THE CHANGE IN THE MINIMUM DRINKING AGE
AND EFFECTS ON MOTOR VEHICLE CRASH RATES IN OHIO

A Thesis

Presented in Partial Fulfillment of the Requirements for
the degree Master of Science in the
Graduate School of the Ohio State University

by
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* * * *
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To My Loving Wife
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PUBLICATIONS


FIELDS OF STUDY

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<tr>
<td>BAC</td>
<td>Blood Alcohol Concentration</td>
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<tr>
<td>BMV</td>
<td>Ohio Bureau of Motor Vehicles</td>
</tr>
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<td>CDC</td>
<td>U.S. Centers for Disease Control and Prevention</td>
</tr>
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<td>DMV, DSV</td>
<td>Daytime - Multiple Vehicle, Daytime - Single Vehicle</td>
</tr>
<tr>
<td>DOT</td>
<td>U.S. Department of Transportation</td>
</tr>
<tr>
<td>DUI</td>
<td>Drinking while Under the Influence</td>
</tr>
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<td>FARS</td>
<td>Fatal Accident Reporting System</td>
</tr>
<tr>
<td>GAO</td>
<td>U.S. General Accounting Office</td>
</tr>
<tr>
<td>HBD</td>
<td>Had Been Drinking</td>
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<tr>
<td>MDA</td>
<td>Minimum Drinking Age</td>
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<tr>
<td>MV, SV</td>
<td>Multiple Vehicle, Single Vehicle</td>
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<tr>
<td>NHTSA</td>
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<td>NMV, NSV</td>
<td>Nighttime - Multiple Vehicle, Nighttime - Single Vehicle</td>
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<tr>
<td>No Alc.</td>
<td>No Alcohol Detected</td>
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<tr>
<td>NSV(M)</td>
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<td>NSV(F)</td>
<td>Nighttime - Single Vehicle with Female Driver</td>
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<td>ODHS</td>
<td>Ohio Department of Highway Safety</td>
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CHAPTER I
INTRODUCTION

For many years, studies have shown significant use of alcohol in young people. Alcohol affects young people starting as early as the eighth and tenth grades (NIDA, 3-10-89), and there is a large volume of evidence noting the relationship between alcohol use and the likelihood of fatal injuries (Anda, et. al., 1988; Smith, et. al., 1989a). While researchers have examined ways of reducing these risks, there are considerable social pressures against restricting the availability of alcohol. This project examined one aspect of the effects of alcohol use in young people, analyzing the change in Ohio's Minimum Drinking Age (MDA) and that change's effect on motor vehicle crash rates in this state. This intervention is aimed at preventing a specific outcome, that being to keep young drivers from drinking and driving. Before interpreting this study, we must understand how prevention is used scientifically.

Prevention can be divided into three phases: primary, secondary, and tertiary. Primary prevention is aimed at reducing known or suspected risk factors for a certain outcome, before that outcome is detectable in the population. Secondary prevention is based on early recognition of signs of a bad outcome, and intervening before the full effects of the outcome are manifested. Tertiary prevention is intervention after the outcome has
been recognized, in an attempt to change the eventual morbidity or mortality associated with that outcome.

Changing the incidence of death or injury associated with alcohol use can be approached via these preventive phases. Primary prevention could be achieved by removing alcohol from the population, as was attempted across the United States during Prohibition, or by limiting distribution by licensing, or establishing restrictions on segments of the population. Secondary prevention could be achieved by highway checkpoints and driving under the influence laws, that are intended to remove at-risk drivers from the highways, or by mechanical devices in the vehicle preventing impaired drivers from starting the vehicle. Tertiary prevention could be aimed at educational and treatment programs for drivers in alcohol-related crashes.

These previous examples are important in understanding the intervention of the minimum drinking age. Establishing a legal age limit for alcohol purchases can be recognized initially as primary prevention, by restricting the use of alcohol in an age group highly prone to drunk driving and automobile crashes. MDA laws also are a form of secondary prevention, as underage drinking drivers can be removed from the roadway by traffic officials, without direct proof of illegal intoxication.

These laws may even be a form of tertiary prevention, through blocking of the "spillover" effect, when an underage person seeking alcohol persuades someone of legal age to purchase alcohol for them. A sixteen or seventeen year-old seeking alcohol may well know an eighteen year-old willing to purchase for them, but would be less likely to know a twenty-one year-old who would agree to their plan. Previous studies
(Douglass, 1980; Williams, et. al., 1983b) have shown direct links, although weak, between drinking age changes and crash rates in these younger drivers.

**The History of Alcohol Control**

It is essential to look at the history of alcohol use and of the alcohol control laws in the United States when studying the high prevalence of young drunk driver involvement in automobile crashes. Many interventions are through legislative means, and these laws are deeply rooted in the societal approaches to alcohol and alcohol abuse.

Alcohol has been the subject of social scrutiny over the past few centuries in Europe, with resulting major effects on current legal precedents. In 1983, Nicholas Dorn presented a theory about the historical roots of alcoholic beverage control laws. English law began restricting alcohol use to better control the social classes emerging after the collapse of the feudal system. As the lower classes achieved the ability to earn an income and dispense with their money as they chose, alcohol use increased, and pubs and taverns became important social outlets for these people (Dorn, 1983).

Fearing the growing political strength of this class, the "Vagrant Statues", circa 1495, emerged. These laws prevented the sales of alcohol in specific settings, and during certain times or days. These laws went beyond restricting the use of alcohol, seeking to control activities such as gambling, loitering, and begging. Dorn (1983) states that this was an approach by the feudal masters to retain control over their former servants, not an attempt to improve health.
This social structure approach shifted to a public health concern in the early twentieth century, in both Europe and in the United States, with a new focus on protecting children. In a study from 1981, Cashman notes the relationship between the birth of the Industrial Revolution and early American efforts to limit alcohol use and abuse. Drunkenness on the job became considerably more dangerous as the jobs became mechanized (Cashman, 1981). Alcohol use and abuse as a public health concern arose during a time that this and other environmental and lifestyle issues, such as poverty, child labor, sanitation, and opium use, were gaining attention for their impact on health and society.

In the early twentieth century, political forces in the United States emerged from this growing public health concern. The Anti-Saloon League, based in Westerville, Ohio, had a goal of eliminating the alcohol industry and the saloon business from American society. As part of the rationing needed during the First World War, these forces supported an all-out ban on the sale and distribution of alcohol (Cohen and Cohen, 1986). The passage of the Eighteenth Amendment to the U.S. Constitution on January 19th, 1919, became the most significant attempt to control alcohol use in American history.

Prohibition, which became effective January 16th, 1920, outlawed the manufacture, transport, and sale of alcoholic beverages with alcohol content of 0.5% or greater within the United States. Yet the provisions of the amendment, and the ensuing enforcement legislation, the Volstead Act, were both vague and difficult to enforce. After passage of these laws, the level of alcohol production actually rose. While much of this production was intended for industrial use, the Volstead Act limited the
power of Treasury agents to monitor for divergence of the product into the blackmarket (Aaron and Musto, 1981).

The Great Depression of the 1930’s saw the collapse of Prohibition, with hope that restoration of the alcohol industry could provide new jobs and new tax income for federal relief programs. One of the key phrases used by repeal advocates was "alcohol control". Aaron and Musto (1981) describe the political and business forces advocating the regulatory control of alcohol production and consumption, without trying to enforce the strict elimination of the substance from society.

The history of Prohibition in the United States has had far-reaching effects on attempts to exert regulatory control or social limits on alcohol consumption. Since possession alone was no longer a crime, other laws had to be devised to inhibit the dangerous use of alcohol. Driving under the influence (DUI) laws, alcohol sales licensing, taxation, and limits on the type or time of alcoholic beverages sales are all examples of governmental controls. The interactions between the federal, state, and local governments have played an important part in the development of these laws (Laurence, 1988).

Alcohol and the Automobile

As the automobile became part of life in the United States, it has also been recognized as a potential safety hazard. Automobile safety statistics were first collected nationally in 1923, by the National Safety Council. Between 1923 and 1963, while both the number of vehicles and the total miles driven increased fourfold, the death rate per 100,000 miles driven decreased by nearly the same amount (Marshall, 1986). This is most likely attributable in part to improvements in automobile design and
improved roads, as well as greater awareness of factors contributing to crashes and ways to prevent them.

Alcohol has been recognized as a significant contributor to automobile crashes for many years. In 1938, Richard Holcomb described efforts to determine methods of objectively measuring intoxication, as well as studying the prevalence of drinking drivers on the roads of Chicago, and their involvement in crashes. Sampling from various times and days of the week, 12 percent of the drivers had positive breath tests for alcohol, and 2% were over 0.10 g/dl blood alcohol concentration (BAC). Comparing these results to information obtained from local hospitals, Holcomb finds that 47% of the drivers involved in personal injury crashes were positive for any trace of alcohol, and 25% were over 0.10 g/dl. This over-representation of the drinking driver in the crash group still serves as a demonstration of the risks of drunk driving.

Two measures can be used to identify crashes likely to be related to alcohol consumption: crash report "had been drinking" designations and surrogate crash measures. The "had been drinking" (HBD) designation by the reporting agency (usually the investigating officer) is considered the most direct route, and can be a highly reliable predictor of alcohol involvement.

However, this reporting varies between states. In some states, the HBD designation is a forced entry, meaning it is a separate field on the crash report form, that must be completed for each report. Other states provide the officer with a list of possible contributing factors in crashes, one of which is alcohol use. In this type of designation, the officer is called on to not only determine whether the driver had been drinking, but
also whether the alcohol use was responsible for the crash (Wagenaar, 1983). This becomes a subjective assessment by the officer, which may vary with weather conditions, public or internal campaigns relating to drunk driving enforcement, or from one officer to another.

As more data were collected focusing on crashes by their type, it was found that drunk driving could be accurately predicted by surrogate crash data. Therefore, even in the absence of direct measures of intoxication, certain types of crashes could be assumed to represent the impact of alcohol on crash rates. In 1959, Haddon and Bradess published their study of single vehicle crashes involving fatalities, finding that 69 percent of these drivers had BAC's of over 0.05 g/dl, and 49% were over 0.15 g/dl. This type of study has led to the establishment of legal limits for intoxication while driving.

Using a special subgroup such as all single vehicle crashes can be criticized because it excludes looking at the "whole picture", such as overall crash rates, or the direct measures obtained by the investigating officer. However, the rationale behind focusing on this type of subgroup includes the following factors: 1) fatal crashes are more frequently reported in detail, compared to minor injury or property damage only crashes, 2) the reports vary only slightly between jurisdictions, 3) BAC's from the drivers are more uniformly collected, and 4) no other evidence is needed to identify the driver as most likely responsible for the circumstances of the crash (Haddon and Bradess, 1959).

Analysis of the Fatal Accident Reporting System (FARS) data in 1987 confirms the use of single vehicle crash data, with 50 percent of these drivers exhibiting BAC's of 0.10 g/dl or more, compared to 30% in
multiple vehicle crashes. Another specific group are crashes occurring at nighttime, where 63% were legally intoxicated, compared to only 24% in daytime crashes (Fell and Nash, 1989). Factoring in gender differences in crash rates results in the three factor surrogate measure: nighttime, single vehicle crashes with male drivers (NSVM). These surrogates are considered less subject to bias, as these determinants are easily and uniformly measured, and require no application of judgment in the process (Wagenaar, 1983).

An important factor in the crash rates among young adults is driving inexperience. Williams and others (1983a) compared neighboring states with differing minimum licensing ages, and found significant differences in fatal crash rates among same-aged drivers in these states. In a later study, all-crash rates were also peaked among young drivers (Williams and Carsten, 1989).

In 1987, Asch and Levy published a multiple regression analysis of national crash data, from which they conclude that driver inexperience is the significant factor in predicting youthful driver crashes, and that alcohol use is an insignificant factor in this analysis. However, their study ignores the BAC data of the FARS (as noted above), and may also include a serious confounding factor, that being the interaction between driving inexperience and drinking inexperience.

This combined inexperience is repeated manifested in youth attitudes toward the effects alcohol will have on their physical abilities and their driving skills. In 1989, Basch and others studied focus groups composed of teen drivers from twelve North American cities, and examined these attitudes. The teens' responses reflected not only
inexperience with alcohol and its physiologic effects, but also with the secondary effects on driving. When asked about having too much alcohol before driving, some responses were "if you can't find the keyhole" and "if I can't even walk" (Basch, et. al., 1989). The perception of risk associated with drunk driving in young people reflects concerns about being apprehended, rather than with safe driving outcomes (Vegega and Klitzner, 1989).

**The Minimum Drinking Age**

The MDA has been important to alcohol control laws since Prohibition. The development of laws separating alcohol availability to adults from that of minors preceded the Prohibition Era, but returned to the legal codes after the amendment was repealed. This legal separation of the role of the adult and the role of the adolescent has also been applied to laws regarding tobacco sales, consent to marriage, and other activities that societal values recognize as "adult" (Mosher, 1980).

Minimum drinking age legislation was not standardized nationally, and ranged, among the states, from 17 to 21 years of age. The 26th U.S. Constitutional Amendment lowered the national voting age from 21 to 18 years of age, in July, 1971. This action prompted many states to lower their legal drinking ages as well, on the premise that if a person is old enough to vote, and to be drafted into the military, then they should not be prohibited from purchasing alcohol. These shifts in the MDA were followed by increases in alcohol consumption in younger people, reflected in studies (Wagenaar, 1983) from several states and Canadian provinces.

In light of this increased consumption, concerns arose about possible increases in youthful drunk driving and crash rates. Analyses
were performed on national data collected by the U.S. Department of Transportation in the late 1960's, mandated by the Highway Safety Act of 1966. Within two years of the drops in MDA in several states, an increase in alcohol related motor vehicle crashes were seen. These increases were further documented (Voas and Moulton, 1980) when the FARS began collecting national crash information in 1975.

A study commissioned by the National Highway Traffic Safety Administration (NHTSA) in 1973 reported increases of 10 to 26 percent in youth crash involvement between 1968 and 1971 (General Accounting Office [GAO], 1987). Cook and Tauchen studied fatal crashes nationally, between 1970 and 1977, and conclude that the automobile fatality rate increased 7% for 18-20 year-old drivers, with additional evidence for increases in fatal crashes among 16-17 year-old drivers (1984). Since 1976, no state has lowered the legal drinking age.

The mid-70's saw the enactment of the 55 mph speed limit, primarily as an energy conservation measure, but no national initiatives aimed at reducing drunk driving appeared until the 1980's. In 1982, the Presidential Commission on Drunk Driving recommended a uniform 21 year-old minimum drinking age (GAO, 1987). By 1984, 42 percent of the state MDA's were already at 21 years of age, but 48% were 19 or lower (Hoxie and Skinner, 1987).

As a number of federal agencies and lobbying groups (e.g. Mothers Against Drunk Driving) began pushing legislators for a national MDA of 21 years of age, several amendments were introduced into the Surface Transportation Assistance Act of 1982 (an appropriations bill allocating federal highway funds). The earliest amendments called for
funding incentives for states that had increased their drinking ages to 21 years (GAO, 1987).

Later, these amendments were altered, and the language changed so that the Secretary of Transportation was given the statutory authority to withhold federal highway funds from states with MDA's lower that 21 years. These funds were in the form of matching grants for construction projects (Congressional and Administrative News, 1984). Several states (including Ohio) were highly resistant to what was construed as a federal intrusion on state rights. However, the linkage of highway funds to the minimum drinking age was tested (South Dakota versus Dole, 1985) and upheld in the federal courts (American Bar Association, 1986).

During the period of time these changes were implemented, the FARS noted progressive declines in the BAC's of 16-20 year-old crash fatality victims (DOT Technical Report, 1989). After MDA changes in nine states, five in the Midwest, a mean reduction of 28 percent was seen in nighttime fatal crash rates (Williams, et. al., 1983b).

The history of the minimum drinking age laws in Ohio is of particular interest to this study, and has mirrored the moves taken in other states. Prior to 1982, Ohio law restricted alcohol sales as follows:

Age 18 - permitted to purchase beer containing less than 3.2% alcohol,

Age 21 - permitted to purchase any intoxicating beverage.

By action of House Bill 357 (1982 Session Laws - Full Text, 1982), enacted August 19th, 1982, the 3.2% classification was abandoned, and
the law rewritten to state:

Age 19 - permitted to purchase any beer,
Age 21 - permitted to purchase any intoxicating beverage.

This law was further revised in 1987 by action of Substitute House Bill 419 (1987 Session Laws - Full Text, 1987), enacted on July 1st, 1987, and made effective August 1st, 1987. This bill was designed to bring Ohio law into compliance with the federal standard, so that highway funding was not jeopardized. This law stated:

Age 21 - permitted to purchase any beer, wine, or other intoxicating beverage.

The enforcement of this change included a "grandfather clause", so that the actual change in the drinking age was gradually instituted over two years. This provision allowed persons who had already reach the legal age before the law was changed to retain the right to purchase alcohol. For example, a 19 year-old whose birthday was July 31st, 1987, would be permitted to purchase alcohol on that date, while someone turning 19 years of age on August 1, 1987, would have to wait until they were 21 years of age (1987 Session Laws - Full Text, 1987).

HYPOTHESIS

Based on these above changes in Ohio law, between August 1st, 1987, and July 31st, 1989, fewer 19 and 20 year-old Ohio drivers were legally permitted to purchase alcohol of any type within the state. This
study addresses the following potential outcomes:

1. Did the change in Ohio’s MDA result in a significant change in the overall crash rates for youthful drivers?
2. Was a significant change seen in surrogate measures for alcohol-related crashes?
3. Was a significant change seen in crash rates for drivers younger than the legal limit (16-18 years of age)?
4. Was a significant change seen in "had been drinking"-reported crash rates?
5. How do changes in crash rates in Ohio compare with other states?
CHAPTER II
MATERIALS AND METHODS

Data collection

Raw data for this analysis have been provided by the Ohio Department of Highway Safety (ODHS), through the Office of the Governor’s Representative on Highway Safety and the Bureau of Motor Vehicles (BMV). Information is collected by all state and local law enforcement agency when reported motor vehicle accidents involving personal injury or property damage of one-hundred fifty dollars or more are reported. This information must be reported to the ODHS within five days of the event (ODHS, 1982).

Most agencies report this information on a standardized report form (OHIO TRAFFIC ACCIDENT REPORT OH-1, see Appendix A) or its equivalent, which is completed by the investigating officer. The data collected include the time of the accident, the number of vehicles involved (single vs multiple vehicles), injuries in the crash, weather conditions, use of seat belts, and any other identified factors contributing to the crash.

In the calculation of crash rates, the numerator is represented by the total number of crash events within a specific time period and group of drivers. From the aggregated data reported to ODHS, numerator data for
this analysis are monthly totals for all fatal crashes, all serious injury crashes and fatal crashes, and all minor injury, serious injury and fatal crashes throughout the state.

In each of these three categories, direct monthly totals were obtained for single vehicle and multiple vehicle crashes, daytime and nighttime crashes, male and female drivers in crashes, and all "had been drinking" and "no alcohol detected" crashes. These direct measures were combined to produce estimates for nighttime/single vehicle, nighttime/multiple vehicle, daytime single vehicle, daytime multiple vehicle, and nighttime/single vehicle/male and nighttime/single vehicle/female crashes.

Direct measures of these subcategories were not available for the full study period. Estimates were derived from the overall proportions of daytime/nighttime, single vehicle/multiple vehicle, and male/female for all crashes. For example, in 1984, there were 40 daytime and 53 nighttime fatal crashes in the 19-20 year old group. Therefore, daytime crashes accounted for 43% of the total. In this same age group, there were 60 single vehicle crashes. Using the estimation method described above, daytime/single vehicle crashes would be $(60 \times .43) = 25.8$ crashes.

The denominator is determined by the total number of drivers at risk, being the total number of licensed drivers corresponding to the numerator group. For this analysis, denominator data were calculated from a spot listing of the total number of licensed drivers from January 1987 to December 1988. Within the records of the BMV, it is impossible to collect data from the entire study period, as the files on individual drivers are continuously updated when the drivers renew their licenses.
Using this spot listing, the monthly variations in the number of licensed drivers were determined. This monthly variation is largely determined by the birthdates of the drivers involved, as well as the dates that they complete driver training courses.

While direct monthly totals were not available for the entire study period, the annual totals of licensed drivers by their age groups and gender are published by the ODHS (ODHS, 1984-1992). Using these annual totals and the monthly variations determined from the spot listing, the monthly totals for licensed drivers from January 1984 to May 1992 were extrapolated.

Within these monthly totals, the numerator and denominator data are subdivided by age, from 16 to 25 years. For this analysis of crash frequency, these data were regrouped as younger drivers not directly affected by the MDA change (ages 16-18 years), and the study group directly affected by the MDA change (ages 19-20 years). Older drivers unaffected by the MDA change (ages 21-25 years) were used as the control group.

Data analysis

The method of data analysis is similar to analyses performed on multi-state data by the National Highway Traffic Safety Administration, in published reports studying the effects of the MDA changes nationally (Arnold, 1985; Womble, 1989). The data are divided by time based on the date the MDA changes became effective. For Ohio, the time series can be identified as follows:
Year-age cells are used to correct for the difference in the number of years and age groups involved. The year-age cells are determined by the amount of time and number of age groups contributed by the affected and the control group. For example, in comparing the 19-20 year old drivers with the 21-25 year old drivers, from Figure 1:

**BEFORE MDA CHANGE**


**AFTER MDA CHANGE**


**FIGURE 2. CALCULATION OF YEAR-AGE CELLS**
After/before ratios for the 19-20 year old drivers are calculated as follows:

\[
\text{RATIO} = \frac{\text{\# CRASHES}^{\text{AFF}}_{\text{AFTER LAW}}}{\text{\# CRASHES}^{\text{AFF}}_{\text{BEFORE LAW}}}\div\text{\# YEAR-AGE CELLS}
\]

\[
\text{AFF = POP. AFFECTED BY MDA CHANGE}
\]

**Figure 3. After / Before Ratio for 19-20 Y.O. Drivers**

This after/before ratio can also be determined for the unaffected group, and that ratio can be used to control for the unaffected group. These ratios can then be converted to crash rates by including the total number of licensed drivers, as in the following two figures:

\[
\text{RATIO} = \frac{\text{\# CRASHES}^{\text{AFF}}_{\text{AFTER LAW}}}{\text{\# CRASHES}^{\text{AFF}}_{\text{BEFORE LAW}}}\div\text{\# YEAR-AGE CELLS}
\]

\[
\text{AFF = POP. AFFECTED BY MDA CHANGE}
\]

\[
\text{RATIO} = \frac{\text{\# CRASHES}^{\text{UN}}_{\text{AFTER LAW}}}{\text{\# CRASHES}^{\text{UN}}_{\text{BEFORE LAW}}}\div\text{\# YEAR-AGE CELLS}
\]

\[
\text{UN = POP. UNAFFECTED BY MDA CHANGE}
\]

**Figure 4. Correction for 21-25 Y.O. Drivers**
The year-age cells cancelled out of the final formula, since the same number of years and age groups are used in determining the number of crashes and the number of licensed drivers.

Confidence intervals for these crash rates are based on the logarithmic transformations of the rate. The denominator data are considered census data, and so, they are free of variance. The logarithmic transformations can then be assumed to be normally distributed based on the large sample sizes drawn from the total population of licensed drivers in the state. The variance and confidence intervals are determined by the following formulae:

\[ O^2 = \sum_{i=1}^{4} [N_i]^{-1} \]

95% CONFIDENCE INTERVAL = \( \text{ln} \left( \text{RATE} \right) \pm 1.96 \sigma \)

\( \sigma^2 = \text{variance} \quad \sigma = \text{standard deviation} \)

FIGURE 6. RATE VARIANCE AND CONFIDENCE INTERVALS
CHAPTER III

RESULTS

Using the methods previously described, the crash rates calculated represent the percentage change in the number of crashes in the study group, compared to the control group, and corrected for the number of licensed drivers in each pool. These crash rates can be directly compared across each type of crash and level of severity.

The 19-20 year old drivers are the group directly affected by the MDA change, and are the primary study group in this analysis. The effects on younger drivers (16-18 years old) can also be quantified by the same methods, and are also examined. Examining effects on younger drivers is useful in considering the "spill-over" effects on these drivers, and determining the long-term effects of the MDA change.

Crash rates were determined for the following levels of severity and types of crashes:

<table>
<thead>
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<th>LEVEL I - FATAL CRASHES</th>
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<tbody>
<tr>
<td>LEVEL II - FATAL AND SERIOUS INJURY CRASHES</td>
</tr>
<tr>
<td>LEVEL III - FATAL, SERIOUS AND MINOR INJURY CRASHES</td>
</tr>
</tbody>
</table>

TABLE 1. LEVELS OF CRASH SEVERITY
**TABLE 2. TYPES OF CRASHES**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total crashes</td>
<td>Daytime - 5:00 AM to 9:00 PM</td>
</tr>
<tr>
<td></td>
<td>Nighttime - 9:00 PM to 5:00 AM</td>
</tr>
<tr>
<td>Single vehicle (SV)</td>
<td></td>
</tr>
<tr>
<td>Multiple vehicle (MV)</td>
<td></td>
</tr>
<tr>
<td>Male drivers (M)</td>
<td></td>
</tr>
<tr>
<td>Female drivers (F)</td>
<td></td>
</tr>
<tr>
<td>Daytime single vehicle (DSV)</td>
<td></td>
</tr>
<tr>
<td>Nighttime single vehicle (NSV)</td>
<td></td>
</tr>
<tr>
<td>Daytime multiple vehicle (DMV)</td>
<td></td>
</tr>
<tr>
<td>Nighttime multiple vehicle (NMV)</td>
<td></td>
</tr>
<tr>
<td>Nighttime single vehicle - male drivers (NSV(M))</td>
<td></td>
</tr>
<tr>
<td>Nighttime single vehicle - female drivers (NSV(F))</td>
<td></td>
</tr>
<tr>
<td>All crashes - driver designated &quot;had been drinking&quot; (HBD)</td>
<td></td>
</tr>
<tr>
<td>All crashes - driver designated &quot;no alcohol detected&quot; (NO ALC.)</td>
<td></td>
</tr>
</tbody>
</table>

Crash rates determined for each of the above types are shown in Table 3 for the directly affected drivers, and in Table 4 for the younger drivers, along with the significance levels. These rates are shown in graphic form in Figures 7-12.
<table>
<thead>
<tr>
<th>TYPE</th>
<th>LEVEL I</th>
<th>LEVEL II</th>
<th>LEVEL III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RATE</td>
<td>95% C.I.</td>
<td>RATE</td>
</tr>
<tr>
<td>TOTAL</td>
<td>-11.57</td>
<td>-28.57, 9.48</td>
<td>-2.32</td>
</tr>
<tr>
<td>DAY</td>
<td>-0.91</td>
<td>-28.03, 36.45</td>
<td>10.50</td>
</tr>
<tr>
<td>NIGHT</td>
<td>-19.26</td>
<td>-39.47, 7.70</td>
<td>-14.91</td>
</tr>
<tr>
<td>SV</td>
<td>-8.22</td>
<td>-30.09, 20.50</td>
<td>-3.99</td>
</tr>
<tr>
<td>MV</td>
<td>-16.06</td>
<td>-40.53, 18.48</td>
<td>0.59</td>
</tr>
<tr>
<td>NSV</td>
<td>-14.98</td>
<td>-41.00, 22.66</td>
<td>-16.57</td>
</tr>
<tr>
<td>NMV</td>
<td>-24.76</td>
<td>-52.82, 20.00</td>
<td>-12.84</td>
</tr>
<tr>
<td>DSV</td>
<td>1.18</td>
<td>-32.76, 52.24</td>
<td>8.27</td>
</tr>
<tr>
<td>DMV</td>
<td>2.83</td>
<td>-41.98, 62.73</td>
<td>13.25</td>
</tr>
<tr>
<td>NSV(M)</td>
<td>-14.54</td>
<td>-43.46, 29.16</td>
<td>-13.59</td>
</tr>
<tr>
<td>NSV(F)</td>
<td>-18.94</td>
<td>-62.98, 27.50</td>
<td>-23.84</td>
</tr>
<tr>
<td>MALE</td>
<td>-8.50</td>
<td>-28.03, 16.32</td>
<td>0.76</td>
</tr>
<tr>
<td>FEMALE</td>
<td>-23.33</td>
<td>-52.04, 22.59</td>
<td>-9.83</td>
</tr>
<tr>
<td>HBD</td>
<td>-5.04</td>
<td>-30.96, 30.61</td>
<td>-5.16</td>
</tr>
<tr>
<td>NO ALC.</td>
<td>NO DATA AVAL.</td>
<td>0.44</td>
<td>-8.04, 9.70</td>
</tr>
</tbody>
</table>

* = DECREASE SIGNIFICANT AT p=0.05  ^ = INCREASE SIGNIFICANT AT p=0.05
SV= SINGLE VEHICLE  MV=MULTIPLE VEHICLE  N=NIGHTTIME  D=DAYTIME
(M)=MALE DRIVER  (F)=FEMALE DRIVER  HBD=HAD BEEN DRINKING
NO ALC.=NO ALCOHOL DETECTED
<table>
<thead>
<tr>
<th>TYPE</th>
<th>RATE</th>
<th>95% C.I.</th>
<th>RATE</th>
<th>95% C.I.</th>
<th>RATE</th>
<th>95% C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>5.99</td>
<td>-13.53, 29.93</td>
<td>3.16</td>
<td>-3.11, 10.06</td>
<td>-0.71</td>
<td>-3.18, 1.83</td>
</tr>
<tr>
<td>DAY</td>
<td>7.71</td>
<td>-18.47, 42.30</td>
<td>12.13</td>
<td>3.06, 21.99</td>
<td>1.75</td>
<td>-1.38, 4.97</td>
</tr>
<tr>
<td>NIGHT</td>
<td>-2.62</td>
<td>-32.40, 32.43</td>
<td>-0.42</td>
<td>-17.38, 1.52</td>
<td>-7.78</td>
<td>-11.42, -3.67*</td>
</tr>
<tr>
<td>SV</td>
<td>14.59</td>
<td>-11.87, 49.00</td>
<td>3.18</td>
<td>-5.49, 12.66</td>
<td>0.32</td>
<td>-3.19, 3.96</td>
</tr>
<tr>
<td>MV</td>
<td>-7.53</td>
<td>-33.08, 27.76</td>
<td>3.47</td>
<td>-5.96, 13.85</td>
<td>0.82</td>
<td>-4.30, 2.79</td>
</tr>
<tr>
<td>NSV</td>
<td>0.63</td>
<td>-32.58, 50.19</td>
<td>-7.89</td>
<td>-19.69, 5.91</td>
<td>-6.81</td>
<td>-12.37, -0.90*</td>
</tr>
<tr>
<td>NIV</td>
<td>-14.74</td>
<td>-47.77, 39.18</td>
<td>-9.00</td>
<td>-21.89, 3.02</td>
<td>-7.07</td>
<td>-13.42, -1.97*</td>
</tr>
<tr>
<td>DSV</td>
<td>17.01</td>
<td>-18.18, 67.34</td>
<td>12.31</td>
<td>0.41, 25.95*</td>
<td>2.77</td>
<td>-1.67, 7.42</td>
</tr>
<tr>
<td>DMV</td>
<td>-4.35</td>
<td>-38.68, 49.21</td>
<td>11.93</td>
<td>-1.17, 26.77</td>
<td>1.65</td>
<td>-2.74, 6.24</td>
</tr>
<tr>
<td>NSV(M)</td>
<td>-14.69</td>
<td>-47.09, 37.57</td>
<td>-9.98</td>
<td>-23.89, 6.47</td>
<td>-8.30</td>
<td>-15.09, -0.97*</td>
</tr>
<tr>
<td>NSV(F)</td>
<td>22.25</td>
<td>-44.10, 167.35</td>
<td>-6.04</td>
<td>-27.11, 21.11</td>
<td>-5.78</td>
<td>-14.99, 4.43</td>
</tr>
<tr>
<td>MALE</td>
<td>-6.61</td>
<td>-26.52, 10.69</td>
<td>-0.84</td>
<td>-6.70, 8.98</td>
<td>-2.29</td>
<td>-5.32, 0.83</td>
</tr>
<tr>
<td>FEMALE</td>
<td>32.80</td>
<td>-11.54, 99.37</td>
<td>5.27</td>
<td>-6.46, 16.47</td>
<td>0.40</td>
<td>-3.76, 4.74</td>
</tr>
<tr>
<td>HBD</td>
<td>17.19</td>
<td>-43.16, 20.66</td>
<td>-20.34</td>
<td>-30.70, -8.42*</td>
<td>17.50</td>
<td>-22.88, -11.73*</td>
</tr>
<tr>
<td>NO ALC.</td>
<td>NO DATA AVAL.</td>
<td>NO DATA AVAL.</td>
<td>8.89</td>
<td>0.67, 17.77^</td>
<td>0.99</td>
<td>-3.78, 1.88</td>
</tr>
</tbody>
</table>

* = DECREASE SIGNIFICANT AT p=0.05 ^ = INCREASE SIGNIFICANT AT p=0.05

SV= SINGLE VEHICLE  MV= MULTIPLE VEHICLE  N= NIGHTTIME  D= DAYTIME
(M)= MALE DRIVER  (F)= FEMALE DRIVER  HBD= HAD BEEN DRINKING
NO ALC.= NO ALCOHOL DETECTED
FIGURE 7. GRAPH - LEVEL I CRASHES, 19-20 Y.O. DRIVERS
FIGURE 8. GRAPH - LEVEL II CRASHES, 19-20 Y.O. DRIVERS
FIGURE 9. GRAPH - LEVEL III CRASHES, 19-20 Y.O. DRIVERS
FIGURE 10. GRAPH - LEVEL I CRASHES, 16-18 Y.O. DRIVERS
Figure 11. Graph - Level II crashes, 16-18 Y.O. drivers

Legend:
- SV = Single vehicle
- MV = Multiple vehicle
- N = Nighttime
- D = Daytime
- M = Male driver
- F = Female driver
- HBD = Had been drinking
- NO ALC. = No alcohol detected
FIGURE 12. GRAPH - LEVEL III CRASHES, 16-18 Y.O. DRIVERS
The assumptions used in the calculating methods for the crash rates are important in understanding and interpreting these results. First, the licensed driver data were extrapolated from a spot measurement taken during a limited portion of the study period. This assumption is dependent on stability in age of licensure distribution throughout the study period. Since the spot measurement was taken from the mid-portion of the study period, the error associated with this assumption should be small.

The second assumption is made in calculating the surrogate measurements of crash involvement. Unfortunately, these measures could not be directly ascertained from the ODHS dataset. Therefore, the estimates are intended to approximate the true values. Any significance placed on these values must be weighed carefully. However, in examining the nighttime crash surrogates (NSV, NMV, NSVMale, and NSVFemale), the accuracy of these estimates is supported by the pattern of significant decreases in the crash rates in the total nighttime crashes, since this is a direct measure from the dataset.

In evaluating this data, the study period must be examined for any identifiable confounding factors. Enforcement of both drunk-driving laws and minimum drinking age laws can vary, in response to media and public-interest group efforts in drawing attention to these issues, and other factors. However, efforts of this type are usually localized or limited to certain seasons of the year (i.e. New Year’s Eve, Prom season). Since the study periods before and after the MDA change span many months, and include data from the entire state, these effects should be minimized.
CHAPTER IV

DISCUSSION

19-20 Year-old Driver Effects

The crash rates seen in all drivers show equivocal results. Level I crash rates declined by 12 percent, controlled for the MDA change unaffected group, and the number of licensed drivers in both groups. For crashes involving male drivers, the rates dropped 8.5%, and in crashes with female drivers, the rate dropped 23%. Although these results were not statistically significant, this is due to the very small number of fatal crashes, compared to the size of the population. As has been seen in several other studies (GAO, 1987), it is necessary to look at specific types of crashes to determine the true effect of this intervention.

The effects of the drinking age change in Ohio were most clearly demonstrated in nighttime crashes, when alcohol use by young people has consistently been shown to be high, based on data from several other states and on national data. For all three levels of crash severity, reductions were seen in the rates of crashes for the MDA-affected group. Ranging from 7% for the Level III, to over 19% for the Level I crashes, this result gives strong support to the effectiveness of the MDA change.

The estimates measuring nighttime crashes involving single vehicles, and nighttime crashes involving single vehicles driven by male drivers, show the same robustness across the levels of crash severity.
The NSV(M) drivers had a 9% drop in the crash rates for Level III crashes, which was significant at the 95% confidence interval.

**Female Drivers**

This study also examined the effects of the MDA change in female drivers. While female drivers comprise 49 percent of the population of licensed drivers, they are underrepresented in the number involved in crashes, ranging from 22% in Level I crashes, to 32% for Level III crashes. This supports the fact, noted by Smith and others in studies based on the Behavioral Risk Factor Surveillance System (1988), that male drivers are considered a greater threat for crashes associated with drunk driving, and for crashes overall.

Even so, consistent declines were seen in all levels of crash severity for nighttime single vehicle crashes involving female drivers, with a statistically significant decline of 23% in Level II crashes. This shows that the drinking age change is effective in reducing risks to female drivers as well as male drivers.

**16-18 Year-old Drivers**

Effects on the younger driver group revealed some similarities to the MDA-affected group. Rates for all crashes failed to show significant differences between the 16-18 year-old drivers, when compared to the 21-25 year-old drivers. Yet, nighttime crashes did show an almost 8 percent drop for the Level III crashes, again reaching significance. This is further reflected in the nighttime single vehicle and nighttime multiple vehicle estimates, with significant decreases in both.

Previous studies failed to show effects in this group. This study design was unique, in that the drinking age change was a two-year
increase, and this resulted in a larger group of younger drivers in the dataset, as well as a smaller interval between this group and the comparison group. Also, in contrast to previous studies of MDA change (GAO, 1987), the younger driver group was analyzed in the same statistical manner used for the affected group. These facts show that these results in the younger drivers are reliable, and that the MDA change in Ohio has clearly changed younger driver risks.

Effects on Reported Alcohol Involvement in Crashes

As noted in Chapter one, other studies note concern about the use of reports of alcohol involvement in crashes, since this is a subjective measure, based on the findings of the investigating officer. In Ohio, the "had been drinking" versus "no alcohol detected" entry is separate from the spaces in which the officer notes the contributing causes of the crash. This makes the determination of alcohol involvement mandatory for the completion of each form, independent of whether the alcohol is considered contributory (ODHS Manual, 1982).

The MDA change in Ohio led to a 10 percent reduction in the "had been drinking" designated crashes in Level III crashes within the MDA-affected driver group, as well as significant reductions in the younger driver group (Level II - 20%, Level III - 17.5%). These changes are similar in size to the measures considered traditionally to be more objective. This supports the use of the "forced entry field" for reporting alcohol involvement, and lends reliability to this measure of alcohol involvement in future studies, at least in Ohio.
Other Effects

In both the MDA-affected group and the younger driver group, some increases were seen in daytime crash rates, notably in the Level III crashes. This may reflect the effects of the increases in rural highway speed limits (Baum, et. al., 1989), which might have a greater effect during the day, when the highways are busier. This concept is corroborated by significant increases in the "no alcohol detected" crashes, in Level III crashes among the MDA-affected group, and Level II crashes for the younger driver group. However, this study does not directly address this issue.

Seat belt use and vehicle speed may change the overall crash rates, or the level of severity. In 1991, the NHTSA and CDC published a study showing that, while seat belt use has increased, the use of alcohol tends to reduce the frequency of seat belt use dramatically (Vegega and Klein, 6-21-91). Another study from 1986 examines occupant injuries based on a standard grading system used to measure the vehicular damage. In this study, vehicles sustaining low levels of damage results in four times more deaths in alcohol intoxicated drivers, compared with sober drivers. This study shows that drinking drivers may get hurt worse, when subjected to a crash of similar force (Kirk, 1988). So, while crash rates in this current study have dropped, it is also likely that while crashes continued to occur, the severity of injuries has been reduced by removing the effects of alcohol use.

Comparison to Other States

The effects seen in this study are complemented by studies performed nationally and in other states. A 1993 study shows a steady
decline in the percentage of BAC's over 0.10 g/dl in all traffic fatalities. The percentage dropped from 46.3% in 1982, to 36% in 1992 (Fell, et. al., 1993). This broad effect in the total driving population shows that intervention like the uniform drinking age are effective and useful.

Other individual states also report similar effects of reducing their drinking age. Decker and others published their results for the MDA change in Tennessee, which became effective between 1984 and 1986. They note a 38 percent reduction in nighttime single vehicle fatalities (1988). Another study revealed net reductions in Illinois, Iowa, Michigan, and Minnesota, comparing the MDA-affected group with older drivers. These reductions ranged from 11 to 45% (Williams, et. al., 1983b), compared to the 8 to 16% reduction seen in Ohio.

Conclusions

The minimum drinking age change in Ohio has been shown to reduce the crash rates in youthful drivers who lost the right to purchase under this law, especially in the types of crashes most often involving alcohol. This study clearly demonstrates the effects on female drivers, who are significantly effected by this change.

This study also reveals the reduced risk to younger drivers, who were not directly affected by the drinking age, but are also protected from death and injury in motor vehicle crashes by this law. Finally, this study shows that the "had been drinking" designation was similarly effected by the MDA change, giving that measure greater reliability in future studies.

The historic perspectives discussed in the introduction lay the foundation for interpreting and understanding the impact of this research. Ohio was one of the last states to conform to the national drinking age
recommendation. Much of this resistance was political in nature, and was based on arguments of state rights versus the central government. However, there was intense lobbying against this change based on concerns about personal liberties and the rights of young people. Assessing the impact of this change can have effects on future efforts directed at the health effects of substance abuse, and other areas of public health policy, especially when the minimum drinking age change was clearly contested by the state government.

One concern about drunk driving policy is that the severity of criminal penalties is based on the outcome of the crash. Studies have shown that swift and severe punishments are successful in reducing the incidence of drinking and driving, yet a drunk driver picked up during a simple traffic violation is handled much differently socially, and with less criminal severity than a drunk driver identified as the cause of a multiple fatality crash (Farrell, 1989). While this has been identified and studied as part of a social framework known as attribution theory (Dejoy, 1989), it fails to serve as an effective deterrent for young drivers.

If criminal penalties cannot be relied on to reduce the number of drinking drivers on the roads, then other approaches must be pursued. The national push for increases in the minimum drinking age, to no less than twenty-one years of age for all states, has been shown to result in all three levels of prevention through a specific and easily applied legislative mechanism. This study shows this effect in Ohio, one of the last states to comply with the national effort. While this change occurred under duress from the federal government (the final legislation included sections allowing for rapid repeal of the MDA change, if the federal threat to
withdraw highway funds was found unconstitutional (1987 Session Laws - Full Text, 1987)), the increased minimum drinking age has been clearly shown to be of substantial benefit to the citizens of Ohio.

Continued efforts must be made to further understand the history behind the American experience with alcohol. Events as long ago as the 15th century have had a lasting impact on the perceptions of our society. These efforts must go beyond educating the public about health concerns, and must penetrate deeply into the fabric of American life. Inroads made into dealing with the problems with tobacco use have required ongoing work over the past fifty years, and gaining control over the abuse of alcohol will be a work of equal, if not greater, import. The evolution of the minimum drinking age is a certain step on that path.
BIBLIOGRAPHY


