residual, irregular, or random effects not a part of the other components.

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.



Y = S + T + I   Y - S = T + I   (Y - S) - T = I

Components and Decomposition of Time-series Data:

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

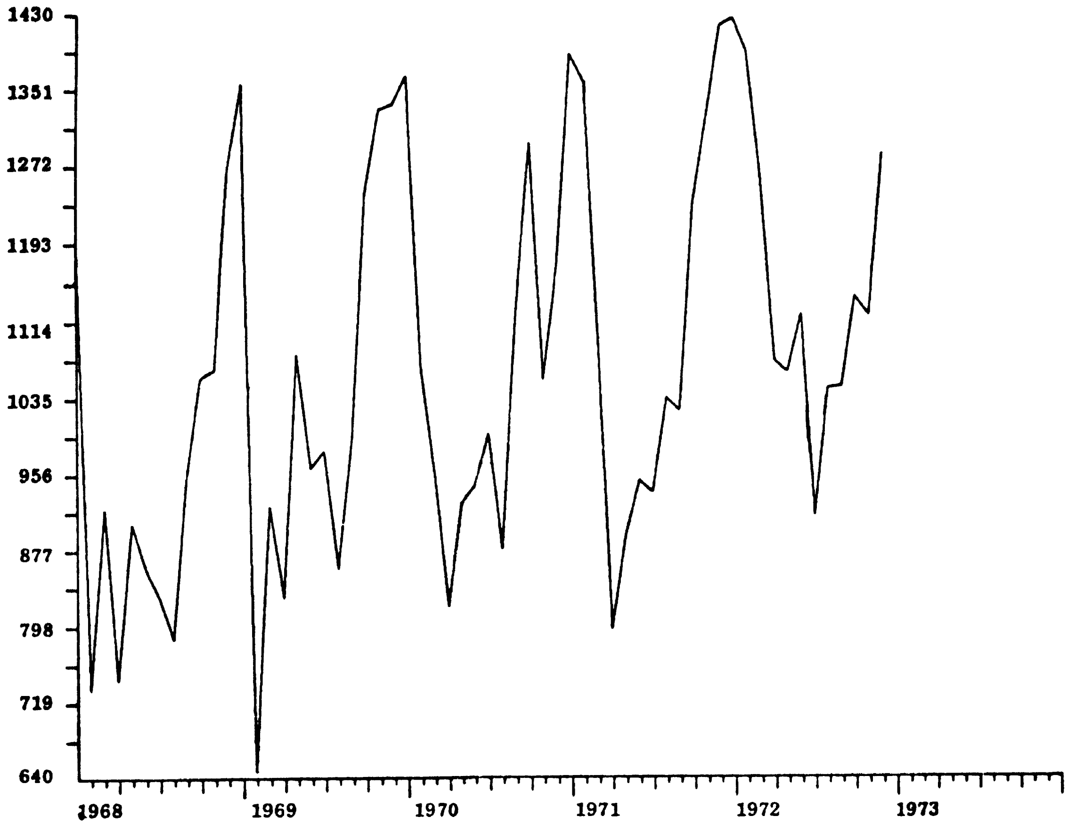
FIGURE 2.2. ANALYSIS FLOW CHART

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: $I = Y - S - T$.

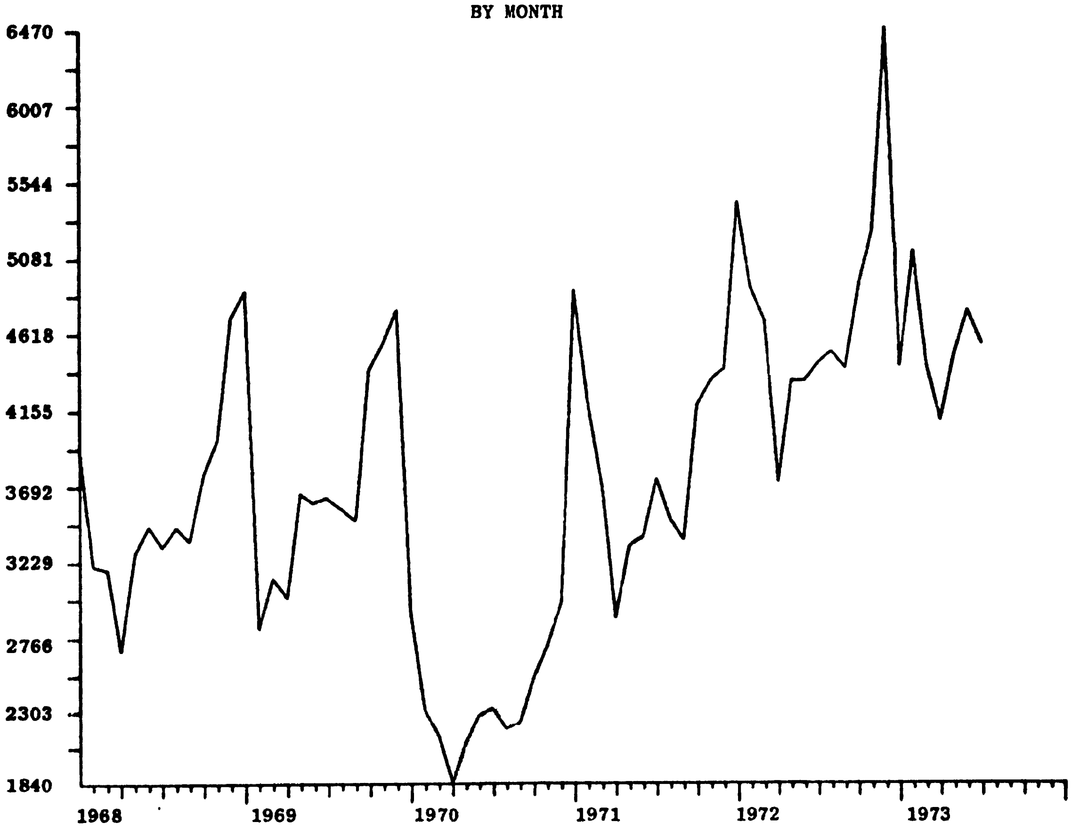
The appropriate statistical procedures subsequently applied require that the time-series be free from systematic trends or cycles and have mean values equal to zero. Therefore seasonal decomposition was accomplished by computing the twelve monthly means of any given dependent variable for all like months, 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 $t\hat{\delta}$ 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

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[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

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[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	$-.11369X10^{-13}$	17.8800	-35.798	36.643
21-45 Total Experience	563.500	117.930	312.000	790.000	$-.50922X10^{-14}$	61.8600	-214.160	175.620
18-20 Had Been Drinking	11.017	4.890	2.000	25.000	$-.15728X10^{-14}$	3.9790	-7.467	10.933
21-45 Had Been Drinking	60.883	12.153	35.000	89.000	$-.20724X10^{-15}$	8.8900	-23.260	28.960
18-20 Three Factor Surrogate	8.400	3.376	3.000	17.000	$-.65133X10^{-15}$	3.0160	-6.293	6.306
21-45 Three Factor Surrogate	25.550	6.940	11.000	43.000	$-.12953X10^{-15}$	6.1551	-14.866	13.637
Total Overall Crash Experience	1063.100	197.390	647.000	1426.000	$-.2783X10^{-14}$	106.1000	-326.120	288.890
Total Overall Had Been Drinking Experience	92.470	14.810	62.000	126.000	$-.32196X10^{-15}$	10.7320	-27.284	30.449
Total Overall Three Factor Surrogate Experience	40.850	9.690	21.000	68.000	$-.62913X10^{-16}$	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	$-.10119X10^{-17}$	.01844	-.03152	.05244
21-45 Three Factor Surrogate	.04659	.01358	.02056	.08558	$.40621X10^{-17}$	.01134	-.03131	.03168

3.0 RESULTS

Results of the analyses will be presented in three stages. The findings of the full quasi-experimental time-series analysis will provide a basis for the development of a position relating the lower legal drinking age to an increase in alcohol-related crashes in two of the three states that changed the law. Following the findings of the time-series analyses the magnitude of the problem will be put into perspective through an examination of the relationships of the time-series $t\hat{\delta}$ statistics and percentage changes for age-specific crash frequencies in the three transitional states. This examination will address the question of social significance of the statistically significant findings of the time-series tests. The final stage of the presentation of results will be a comparative analysis of the age-specific frequency distributions of the three-factor-surrogate for young drivers in all states in the design. The primary purposes of the analysis of distributions are to better understand the results of the time-series analyses and to provide a basis for predictions regarding the potential impact of legal changes in Texas and Pennsylvania.

3.1 TIME-SERIES ANALYSES

<u>Michigan</u>. Eleven analytic variables in each of five Michigan data files were tested for statistically significant changes following the effective date of the lower legal drinking age in Michigan, January 1, 1972. Table 3.1 presents the $t\hat{\delta}$ values for five Michigan files. Considering first the three 18- to 20-year-old measures of alcohol involvement, it can be seen that reported alcohol involvement shifted in level in four of the five files. In Wayne

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 Statewide 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.

No time-series measures shifted at a statistically significant level in Vermont following the lower legal drinking age. 18- to 20-year-old alcohol-related crash involvements remained unchanged as did total crash involvements. The only $t\hat{\delta}$ values of consequence were of the 21- to 45-year-old alcohol-related crash frequencies which suggested a small decrease in 1972. Unlike Michigan and Maine, there is little basis for suspecting that further analyses might demonstrate an impact of the lower legal drinking age in Vermont.

<u>Pennsylvania and Texas</u>. The results of time-series analyses of the 21-year-old control states, Pennsylvania and Texas, are presented in Table 3.3. No $t\hat{\delta}$ values were computed for reported alcohol-involvement. The lack of 1971 and 1972 data for reported alcohol-involvement in Texas and previously identified under-reporting in Pennsylvania, prevented time-series analyses.

In both states the 18- to 20-year-old total crash involvement remained relatively constant, however, the total 21- to 45-year-old experience shifted positively, and significantly, in 1972. Neither state experienced a shift in level of the three-factor-surrogate frequencies, however, in Pennsylvania both age-specific surrogate rates shifted significantly. The age-specific rates shifted negatively in Texas in 1972, although the shifts were not statistically significant.

The increased 18- to 20-year-old three-factor-surrogate rate in Pennsylvania is unrelated to an extraneous influence, such as a legal change specific to the young age group, because a shift in the same direction and of comparable magnitude and significance occurred for the 21- to 45-year-old group as well. No alcohol-involvement measure changed significantly in Texas. Therefore, there is no evidence that the alcohol-related crash experience in Pennsylvania or Texas paralleled the Michigan experience in 1972.

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

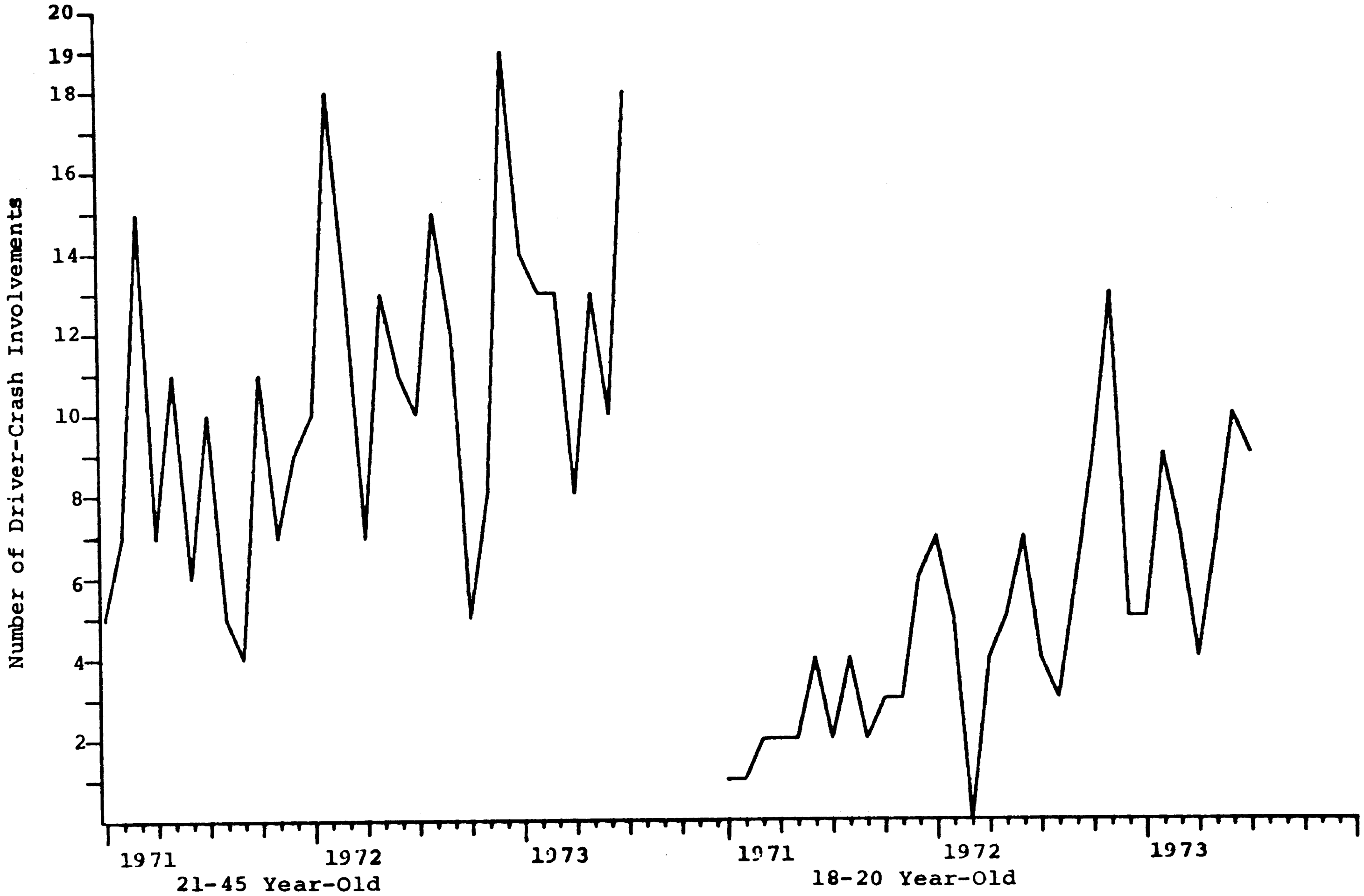

FIGURE 3.1. THREE-FACTOR-SURROGATE DRIVER-CRASH INVOLVEMENTS IN 15% SAMPLE OF NON-DETROIT, WAYNE COUNTY, MICHIGAN BY MONTH

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.

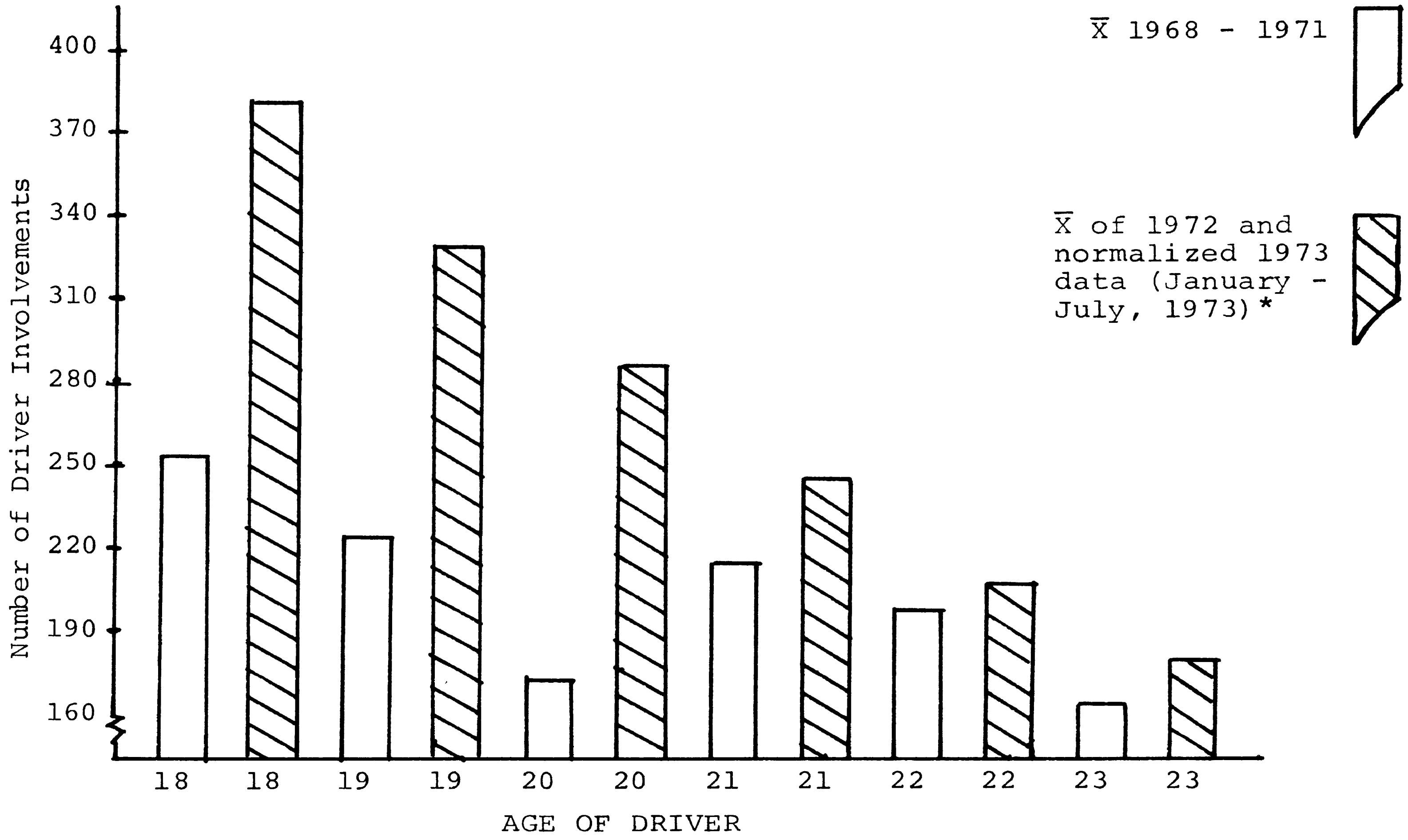

FIGURE 3.2. MICHIGAN STATEWIDE (15% SAMPLE) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

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

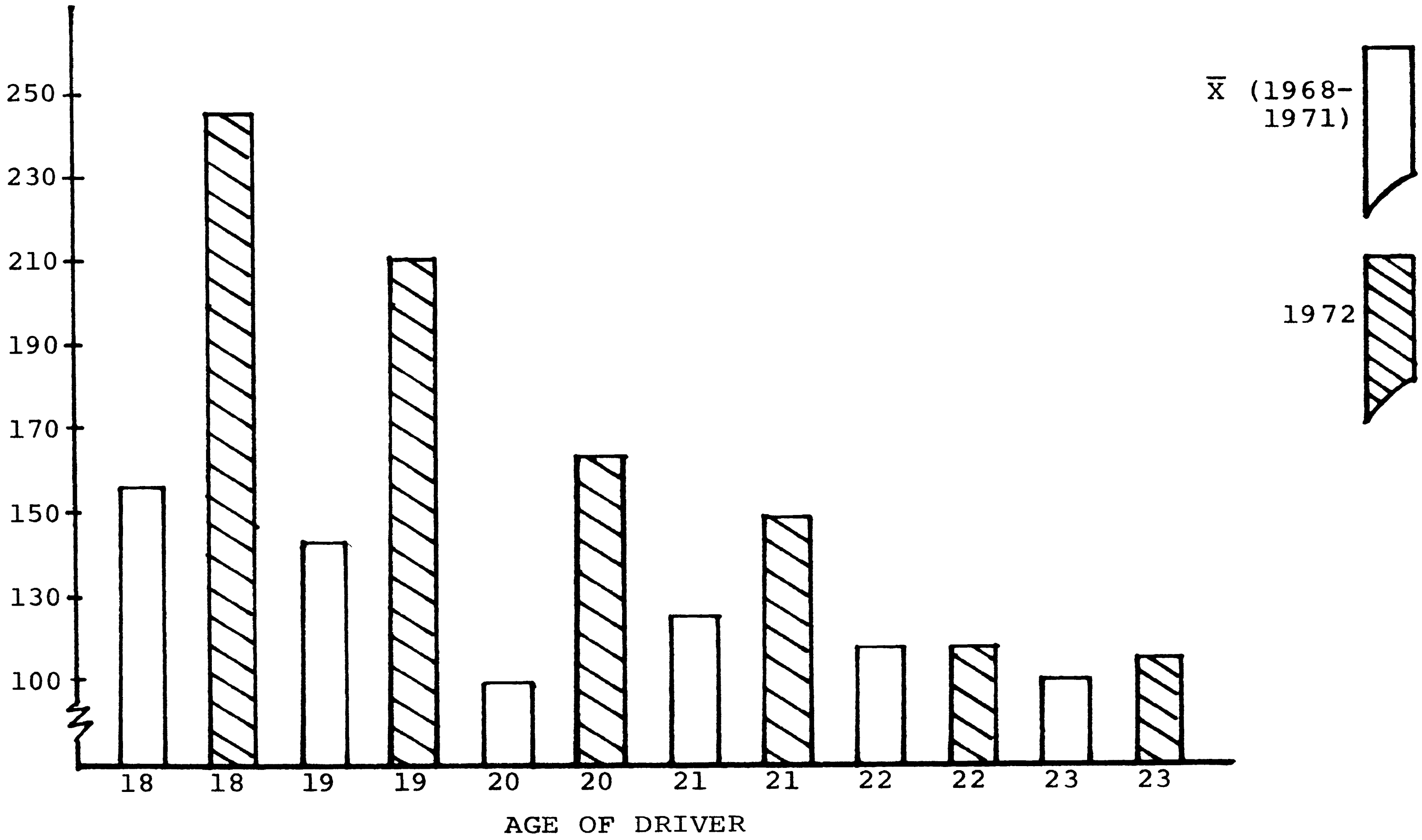

FIGURE 3.3. OAKLAND COUNTY THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

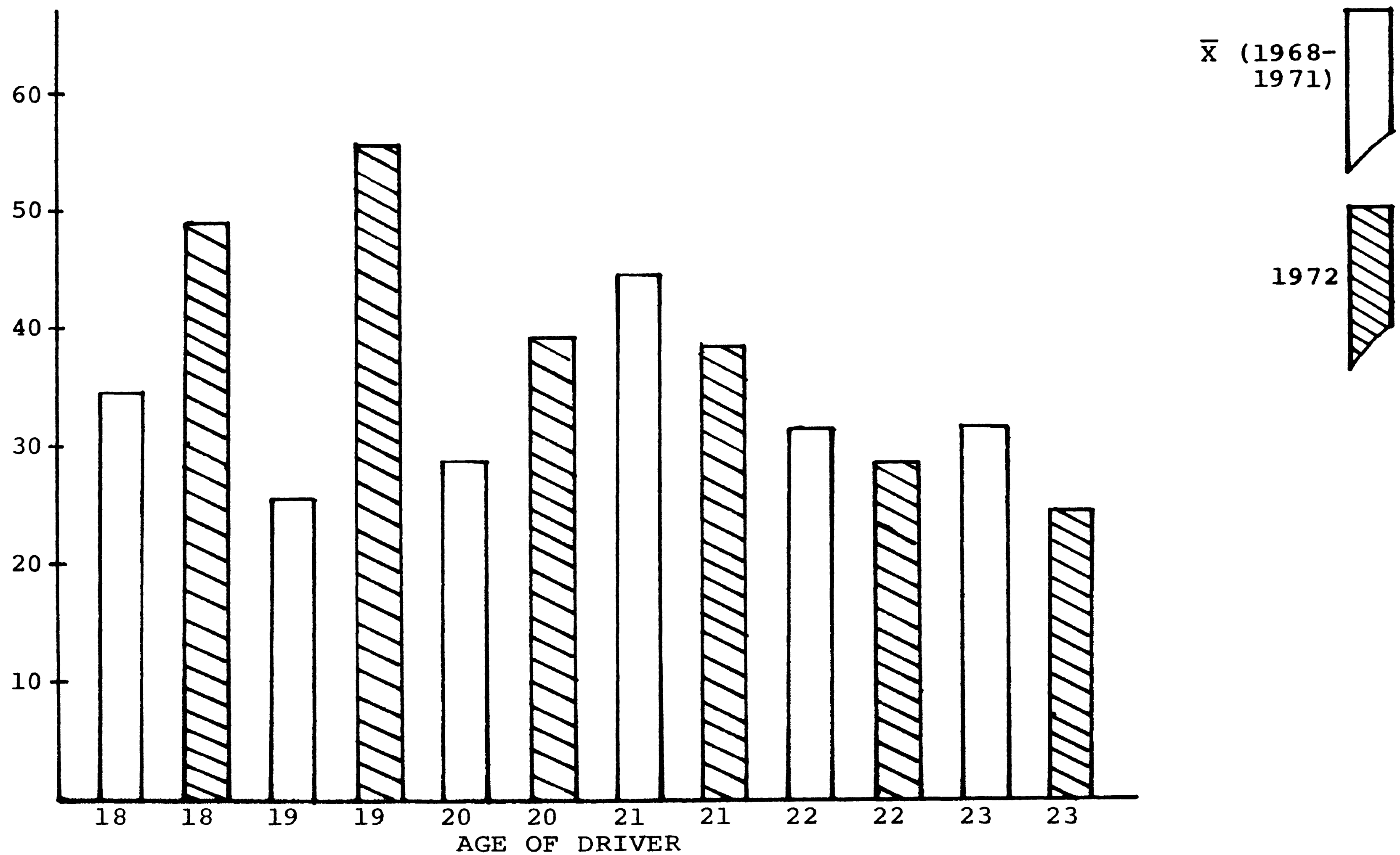

FIGURE 3.4. WASHTENAW COUNTY THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

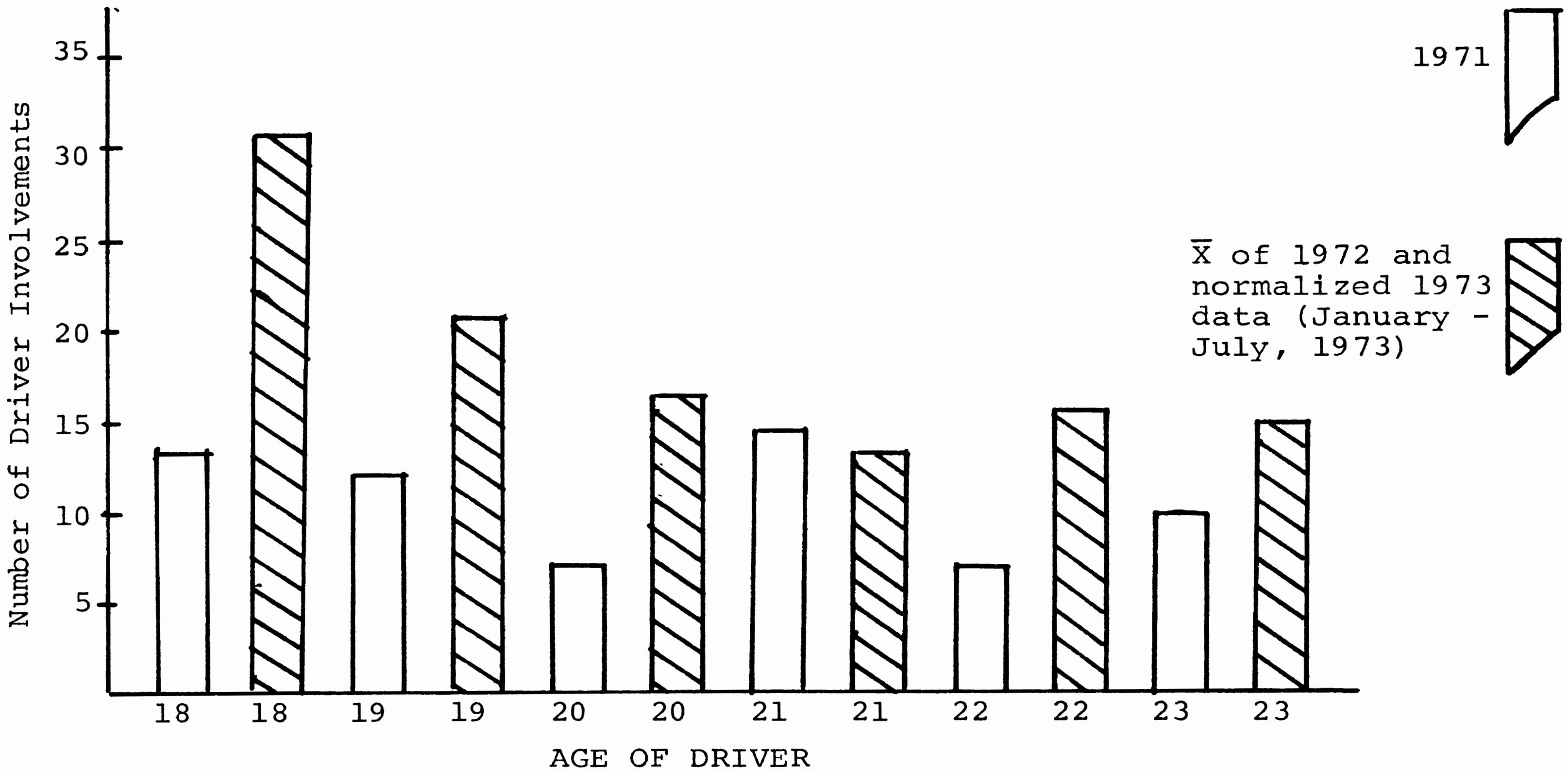

FIGURE 3.5. WAYNE COUNTY, MICHIGAN (15% SAMPLE, EXCLUDING DETROIT) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE

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 after 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.

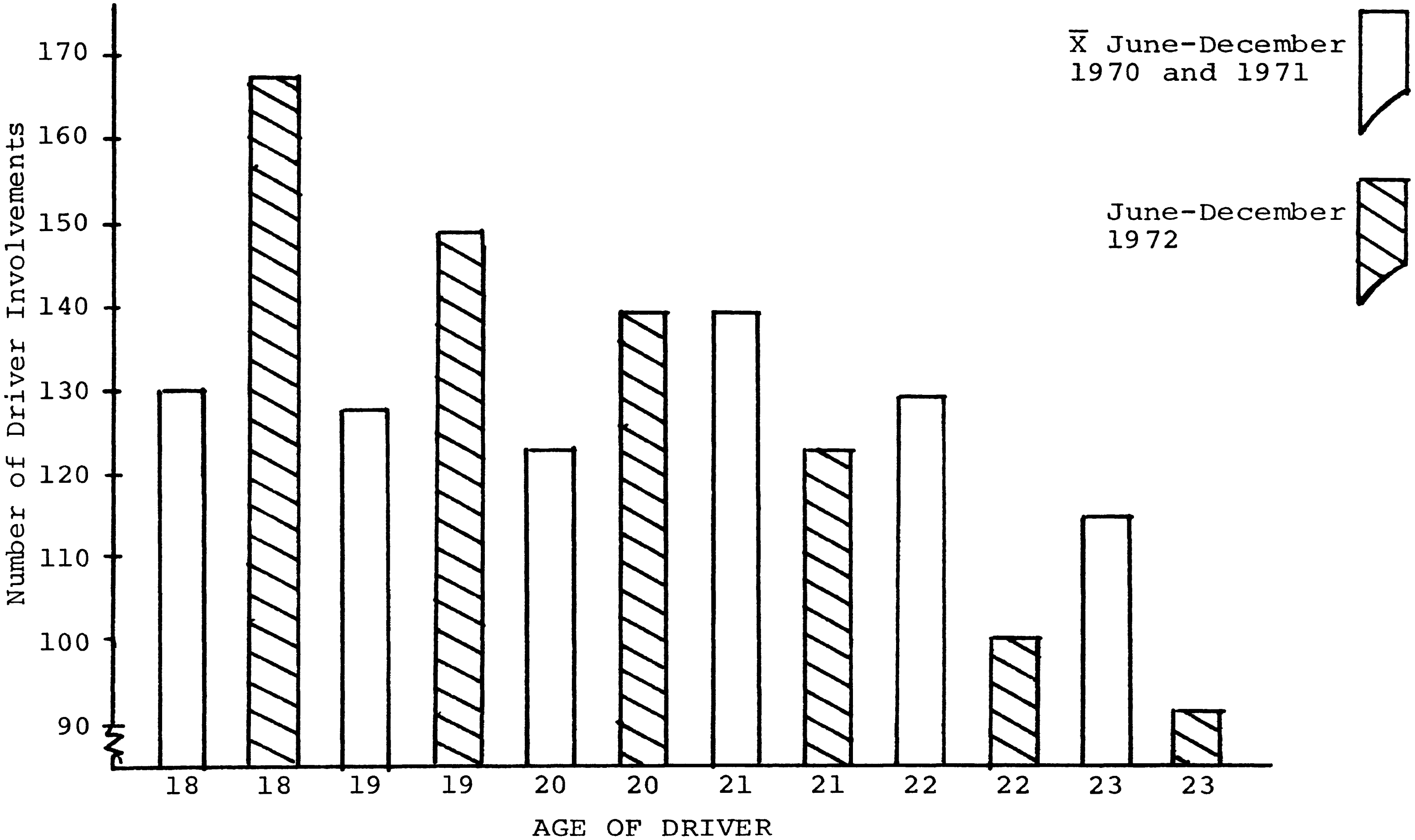

FIGURE 3.6. MAINE THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE*

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

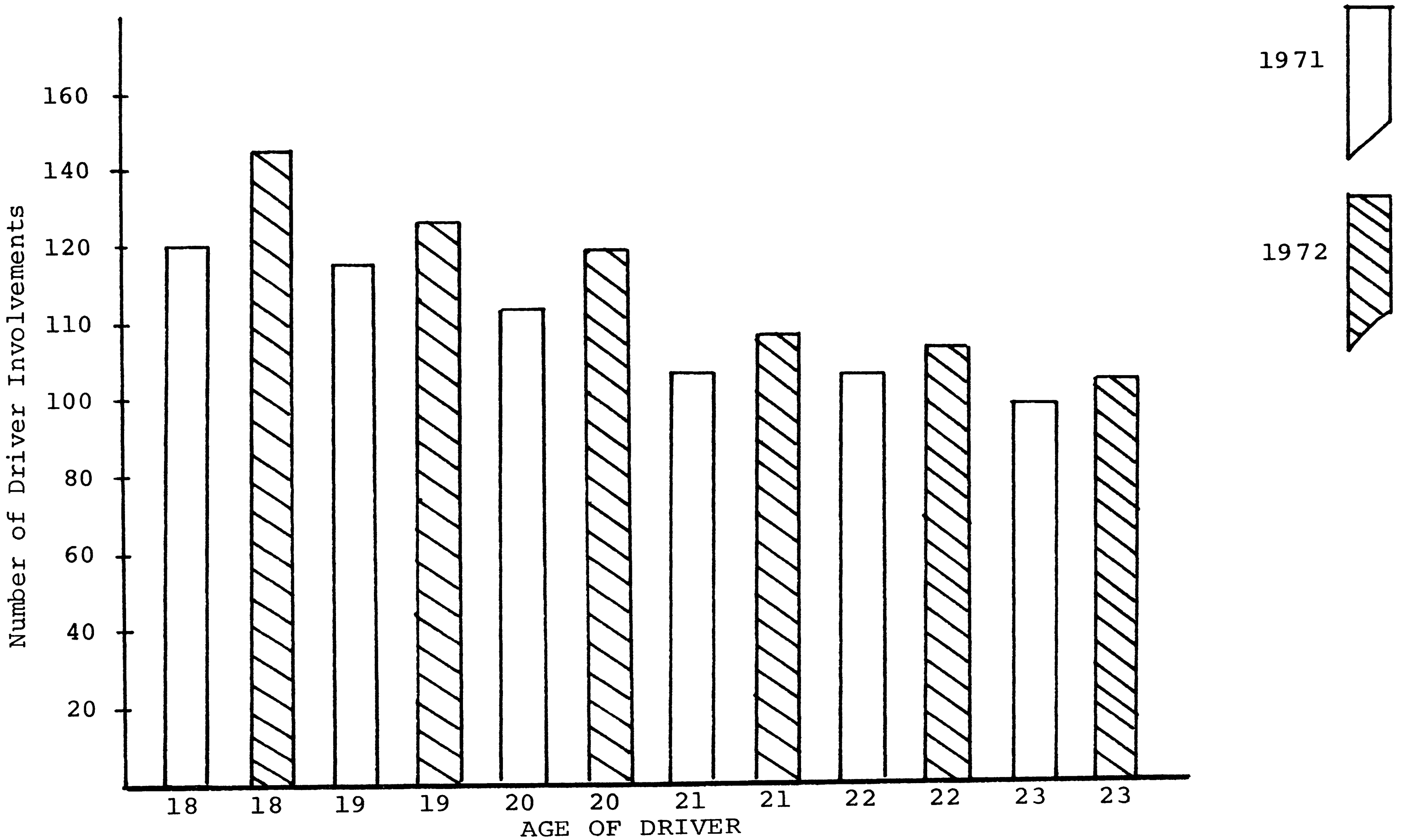

FIGURE 3.7. VERMONT THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND YEAR 1971 and 1972

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 after 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 before 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 after 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

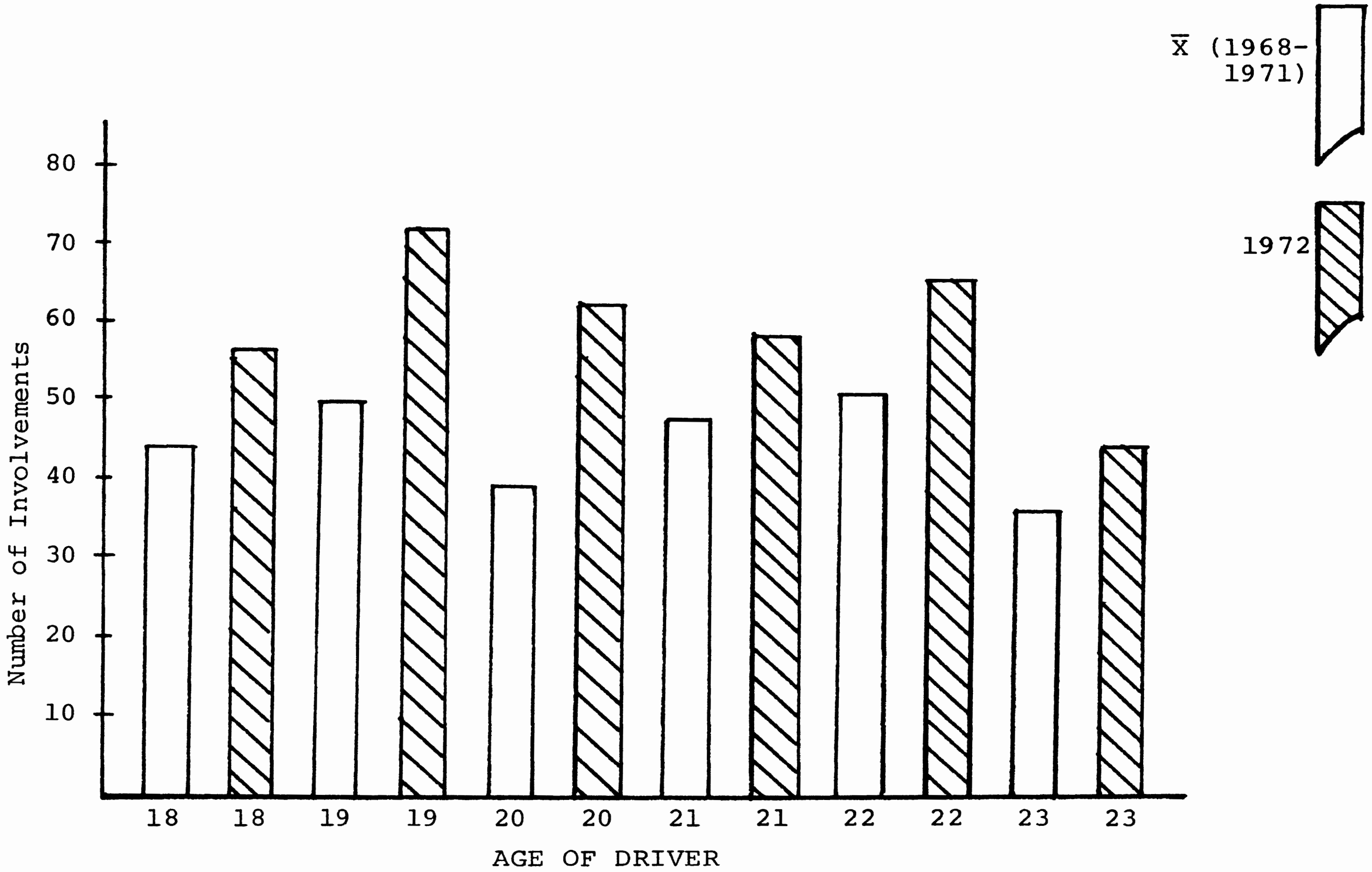

FIGURE 3.8. PENNSYLVANIA (5% SAMPLE) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER LOWER LEGAL DRINKING AGE CHANGED IN MICHIGAN AND VERMONT (1972)

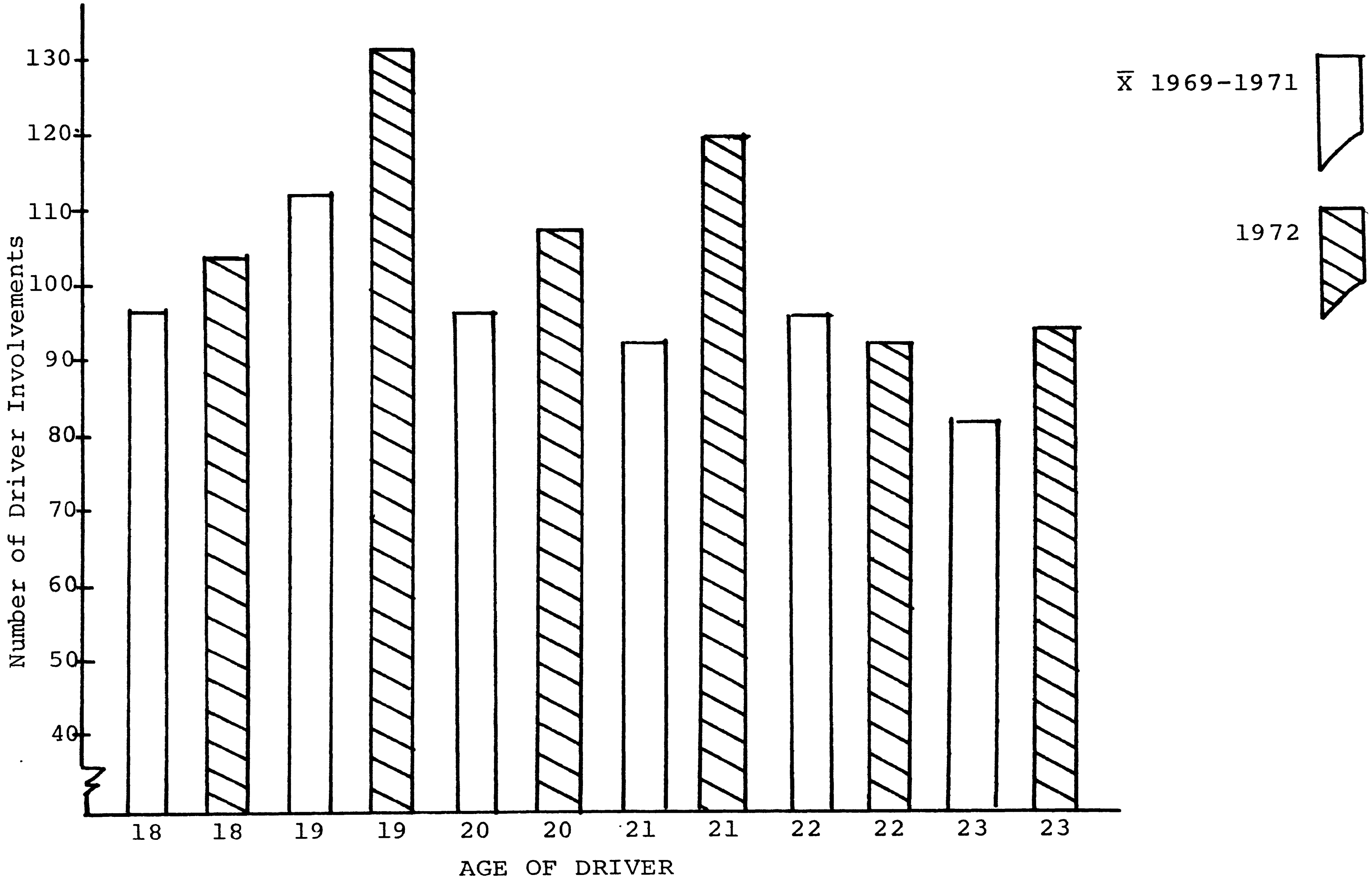

FIGURE 3.9. TEXAS (5% SAMPLE) THREE-FACTOR-SURROGATE FREQUENCY DISTRIBUTIONS BY AGE AND PERIOD BEFORE AND AFTER THE LOWER LEGAL DRINKING AGES IN MICHIGAN AND VERMONT

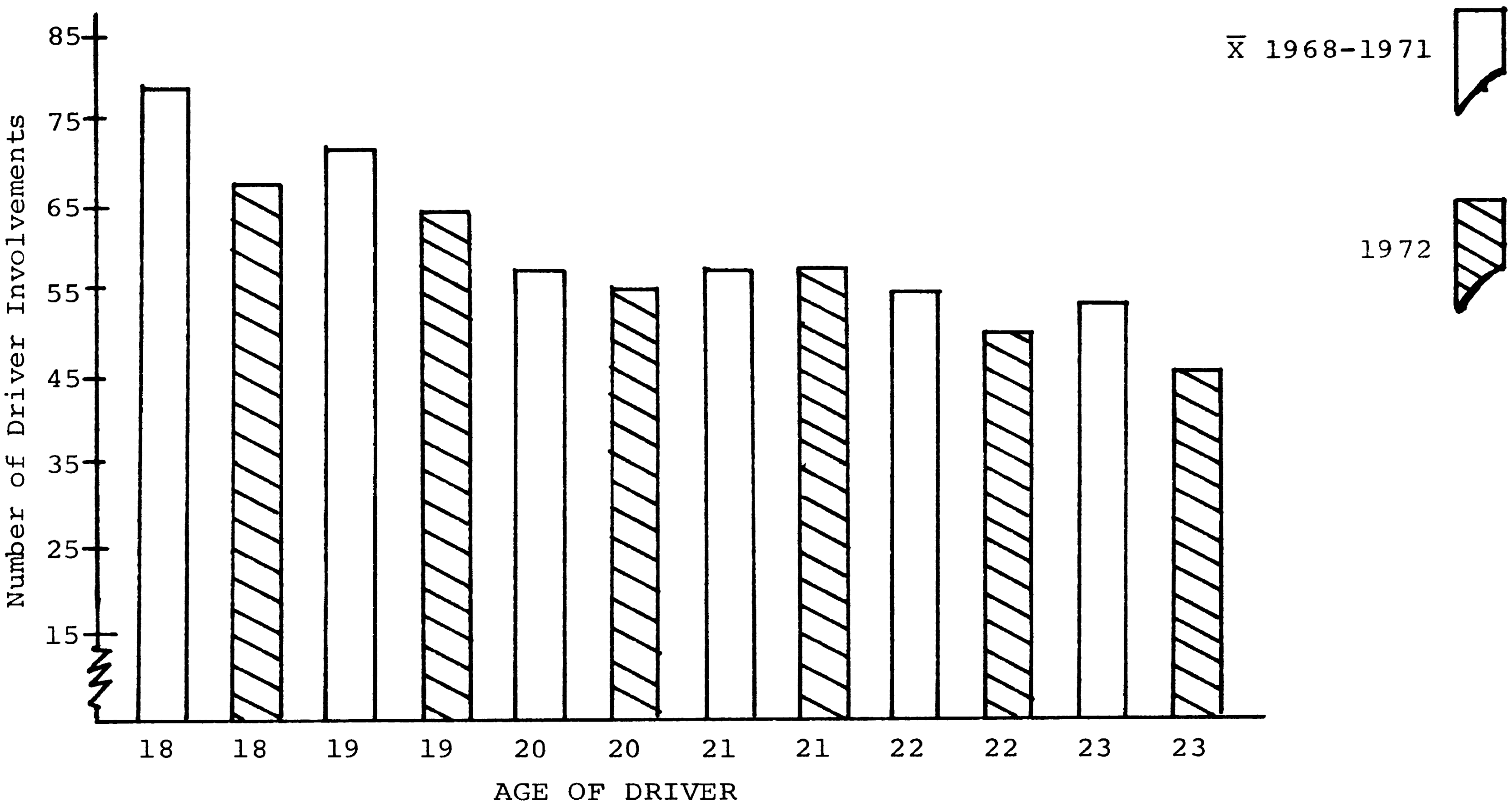

FIGURE 3.10. NEW YORK STATE (5% SAMPLE) THREE-FACTOR-SURROGATE AGE-SPECIFIC FREQUENCY DISTRIBUTIONS BY AGE OF DRIVER AND PERIOD BEFORE AND AFTER LEGAL DRINKING AGE CHANGES IN MICHIGAN AND VERMONT

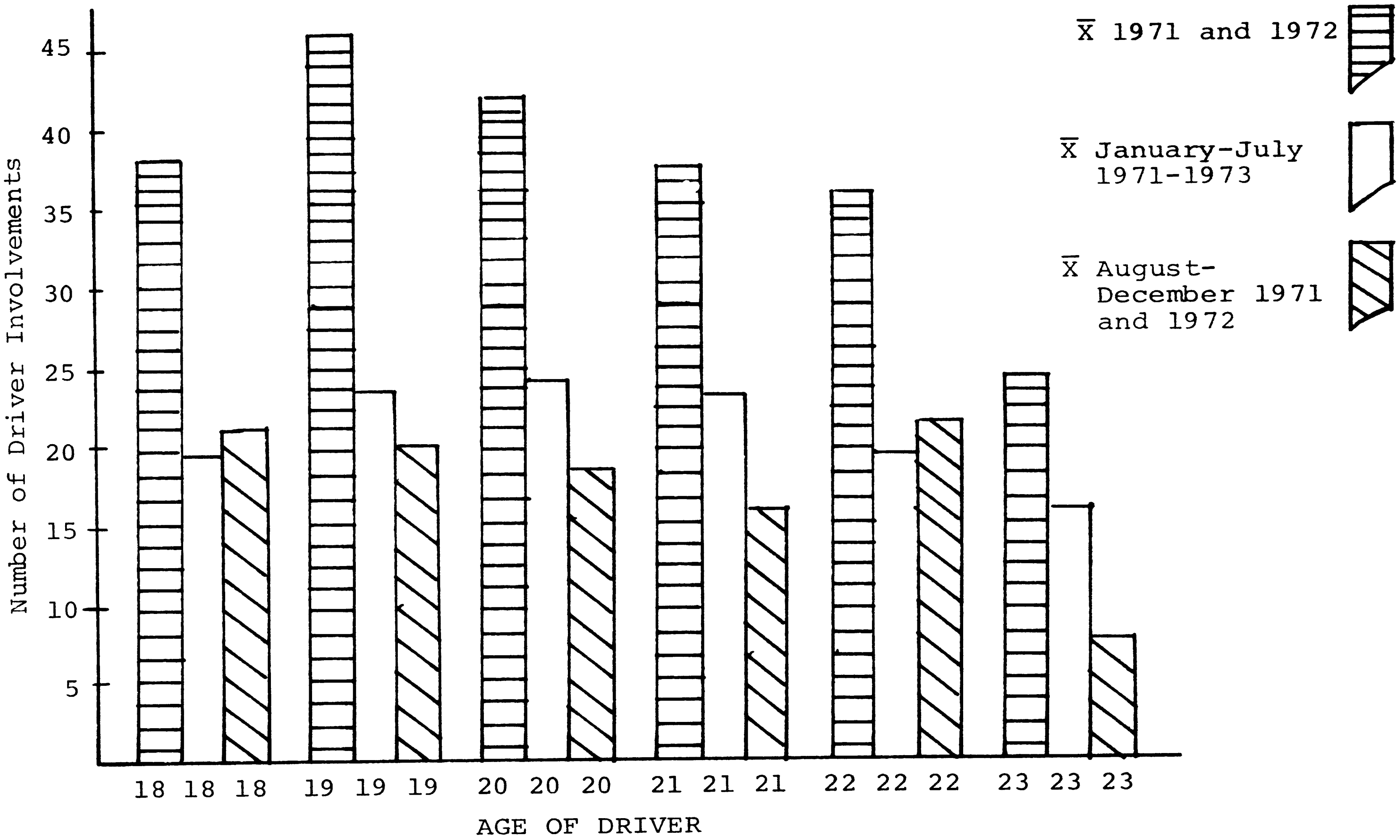

FIGURE 3.11. LOUISIANA (10% SAMPLE) THREE-FACTOR-SURROGATE AGE-SPECIFIC FREQUENCY DISTRIBUTIONS BY AGE OF DRIVER DEMONSTRATING SEASONAL DIFFERENCES

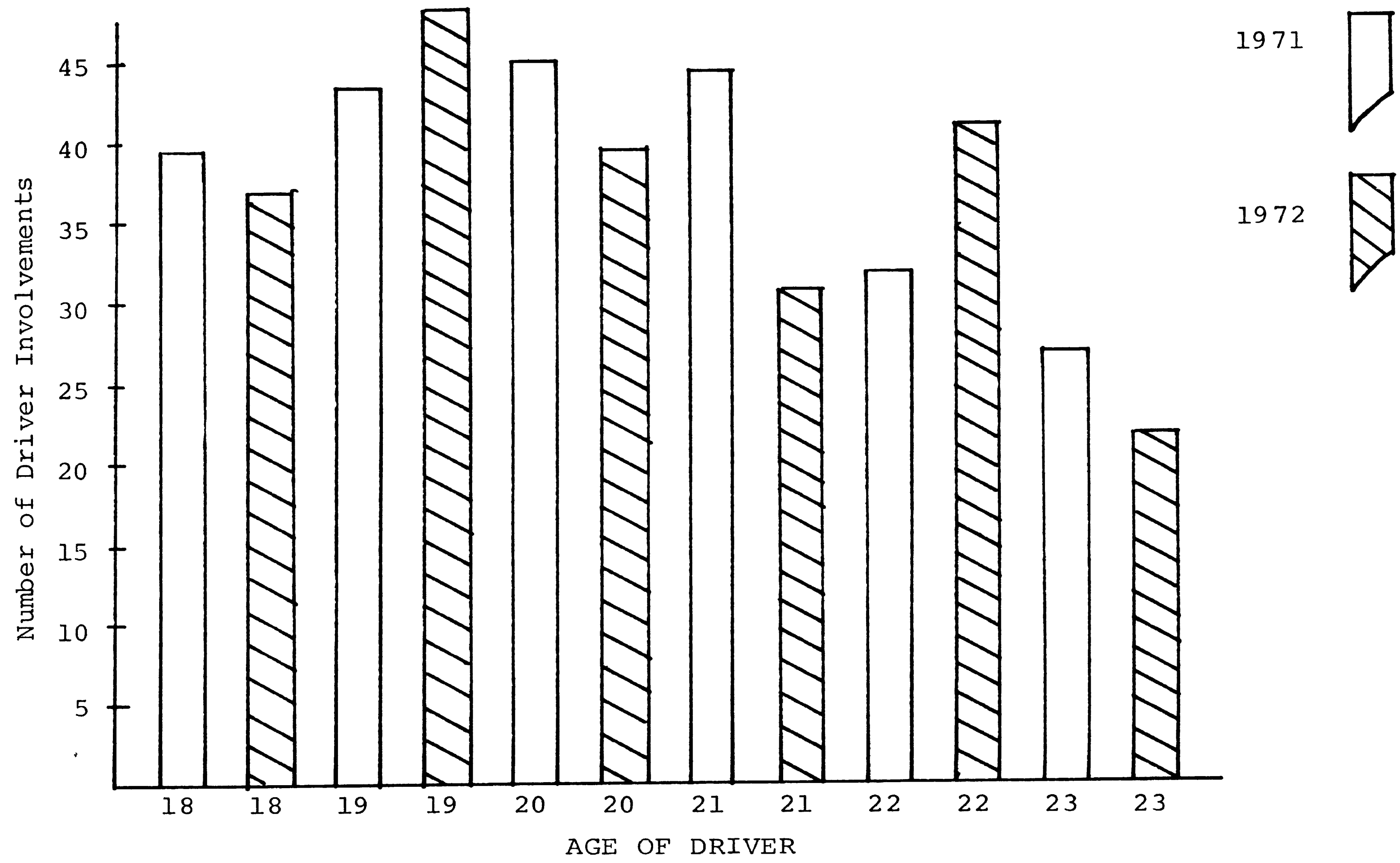

FIGURE 3.12. LOUISIANA (10% SAMPLE) THREE-FACTOR-SURROGATE AGE-SPECIFIC FREQUENCY DISTRIBUTIONS BY AGE OF DRIVER DEMONSTRATING ATYPICAL 22-YEAR-OLD FREQUENCY, ATTRIBUTED TO AUGUST-DECEMBER, 1972 22-YEAR-OLD EXPERIENCE

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 impredlate 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 <u>above the level established by a four year pre-intervention time-series</u>.

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 <u>below the expected level</u>.

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 <u>within the limits of expectation</u>. 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, over-reacted 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.

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

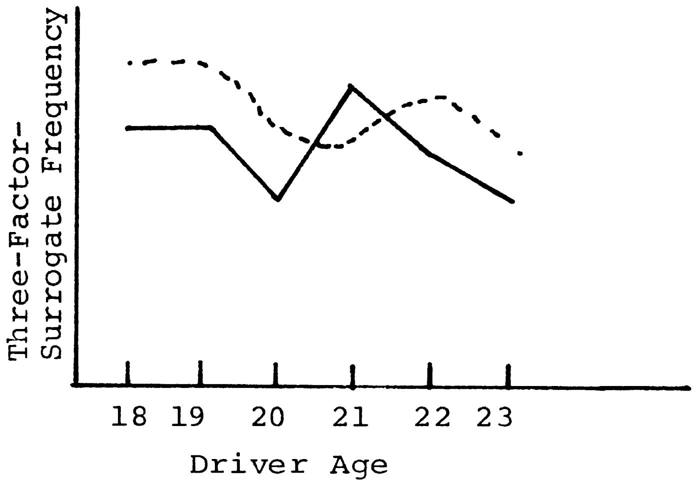
4.3 THE PATTERNS OF CHANGE

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.

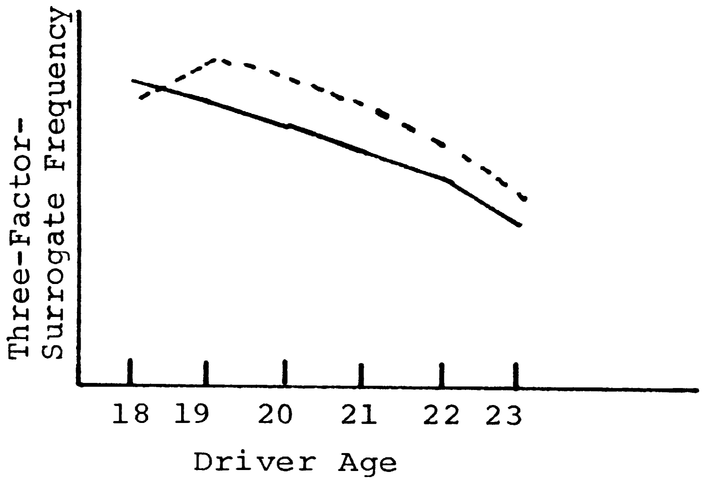
Figure 4.1 presents generalized bimodal and skewed distributions that were characteristic of the three-factor-surrogate crash data examined in this study. The figure lists jurisdictions by time period for which the generalized distribution patterns apply. The analyses show that of the jurisdictions where 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.

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[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.

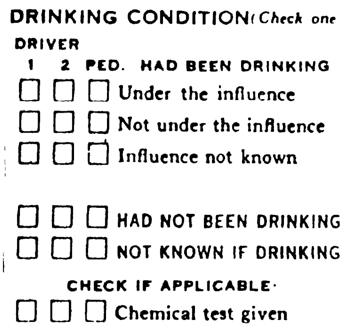
This appendix will detail the operational formats and meanings of reported alcohol involvement during the study period in the seven states under investigation. The inconsistencies between jurisdictions and over time required the development of a more satisfactory surrogate dependent variable for analysis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



NEW FORM
(1971-1973)

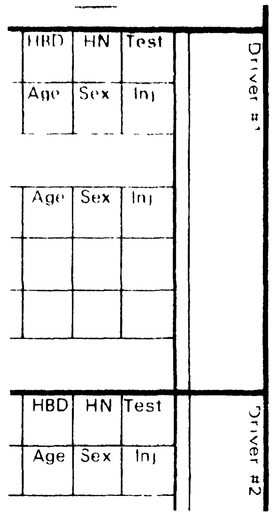


FIGURE A.1. MICHIGAN ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

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.

sets before and after the new form was introduced. These operational procedures were used for Michigan data which were affected by the form changes in 1971.

A.3 VERMONT

The data received from Vermont included alcohol-involvement information as components of a non-specific category of accident causation. All causation is translated in terms of violations. This proved to be true of several other states and presented a problem regarding the comparability of measurements across jurisdictions. The Vermont Department of Motor Vehicles, under "Cause of Accidents" lists 41 possibilities of violations including #13: "Operator had been drinking" and #14: "Operator under influence" (of alcohol). The range of possibilities is listed in Figure A.2.

As can be seen from the list, the available options from which a police can choose suggests that in Vermont, relative to states such as Michigan in which attention is directed specifically to alcohol involvement, evidence of drinking that is less than obvious is less likely to be reported.

Presumably, in Vermont the accident investigator can identify as many of the listed accident causes that apply. However, only "...the most serious accident causing violation as the primary cause."[53] Only one causative factor was coded and and available in digital form.

A.4 MAINE

In Maine, alcohol involvement was coded under a variable entitled "Physical condition of drivers". While not to the extent found in Vermont, Maine also includes response categories other than alcohol-related from which the crash

53 U.J. Sartorelli, Chief, Analysis and Information Section. "Coding of all Police (investigated) Motor Vehicle Accidents", Vermont Department of Motor Vehicles (the standard code manual), January 1, 1969, p.3.

VERMONT DEPARTMENT OF MOTOR VEHICLES

Cause of Accidents
Accident by Location

1. Driving left of center
2. Speed too high for road conditions
3. Speed in excess of legal limits
4. Passing way ahead not clear
5. Road slippery from ice, snow, etc.
6. Following too close
7. Failed to yield right of way
8. Failure to stop for stop sign
9. Entering into roadway without due care and caution
10. Leaving parking space inattentively
11. Failure to signal
12. Disregard traffic control
13. Operator had been drinking
14. Operator under influence
15. Operator inattentive
16. Operator fell asleep
17. Operator had physical defect
18. Operator used poor judgment
19. Careless operator of bicycle
20. Mechanical failure or defect
21. Animal in roadway
22. Backing into highway
23. Leaving vehicle improperly secured
24. Operator inexperienced
25. Improper action of uninvolved operator
26. Improper backing in traffic
27. Object falling from moving vehicle & striking another vehicle
28. Object thrown up from highway by moving vehicle & striking another vehicle
29. Improperly parked vehicle
30. Attempting to pass while being passed
31. Careless pedestrian
32. Miscellaneous
33. Undertimined
34. Failure use due care & caution at intersection
35. Failure stop at red light
36. Occupant fell from vehicle
37. Defective equipment
38. Tire blew out
39. Other--road condition - narrow
40. Improper passing
41. Drugs

FIGURE A.2. VERMONT ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT investigator must chose the most significant condition. The Maine codes are not violations. The possible response categories in Maine are listed in Figure A.3.

Condition of Drivers

The physical condition of drivers will be coded as follows:

Physical Condition of Drivers	Code
Apparently normal	01
Had been drinking	02
Under influence of liquor	03
Under influence of drugs	04
Fatigued	05
Asleep	06

FIGURE A.3. MAINE ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

It is only possible to speculate about the mutual independence of an apparently fatigued condition (05) and less than intoxicated evidence of drinking (02). As in Vermont, documentation regarding the presence or absence of drinking by a crash-involved driver is less uniform than in Michigan, with Michigan's revised accident reporting procedure.

A.5 TEXAS

The HSRI police report level data files on Texas were used in this research. No alcohol-involvement data were coded for 1971 and 1972. For 1969 and 1970, however, alcohol involvement data were built into the files in the form of optional responses under the general category of Driver Violations. Two violations were possible valid codes for any single driver-involvement in a crash. The single value that addressed the question of drinking was one of several possibilities under "Driver Violation #2". The format of the Texas data appear in Figure A.4.

DRIVER VIOLATION #1

0. NO FACTOR IN THIS VARIABLE APPLIES
1. SPEEDING OVER LIMIT OR DURING UNSAFE CONDITIONS
2. FAILED TO YIELD RIGHT OF WAY
3. DISREGARDED TRAFFIC SIGNAL
4. IMPROPER TURN, WIDE RIGHT
5. IMPROPER TURN, CUT CORNER ON LEFT
6. IMPROPER TURN, IMPROPER LANE
7. WRONG SIDE, NOT PASSING
8. WRONG WAY ON ONE WAY ROAD
9. MISSING DATA

THE ABOVE CODES ARE FOR VIOLATIONS COMMITTED BY DRIVERS OF MOTOR VEHICLES.

IF THE CASE TRAFFIC UNIT IS A PEDESTRIAN, THIS VARIABLE DESCRIBES THE PEDESTRIAN'S ACTION, AND THE CODES HAVE THE FOLLOWING MEANINGS:

1. CROSSING OR ENTERING ROADWAY
2. GETTING ON OR OFF VEHICLE
3. WALKING IN ROADWAY - WITH TRAFFIC
4. WALKING IN ROADWAY - AGAINST TRAFFIC
5. HITCH-HIKING OR STANDING IN ROADWAY
6. PUSHING OR WORKING ON VEHICLE
7. OTHER WORKING OR PLAYING IN ROADWAY
8. NOT IN ROADWAY
9. MISSING DATA

DRIVER VIOLATION #2

0. NO FACTOR IN THIS VARIABLE APPLIES
1. FOLLOWING TOO CLOSELY
2. IMPROPER PASSING
3. NO SIGNAL OR WRONG SIGNAL OF INTENT
4. IMPROPER START FROM PARKED POSITION
5. FAIL TO YIELD RIGHT OF WAY TO PEDESTRIAN
6. IMPROPER PARKING
7. UNDER INFLUENCE OF ALCOHOL
8. UNDER INFLUENCE OF DRUGS
9. OTHER FACTOR OF MISSING DATA

THE ABOVE CODES ARE FOR VIOLATIONS COMMITTED BY DRIVERS OF MOTOR VEHICLES.

IF THE CASE TRAFFIC UNIT IS A PEDESTRIAN, THE CODES HAVE THE FOLLOWING MEANINGS:

1. PEDESTRIAN DRINKING
2. PEDESTRIAN NOT DRINKING
3. UNKNOWN IF PEDESTRIAN DRINKING
9. MISSING DATA

FIGURE A.4. TEXAS ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

The data for each driver included one selection of Violation #1 and one from Violation #2. It can be seen that only code value (7) under Driver Violation #2 addressed the question of drinking and this is in itself a most extreme subset of a general question of alcohol involvement.

Texas data also included a variable which appeared to present the possibility of a better measure of drinking involvement, "Driver Impairment". As seen in Figure A.5, however, the impairment variable includes no valid code regarding alcohol involvement.

DRIVER IMPAIRMENT

1. EYESIGHT DEFECTIVE
2. HEARING DEFECTIVE
3. LIMBS MISSING
4. OTHER PHYSICAL IMPAIRMENT
5. ILL
6. FATIGUED OR ASLEEP
7. MENTALLY ABNORMAL
8. OTHER HANDICAP
9. MISSING DATA

THE ABOVE CODES ARE FOR IMPAIRMENT OF DRIVERS OF MOTOR VEHICLES.

FIGURE A.5. TEXAS DRIVER IMPAIRMENT CODES

It is interesting to note that valid codes in Texas for impairment, such as fatigue, were valid options to alcohol involvement in data from other states.

A.6 PENNSYLVANIA

The Police Accident Report form in Pennsylvania contained no forced response to drinking-involvement questions. Pennsylvania data included alcohol-involvement information under a general category "Causes Attributed to Driver Condition" which was itself a subset of "Contributing Conditions". Indication of drinking by a driver was the result of a content analysis of the "Narrative" and "Violations Indicated" sections of the official accident report form. From inspection of information recorded on the forms, valid codes regarding alcohol involvement were entered into the final accident file. Figure A.6 shows the valid codes under "Causes attributed to driver condition" in Pennsylvania.

Causes attributed to driver condition

50................Drowsiness, asleep
51................Under effects of alcohol, drunk, offending driver (Use only if charged)
52................Poor eyesight, or no glasses when needed
53................Physical disability
54................Illness, stroke, heart attack, etc.
55................Other, Inexperience, driver error
96................Effects of drugs, under the influence
26................Under effects of alcohol, drunk, Involved driver (Only if charged)
27................Drinking indicated, offending driver (not charged)
29................Drinking indicated, involved driver (not charged)

FIGURE A.6. PENNSYLVANIA ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

Again, the format includes a mixed-bag of violations, physical impairments or driver negligence. Low frequencies of valid codes (51), (26), (27), or (29) in the Pennsylvania data suggested that little attention was directed toward the possibility of alcohol involvement during the study period. The notorious difficulty police are faced with in getting a conviction, once charges of driving while intoxicated are made, suggests that investigating officers in Pennsylvania tend to document other contributing causes less problematic than alcohol involvement.

A.7 LOUISIANA

The Louisiana official accident report form included a forced response category of "had been drinking" under a section entitled "Condition of Drivers and Pedestrians". Only one of eleven valid codes was possible, however, and the alternatives included categories of both negligence and physical handicaps. The Louisiana form is shown in Figure A.7 and is much like forms in Pennsylvania and Maine, considering the valid codes which are options to alcohol involvement. Unlike Texas and Vermont, documentation of drinking by an involved driver or pedestrian did not imply, necessarily, that a violation had been commited.

	Driver 1	Driver 2	Pedestrian	
A	☐	☐	☐	Apparently asleep
B	☐	☐	☐	Inattentive or distracted
C	☐	☐	☐	Illiness
D	☐	☐	☐	Eyesight defect
E	☐	☐	☐	Fainting, blackout, etc.
F	☐	☐	☐	Hearing defect
G	☐	☐	☐	Fatigue
H	☐	☐	☐	Other body defects
I	☐	☐	☐	Had been drinking
J	☐	☐	☐	Condition unknown
K	☐	☐	☐	Normal

FIGURE A.7. LOUISIANA ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

A.8 NEW YORK

In New York there appeared to be a discrepancy between the valid code for alcohol involvement in a crash and the definition of such involvement in the official report form. On the form the question was specifically addressed under the section "Apparent Condition of Driver" which was identical for all involved drivers. The valid codes on the form, as shown in Figure A.8 included: "Normal, Ill, Physical Defect, Fell Asleep and Had Been Drinking".

Motorist Ident.No. Exactly as Printed on License

Date of
Birth: Mo._____ Day_____ Year_____ Sex: ☐ Male ☐ Female

State of License ☐ New York Give State if Other__________

☐ Unlicensed ☐ N.Y. Learner's Permit ☐ N.Y. Interim Permit

Apparent Condition of Driver

☐ Normal ☐ Ill ☐ Physical Defect ☐ Fell Asleep ☐ Had Been Drinking

Describe Damage to Vehicle

Estimated Cost of Repairs

Plate No.	State of Registration	Expiration Month	Year

FIGURE A.8. NEW YORK ALCOHOL INVOLVEMENT - OFFICIAL OPERATIONAL FORMAT

In the digitally coded accident data received from the New York Department of Transportation, however, alcohol involvement was recorded as either "Drinking Involved" and/or "Apparently Intoxicated" along with ten optional codes under a categorical variable entitled "Special Condition Involved" - of which only one selection was valid. The format of New York data on this question, Figure A.9, demonstrated lack of specificity in these data regarding alcohol involvement in a crash. Questions of comprehensiveness of reporting alcohol involvement and validity of documentation were obvious.

SPECIAL CONDITION INVOLVED - (1 space)

Code special conditions as follows:

1 = Drinking involved, appeared intoxicated
2 = Physical defect involved
3 = Apparent illness involved
4 = Falling asleep involved
5 = Apparent vehicle defects involved
6 = Apparent road defects (holes, ruts, road gives way, etc.)
7 = Blinded by headlights
8 = Inattention to driving
9 = Improper pedestrian action
10 = No special condition involved
11 = Hit & Run

FIGURE A.9. CODED "SPECIAL CONDITIONS" NEW YORK STATE ACCIDENT DATA

APPENDIX B

EMPIRICAL DEVELOPMENT OF A SURROGATE MEASURE OF ALCOHOL-INVOLVEMENT IN OFFICIAL ACCIDENT DATA

EMPIRICAL DEVELOPMENT OF A SURROGATE MEASURE OF ALCOHOL-INVOLVEMENT IN OFFICIAL ACCIDENT DATA

Appendix A presented a detailed discussion of the operational forms of the reported alcohol-involvement variables in each of the seven states that are included in the present research. It has been argued that operational non-comparability of the alcohol-involvement measures between states, and in two states, non-comparability over time, prevents meaningful comparative time-series analyses. In order to overcome the shortcomings of reported alcohol-involvement in the official state accident files available for analyses, a multivariate analysis strategy was employed to develop an alternative measure. This discussion describes the empirical development of a surrogate measure of alcohol-involvement. The surrogate has been found to be applicable to both young and old drivers with equal reliability over time and between eleven jurisdictions in the quasi-experimental design. The validity of the empirical surrogate is discussed on the basis of several independent studies of the role of alcohol in accident causation.

The purpose of the analytic strategy was to determine sets of independent variables from accident investigation forms which interactively provide the best predictions of alcohol-involvement. A computer algorithm known as AID (Automatic Interaction Detector)[54] was used for this purpose. The AID analysis algorithm involves the successive segregation of sample sub-groups through the stepwise application

[54] Sonquist, J.A. and Morgan, J.N. The Detection of Interaction Effects-A Report on a Computer Program for the Selection of Optimal Combinations of Explanatory Variables. Monograph #35. Survey Research Center, Institute for Social Research, The University of Michigan, 1964, p.1.

of one-way analysis of variance techniques.[55] The program is most useful in studying the interrelationships among a set of up to 37 independent variables. One variable is selected as a dependent variable and the program examines all non-symmetrical binary splits based upon all values of each independent measure.[56] Linearity and additivity assumptions inherent in conventional multiple regression techniques are not required. The result of the AID analysis is the identification of the subgroup which maximizes one's ability to predict values of the dependent variable.

Alcohol-involvement, as reported in two analytic files, was selected as the best available dependent variable for the purposes of the present analysis. The "had been drinking" question in the Oakland County, Michigan, 1972 file was selected because previous experience with police enforcement activities in Oakland County provided a level of confidence in the consistency of reporting practices. In addition, the operational form of the variable in Oakland County in 1972 was a forced-response question in which the investigating officer was required to attend to the question and check "had been drinking" or "had not been drinking" for each driver involved in a given crash. Missing data were present in cases where the investigating officer omitted the question altogether, however missing data in Oakland County, 1972, represented only 9.6% of over 22,000 driver involvements. Texas statewide data for 1970 were selected as a comparison population because the violation-related meaning of the alcohol-involvement variable in the 5% Texas file was considered to be a conservative measure which would

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[55] Sonquist, J.A. Multivariate Model Building - The Validation of a Search Strategy. Survey Research Center, Institute for Social Research, The University of Michigan, 1970, p.vii.

[56] Selected "best" splits represents the two-way binary division of the independent variable which maximizes the explained sums of squares of variability in the dependent variable.

be reasonably reliable and valid. Texas data were chosen also because of the geographic and social differences between southeastern Michigan and Texas. The reasoning behind this jurisdiction selection was that if multivariate models of alcohol-involvement derived from these remote jurisdictions were similar, or identical, there would be more confidence in the generalizability of the model produced.

AID analyses were replicated for 18- to 20-year-old drivers and 21- to 45-year-old drivers in Texas and Oakland County, Michigan. Reported alcohol-involvement was taken as a binomial dependent variable and the program divided the data into successive binary splits, by all possible combinations of measurement levels, for all independent variables. All possible binary splits were analysed for each independent variable, and the split which accounted for the widest variation on the dependent variable was plotted as the first predicting split. The procedure was replicated for each resulting subgroup which generated further binary divisions. The resulting diagram presented interactive relationships among the independent variables, for various combinations of levels of measurement, and the order of prediction importance.

Independent variables were selected that were considered to be relatively free of judgmental variation (error) on the part of the accident investigator. Pre-crash movements (apparent), violations codes such as speeding, reckless driving, etc., were not included in the analyses as independent variables because these measures are open to challenge as being subjective. Therefore, objectively measured variables were chosen that would provide a prediction model of consistent meaning and reliability. The following independent variables were included in AID analyses of Texas 1970 and Oakland County, Michigan, 1972 data.

Day of Week:

Sunday-Saturday

Hour of Day:

6AM-9AM
9AM-11:59AM
Noon-2:59AM
3PM-5:59PM

Accident Type:

Rollover
Went off road
Crossed road
Hit another vehicle
Hit fixed object
Hit non-vehicular moving object
Other

Accident Severity:

Fatal
Injury
Property damage

Number of Moving Vehicles:

1-4

Investigation Agency:

State police
City police
Township police or constable
Other (military, etc.)

Population of Area in Which Crash Occurred:

Township or rural
Less than 1,000
1,000-2,500
2,500-5,000
5,000-10,000
10,000-25,000
25,000-50,000
50,000-100,000
100,000-250,000
Missing data

Driver Age:

18-20
21-45

Driver Sex:

Male
Female

Model Year of Vehicle:

Before 1964
1964-66
1967-68
1969-70
More recent

In the execution of the AID analyses, subgroup minimum size was set at n=20 and statistical significance for binary divisions was established at $p \geq .01$. More liberal limits on the analytic procedure would have extended the number of subgroup divisions with little predictive improvement.

Inspection of Figures B.1 and B.2 indicates that, if one begins with the base group where a proportion of the population had been drinking, and follows the uppermost path,

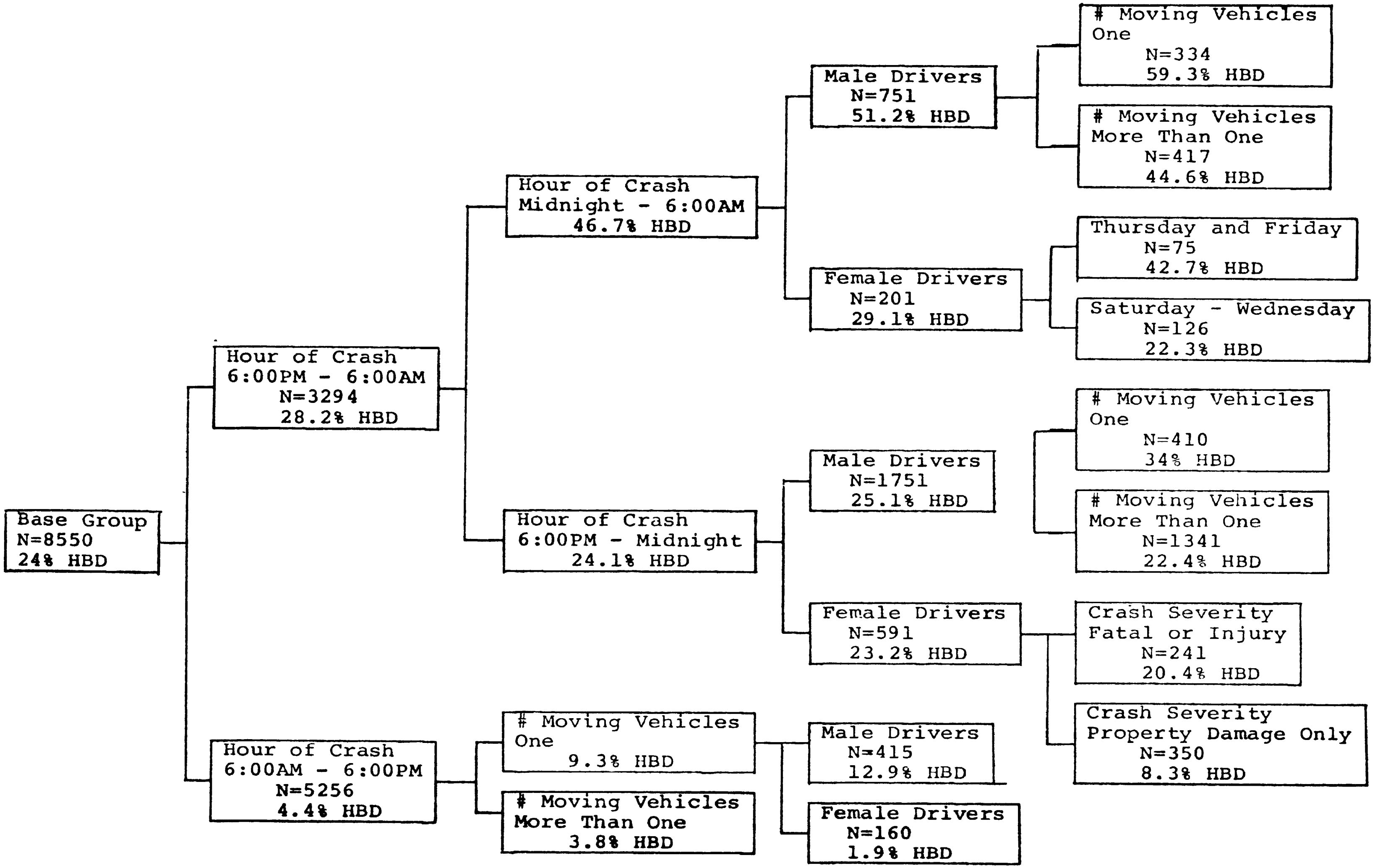

FIGURE B.1. AID ANALYSIS OF OAKLAND COUNTY, MICHIGAN 18-20 YEAR-OLD DRIVERS "HAD BEEN DRINKING" (HBD) AS DEPENDENT VARIABLE, 1972 DATA

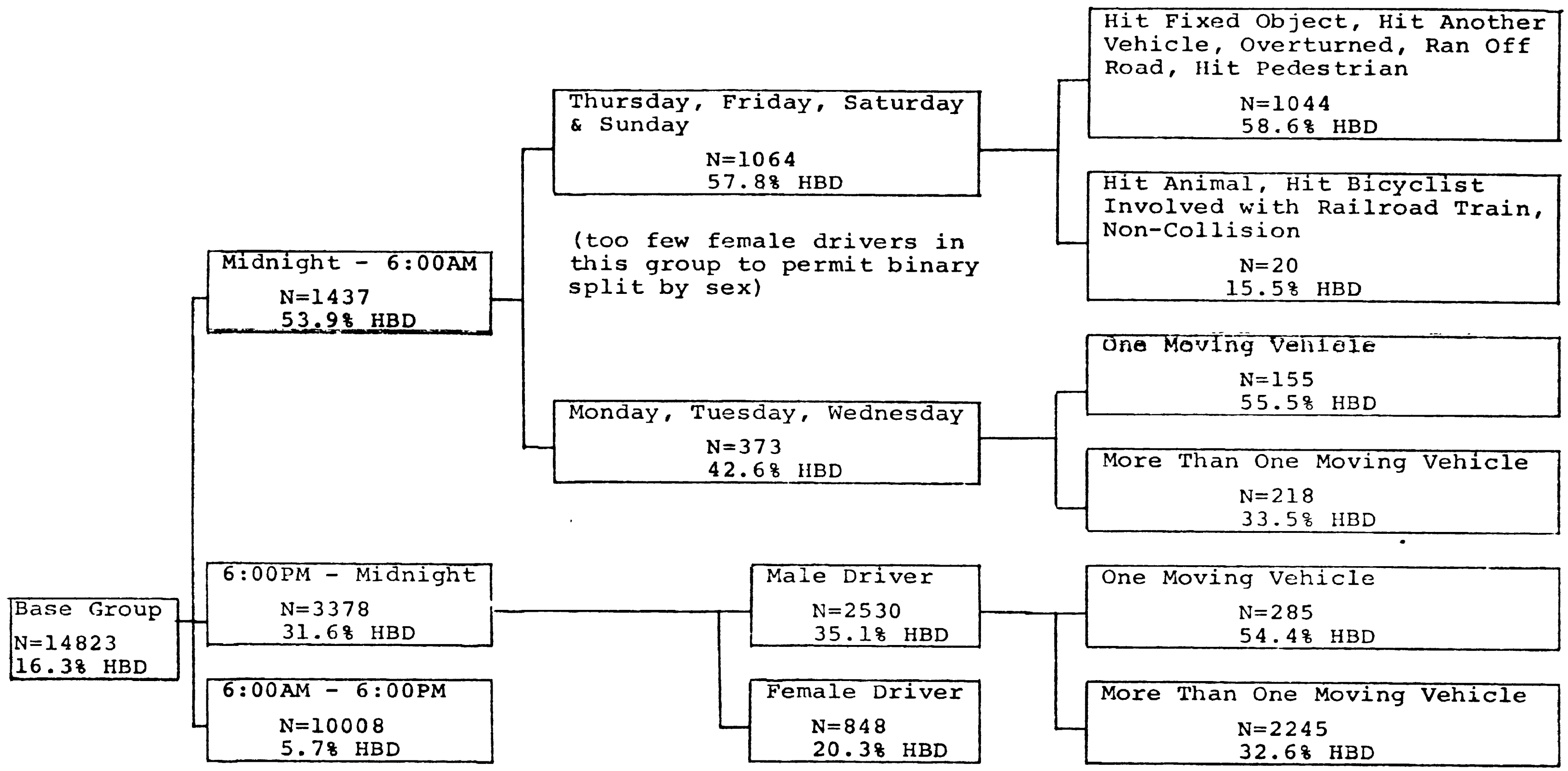

FIGURE B.2. AID ANALYSIS OF OAKLAND COUNTY, MICHIGAN 21-45 YEAR-OLD DRIVERS "HAD BEEN DRINKING" (HBD) AS DEPENDENT VARIABLE, 1972 DATA the final cell is the "worst case" in terms of proportion with drinking involved. Similarly, if the lower paths are followed from the base group, the "best paths" can be identified.

Figures B.3 and B.4 presents the worst paths for a number of AID analyses for Oakland County, Michigan 1972 and the state of Texas, 1970. Separate analyses were performed for age subgroups (18-20 year old drivers, 16-20 year old drivers, 21-45 year old drivers).

Inspection of Figures B.3 and B.4 reveals several interesting points. The most striking outcome is the consistency of the Hour of Day factor as the most important single prediction of alcohol-involved crashes. The dark hours of the night defined either as 9:00PM-6:00AM, 9:00PM-4:00AM or Midnight to 6:00AM always enter the worst paths first. In Oakland County, Michigan this factor alone doubles the proportion of drivers who had been drinking in the base group. Similarly in the Texas analyses the base group proportion is greatly increased with only one factor in the model - time of the crash.

The second most striking outcome of these analyses is the discrepancy between Texas and Oakland County of the proportion of HBD drivers in the base groups. In Oakland County between 16.3% and 24.0% of all drivers had been drinking while in Texas the range of percent HBD is just 5.9-8.5%. This is more likely to be an artifact of the reporting of alcohol-involvement rather than a substantive difference between Texas and Oakland County crash-involved driving populations. Perhaps the Texas investigators have a priori notions concerning where, when and under what circumstances a driver is likely to have been drinking to levels of intoxication. If so, then these a priori notions appear to be quite valid. This would suggest that Texas investigators selectively pursue evidence of drinking with violation

16-20 Year Old Drivers

Base Group	Factor: Hour of Day	Factor: Driver Sex	Factor: Accident Severity
N=13,789 22.9% HBD*	Midnight-6:00AM N=1282 44.2% HBD	Male N=1022 46.5% HBD	Fatal or Injury Producing N=461 66.6% HBD

18-20 Year Old Drivers

Base Group	Factor: Hour of Day	Factor: Driver Sex	Factor: Number of Moving Vehicles
N=8550 24.0% HBD	Midnight-6:00AM N=952 46.7% HBD	Male N=751 51.2% HBD	One 59.3% HBD

21-45 Year Old Drivers

Base Group**	Factor: Hour of Day	Factor: Day of Week	Factor: Accident Type
N=14823 16.3% HBD	Midnight-6:00AM N=1437 53.9% HBD	Thursday Sunday N=1064 57.9% HBD	Hit: Fixed Object, Another Moving Vehicle, Parked Vehicle, Overturned, Ran-off Roadway, Hit a Pedestrian N=1044 58.6% HBD

(too few female drivers in this group to permit binary split by sex)

*Had Been Drinking
**Odd ages (21,23,...,45)

FIGURE B.3. OAKLAND COUNTY, MICHIGAN 1972 DATA

18-20 Year Old Drivers

Base Group
N=4047
5.9% HBD*

Factor: Hour of Day
9:00PM-6:00AM
N=667
22.8% HBD

Factor: Investigation
Texas Department of Public Safety
N=201
34.8% HBD

Factor: Accident Type
Hit a Pedestrian, Parked Car or a Fixed Object
N=179
66.7% HBD

(too few female drivers in this group to permit binary split by sex)

21-45 Year Old Drivers

Base Group**
N=8617
8.5% HBD

Factor: Hour of Day
9:00PM-4:00AM
N=1125
31.1% HBD

Factor: Accident Type
Hit: Pedestrian, Parked or Moving Vehicle, Fixed Object, Ran-off Road or Overturned in Roadway
N=360
55.6% HBD

Factor: Investigation
Texas Department of Public Safety & City Police Departments
N=333
58.6% HBD

Factor: Driver Sex
Male
N=297
61.3% HBD

*Had Been Drinking
**Odd ages (21,23,...,45)

FIGURE B.4. TEXAS 1970 DATA

charges in mind while Oakland County investigators address the possibility of a wider range of alcohol-involvement. The discrepancies between Texas and Oakland County base group proportions are eliminated as the multivariate model unfolds.

Throughout these analyses the consistency of specific types of accidents (ran-off-roadway, hit fixed object, single vehicle involvement, etc.) and involvement of male rather than female drivers is noteworthy.

From the AID analyses three factors were identified that consistently enter into prediction models for alcohol-related crashes - time of crash, sex of driver, number of moving vehicles. Taking these three independent variables factors and subsetting total crash populations to isolate crashes which occurred between 9:00PM-6:00AM, with Male Drivers involving a Single Moving Vehicle, the proportion of alcohol-involvement is consistently about 53-63%, between jurisdictions and age groups. Consistency is achieved regardless of the initial proportion of the total crash population which is reputed to be alcohol-involved, and which is believed to be highly influenced by administrative and operational variations between jurisdictions.

The three-factor surrogate as developed above is compatible with a large body of knowledge regarding the interaction of drinking and driving. O'Day[57,58] also using AID analyses, demonstrated the importance of the dark hours of

[57] O'Day, J. "Characteristics of Alcohol Involvement in Michigan Fatalities 1966-1969". HIT LAB Reports. Highway Safety Research Institute, The University of Michigan, October 1970, pp.4-8.

[58] O'Day, J., op.cit., 1970, pp.13-14.

the night in predictions of fatal accidents in Michigan between 1966 and 1969. Clark, et al.[59,60] reported that time of night was the single most consistent predictor of high blood alcohol concentrations (BAC) in a three-year replication of roadside BAC surveys in Washtenaw County, Michigan. Filkins, et al.[61] similarly demonstrated that among Wayne County, Michigan fatalities, the drivers who were killed during the night were most likely to have been drinking. Zylman has reported that, "...nighttime crashes, single vehicle crashes, and crashes involving drivers between 20 and 60 years old are more likely to involve alcohol than multivehicle crashes that occur in the daytime and involve drivers who are under 20 or more than 60 years old".[62] Here, time of night, number of involved vehicles, and driver age are used, in much the same way as the present AID analyses would suggest. It is quite true that 20- to 60-year-old drivers are more likely to have high BACs than younger drivers, however it is also true that lower BACs can contribute to accident involvement among younger drivers than among older

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[59] Clark, C.D., Compton, M.J., Douglass, R.L. and Filkins, L.D. _op.cit._, 1973, pp.8-11.

[60] Clark, C.D., Compton, M.J., Douglas, R.L. and Filkins, L.D. "A Three Year Comparison of Alcohol-Related Driving Behavior in Washtenaw County, Michigan." _HIT LAB Reports_. Highway Safety Research Institute, The University of Michigan, October 1973, pp.1-14.

[61] Filkins, L.D., Clark, C.D., Rosenblatt, C.A., Carlson, W.L., Kerlan, M.W. and Manson, H. _Alcohol Abuse and Traffic Safety: A Study of Fatalities, DWI Offenders, Alcoholics, and Court-Related Treatment Approaches_. Final Report. Highway Safety Research Institute, The University of Michigan, Ann Arbor, June 1970, p.257.

[62] Zylman, R. "Overemphasis on Alcohol May Be Costing Lives." _The Police Chief_, Vol. 41, No. 1, January 1974, p.66.

ones. The present AID analyses do not discriminate significantly between the 18-20 and 21-45 age groups in terms of the proportion which had been drinking after the same three factors are interpreted interactively. The present three-factor-surrogate is considered to be valid and reliable for all jurisdictions in the quasi-experimental design and for both young and old drivers.

APPENDIX C

ANALYSIS OF DATA AS A TIME-SERIES QUASI-EXPERIMENT

ANALYSIS OF DATA AS A TIME-SERIES QUASI-EXPERIMENT

The purpose of the analysis is to determine if, within the framework of the quasi-experimental design, a measurable and statistically significant change in the level of alcohol-related crashes occurred among newly enfranchised drinking populations. In that it is possible to only approximate an experimental situation, it is necessary to impose certain statistical models on the time-series data which will effect additional controls for extraneous rival hypotheses. This section is concerned with the problem of measuring a change in level of the time-series accident data and making statistical inferences regarding such changes.

The statistical model upon which the analysis is based was developed by Box and Tiao (1965). Box and Tiao presented an analytic technique for estimating and making inferences about a change in level of non-stationary time-series measurements. The model upon which the analysis is based is restrictive; however, by decomposing the data according to an additive general model of time-series data and by transforming data into indices the assumptions of the model can be largely met.

Glass (1968), Glass, Tiao and Maguire (1971) and Maguire and Glass (1967) have described the application of the principle technique first developed by Box and Tiao to empirical settings. The model these authors employed was a special case of the integrated moving average process:

$$Z_t = L + \gamma \sum_{j=1}^{t-1} a_{t-j} + a_t, \qquad t=1,\ldots,n. \tag{1}$$

where:

- L is a location parameter which is descriptive of the overall general level of the series,
- γ is a parameter which depends upon the inter-dependency of the observations in the series,
- a_t is an observation of a random normal variable with mean 0 and variance σ^2.

Formula (1) described the n_1 observations taken prior to the introduction of a treatment, e.g., the lower legal drinking age. The n_2 observations following the introduction of the treatment differ from (1) only in that a treatment effect, δ, is present.

$$Z_t = L + \gamma \sum_{j=1}^{t-1} a_{t-j} + a_t + \delta, \qquad t=n_2,\ldots,n_1+n_2. \tag{2}$$

The parameter δ is the increment or decrement in the level of the time-series due to the introduction of the treatment. The treatment, under this model, is assumed to work an immediate and constant effect, δ, upon the time-series.

As applied, for instance to the Connecticut crackdown on speeding in 1955, the treatment parameter was instantly imposed upon the entire driving population of that state. Further, the investigators were able to obtain $n_1=60$ monthly measures prior to the treatment's introduction and $n_2=48$ monthly measures after the legal change.[63]

Inferences based on the model described assume an exponential weighting of the observations in n_1 and n_2 series most proximal to the treatment point. Observations more removed from the treatment point are assigned lesser importance and influence in the analysis.

In the present investigation of the effect on highway safety of lower legal drinking age, two characteristics of the legal change and the availability of data to us do not permit a valid application of the Box and Tiao technique as utilized by earlier legal impact investigators. The lower legal drinking age, rather than defining a more restrictive acceptable behavior as in the crackdown on speeding, permits a population to purchase and consume alcoholic beverages (legally) for the first time. Conceptually, the difference between more restrictive and a more permissive legal change suggests that, with consideration to social norms regarding both police enforcement and drinking practices, more immediate compliance is likely to result among a population faced with a restrictive and enforced legal change than a more permissive change. A stepwise chain of events and learning curves logically preceded the effect of a permissive legal change on crash involvement. It seems reasonable that young people needed to: 1) learn about the legal change, 2) to decide to take advantage of the new legal right to purchase alcoholic beverages, 3) to, in many cases learn to drink or change existing drinking patterns, and then, 4) to drive after drinking more often and after more drinking

[63]Glass, op.cit., 1968, p.60.

before the lower legal age will have a measurable effect on the highway environment. The relationship of the legal change of age of majority legislation on highway safety is much more complex and less direct than a legal crackdown on a particular aspect of driving behavior.

A second problem associated with the assumption of an immediate general effect of the legal change being investigated is that, unlike the Connecticut crackdown the entire population of new legal drinkers is not affected immediately. Not only do young people need to pass through a series of learning curves, decision making and behavioral changes before the highway environment is affected, but also the distribution of birth dates throughout the year tends to graduate young people into the enfranchised population over an annual cycle. It was necessary to measure the impact of the lower legal drinking age not as an immediate effect, but rather as a gradual impact over the full n_2 time period following the new laws.

A more pragmatic difficulty is that the legal impact of this study is recent and a maximum of only n_2=19 monthly measures were available for analysis. The short duration of the n_2 period (most often 12 months) suggests that measurements of the last observation in the n_2 series are at least as important as the first n_2 measurement. Indeed, if learning curves have as great an influence on young drivers' behavior as the fact of a new law, then equalizing the value of short duration post-series observations is mandatory, rather than exponentially weighting the observations most proximal to the impact point of intervention.

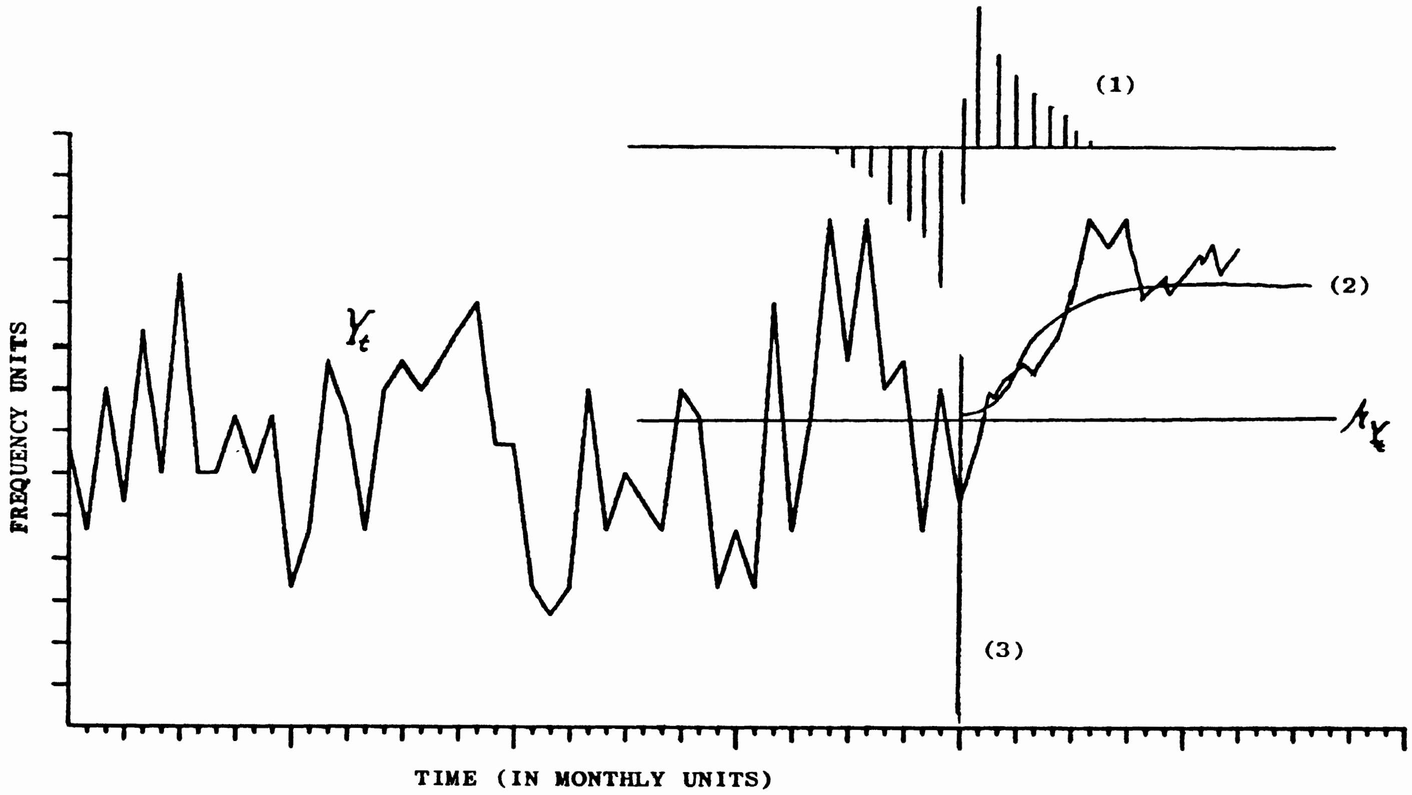

FIGURE C.1. HYPOTHETICAL TIME-SERIES OF ALCOHOL-RELATED CRASH FREQUENCIES WITH EXPONENTIAL WEIGHTING FUNCTION AND ONE-YEAR LEARNING CURVE SUPERIMPOSED ON Y_t

Figure C.1 illustrates the difficulty presented when an impact confounded by learning curves is investigated with an integrated moving average model such as the Box Tiao model used by Glass; a measurable effect could be masked by the exponential weighting functions. In the figure:

(1) Are exponential weighting functions with exponential decay associated with distance from the impact point,

(2) A hypothetical learning curve reaching peak at the end of 12 months,

(y_t) A superimposed time-series of crash data,

(3) Point of intervention.

In order to avoid the problems identified with the appropriateness of the integrated moving average model an alternative autoregressive model which Box and Tiao presented was adopted. Given adequate pre and post time periods, the integrated moving average model is superior to an autoregressive one in terms of limiting causal inferences to the "treatment". The data available in the present study, however, invalidate the use of an integrated moving average model. Valuable time points of the after series would be lost and quite possibly invalid inferences would be made.

Development of the test statistic $t\hat{\delta}$ is as follows. On the assumption that the series is generated by a first order autoregressive process which starts at t=1, then:

$$z_1 = L + \alpha_1, \tag{3}$$

$$z_p = L + \rho \sum_{j=1}^{p-1} \rho^{j-1}\alpha_{p-j} + \alpha_\rho \qquad (p=2,\ldots,n_1) \tag{4}$$

and

$$z_p = L + \delta + \rho \sum_{j=1}^{p-1} \rho^{j-1}\alpha_{p-j} + \alpha_p \qquad (p=n_1+1,\ldots,n_1+n_2) \tag{5}$$

with $|\rho|<1$
instead of:

$$z_1 = L + \alpha_1, \tag{6}$$

$$z_p = L + \gamma_0 \sum_{j=1}^{p-1} \alpha_{p-j} + \alpha_p \tag{7}$$

$$= \gamma_0 \sum_{j=0}^{p-2} (1-\gamma_0)^j z_{p-1-j} + (1-\gamma_0)^{p-1} L + \alpha_p$$

$$(p=2,\dots,n_1) \tag{8}$$

$$z_p = L + \delta + \gamma_0 \sum_{j=1}^{p-1} \alpha_{p-j} + \alpha_p \tag{9}$$

$$= \gamma_0 \sum_{j=1}^{p-2} (1-\gamma_0)^j z_{p-1-j} + (1-\gamma_0)^{p-1} L$$

$$+ (1-\gamma_0)^{p-(n_1+1)} \delta + \alpha_p \qquad (p=n_1+1,\dots,n_1+n_2) \tag{10}$$

as in the integrated moving average model.[64]

The γ_0 terms are absent in the autoregressive model. According to Box and Tiao, L may be regarded as the mean and δ the shift in mean associated with the treatment variable, the lower legal drinking age. For any specific value of the autoregressive coefficient ρ, $(\rho=\rho_0)$ the transformation

[64] Box and Tiao, op.cit., 1965, pp.182-3,187.

$$y_1 = z_1 \tag{11}$$

$$y_p = z_p - \rho_0 z_{p-1} \tag{12}$$

can be written and the linear model becomes

$$y = X\theta + \varepsilon \tag{13}$$

where

$$Y = \begin{vmatrix} y_1 \\ \vdots \\ y_{n_1} \\ \hline \vdots \\ y_{n_1+n_2} \end{vmatrix} \quad ; \qquad X = \left| \begin{array}{cc} 1 & 0 \\ (1-\rho_0) & \\ \vdots & \vdots \\ (1-\rho_0) & 0 \\ \hline (1-\rho_0) & 1 \\ & (1-\rho_0) \\ \vdots & \vdots \\ (1-\rho_0) & (1-\rho_0) \end{array} \right| ; \ \theta = \binom{L}{\delta}$$

and ε is the Nx1 vector of random normal deviates with common variance σ^2.

The authors stated that:

$$(x'x)^{-1} = c \begin{bmatrix} 1+(n_2-1)(1-\rho_0)^2 & -(1-\rho_0)-(n_2-1)(1-\rho_0)^2 \\ -(1-\rho_0)-(n_2-1)(1-\rho_0)^2 & 1+(N-1)(1-\rho_0)^2 \end{bmatrix}, \tag{14}$$

$$c^{-1} = n_1(n_2-1)(1-\rho_0)^4 - 2(n_2-1)(1-\rho_0)^3 + (n_1+2n_2-3)(1-\rho_0)^2 + 1 \tag{15}$$

In terms of the z's, the estimates $(\hat{L},\hat{\delta})$, required for practical application, are given by:

$$\hat{L} = \frac{1}{1 + (N-1)(1-\rho_0)^2}\{(1-\rho_0)^2 \sum_{i-1}^{N-1} z_i + \rho_0 z_1$$

$$+ (1-\rho_0) z_N - [(1-\rho_0) + (n_2-1)(1-\rho_0)^2]\hat{\delta}\} \tag{16}$$

$$\hat{\delta} = g_1(z_{n_1+1},\ldots,z_{n_1+n_2};\rho_0) - g_2(z_1,\ldots,z_{n_1};\rho_0), \tag{17}$$

where

$$g_1(z_{n_1+1},\ldots,z_{n_1+n_2};\rho_0) = c[a_1 z_{n_{1+1}} + a_2 \sum_{i=n_2+2}^{N} z_i$$

$$+ a_3 z_{n_1+n_2}], \tag{18}$$

$$g_2(z_1,\ldots,z_{n_1};\rho_0) = c[b_1 z_1 + b_2 \sum_{i=2}^{n_1-1} z_i + b_3 z_{n_1}] \tag{19}$$

with

$$a_1 = n_1(1-\rho_0)^4 - N(1-\rho_0)^3 + N(1-\rho_0)^2 + \rho_0,$$

$$a_2 = (1-\rho_0)^2[n_1(1-\rho_0)^2 + \rho_0],$$

$$a_3 = (1-\rho_0)[n_1(1-\rho_0)^2 + \rho_0],$$

$$b_1 = (1-\rho_0)[(1-\rho_0)^2 + \rho_0]\ [n_2(1-\rho_0) + \rho_0],$$

$$b_2 = (1-\rho_0)^3[n_2(1-\rho_0) + \rho_0]$$

and

$$b_3 = (1-\rho_0)^2[n_2(1-\rho_0) + \rho_0] + \rho_0[1 + (N-2)(1-\rho_0)^2$$
$$- (n_2-1)(1-\rho_0)^3]. \qquad (20)$$

For a specific value, $\rho=\rho_0$, the sampling distribution of the quantity

$$\frac{(\hat{\delta}-\delta)}{\{s^2c[1-(N-1)(1-\rho_0)^2\}^{1/2}} \qquad (21)$$

is the student t distribution with (n_1+n_2-2) degrees of freedom with

$$s^2 = \frac{1}{n_1+n_2-2}\{(z_1-\hat{L})^2 + \sum_{i=2}^{n_1}[z_i-\rho_0 z_{i-1} - \hat{L}(1-\rho_0)]^2$$
$$+ [z_{n_1+1} - \rho_0 z_{n_1} - \hat{L}(1-\rho_0) - \hat{\delta}]^2$$
$$+ \sum_{i=n_1+2}^{N}[z_i-\rho_0 z_{i-1} - (1-\rho_0)(\hat{L}+\hat{\delta})]^2\}. \qquad (22)$$

[65]

[65] Box and Tiao, op.cit., 1965, pp.187-8.

To apply this technique when ρ_0 is unknown, $\hat{\rho}$ has to be estimated from the data. Box and Jenkins provided the basis for the formula used in the present study.[66]

$$\hat{\rho} = \frac{\sum_{t=1}^{n-1} (z_t-\bar{z})(z_{t+1}-\bar{z})}{\sum_{t=1}^{n} (z_t-\bar{z})^2}, \tag{23}$$

where z_t is the observation at time t.

In the event that $\bar{z}$ is known to be zero, the estimate may be simplified to:

$$\hat{\rho} = \frac{\sum_{t=1}^{n-1} z_t z_{t+1}}{\sum_{t=1}^{n-1} z_t^2} . \tag{24}$$

The standard deviation of $\hat{\rho}$ is approximately

$$\hat{\sigma}^2_{\hat{\rho}} = \frac{(1-\hat{\rho}^2)}{n-1} \tag{25}$$

or,

$$\hat{\sigma}^2_{\hat{\rho}_1} = (n-1)^{-1}\left[1-\frac{\left(\sum_{t=1}^{n-1} z_t z_{t+1}\right)^2}{\left(\sum_{j=1}^{n-1} z_j^2\right)\left(\sum_{k=2}^{n-1} z_n^2\right)}\right] \tag{26}$$

(to terms of order less than 1/n).

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[66] G.E.P. Box and G.M. Jenkins. Time Series Analysis - Forecasting and Control. San Francisco: Holden-Day, pp.32-36, 1970.

Slight modifications which are often used include:

$$\hat{\rho}_1 = \frac{n}{n-1}\,\hat{\rho} \tag{27}$$

and

$$\hat{\rho}_2 = \frac{\sum_{t=1}^{n-1} z_t z_{t+1}}{\sum_{j=2}^{n-1} z_j^2}\ . \tag{28}$$

$\hat{\delta}$ is the difference between two weighted averages as given in its definition (Equation 2). The generally restrictive nature of the auto-regressive model is that the weight functions for the averages in the before and after series are uniform. The model is only acceptable if observations near the beginning and the end of the series should have as much weight in the estimation of $\hat{\delta}$ as those close to the impact event. Such is the case in the study of the lower legal drinking age, given the short-term data available and the lack of immediacy with which the new laws could have affected all potentially enfranchised new drinkers.

The Box and Tiao model is restrictive, also, in that a number of assumptions regarding the data are required.

(1) The series, before and after a treatment is introduced, is free of linear trend.

(2) The series is free of regular repeating cycles.

An additive model of time-series data can be stated, in the abstract as:

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

where

Y = the line

S = seasonal cyclic components

C = cyclic components other than seasonal

T = linear trend components

I = irregular components not explained by other components

In the crash data we acquired for analysis we have not been able to identify cyclic components other than those explained by seasonal variations. Therefore a lesser model was adopted such that:

$$Y = S + T + I$$

A simple transformation:

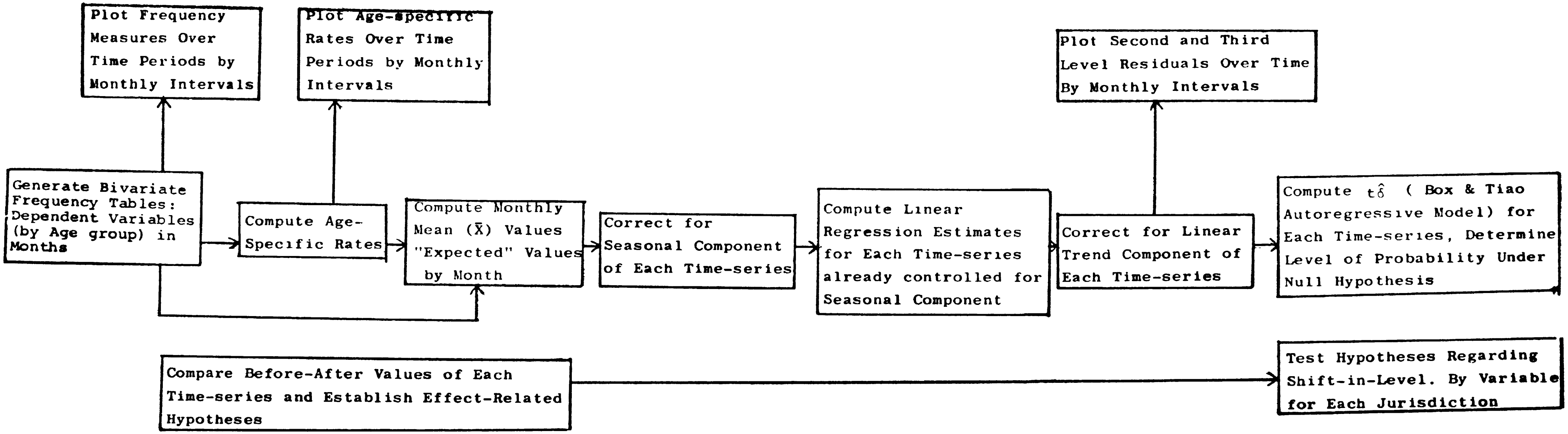
$$(Y-T) - S = I\ ,$$

demonstrates that if the series is decomposed and seasonal and and trend components are removed, irregulars, or residuals, are isolated which meet the assumptions of the Box and Tiao model. That is, in fact, what was done for each of several variables in each jurisdiction of our analysis.

Seasonal decomposition was accomplished by computing the mean value of any given dependent variable by monthly strata and then substracting the mean, expected, value from each monthly observation. The expected, cyclic, variation in each series was removed.

Data corrected for seasonal effect then were submitted to linear regression analysis. The least squares plot was computed and residuals about the line were saved. In this way the trend component of the series was removed. The residuals define the irregular component I in the general time-series model. Because both seasonal and trend components have been removed we call the resultant irregular data a second-order residual. The residuals were then segregated into n_1 pre-intervention observations and n_2 post-intervention observations and the test statistic $t\hat{\delta}$ was computed for each of eleven variables for each of eleven analytic jurisdictions.

The entire analysis process is presented in a flow-diagram in C.2.



$Y = S + T + I$ $\qquad$ $Y - S = T + I$ $\qquad$ $(Y - S) - T = I$

Components and Decomposition of Time-series Data:

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

FIGURE C.2. ANALYSIS FLOW CHART

APPENDIX D

TIME-SERIES FREQUENCY POLYGONS OF ELEVEN ANALYTIC VARIABLES IN WASHTENAW COUNTY, MICHIGAN 1968-1972

TIME-SERIES FREQUENCY POLYGONS OF ELEVEN ANALYTIC VARIABLES IN WASHTENAW COUNTY, MICHIGAN 1968-1972

The following plots demonstrate the effectiveness of the time-series decomposition techniques used in the present investigation regarding the control of linear trend and regular seasonal cycles. According to the general additive model

$$Y = T + S + I,$$

where:

Y = the time-series;

T = linear trend components;

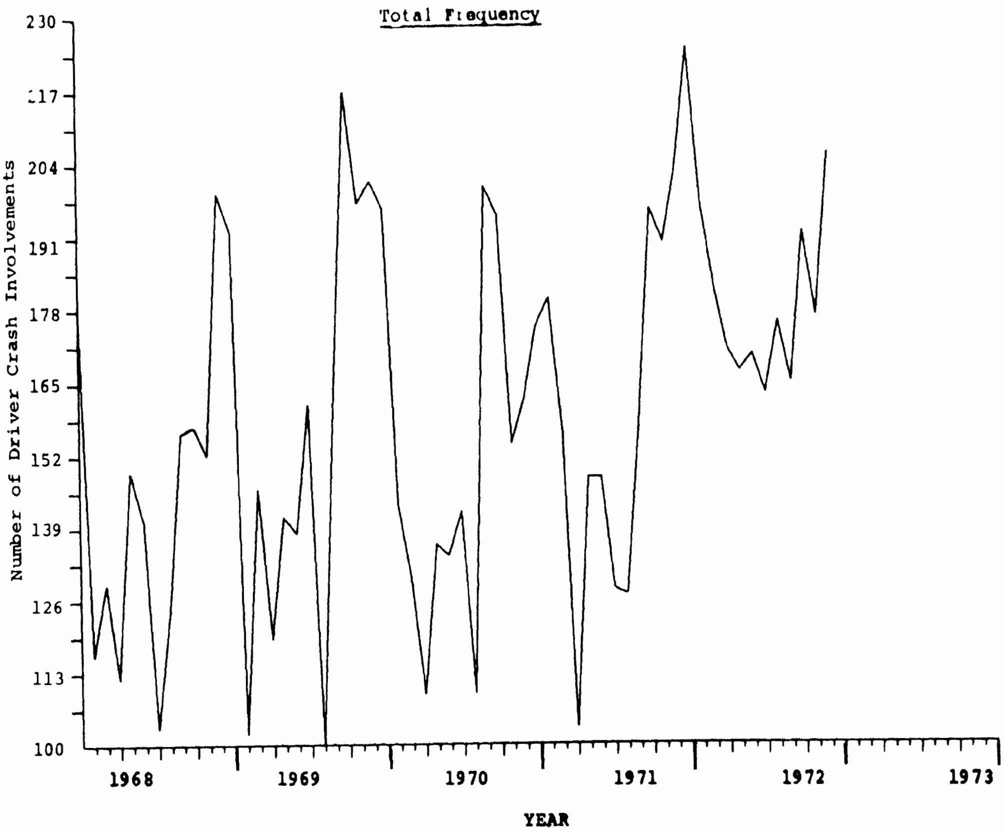
S = regular seasonal cyclic components; and

I = irregular components (residuals).

As discussed in Appendix C and in Section 2, the second level irregulars, residuals, are frequency data controlled for linear trend and seasonal cycles. Third level residuals are age-specific rates that are further controlled for linear trend, not otherwise associated with population change, and seasonal cycles.

The eleven analytic variables include:

Total 18-20 year old crash experience	(D.1)
Total 21-45 year old crash experience	(D.2)
18-20 year old HBD crash experience	(D.3)
21-45 year old HBD crash experience	(D.4)
18-20 year old three-factor-surrogate crash experience	(D.5)
21-45 year old three-factor-surrogate crash experience	(D.6)
Total crash experience, all ages	(D.7)
Total HBD crash experience, all ages	(D.8)
Total year old three-factor-surrogate crash experience, all ages	(D.9)
18-20 age-specific three-factor-surrogate rate	(D.10)
21-45 age-specific three-factor-surrogate rate	(D.11)



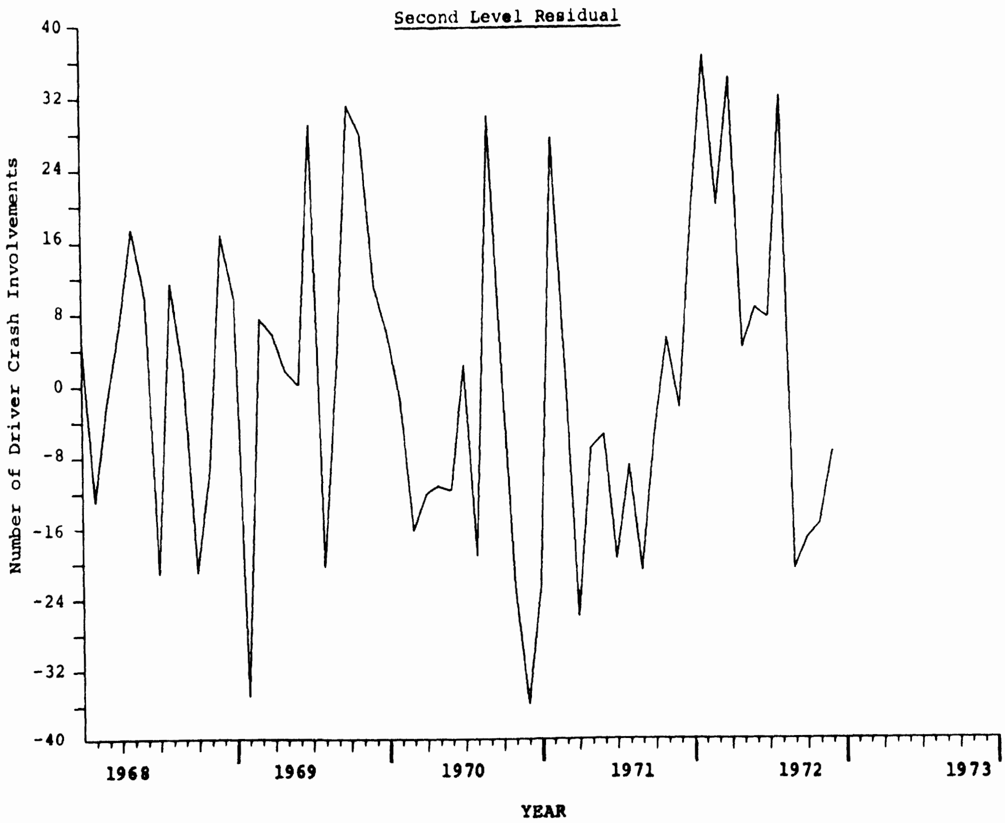
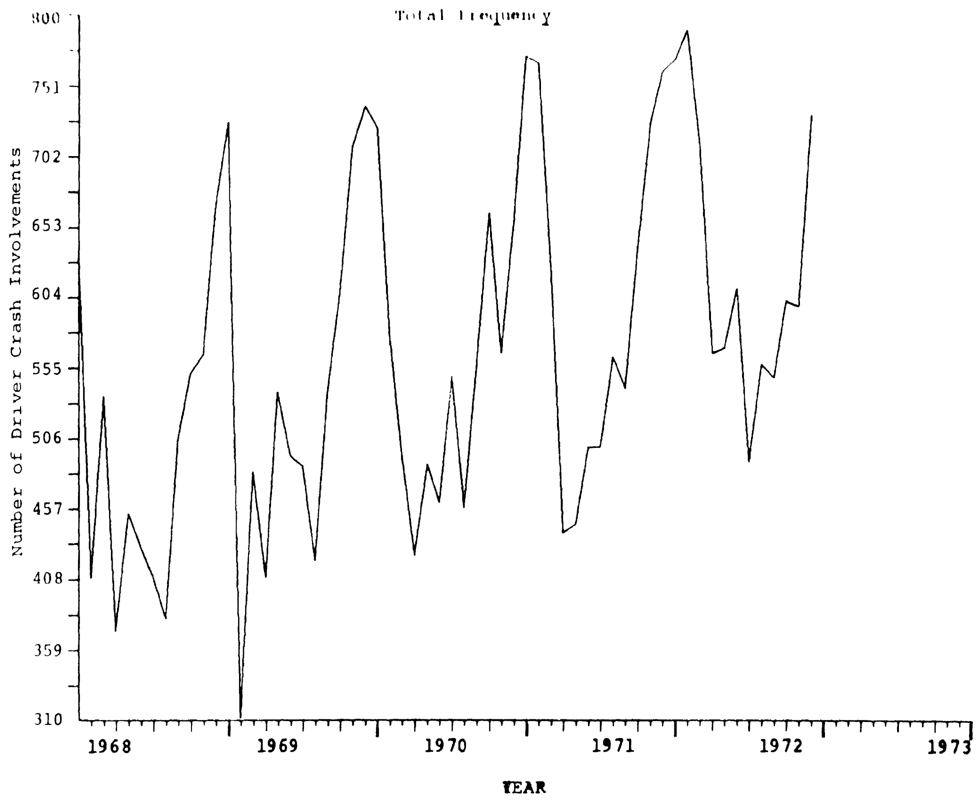


FIGURE D.1. TOTAL 18-20 YEAR-OLD DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



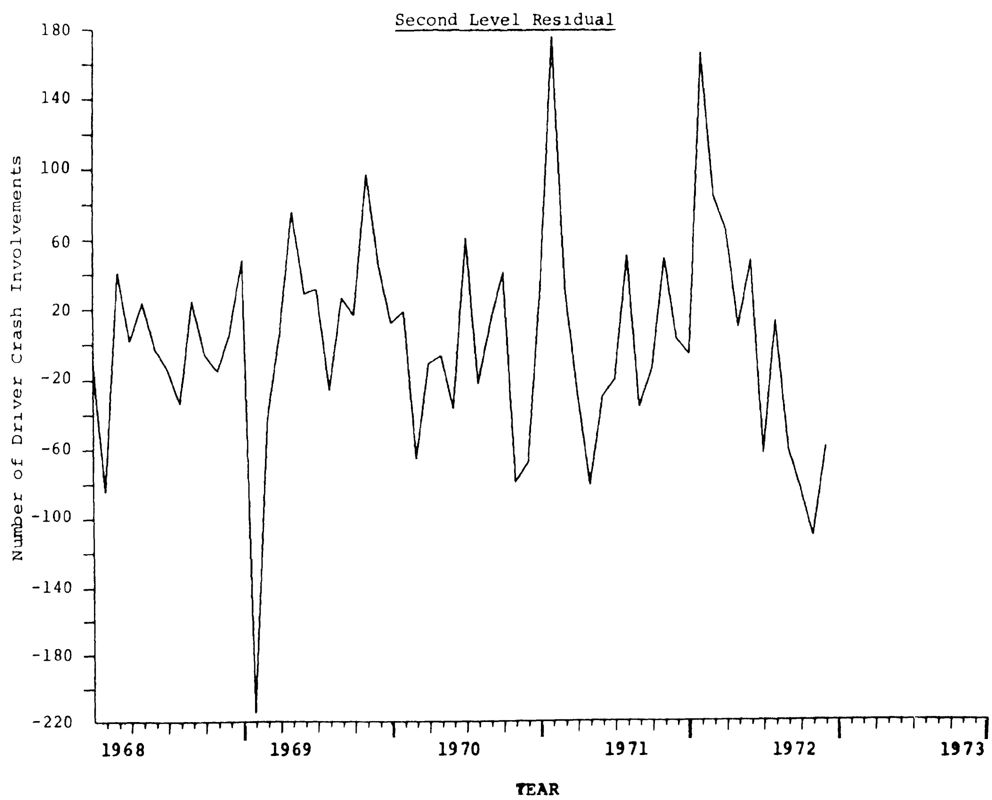
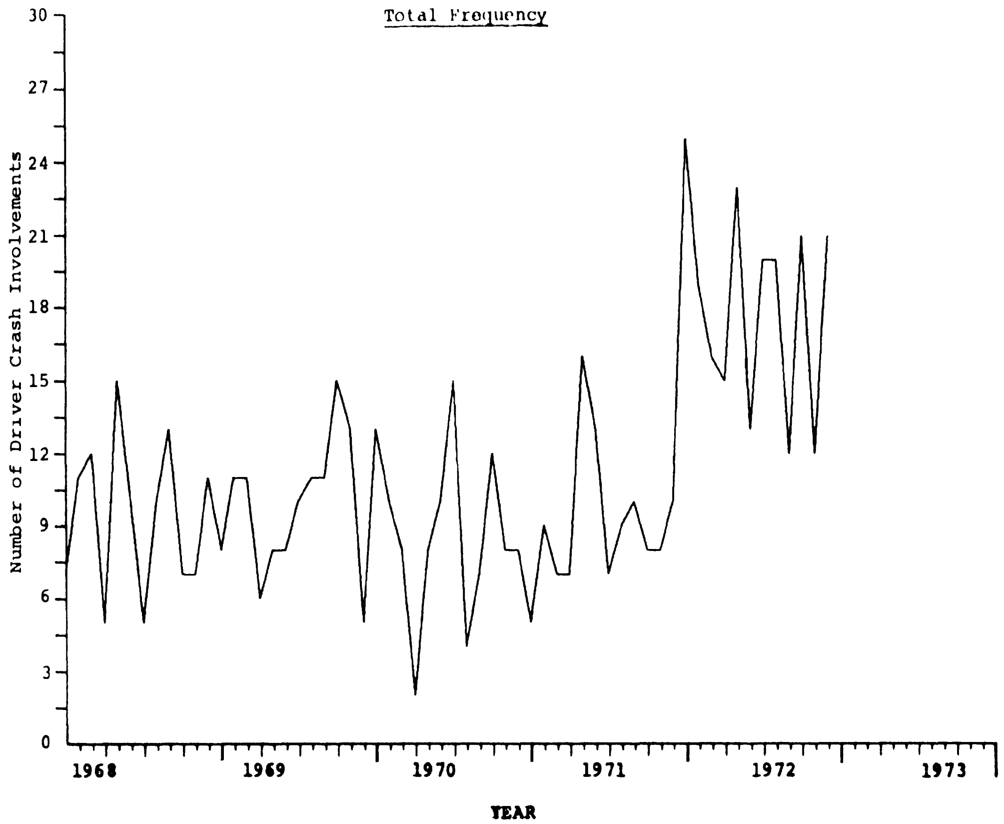


FIGURE D.2. TOTAL 21-45 YEAR OLD DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



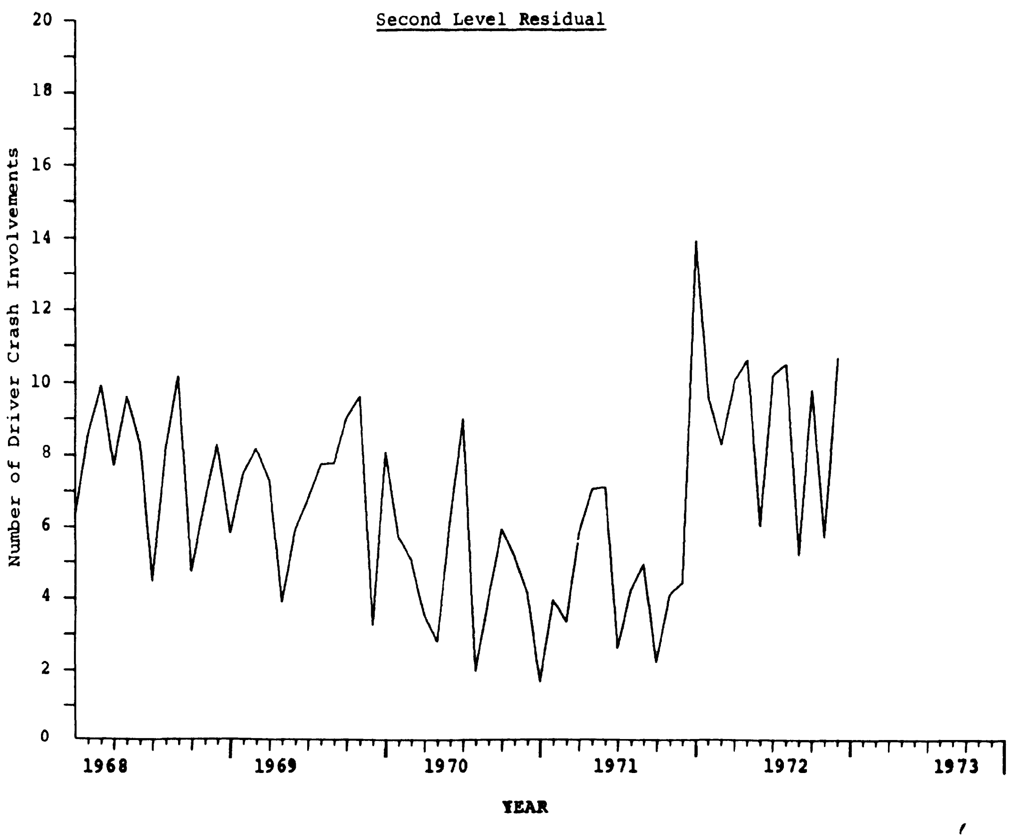
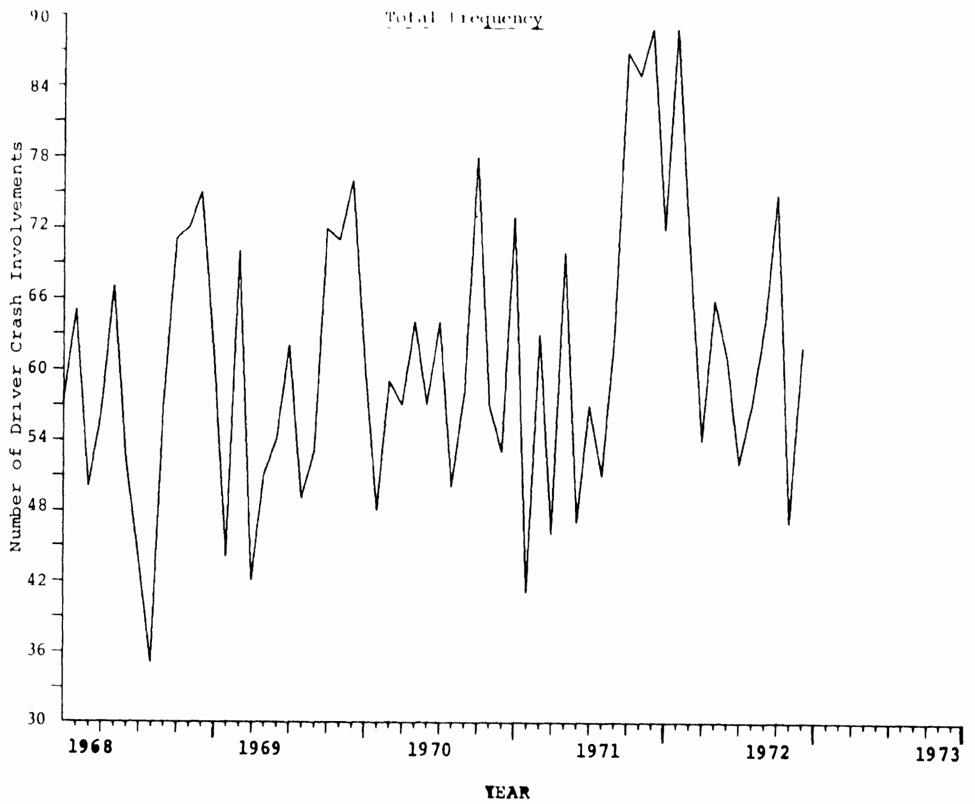


FIGURE D.3. 18-20 YEAR OLD "HBD" DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



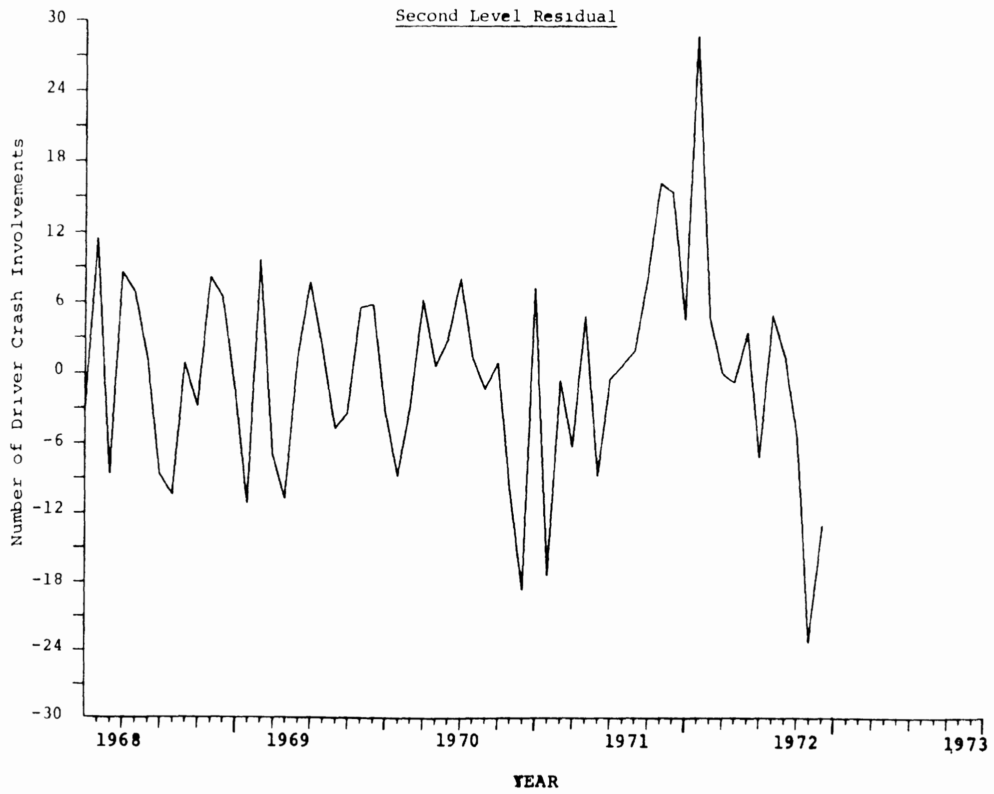
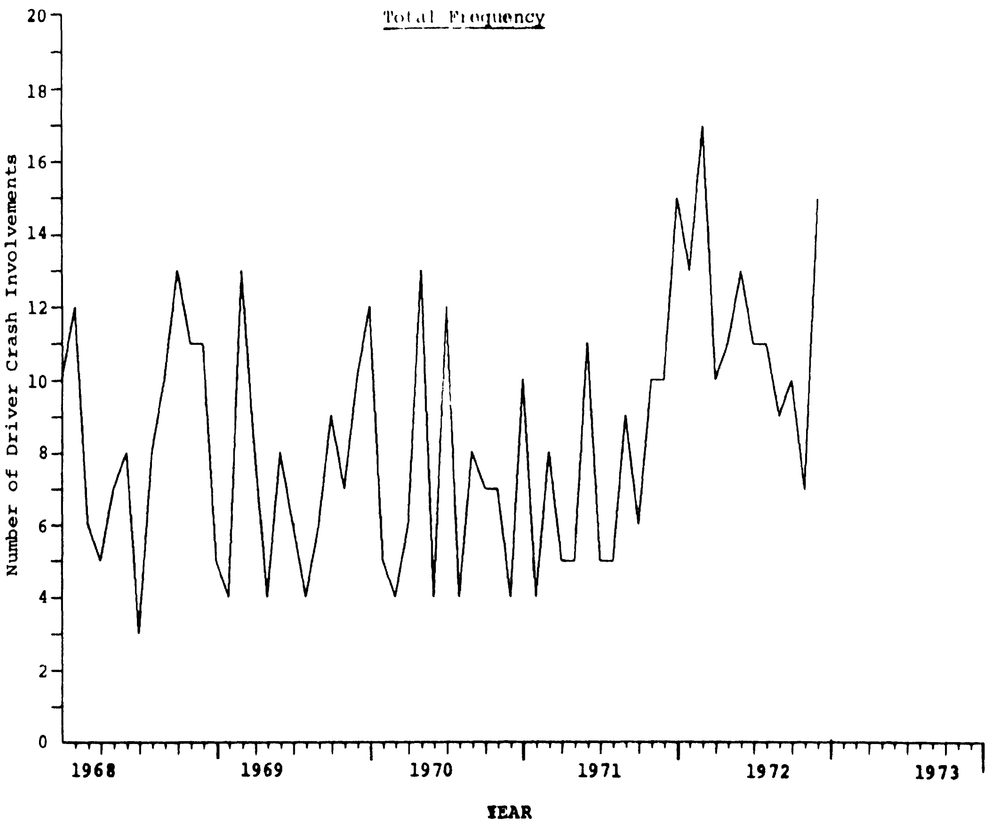


FIGURE D.4. 21-45 YEAR OLD "HBD" DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



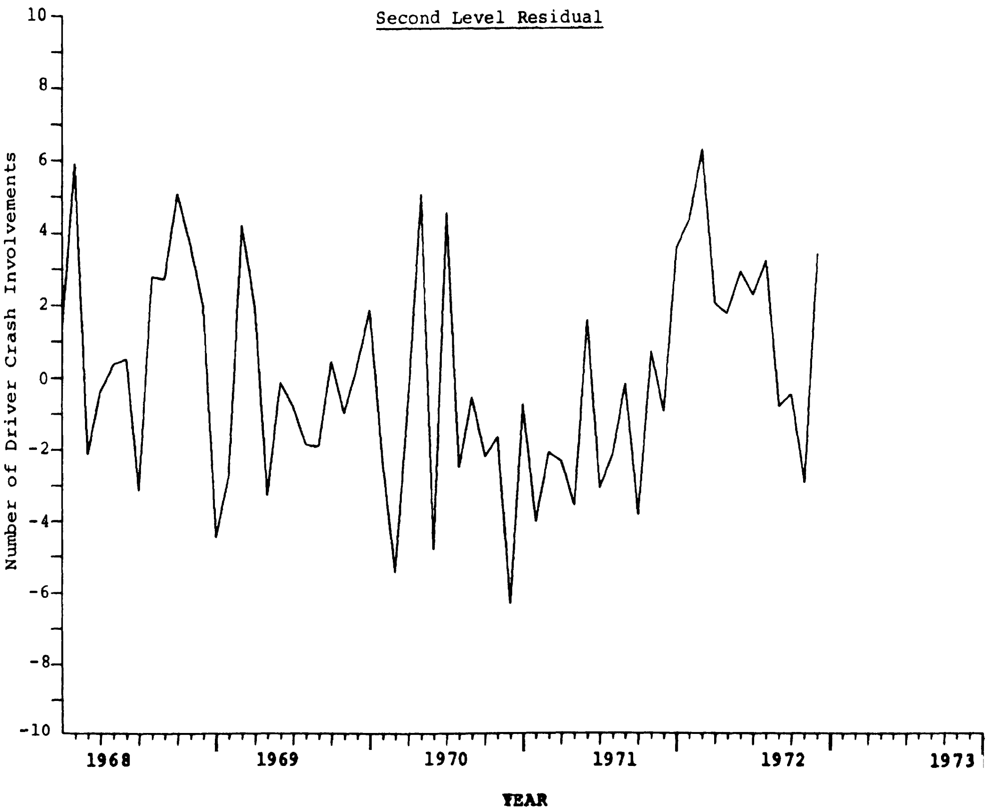
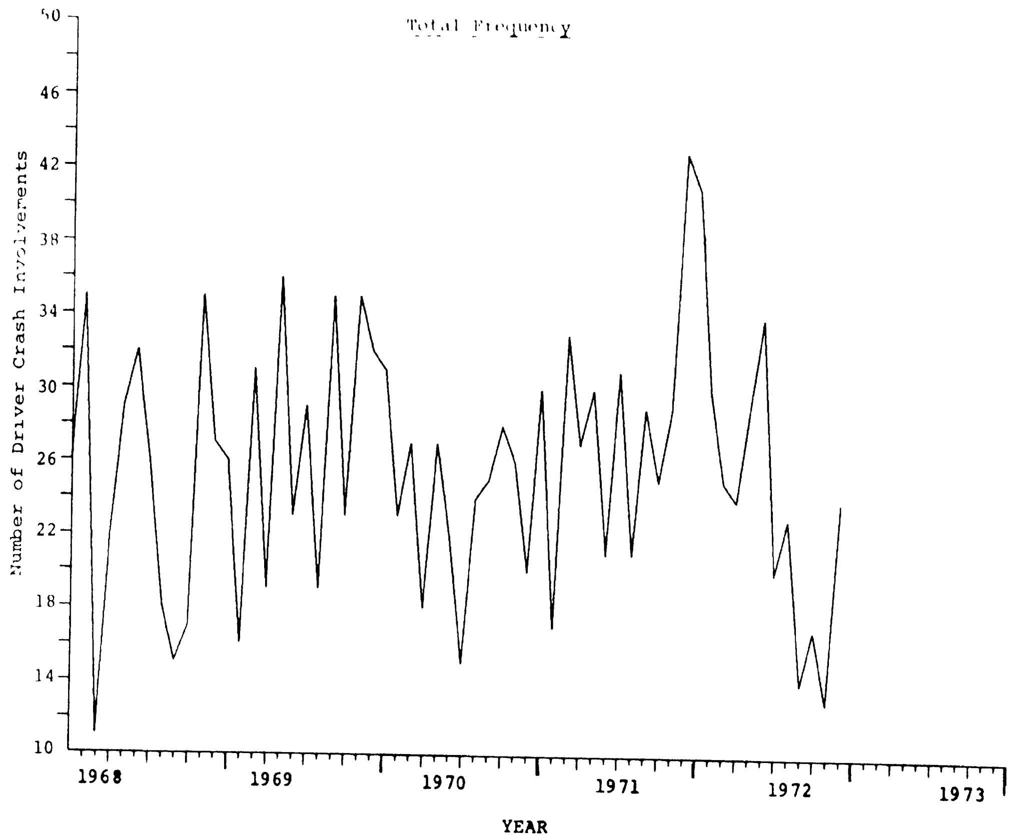


FIGURE D.5. 18-20 YEAR OLD THREE-FACTOR-SURROGATE DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



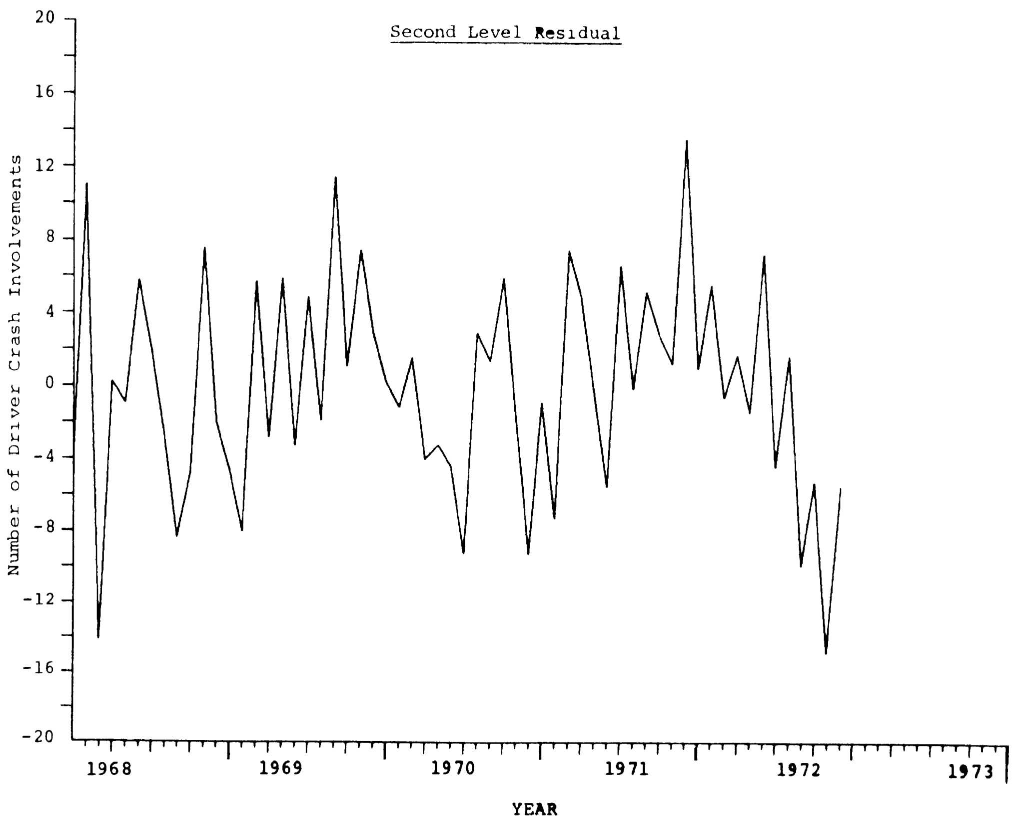


FIGURE D.6. 21-45 YEAR OLD THREE-FACTOR-SURROGATE DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH

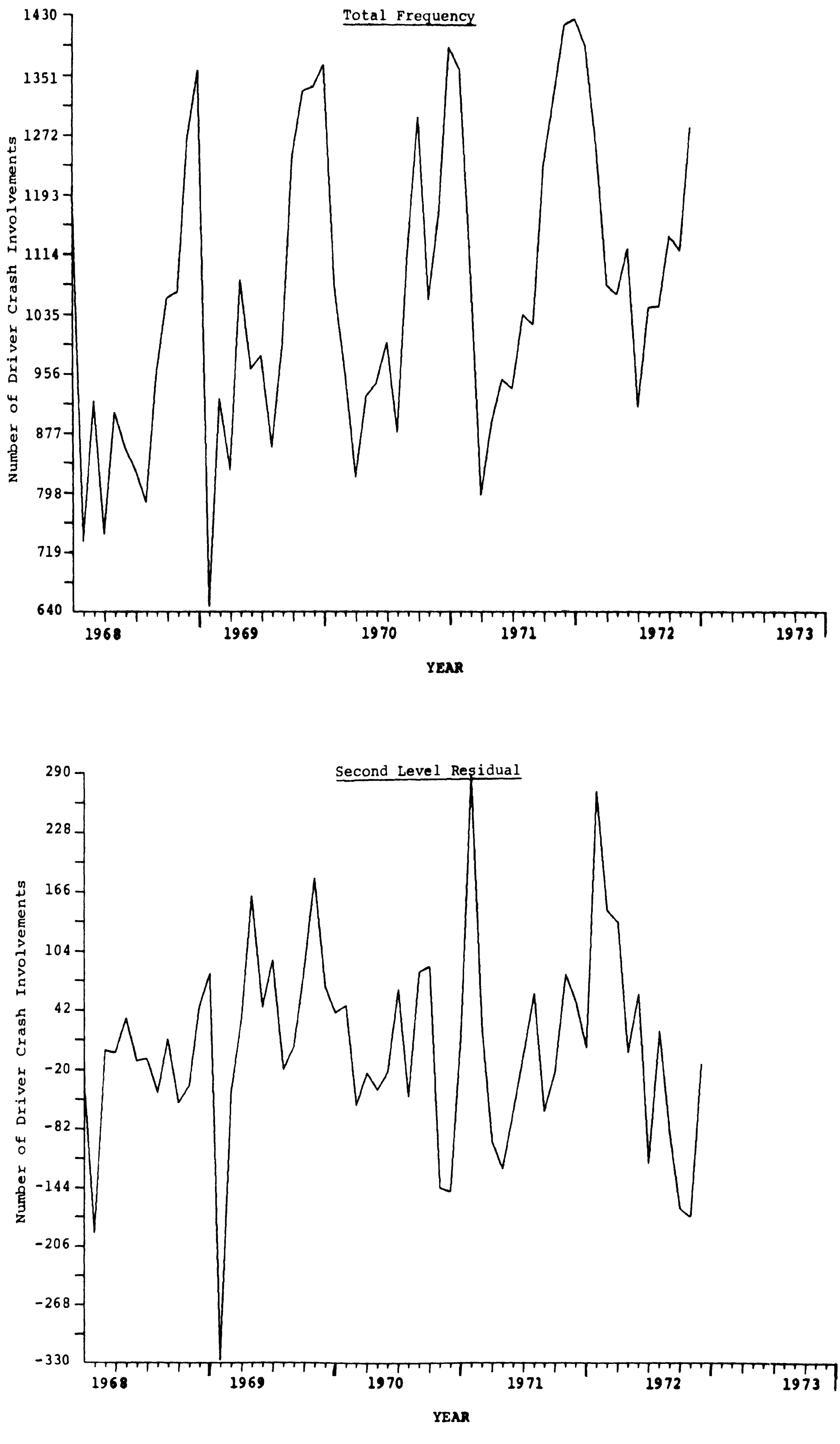


FIGURE D.7. TOTAL DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH

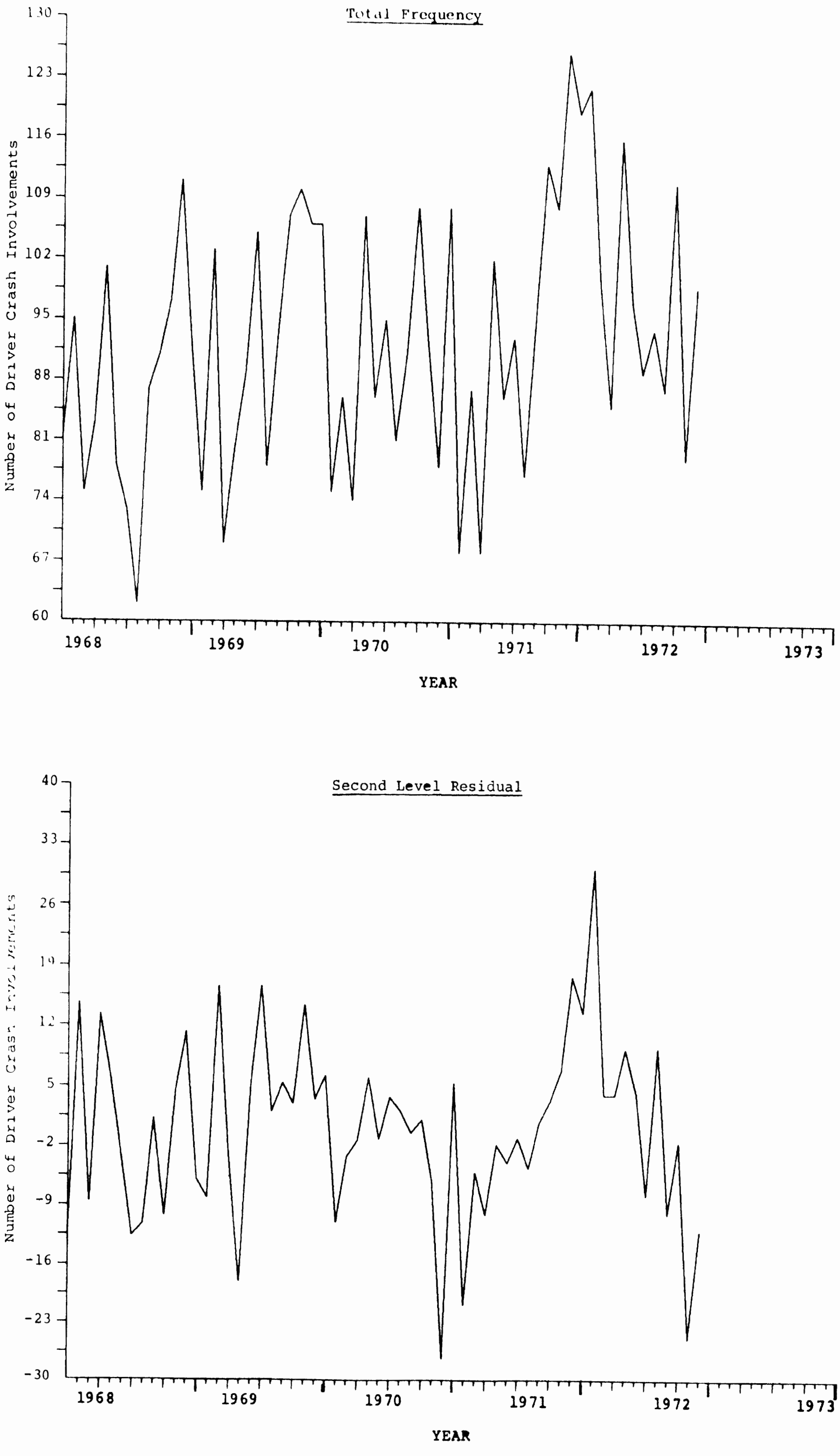
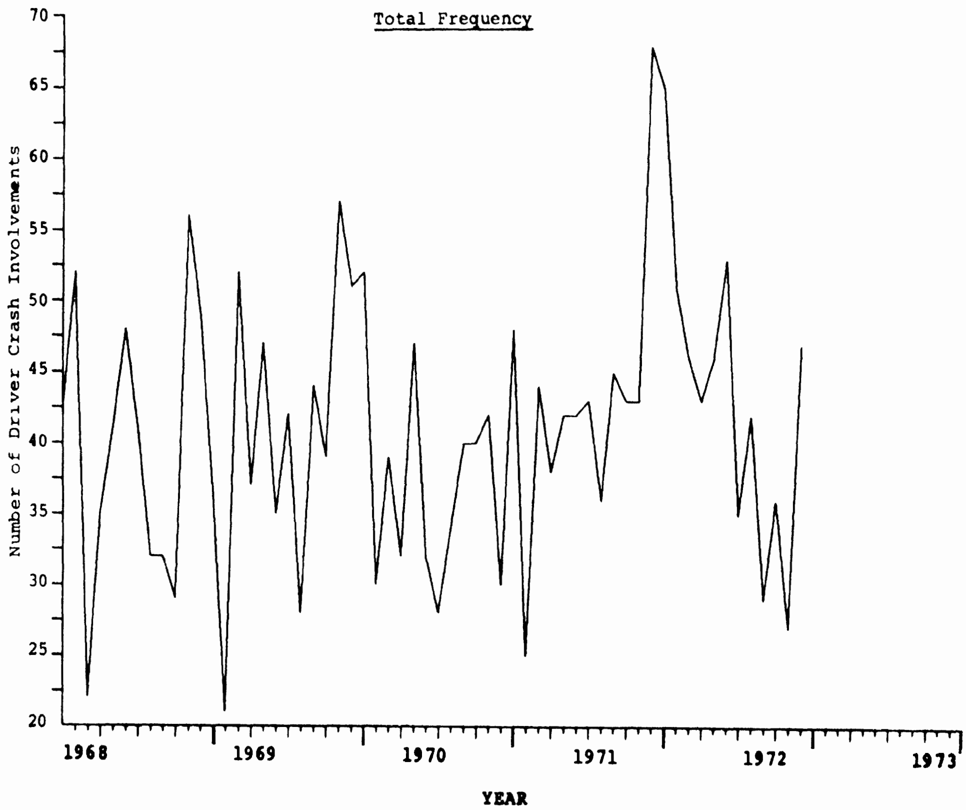


FIGURE D.8. TOTAL "HBD" DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



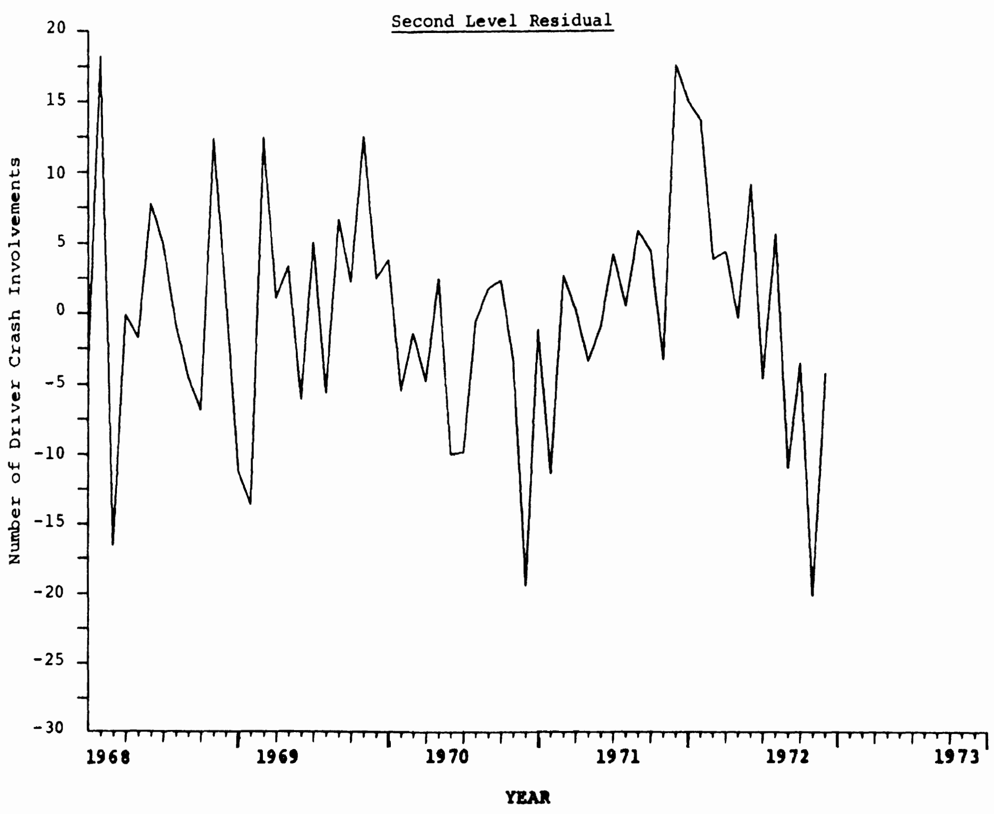
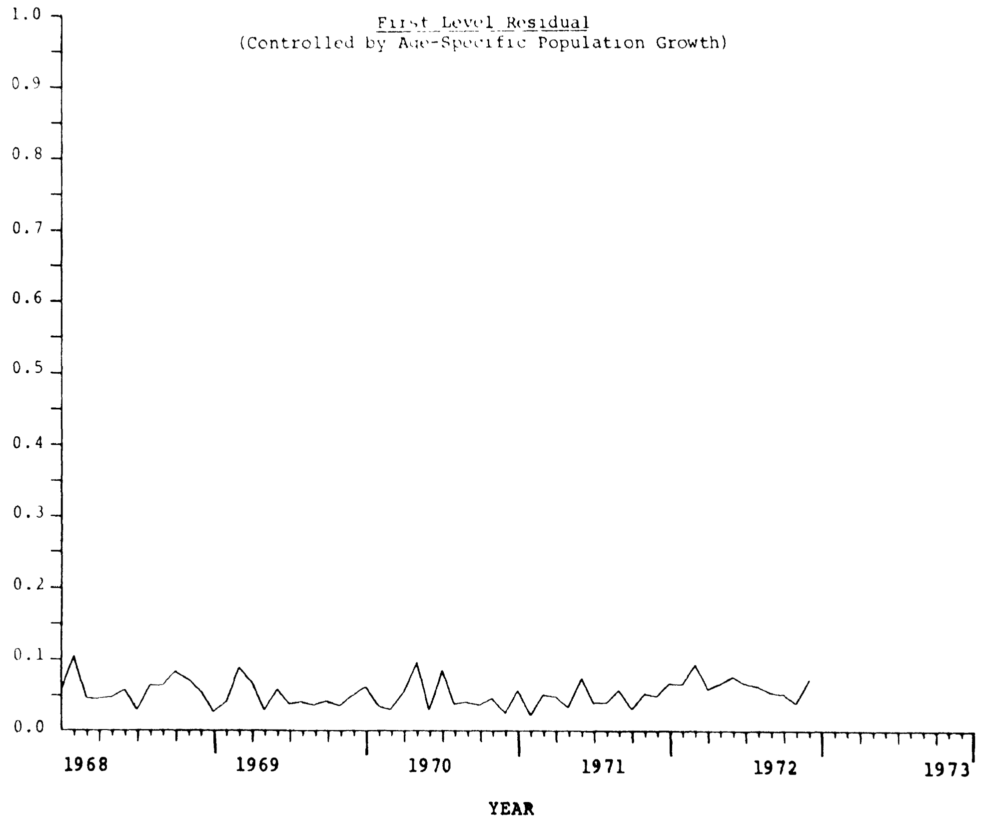


FIGURE D.9. TOTAL THREE-FACTOR-SURROGATE DRIVER CRASH INVOLVEMENTS IN WASHTENAW COUNTY, MICHIGAN BY MONTH



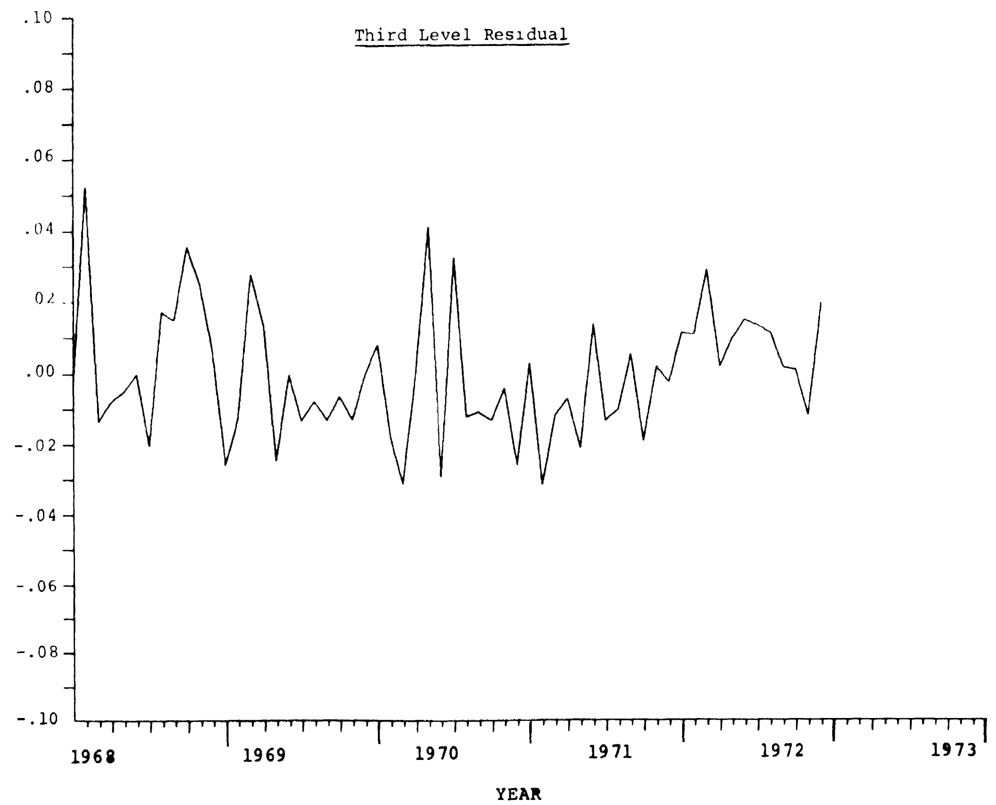
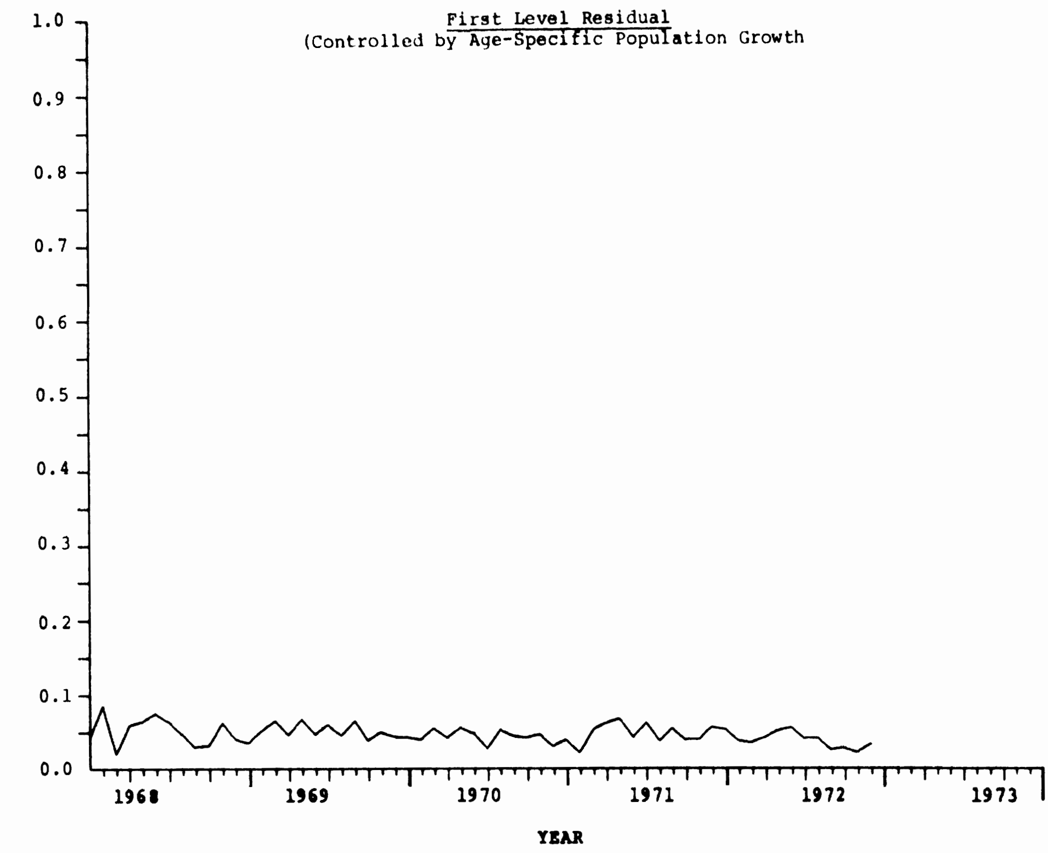


FIGURE D.10. 18-20 YEAR OLD AGE-SPECIFIC THREE-FACTOR-SURROGATE RATE WASHTENAW COUNTY, MICHIGAN 1968-1972



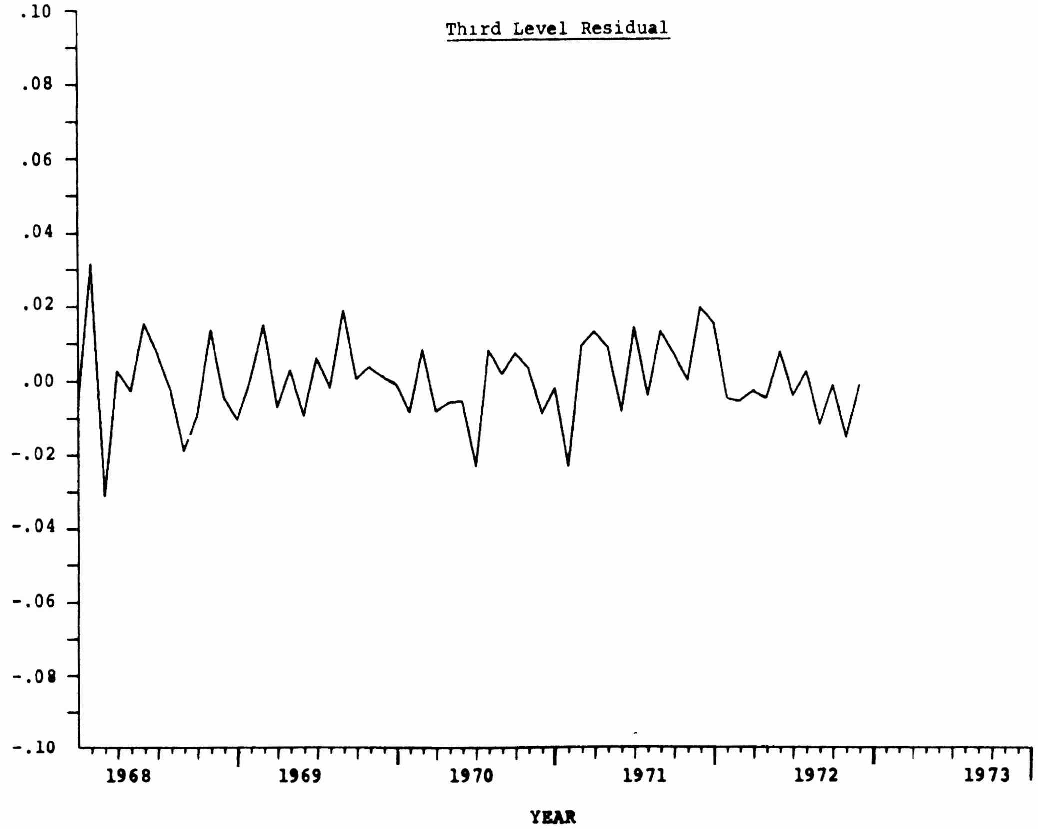


FIGURE D.11. 21-45 YEAR OLD AGE-SPECIFIC THREE-FACTOR SURROGATE RATE WASHTENAW COUNTY, MICHIGAN 1968-1972

APPENDIX E

TABULAR CRASH DATA FOR FULL QUASI-EXPERIMENTAL DESIGN

TABULAR CRASH DATA FOR FULL QUASI-EXPERIMENTAL DESIGN

The following tables present grouped data for all eleven analytic files in the quasi-experimental design. Three tables are included for each of eleven jurisdictions including:

(1) Annual driver involvements for total crash involvements (T); reported alcohol-related involvements (HBD); and three-factor-surrogate (3f) crash involvements,

(2) Annual age-specific driver involvement rates by type of crash, and

(3) Driver involvements by month and crash type.

The following tables are included:

E.1

MICHIGAN STATEWIDE

Annual Driver Involvements by Age Group and Type

	1968		
	AGE GROUPS		
	ALL	18-20	21-45
T	37481	5576	18689
HBD	5733	658	3535
3f	3048	621	1752

	1969		
	AGE GROUPS		
	ALL	18-20	21-45
T	41164	6251	20331
HBD	6383	717	3924
3f	3239	693	1820

	1970		
	AGE GROUPS		
	ALL	18-20	21-45
T	41878	6210	20738
HBD	5905	680	3679
3f	3125	598	1801

	1971		
	AGE GROUPS		
	ALL	18-20	21-45
T	42147	6182	21067
HBD	5902	697	3613
3f	3418	653	1928

	1972		
	AGE GROUPS		
	ALL	18-20	21-45
T	48160	7877	23720
HBD	7173	1242	4139
3f	4213	973	2103

	1973		
	AGE GROUPS		
	ALL	18-20	21-45
T	26603	4438	13032
HBD	3932	713	2249
3f	2311	513	1184

	1973'		
	AGE GROUPS		
	ALL	18-20	21-45
T	45606	7608	22341
HBD	6741	1222	3855
3f	3962	879	2030

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
T	237433	36534	117577
HBD	35028	4707	21139
3f	19354	4051	10588

	BEFORE		
	AGE GROUPS		
	ALL	18-20	21-45
T	162670	24219	80825
HBD	23923	2752	14751
3f	12830	2565	7301

	AFTER		
	AGE GROUPS		
	ALL	18-20	21-45
T	74763	12315	36752
HBD	11105	1955	6388
3f	6524	1486	3287

E.2

MICHIGAN STATEWIDE

Annual Age-Specific Driver Involvement Rates by Type

	1968		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.153	.118	.189
3f	.081	.111	.094

1969		
AGE GROUPS		
ALL	18-20	21-45
.155	.115	.193
.079	.111	.090

1970		
AGE GROUPS		
ALL	18-20	21-45
.141	.110	.177
.075	.096	.087

	1971		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.140	.113	.172
3f	.081	.106	.092

1972		
AGE GROUPS		
ALL	18-20	21-45
.149	.158	.174
.087	.124	.089

1973		
AGE GROUPS		
ALL	18-20	21-45
.148	.161	.173
.087	.116	.091

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.148	.129	.180
3f	.082	.111	.090

	BEFORE		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.147	.114	.183
3f	.079	.106	.090

AFTER		
AGE GROUPS		
ALL	18-20	21-45
.149	.159	.174
.087	.121	.089

MICHIGAN STATEWIDE 1968

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3529	530	1854	2784	404	1393	2783	422	1465
HBD	438	51	265	405	52	241	443	55	268
3f	246	58	132	185	38	103	223	43	133

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2339	354	1133	2861	441	1402	3050	495	1454
HBD	414	43	257	467	52	290	451	56	290
3f	193	43	109	271	49	154	280	62	160

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2988	476	1439	3109	472	1525	2994	450	1481
HBD	467	54	284	529	74	322	441	52	281
3f	251	53	148	261	57	148	238	50	134

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3290	446	1648	3557	479	1756	4197	607	2139
HBD	507	47	305	566	58	348	605	64	384
3f	254	51	144	338	61	198	308	56	189

MICHIGAN STATEWIDE 1969

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	4393	634	2340
HBD	526	51	341
3f	233	40	147

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2540	355	1294
HBD	433	46	265
3f	215	32	133

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	2813	443	1375
HBD	453	61	286
3f	228	45	135

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	2658	399	1314
HBD	445	49	269
3f	230	50	121

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	3286	507	1609
HBD	564	56	354
3f	280	55	156

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	3287	533	1580
HBD	487	53	311
3f	302	80	164

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	3357	576	1579
HBD	510	71	294
3f	273	58	153

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	3284	478	1598
HBD	563	59	345
3f	250	47	146

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	3135	471	1492
HBD	475	57	262
3f	224	51	119

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	3926	558	1898
HBD	603	73	370
3f	293	71	158

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	4163	624	2046
HBD	641	65	399
3f	383	81	209

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	4322	673	2206
HBD	683	76	428
3f	328	83	179

MICHIGAN STATEWIDE 1970

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4358	647	2214	3521	530	1813	3073	425	1564
HBD	495	49	309	494	57	309	467	52	306
3f	263	57	136	230	40	137	263	50	172

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2657	405	1331	3110	475	1524	3366	521	1621
HBD	438	50	285	499	61	320	493	61	328
3f	209	41	129	267	47	156	245	48	136

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3427	536	1652	3226	506	1565	3224	470	1507
HBD	442	58	266	475	58	299	468	55	281
3f	243	65	125	239	41	141	235	50	134

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3649	496	1788	3813	560	1886	4454	639	2273
HBD	539	58	322	563	60	344	532	61	310
3f	289	62	154	352	56	205	290	41	176

MICHIGAN STATEWIDE 1971

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4544	640	2384	3907	559	2030	3330	465	1735
HBD	516	49	323	378	43	230	427	36	268
3f	250	44	140	210	39	114	224	38	145

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2624	332	1331	3087	479	1509	3095	484	1486
HBD	468	43	297	519	66	324	457	61	277
3f	262	36	158	266	47	151	297	59	173

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3433	556	1626	3234	526	1527	3052	415	1471
HBD	494	72	286	505	77	278	482	69	279
3f	335	77	179	266	59	144	235	40	126

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3840	511	1905	3936	581	2016	4065	634	2047
HBD	575	61	365	486	51	306	595	69	380
3f	382	74	230	359	78	188	332	62	180

MICHIGAN STATEWIDE 1972

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4473	700	2352	4141	610	2208	3867	613	1961
HBD	609	105	356	572	83	358	540	99	321
3f	392	86	200	319	66	173	322	69	172

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3053	498	1523	3646	646	1723	3733	651	1760
HBD	494	84	284	613	118	357	540	89	308
3f	308	69	149	351	91	169	359	85	179

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3782	667	1797	3834	643	1823	3704	592	1770
HBD	617	111	343	596	109	338	609	109	361
3f	325	71	165	354	84	160	342	90	166

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4061	653	1891	4394	702	2119	5472	902	2793
HBD	617	111	351	618	112	328	748	112	434
3f	345	72	172	401	100	205	395	90	193

WASHTENAW COUNTY, MICHIGAN

Annual Driver Involvements by Age Group and Type

	1968			1969			1970		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	11311	1717	5914	12540	1878	6461	12598	1810	6614
HBD	1034	113	701	1107	117	705	1079	105	706
3f	479	104	293	489	84	324	446	86	286

	1971			1972					
	AGE GROUPS			AGE GROUPS					
	ALL	18-20	21-45	ALL	18-20	21-45			
T	13448	1911	7278	13887	2191	7543			
HBD	1131	109	772	1197	217	769			
3f	517	88	336	520	142	294			

				TOTAL					
				AGE GROUPS					
				ALL	18-20	21-45			
T				63784	9507	33810			
HBD				5548	661	3653			
3f				2451	504	1533			

	BEFORE						AFTER		
	AGE GROUPS						AGE GROUPS		
	ALL	18-20	21-45				ALL	18-20	21-45
T	49897	7316	26267				13887	2191	7543
HBD	4351	444	2884				1197	217	769
3f	1931	362	1239				520	142	294

WASHTENAW COUNTY, MICHIGAN

Annual Age-Specific Driver Involvement Rates by Type

	1968			1969			1970		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.091	.066	.119	.088	.062	.109	.086	.058	.107
3f	.042	.061	.050	.039	.045	.050	.035	.048	.043

	1971			1972		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.084	.057	.106	.086	.099	.101
3f	.038	.046	.046	.037	.065	.039

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.087	.070	.108
3f	.038	.053	.045

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.087	.061	.110	.086	.099	.101
3f	.039	.049	.047	.037	.065	.039

WASHTENAW COUNTY, MICHIGAN 1968

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1201	180	637	733	116	409	920	129	535
HBD	81	7	57	95	11	65	75	12	50
3f	49	10	26	52	12	35	22	6	11

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	743	112	372	904	149	454	857	140	430
HBD	83	5	56	101	15	67	78	10	52
3f	35	5	22	41	7	29	48	8	32

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	828	103	409	785	124	381	953	156	505
HBD	73	5	44	62	10	35	87	13	57
3f	41	3	26	32	8	18	32	10	15

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1056	157	551	1064	152	564	1267	199	667
HBD	91	7	71	97	7	72	111	11	75
3f	29	13	17	56	11	35	49	11	27

WASHTENAW COUNTY, MICHIGAN 1969

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1358	192	726	647	102	312	923	146	483
HBD	91	8	61	75	11	44	103	11	70
3f	36	5	26	21	4	16	52	13	31

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	828	119	409	1081	141	538	962	138	494
HBD	69	6	42	80	8	51	89	8	54
3f	37	8	19	47	4	36	35	8	23

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	980	161	487	858	100	421	994	164	539
HBD	105	10	62	78	11	49	94	11	53
3f	42	6	29	28	4	19	44	6	35

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1243	217	606	1330	197	709	1336	201	737
HBD	107	15	72	110	13	71	106	5	76
3f	39	9	23	57	7	35	51	10	32

WASHTENAW COUNTY, MICHIGAN 1970

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1365	196	722	1069	143	577	959	130	493
HBD	106	13	61	75	10	48	86	8	59
3f	52	12	31	30	5	23	39	4	27

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	819	109	424	926	136	488	943	134	461
HBD	74	2	57	107	8	64	86	10	57
3f	32	6	18	47	13	27	32	4	22

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	998	142	549	878	109	457	1120	200	557
HBD	95	15	64	81	4	50	91	7	58
3f	28	12	15	34	4	24	40	8	25

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1296	195	663	1054	154	565	1171	162	658
HBD	108	12	78	92	8	57	78	8	53
3f	40	7	28	42	7	26	30	4	20

WASHTENAW COUNTY, MICHIGAN 1971

Driver Involvements by Month, Age Groups, and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1388	175	722	1359	180	767	1089	156	622
HBD	108	5	73	68	9	41	87	7	63
3f	48	10	30	25	4	17	44	8	33

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	795	103	440	892	148	446	950	148	500
HBD	68	7	46	102	16	70	86	13	47
3f	38	5	27	42	5	30	42	11	21

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	938	128	500	1035	127	563	1023	157	541
HBD	93	7	57	77	9	51	95	10	63
3f	43	5	31	36	5	21	45	9	29

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1234	196	640	1327	190	726	1418	203	761
HBD	113	8	87	108	8	85	126	10	89
3f	43	6	25	43	10	29	68	10	43

WASHTENAW COUNTY, MICHIGAN 1972

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1426	225	769
HBD	119	25	72
3f	65	15	41

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1391	197	790
HBD	122	19	89
3f	51	13	30

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	1260	182	708
HBD	99	16	70
3f	46	17	25

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	1074	171	565
HBD	85	15	54
3f	43	10	24

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1063	167	569
HBD	116	23	66
3f	46	11	29

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	1122	170	611
HBD	97	13	61
3f	53	13	34

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	913	163	490
HBD	89	20	52
3f	35	11	20

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	1045	176	558
HBD	94	20	57
3f	42	11	23

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1047	165	549
HBD	87	12	64
3f	29	9	14

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1140	192	603
HBD	111	21	75
3f	36	10	17

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1121	177	599
HBD	79	12	47
3f	27	7	13

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1285	206	732
HBD	99	21	62
3f	47	15	24

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OAKLAND COUNTY, MICHIGAN

Annual Driver Involvements by Age Group and Type

	1968		
	AGE GROUPS		
	ALL	18-20	21-45
T	44926	6031	22197
HBD	6338	638	3903
3f	2052	401	1186

	1969		
	AGE GROUPS		
	ALL	18-20	21-45
T	51798	7058	25414
HBD	7159	714	4381
3f	2302	416	1303

	1970		
	AGE GROUPS		
	ALL	18-20	21-45
T	52994	7154	26040
HBD	6478	688	3881
3f	2051	391	1174

	1971		
	AGE GROUPS		
	ALL	18-20	21-45
T	52652	7199	25701
HBD	6532	692	3953
3f	2170	382	1180

	1972		
	AGE GROUPS		
	ALL	18-20	21-y5
T	60900	9165	29658
HBD	7884	1212	4511
3f	2940	616	1331

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
T	263270	36607	129010
HBD	34391	3944	20629
3f	11515	2206	6174

	BEFORE		
	AGE GROUPS		
	ALL	18-20	21-45
T	202370	27442	99352
HBD	26507	2732	16118
3f	8575	1590	4843

	AFTER		
	AGE GROUPS		
	ALL	18-20	21-45
T	60900	9165	29658
HBD	7884	1212	4511
3f	2940	616	1331

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OAKLAND COUNTY, MICHIGAN

Annual Age-Specific Driver Involvement Rates by Type

1968

	ALL	18-20	21-45
HBD	.141	.106	.176
3f	.046	.066	.053

1969

	ALL	18-20	21-45
HBD	.138	.101	.172
3f	.044	.059	.051

1970

	ALL	18-20	21-45
HBD	.122	.096	.149
3f	.039	.055	.045

1971

	ALL	18-20	21-45
HBD	.124	.096	.154
3f	.041	.053	.046

1972

	ALL	18-20	21-45
HBD	.129	.132	.152
3f	.048	.067	.045

TOTAL

	ALL	18-20	21-45
HBD	.131	.108	.160
3f	.044	.060	.048

BEFORE

	ALL	18-20	21-45
HBD	.131	.100	.162
3f	.042	.058	.049

AFTER

	ALL	18-20	21-45
HBD	.129	.132	.152
3f	.048	.067	.045

OAKLAND COUNTY, MICHIGAN 1968

Driver Involvements by Month, Age Group and Type

JANUARY

	AGE GROUPS		
	ALL	18-20	21-45
T	4318	532	2269
HBD	558	60	348
3f	170	34	94

FEBRUARY

	AGE GROUPS		
	ALL	18-20	21-45
T	3219	414	1639
HBD	462	42	283
3f	138	28	87

MARCH

	AGE GROUPS		
	ALL	18-20	21-45
T	3679	497	1880
HBD	520	51	323
3f	174	32	98

APRIL

	AGE GROUPS		
	ALL	18-20	21-45
T	2861	395	1393
HBD	419	56	239
3f	113	24	67

MAY

	AGE GROUPS		
	ALL	18-20	21-45
T	3499	477	1713
HBD	527	64	334
3f	159	32	94

JUNE

	AGE GROUPS		
	ALL	18-20	21-45
T	3797	551	1798
HBD	493	51	305
3f	184	36	96

JULY

	AGE GROUPS		
	ALL	18-20	21-45
T	3459	499	1666
HBD	435	37	280
3f	149	26	77

AUGUST

	AGE GROUPS		
	ALL	18-20	21-45
T	3374	466	1635
HBD	471	57	280
3f	180	39	102

SEPTEMBER

	AGE GROUPS		
	ALL	18-20	21-45
T	3671	511	1730
HBD	474	49	281
3f	181	33	107

OCTOBER

	AGE GROUPS		
	ALL	18-20	21-45
T	4038	484	1935
HBD	586	51	343
3f	170	31	101

NOVEMBER

	AGE GROUPS		
	ALL	18-20	21-45
T	4015	521	1983
HBD	623	51	383
3f	176	37	100

DECEMBER

	AGE GROUPS		
	ALL	18-20	21-45
T	4996	684	2556
HBD	770	69	504
3f	258	49	163

OAKLAND COUNTY, MICHIGAN 1969

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	5363	700	2788	2922	364	1438	3674	485	1811
HBD	665	49	438	471	57	272	496	42	307
3f	184	33	114	160	27	93	160	21	94

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3487	469	1745	4171	577	2018	4304	644	2041
HBD	514	56	328	618	65	369	551	53	326
3f	192	38	113	208	40	114	176	36	92

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4102	643	1899	4022	584	1940	3812	509	1840
HBD	481	51	289	607	63	362	546	51	331
3f	176	34	90	182	33	103	174	29	94

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	5090	610	2498	5176	694	2526	5675	779	2870
HBD	663	56	399	703	79	418	844	92	542
3f	206	32	111	234	46	136	250	47	149

OAKLAND COUNTY, MICHIGAN 1970

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	6053	844	3004	4519	552	2358	3899	502	1968
HBD	611	76	351	539	45	317	582	57	351
3f	185	35	96	164	27	105	185	40	111

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3623	485	1775	4307	597	2102	4430	615	2119
HBD	478	60	280	604	59	381	505	54	323
3f	151	41	78	191	32	110	182	30	111

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4035	595	1933	3849	550	1822	3945	554	1937
HBD	448	56	268	464	38	286	509	62	299
3f	160	35	89	173	30	91	134	31	76

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4334	559	2126	4205	550	2017	5795	751	2879
HBD	574	65	329	490	61	284	674	55	412
3f	184	33	108	167	33	88	175	24	111

OAKLAND COUNTY, MICHIGAN 1971

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	5544	751	2814	4762	604	2459	4224	565	2083
HBD	583]	60	357	510	38	330	479	43	272
3f	195	34	105	167	19	114	156	26	91

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3287	428	1585	3910	565	1889	4210	620	1962
HBD	480	49	280	520	58	331	477	56	288
3f	142	16	73	169	26	94	203	34	114

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4018	558	1933	3909	602	1832	3924	529	1845
HBD	519	56	309	543	80	313	464	50	281
3f	173	38	89	179	36	95	179	33	96

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4840	631	2348	4618	599	2318	5406	747	2633
HBD	639	65	384	517	58	312	801	79	496
3f	207	45	106	181	36	78	219	39	125

OAKLAND COUNTY, MICHIGAN 1972

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	5523	819	2786	4910	678	2445	4922	722	2397
HBD	628	88	357	619	74	377	658	90	377
3f	264	60	114	217	48	105	243	46	122

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3882	583	1884	4907	811	2285	4909	789	2299
HBD	535	90	311	662	108	374	603	98	338
3f	216	43	97	215	44	102	244	55	120

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4455	704	2131	4865	784	2292	4659	661	2259
HBD	569	95	311	547	89	298	667	108	367
3f	258	54	109	249	56	101	217	47	86

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4993	713	2419	5397	794	2611	7478	1107	3850
HBD	670	96	397	727	108	413	999	168	591
3f	240	46	115	245	51	109	332	66	151

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WAYNE COUNTY, MICHIGAN

Annual Driver Involvements by Age Group and Type

1971

	AGE GROUPS ALL	18-20	21-45
T	3005	409	1453
HBD	442	43	271
3f	181	32	97

1972

	AGE GROUPS ALL	18-20	21-45
T	5113	728	2508
HBD	762	112	442
3f	299	58	141

1973

	AGE GROUPS ALL	18-20	21-45
T	3056	488	1511
HBD	467	73	265
3f	200	51	89

1973

	AGE GROUPS ALL	18-20	21-45
T	5239	837	2590
HBD	801	125	454
3f	343	87	153

TOTAL

	AGE GROUPS ALL	18-20	21-45
T	11174	1625	5472
HBD	1671	228	978
3f	680	151	327

BEFORE

	AGE GROUPS ALL	18-20	21-45
T	3005	409	1453
HBD	442	43	271
3f	181	32	97

AFTER

	AGE GROUPS ALL	18-20	21-45
T	8169	1216	4019
HBD	1229	185	707
3f	499	119	230

WAYNE COUNTY, MICHIGAN

Annual Age-Specific Driver Involvement Rates by Type

	1971			1972			1973		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.147	.105	.187	.149	.154	.176	.153	.150	.175
3f	.060	.078	.067	.058	.093	.056	.065	.105	.059

				TOTAL					
				AGE GROUPS					
				ALL	18-20	21-45			
HBD				.150	.140	.179			
3f				.061	.093	.060			

	BEFORE						AFTER		
	AGE GROUPS						AGE GROUPS		
	ALL	18-20	21-45				ALL	18-20	21-45
HBD	.147	.105	.187				.150	.152	.176
3f	.060	.078	.067				.061	.098	.057

WAYNE COUNTY, MICHIGAN 1971

Driver Involvements by Month, Age Group and Type

JANUARY	AGE GROUPS		
	ALL	18-20	21-45
T	302	35	146
HBD	34	1	24
3f	11	1	5

FEBRUARY	AGE GROUPS		
	ALL	18-20	21-45
T	294	.45	137
HBD	31	2	22
3f	14	1	7

MARCH	AGE GROUPS		
	ALL	18-20	21-45
T	248	34	120
HBD	55	5	33
3f	20	2	15

APRIL	AGE GROUPS		
	ALL	18-20	21-45
T	221	26	114
HBD	44	3	31
3f	12	2	7

MAY	AGE GROUPS		
	ALL	18-20	21-45
T	209	29	108
HBD	39	7	26
3f	17	2	11

JUNE	AGE GROUPS		
	ALL	18-20	21-45
T	224	28	109
HBD	25	2	14
3f	14	4	6

JULY	AGE GROUPS		
	ALL	18-20	21-45
T	241	28	118
HBD	41	3	23
3f	16	2	10

AUGUST	AGE GROUPS		
	ALL	18-20	21-45
T	236	27	124
HBD	48	4	30
3f	12	4	5

SEPTEMBER	AGE GROUPS		
	ALL	18-20	21-45
T	225	39	96
HBD	43	5	24
3f	10	2	4

OCTOBER	AGE GROUPS		
	ALL	18-20	21-45
T	255	32	110
HBD	20	1	13
3f	17	3	11

NOVEMBER	AGE GROUPS		
	ALL	18-20	21-45
T	250	35	125
HBD	36	5	18
3f	15	3	7

DECEMBER	AGE GROUPS		
	ALL	18-20	21-45
T	300	51	146
HBD	26	5	13
3f	23	6	9

WAYNE COUNTY, MICHIGAN 1972

Driver Involvement by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	464	58	231
HBD	84	12	50
3f	26	7	10

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	428	60	225
HBD	72	10	47
3f	35	5	18

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	384	48	194
HBD	66	11	39
3f	28	0	13

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	353	46	188
HBD	62	8	41
3f	15	4	7

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	370	56	177
HBD	49	8	32
3f	25	5	13

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	413	69	199
HBD	54	7	30
3f	25	7	11

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	429	67	208
HBD	46	8	25
3f	19	4	10

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	345	46	172
HBD	59	6	36
3f	21	3	15

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	407	53	206
HBD	69	8	44
3f	26	6	12

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	441	88	188
HBD	54	18	21
3f	21	9	5

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	490	56	226
HBD	55	4	32
3f	24	13	8

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	589	81	294
HBD	42	12	45
3f	34	5	19

WAYNE COUNTY, MICHIGAN 1973

Driver Involements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	413	60	208	467	69	229	461	82	231
HBD	74	7	46	55	10	33	57	10	34
3f	33	5	14	27	9	13	31	7	13

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	409	65	197	447	67	232	417	74	198
HBD	63	12	32	82	12	49	57	11	28
3f	18	4	8	29	7	13	28	10	10

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	442	71	216						
HBD	79	11	43						
3f	34	9	18						

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T									
HBD									
3f									

E.13

MICHIGAN FATAL CRASHES

Annual Driver Involvements by Age Group and Type

1968

	AGE GROUPS ALL	18-20	21-45
T	3057	373	1610
HBD	117	18	70
3f	684	110	408

1969

	AGE GROUPS ALL	18-20	21-45
T	3265	426	1633
HBD	196	24	134
3f	692	111	391

1970

	AGE GROUPS ALL	18-20	21-45
T	2815	360	1648
HBD	232	21	168
3f	604	77	366

1971

	AGE GROUPS ALL	18-20	21-45
T	3289	389	1549
HBD	1130	135	646
3f	851	120	396

1972

	AGE GROUPS ALL	18-20	21-45
T	3453	482	1556
HBD	1252	197	671
3f	890	150	391

TOTAL

	AGE GROUPS ALL	18-20	21-45
T	18879	2030	7996
HBD	2927	395	1689
3f	3721	568	1952

BEFORE

	AGE GROUPS ALL	18-20	21-45
T	12426	1548	6440
HBD	1675	198	1018
3f	2831	418	1561

AFTER

	AGE GROUPS ALL	18-20	21-45
T	3453	482	1556
HBD	1252	197	671
3f	890	150	391

E.14

MICHIGAN FATAL CRASHES

Annual Age-Specific Driver Involvement Rates by Type

	1968		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.038	.048	.043
3f	.224	.295	.253

	1969		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.060	.056	.082
3f	.212	.261	.239

	1970		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.082	.058	.102
3f	.215	.214	.222

	1971		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.344	.347	.417
3f	.259	.308	.256

	1972		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.363	.409	.431
3f	.258	.311	.251

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.155	.195	.211
3f	.197	.280	.244

	BEFORE		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.135	.128	.158
3f	.228	.270	.242

	AFTER		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.363	.409	.431
3f	.258	.311	.251

MICHIGAN FATAL CRASHES 1968

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	174	20	96	208	21	119	187	28	92
HBD	3	2	0	5	0	3	5	1	3
3f	37	7	24	42	7	24	55	12	29

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	183	34	91	282	36	150	289	41	142
HBD	10	3	5	15	1	11	11	1	7
3f	38	6	25	78	11	46	54	7	27

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	270	31	149	284	35	145	286	33	170
HBD	6	1	5	13	3	4	15	0	11
3f	68	15	38	63	9	40	74	9	54

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	320	32	163	352	40	191	222	22	102
HBD	10	3	5	9	0	6	15	3	10
3f	65	9	33	58	8	39	52	10	29

MICHIGAN FATAL CRASHES 1969

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	179	16	92	202	21	115	208	33	99
HBD	8	0	7	12	0	9	17	0	13
3f	36	5	20	44	6	25	58	10	31

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	223	29	123	290	42	166	304	43	143
HBD	17	3	12	15	2	13	18	5	8
3f	58	11	35	50	6	33	59	10	30

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	298	41	155	320	40	163	299	38	153
HBD	18	2	12	11	3	7	19	2	13
3f	65	11	34	61	9	36	66	10	33

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	313	40	111	317	42	151	312	41	162
HBD	20	2	13	22	4	12	19	1	15
3f	82	13	44	54	10	36	59	10	34

MICHIGAN FATAL CRASHES 1970

Driver Involvements by Month, Age Group and Type

JANUARY

	AGE GROUPS		
	ALL	18-20	21-45
T	239	38	120
HBD	11	1	9
3f	44	10	24

FEBRUARY

	AGE GROUPS		
	ALL	18-20	21-45
T	184	22	102
HBD	14	1	12
3f	43	3	27

MARCH

	AGE GROUPS		
	ALL	18-20	21-45
T	183	21	111
HBD	16	1	9
3f	44	3	33

APRIL

	AGE GROUPS		
	ALL	18-20	21-45
T	187	25	101
HBD	18	1	13
3f	40	4	25

MAY

	AGE GROUPS		
	ALL	18-20	21-45
T	266	34	152
HBD	11	2	7
3f	72	10	50

JUNE

	AGE GROUPS		
	ALL	18-20	21-45
T	268	34	147
HBD	27	2	18
3f	63	7	33

JULY

	AGE GROUPS		
	ALL	18-20	21-45
T	248	31	145
HBD	28	2	26
3f	52	7	35

AUGUST

	AGE GROUPS		
	ALL	18-20	21-45
T	268	38	147
HBD	19	2	14
3f	50	7	26

SEPTEMBER

	AGE GROUPS		
	ALL	18-20	21-45
T	290	37	157
HBD	28	2	21
3f	50	6	26

OCTOBER

	AGE GROUPS		
	ALL	18-20	21-45
T	274	36	130
HBD	18	2	10
3f	61	9	33

NOVEMBER

	AGE GROUPS		
	ALL	18-20	21-45
T	217	26	110
HBD	23	4	14
3f	47	7	29

DECEMBER

	AGE GROUPS		
	ALL	18-20	21-45
T	191	18	226
HBD	19	1	15
3f	38	4	25

MICHIGAN FATAL CRASHES 1971

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	233	24	97	208	15	105	247	37	112
HBD	59	5	38	59	7	35	95	12	50
3f	64	6	28	49	5	25	65	11	25

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	216	22	104	286	33	141	295	44	138
HBD	88	10	52	110	13	58	85	14	49
3f	42	4	22	80	10	40	82	16	29

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	319	40	160	339	44	160	228	28	87
HBD	90	18	54	134	15	76	73	1	37
3f	85	9	44	103	18	50	64	13	23

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	326	40	157	311	33	150	281	29	138
HBD	116	16	71	109	11	64	112	13	62
3f	83	12	44	66	7	31	68	9	35

MICHIGAN FATAL CRASHES 1972

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	238	32	105	247	27	127	231	33	103
HBD	104	16	53	91	15	49	105	15	52
3f	68	7	34	67	4	37	65	11	33

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	227	31	106	315	44	148	311	59	129
HBD	97	14	58	94	13	57	107	21	55
3f	71	12	36	63	14	28	80	18	24

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	332	48	157	317	55	132	334	47	139
HBD	115	19	70	88	15	44	137	23	69
3f	83	15	36	74	17	27	103	16	49

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	339	39	155	276	26	122	286	41	133
HBD	118	17	64	89	10	46	107	19	54
3f	74	17	28	63	7	24	79	12	35

MAINE

Annual Driver Involvements by Age Group and Type

	1970			1971			1972		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44	ALL	18-19	20-44
T	45299	4045	24243	45216	3870	24629	41201	4089	18603
HBD	3213	237	2145	3050	259	2130	3179	376	2138
3f	2725	356	1878	2491	366	1689	2494	435	1602

	TOTAL		
	AGE GROUPS		
	ALL	18-19	20-44
T	131716	12004	67475
HBD	9442	872	6413
3f	7710	1157	5169

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44
T	106926	9404	55846	24790	2600	11629
HBD	7323	573	5042	2119	299	1371
3f	6050	843	4148	1660	314	1021

MAINE

Annual Age-Specific Driver Involvement Rates by Type

	1970			1971			1972		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44	ALL	18-19	20-44
HBD	.071	.059	.088	.067	.067	.086	.077	.092	.115
3f	.060	.088	.077	.055	.095	.069	.061	.106	.086

	TOTAL		
	AGE GROUPS		
	ALL	18-19	20-44
HBD	.072	.073	.095
3f	.059	.096	.077

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44
HBD	.068	.061	.090	.085	.115	.118
3f	.057	.090	.074	.067	.121	.088

E.18

MAINE 1970

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-19	20-44
T	3740	313	2024
HBD	259	9	176
3f	209	16	160

	FEBRUARY		
	AGE GROUPS		
	ALL	18-19	20-44
T	3435	279	1901
HBD	261	17	175
3f	207	23	141

	MARCH		
	AGE GROUPS		
	ALL	18-19	20-44
T	3466	297	1865
HBD	256	19	160
3f	213	28	143

	APRIL		
	AGE GROUPS		
	ALL	18-19	20-44
T	2727	226	1460
HBD	234	19	180
3f	185	21	134

	MAY		
	AGE GROUPS		
	ALL	18-19	20-44
T	2763	265	1492
HBD	258	24	160
3f	210	30	139

	JUNE		
	AGE GROUPS		
	ALL	18-19	20-44
T	3150	318	1529
HBD		21	145
3f	238	30	162

	JULY		
	AGE GROUPS		
	ALL	18-19	20-44
T	3615	336	1819
HBD	259	21	153
3f	263	44	164

	AUGUST		
	AGE GROUPS		
	ALL	18-19	20-44
T	3781	232	1973
HBD	323	25	220
3f	257	40	178

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	3204	329	1658
HBD	265	17	186
3f	218	34	147

	OCTOBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	3641	323	1963
HBD	327	29	233
3f	266	37	187

	NOVEMBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	3303	302	1794
HBD	263	18	176
3f	266	32	184

	DECEMBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	8474	704	4765
HBD	281	18	181
3f	193	21	139

MAINE 1971

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-19	20-44
T	6393	469	3770
HBD	230	19	133
3f	129	18	84

	FEBRUARY		
	AGE GROUPS		
	ALL	18-19	20-44
T	5018	345	2788
HBD	181	10	119
3f	116	11	83

	MARCH		
	AGE GROUPS		
	ALL	18-19	20-44
T	4382	305	2459
HBD	210	8	160
3f	136	11	112

	APRIL		
	AGE GROUPS		
	ALL	18-19	20-44
T	2740	225	1482
HBD	226	15	162
3f	160	19	112

	MAY		
	AGE GROUPS		
	ALL	18-19	20-44
T	2938	259	1627
HBD	290	24	215
3f	230	30	160

	JUNE		
	AGE GROUPS		
	ALL	18-19	20-44
T	3018	313	1576
HBD	271	28	193
3f	279	52	172

	JULY		
	AGE GROUPS		
	ALL	18-19	20-44
T	3507	318	1862
HBD	279	22	207
3f	242	37	164

	AUGUST		
	AGE GROUPS		
	ALL	18-19	20-44
T	3695	377	1880
HBD	274	28	183
3f	265	47	174

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	2961	273	1542
HBD	238	25	170
3f	218	33	143

	OCTOBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	2983	277	1573
HBD	311	22	224
3f	247	33	174

	NOVEMBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	3142	286	1703
HBD	233	24	165
3f	240	37	160

	DECEMBER		
	AGE GROUPS		
	ALL	18-19	20-44
T	4439	423	2367
HBD	307	34	199
3f	229	38	151

MAINE 1972

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44	ALL	18-19	20-44
T	3289	329	1789	4212	356	2307	3677	312	2021
HBD	191	16	146	193	11	128	178	13	132
3f	158	25	117	139	19	93	155	24	106

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44	ALL	18-19	20-44
T	2553	236	1286	2680	256	1395	3017	378	1488
HBD	221	15	154	277	22	207	301	41	203
3f	175	20	120	207	33	145	256	50	154

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44	ALL	18-19	20-44
T	3398	400	1683	3491	385	1752	2921	307	1470
HBD	341	58	218	297	50	185	298	46	193
3f	295	66	167	251	56	143	212	35	139

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-19	20-44	ALL	18-19	20-44	ALL	18-19	20-44
T	3084	277	1559	3535	353	1853	5344	500	1824
HBD	315	44	110	268	33	179	299	27	203
3f	230	34	143	223	40	150	193	33	125

VERMONT

Annual Driver Involvements by Age Group and Type

	1971			1972		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
T	27650	3771	13959	27951	4069	14184
HBD	1626	241	962	1849	301	1061
3f	2199	393	1012	2230	448	1079

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
T	55601	7840	28143
HBD	3475	542	2023
3f	4429	841	2091

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
T	27650	3771	13959	27951	4069	14184
HBD	1626	241	962	1849	301	1061
3f	2199	393	1012	2230	448	1079

VERMONT

Annual Age-Specific Driver Involvement Rates by Type

	1971			1972		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.059	.064	.069	.066	.074	.075
3f	.080	.104	.072	.080	.110	.076

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.062	.069	.072
3f	.080	.107	.074

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.059	.064	.069	.066	.074	.075
3f	.080	.104	.072	.080	.110	.076

VERMONT 1971

Driver Involvements by Month, Age Group and Type

	JANUARY ALL	JANUARY 18-20	JANUARY 21-45	FEBRUARY ALL	FEBRUARY 18-20	FEBRUARY 21-45	MARCH ALL	MARCH 18-20	MARCH 21-45
T	3239	442	1735	2915	327	1588	2792	289	1530
HBD	107	14	53	85	8	51	88	10	54
3f	128	19	73	130	15	64	160	12	73

	APRIL ALL	APRIL 18-20	APRIL 21-45	MAY ALL	MAY 18-20	MAY 21-45	JUNE ALL	JUNE 18-20	JUNE 21-45
T	1585	195	797	1721	245	838	1797	296	847
HBD	89	8	55	146	20	92	141	24	88
3f	154	21	68	171	31	76	198	43	92

	JULY ALL	JULY 18-20	JULY 21-45	AUGUST ALL	AUGUST 18-20	AUGUST 21-45	SEPTEMBER ALL	SEPTEMBER 18-20	SEPTEMBER 21-45
T	2219	311	1023	2324	326	1098	1784	283	841
HBD	168	22	92	150	17	91	157	30	93
3f	222	44	90	219	38	102	206	49	88

	OCTOBER ALL	OCTOBER 18-20	OCTOBER 21-45	NOVEMBER ALL	NOVEMBER 18-20	NOVEMBER 21-45	DECEMBER ALL	DECEMBER 18-20	DECEMBER 21-45
T	2039	293	984	2280	339	1131	2955	425	1547
HBD	161	29	94	156	23	94	178	36	105
3f	204	36	92	196	45	86	211	40	108

VERMONT 1972

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2705	402	1435
HBD	135	15	85
3f	205	32	115

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2813	349	1555
HBD	132	14	71
3f	171	27	97

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	2253	316	1194
HBD	131	18	73
3f	168	38	76

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	1777	235	902
HBD	181	25	107
3f	166	35	74

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1673	248	798
HBD	162	29	90
3f	164	33	77

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	1839	302	869
HBD	128	25	72
3f	199	52	83

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2248	351	1086
HBD	173	37	94
3f	189	32	95

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	2232	309	1101
HBD	177	27	104
3f	201	41	94

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2098	335	939
HBD	170	25	109
3f	191	41	86

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2290	334	1089
HBD	191	40	96
3f	189	38	86

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2627	366	1396
HBD	131	24	80
3f	189	39	100

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	3396	522	1820
HBD	138	22	80
3f	198	40	96

LOUISIANA

Annual Driver Involvements by Age Group and Type

	1971			1972			1973		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	21954	2401	10830	24399	2752	11767	14698	1750	7483
HBD	1057	107	650	1159	127	692	643	62	406
3f	589	127	357	533	123	299	373	70	224

	1973								
	AGE GROUPS								
	ALL	18-20	21-45						
T	25197	3000	12828						
HBD	1102	106	696						
3f	639	120	384						

				TOTAL					
				AGE GROUPS					
				ALL	18-20	21-45			
T				61051	6903	30080			
HBD				2139	296	1748			
3f				1495	320	880			

	BEFORE						AFTER		
	AGE GROUPS						AGE GROUPS		
	ALL	18-20	21-45				ALL	18-20	21-45
T	21954	2401	10830				39097	4502	19250
HBD	1057	107	650				1802	189	1098
3f	589	127	357				906	193	523

LOUISIANA

Annual Age-Specific Driver Involvement Rates by Type

1971

	AGE GROUPS		
	ALL	18-20	21-45
HBD	.048	.045	.060
3f	.027	.053	.033

1972

	AGE GROUPS		
	ALL	18-20	21-45
HBD	.048	.046	.059
3f	.022	.045	.025

1973

	AGE GROUPS		
	ALL	18-20	21-45
HBD	.044	.035	.054
3f	.025	.040	.030

TOTAL

	AGE GROUPS		
	ALL	18-20	21-45
HBD	.035	.043	.058
3f	.024	.046	.029

BEFORE

	AGE GROUPS		
	ALL	18-20	21-45
HBD	.048	.045	.060
3f	.027	.053	.033

AFTER

	AGE GROUPS		
	ALL	18-20	21-45
HBD	.046	.042	.057
3f	.023	.043	.027

LOUISIANA 1971

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1582	182	778	1678	175	837	1691	180	837
HBD	85	11	60	92	10	55	85	6	48
3f	46	10	28	45	13	24	45	8	28

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1661	195	857	1789	202	857	1807	220	851
HBD	88	6	63	83	8	57	69	8	35
3f	53	11	32	62	12	40	38	9	18

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1934	203	945	1939	227	977	1901	208	939
HBD	85	10	45	85	6	56	74	10	47
3f	35	8	23	50	9	31	41	14	23

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1834	171	930	1930	209	930	2208	229	1092
HBD	105	11	61	93	14	53	113	7	70
3f	62	12	42	43	10	22	69	11	46

LOUISIANA 1972

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1941	186	991	1845	209	892	1974	229	953
HBD	101	4	73	102	14	64	98	13	55
3f	49	5	29	47	15	27	41	5	26

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1932	209	941	2063	217	779	1960	227	1018
HBD	91	9	57	96	12	51	89	13	54
3f	51	12	28	42	8	21	34	11	16

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2071	240	996	2034	277	985	2062	244	998
HBD	101	10	63	89	12	52	100	10	58
3f	45	5	29	41	17	14	49	10	31

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2046	213	1014	2103	240	1042	2368	261	1158
HBD	89	12	52	95	11	55	108	7	58
3f	52	17	33	38	12	17	44	6	28

LOUISIANA 1973

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2090	226	1031	1910	208	942	2383	284	1192
HBD	84	10	55	82	4	52	109	11	74
3f	58	9	37	46	7	34	59	12	35

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2060	271	1016	2149	258	1297	2129	250	1039
HBD	98	12	61	94	12	56	95	8	63
3f	60	16	34	46	9	26	52	9	27

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	1977	253	966						
HBD	81	5	45						
3f	52	8	31						

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T									
HBD									
3f									

NEW YORK

Annual Driver Involvements by Age Group and Type

	1968-1969			1970			1971		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	73241	6951	36166	36146	3602	18279	32689	3273	17253
HBD	1275	185	753	567	64	361	573	71	345
3f	2109	443	1261	849	167	528	829	179	496

	1972		
	AGE GROUPS		
	ALL	18-20	21-45
T	34068	3611	17880
HBD	622	74	396
3f	861	168	532

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
T	176144	17437	89578
HBD	3037	394	1855
3f	4648	957	2817

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
T	142076	13826	71698	34068	3611	17880
HBD	2415	320	1459	622	74	396
3f	3787	789	2285	861	168	532

NEW YORK

Annual Age-Specific Driver Involvement Rates by Type

1968-1969

	AGE GROUPS ALL	18-20	21-45
HBD	.0174	.0266	.0208
3f	.0288	.0637	.0349

1970

	AGE GROUPS ALL	18-20	21-45
HBD	.0157	.0178	.0197
3f	.0235	.0464	.0289

1971

	AGE GROUPS ALL	18-20	21-45
HBD	.0175	.0217	.0200
3f	.0254	.0547	.0287

1972

	AGE GROUPS ALL	18-20	21-45
HBD	.0183	.0205	.0221
3f	.0253	.0465	.0298

TOTAL

	AGE GROUPS ALL	18-20	21-45
HBD	.0172	.0226	.0207
3f	.0264	.0549	.0314

BEFORE

	AGE GROUPS ALL	18-20	21-45
HBD	.0170	.0231	.0203
3f	.0267	.0571	.0319

AFTER

	AGE GROUPS ALL	18-20	21-45
HBD	.0183	.0205	.0221
3f	.0253	.0465	.0298

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NEW YORK 1968-69

Driver Involvements by Months, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	6630	543	3285
HBD	65	9	41
3f	135	20	95

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	5540	482	2727
HBD	94	14	60
3f	147	38	85

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	5586	483	2749
HBD	123	14	61
3f	181	31	115

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	5040	492	2440
HBD	112	18	67
3f	173	46	90

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	5921	559	2811
HBD	95	16	58
3f	195	38	125

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	5795	556	2778
HBD	120	13	70
3f	173	28	109

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	5522	592	2790
HBD	93	8	58
3f	159	35	95

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	5788	632	2813
HBD	115	24	67
3f	192	50	101

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	5580	517	2835
HBD	97	17	54
3f	174	35	101

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	6424	583	3086
HBD	109	15	62
3f	179	35	103

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	7180	672	3644
HBD	129	19	83
3f	222	52	129

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	8235	840	4208
HBD	123	18	72
3f	179	35	113

NEW YORK 1970

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	4687	453	2402	3382	291	1752	2950	248	1565
HBD	61	4	37	46	7	31	57	4	41
3f	45	6	30	54	6	41	77	14	53

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2714	266	1383	2899	313	1425	2853	310	1401
HBD	53	5	38	68	10	40	50	7	34
3f	83	15	44	95	20	63	81	16	46

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2544	279	1277	2527	282	1273	2439	227	1187
HBD	48	7	26	31	3	20	37	3	25
3f	83	25	41	73	15	43	55	9	41

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2811	292	1361	2865	273	1466	3475	368	1787
HBD	46	5	26	28	3	19	42	6	24
3f	65	13	39	68	16	37	70	12	50

NEW YORK 1971

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3169	300	1705	2749	267	1488	2842	263	1526
HBD	36	7	20	30	4	18	33	5	18
3f	48	7	34	58	6	41	57	11	36

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2394	230	1230	2646	286	1396	2628	278	1383
HBD	46	2	31	58	8	35	41	10	22
3f	69	16	42	85	15	54	90	24	49

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2656	274	1375	2584	284	1328	2382	249	1247
HBD	46	4	25	43	8	27	36	1	24
3f	72	17	37	74	22	37	55	16	33

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2776	276	1464	2941	271	1546	2922	295	1565
HBD	61	11	36	70	5	43	73	6	46
3f	72	15	45	75	16	48	74	14	40

NEW YORK 1972

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2835	318	1469
HBD	30	5	17
3f	74	16	47

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	3074	292	1704
HBD	45	3	33
3f	81	13	54

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	2711	288	1456
HBD	37	4	30
3f	82	17	49

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	2488	247	1342
HBD	47	4	29
3f	52	11	31

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2884	307	1514
HBD	54	12	24
3f	66	14	42

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	2834	331	1484
HBD	59	6	38
3f	65	12	40

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2735	334	1350
HBD	54	8	33
3f	67	13	34

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	2613	293	1333
HBD	57	5	41
3f	79	19	47

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2696	256	1406
HBD	62	11	38
3f	76	17	44

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2980	303	1540
HBD	64	7	37
3f	65	12	41

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2880	304	1495
HBD	32	3	18
3f	73	13	49

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	3338	338	1787
HBD	81	6	58
3f	81	11	54

TEXAS

Annual Driver Involvements by Age Group and Type

	1969			1970			1971		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	32224	4035	16256	33204	4157	16724	33140	4174	16490
HBD	2251	193	1453	2274	242	1437	NA	NA	NA
3f	1598	282	983	1643	333	960	1590	306	984

	1972		
	AGE GROUPS		
	ALL	18-20	21-45
T	36505	4758	18114
HBD	NA	NA	NA
3f	1716	352	976

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
T	135073	17124	67584
HBD	4525	435	2890
3f	6547	1273	3903

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
T	98568	12366	49470	36505	4758	18114
HBD	4525	435	2890	NA	NA	NA
3f	4831	921	2927	1716	352	976

TEXAS

Annual Age-Specific Driver Involvement Rates by Type

	1969			1970			1971		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.070	.048	.089	.068	.058	.086	NA	NA	NA
3f	.050	.070	.060	.049	.080	.057	.048	.073	.060

	1972		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	NA	NA	NA
3f	.047	.074	.054

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	NA	NA	NA
3f	.048	.074	.058

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	NA	NA	NA	NA	NA	NA
3f	.049	.074	.059	.047	.074	.054

TEXAS 1969

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2454	316	1265	2414	293	1228	2702	315	1411
HBD	178	20	117	185	10	116	222	19	145
3f	135	30	90	115	12	78	133	23	85

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2510	301	1276	2759	370	1380	2518	330	1252
HBD	174	7	125	185	20	115	164	19	98
3f	125	22	87	137	26	83	129	28	65

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2548	310	1280	2812	343	1409	2621	356	1319
HBD	166	10	112	177	19	104	176	18	113
3f	129	21	77	152	23	86	106	22	66

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2952	353	1480	2797	349	1391	3137	399	1565
HBD	204	20	134	195	10	127	225	21	147
3f	139	26	82	124	21	78	174	28	106

TEXAS 1970

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2623	324	1372	2654	323	1388	2962	401	1506
HBD	199	14	127	214	27	148	219	22	132
3f	153	31	92	158	23	109	152	33	86

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2575	304	1311	2939	363	1510	2563	331	1275
HBD	138	16	89	212	21	136	167	14	99
3f	106	22	64	137	26	86	152	20	63

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2683	337	1314	2809	354	1420	2771	335	1363
HBD	167	11	114	164	16	108	166	22	105
3f	138	25	74	146	22	98	123	24	67

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3022	357	1510	2667	329	1324	2936	399	1431
HBD	205	31	124	196	16	118	227	32	137
3f	134	38	68	121	27	72	166	42	81

TEXAS 1971

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2426	308	1229
HBD	NA	NA	NA
3f	137	25	85

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2441	295	1267
HBD	NA	NA	NA
3f	121	23	82

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	2620	323	1324
HBD	NA	NA	NA
3f	112	18	75

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	2661	338	1361
HBD	NA	NA	NA
3f	121	31	73

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2680	340	1363
HBD	NA	NA	NA
3f	160	26	102

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	2581	324	1254
HBD	NA	NA	NA
3f	110	17	71

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2719	319	1392
HBD	NA	NA	NA
3f	145	25	87

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	2871	361	1382
HBD	NA	NA	NA
3f	140	30	82

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2917	391	1414
HBD	NA	NA	NA
3f	98	15	64

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	3074	399	1498
HBD	NA	NA	NA
3f	141	36	80

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2876	376	1393
HBD	NA	NA	NA
3f	120	26	71

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	3274	400	1613
HBD	NA	NA	NA
3f	185	34	112

TEXAS 1972

Driver Involvements by Month, Age Group and Type

	JANUARY			FEBRUARY			MARCH		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2891	357	1447	2616	317	1347	2887	351	1456
HBD	NA	NA	NA	NA	NA	NA	NA	NA	NA
3f	147	27	90	109	25	69	125	22	79

	APRIL			MAY			JUNE		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2908	396	1441	2887	394	1413	2984	385	1524
HBD	NA	NA	NA	NA	NA	NA	NA	NA	NA
3f	150	31	75	137	27	81	142	39	75

	JULY			AUGUST			SEPTEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	2954	385	1448	3215	461	1596	3155	397	1563
HBD	NA	NA	NA	NA	NA	NA	NA	NA	NA
3f	147	29	82	138	28	70	138	21	83

	OCTOBER			NOVEMBER			DECEMBER		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
T	3157	390	1545	3227	430	1564	3624	495	1770
HBD	NA	NA	NA	NA	NA	NA	NA	NA	NA
3f	154	34	86	141	31	78	188	38	108

PENNSYLVANIA

Annual Driver Involvements by Age Group and Type

	1968 ALL	1968 18-20	1968 21-45	1969 ALL	1969 18-20	1969 21-45	1970 ALL	1970 18-20	1970 21-45
T	19428	2111	8989	21148	2450	9967	20868	2358	9457
HBD	60	4	33	87	4	49	175	12	98
3f	626	130	365	718	137	441	736	162	453

	1971 ALL	1971 18-20	1971 21-45	1972 ALL	1972 18-20	1972 21-45
T	20911	2526	10030	24198	2756	11674
HBD	245	18	141	324	25	197
3f	760	146	478	952	189	574

	TOTAL ALL	TOTAL 18-20	TOTAL 21-45
T	106553	12201	50117
HBD		63	518
3f		764	2311

	BEFORE ALL	BEFORE 18-20	BEFORE 21-45	AFTER ALL	AFTER 18-20	AFTER 21-45
T	82355	9445	38443	24198	2756	11674
HBD	567	38	321	324	25	197
3f	2840	575	1737	952	189	574

PENNSYLVANIA

Annual Age-Specific Driver Involvement Rates by Type

	1968			1969			1970		
	AGE GROUPS			AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.00309	.00189	.00367	.00411	.00163	.00492	.00839	.00509	.01036
3f	.032	.062	.041	.034	.056	.044	.035	.069	.048

	1971			1972		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.01172	.00713	.01406	.01339	.00907	.01688
3f	.036	.058	.048	.039	.069	.049

	TOTAL		
	AGE GROUPS		
	ALL	18-20	21-45
HBD	.00836	.00516	.01034
3f	.036	.063	.046

	BEFORE			AFTER		
	AGE GROUPS			AGE GROUPS		
	ALL	18-20	21-45	ALL	18-20	21-45
HBD	.00688	.00402	.00835	.01339	.00907	.01688
3f	.034	.061	.045	.039	.069	.049

PENNSYLVANIA 1968

Driver Involvements by Month, Age Group and Type

JANUARY

	AGE GROUPS ALL	18-20	21-45
T	1763	170	892
HBD	5	0	3
3f	51	11	34

FEBRUARY

	AGE GROUPS ALL	18-20	21-45
T	1518	126	757
HBD	3	0	2
3f	45	4	28

MARCH

	AGE GROUPS ALL	18-20	21-45
T	1483	143	744
HBD	1	0	1
3f	37	6	28

APRIL

	AGE GROUPS ALL	18-20	21-45
T	1265	127	582
HBD	4	0	1
3f	42	13	22

MAY

	AGE GROUPS ALL	18-20	21-45
T	1727	189	799
HBD	5	0	3
3f	68	10	44

JUNE

	AGE GROUPS ALL	18-20	21-45
T	1561	192	687
HBD	4	0	0
3f	46	11	28

JULY

	AGE GROUPS ALL	18-20	21-45
T	1436	179	639
HBD	3	0	2
3f	51	11	29

AUGUST

	AGE GROUPS ALL	18-20	21-45
T	1523	177	712
HBD	4	0	2
3f	42	14	27

SEPTEMBER

	AGE GROUPS ALL	18-20	21-45
T	1504	186	696
HBD	4	0	2
3f	47	10	23

OCTOBER

	AGE GROUPS ALL	18-20	21-45
T	1714	189	755
HBD	6	0	5
3f	58	8	37

NOVEMBER

	AGE GROUPS ALL	18-20	21-45
T	1749	175	752
HBD	11	3	4
3f	72	14	35

DECEMBER

	AGE GROUPS ALL	18-20	21-45
T	2185	258	974
HBD	10	1	8
3f	67	18	30

PENNSYLVANIA 1969

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1858	178	888
HBD	10	0	7
3f	61	7	43

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1591	188	773
HBD	10	0	4
3f	41	4	28

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	1608	184	772
HBD	7	1	5
3f	58	11	38

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	1510	170	697
HBD	8	0	4
3f	41	8	22

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1724	212	800
HBD	6	0	3
3f	53	11	35

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	1671	208	756
HBD	4	0	3
3f	50	11	28

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1588	187	736
HBD	4	0	3
3f	49	9	30

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	1645	226	711
HBD	2	0	1
3f	62	18	35

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1635	175	775
HBD	10	1	2
3f	80	16	48

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1845	195	856
HBD	10	0	7
3f	71	12	45

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1961	222	976
HBD	9	1	6
3f	89	18	55

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2512	305	1227
HBD	7	1	4
3f	63	12	34

PENNSYLVANIA 1970

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1718	193	784
HBD	12	1	7
3f	59	12	36

FEBRUARY		
AGE GROUPS		
ALL	18-20	21-45
1722	194	785
13	1	7
60	13	37

MARCH		
AGE GROUPS		
ALL	18-20	21-45
1725	194	786
13	1	7
60	13	37

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	1729	195	786
HBD	14	1	8
3f	60	13	37

MAY		
AGE GROUPS		
ALL	18-20	21-45
1733	196	788
14	1	8
61	13	37

JUNE		
AGE GROUPS		
ALL	18-20	21-45
1737	196	788
14	1	8
61	13	38

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1741	197	789
HBD	15	1	8
3f	62	14	38

AUGUST		
AGE GROUPS		
ALL	18-20	21-45
1745	197	789
15	1	9
62	14	38

SEPTEMBER		
AGE GROUPS		
ALL	18-20	21-45
1749	198	790
16	1	9
62	14	38

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1753	199	790
HBD	16	1	9
3f	63	14	39

NOVEMBER		
AGE GROUPS		
ALL	18-20	21-45
1756	199	791
16	1	9
63	14	39

DECEMBER		
AGE GROUPS		
ALL	18-20	21-45
1760	200	791
17	1	9
63	15	39

PENNSYLVANIA 1971

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2085	238	1081
HBD	16	2	9
3f	75	18	47

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1839	203	952
HBD	27	1	15
3f	51	7	36

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	1713	187	842
HBD	19	1	14
3f	55	6	41

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	1536	195	732
HBD	25	4	13
3f	59	10	37

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1699	194	804
HBD	28	1	17
3f	73	15	49

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	1561	210	711
HBD	23	3	14
3f	65	13	37

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1713	238	822
HBD	22	1	12
3f	41	5	30

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	1644	201	765
HBD	30	1	12
3f	70	15	41

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1547	204	700
HBD	11	0	6
3f	52	11	32

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1766	217	833
HBD	13	1	10
3f	81	16	49

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1873	215	880
HBD	9	0	5
3f	73	15	42

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1935	224	908
HBD	22	3	14
3f	65	15	37

PENNSYLVANIA 1972

Driver Involvements by Month, Age Group and Type

	JANUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1950	213	994
HBD	21	0	11
3f	77	13	54

	FEBRUARY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2365	254	1197
HBD	14	2	7
3f	71	21	38

	MARCH		
	AGE GROUPS		
	ALL	18-20	21-45
T	1897	173	935
HBD	27	1	20
3f	68	14	41

	APRIL		
	AGE GROUPS		
	ALL	18-20	21-45
T	1734	186	866
HBD	24	2	17
3f	80	12	56

	MAY		
	AGE GROUPS		
	ALL	18-20	21-45
T	2005	236	984
HBD	23	1	14
3f	88	12	58

	JUNE		
	AGE GROUPS		
	ALL	18-20	21-45
T	2047	256	946
HBD	29	2	15
3f	81	13	49

	JULY		
	AGE GROUPS		
	ALL	18-20	21-45
T	1902	235	910
HBD	32	7	15
3f	72	17	43

	AUGUST		
	AGE GROUPS		
	ALL	18-20	21-45
T	1808	223	828
HBD	22	3	14
3f	68	13	35

	SEPTEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	1843	225	871
HBD	26	1	15
3f	80	13	50

	OCTOBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2104	218	982
HBD	33	2	18
3f	87	15	53

	NOVEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2136	236	993
HBD	30	1	20
3f	84	25	42

	DECEMBER		
	AGE GROUPS		
	ALL	18-20	21-45
T	2407	301	1168
HBD	43	3	31
3f	96	21	55