

# Preventing Highway Crashes by Raising the Legal Minimum Age for Drinking: The Michigan Experience 6 Years Later

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Results of a 6-year follow-up of previous research evaluating the effects of Michigan's December 1978 increase in the legal drinking age from 18 to 21 are reported. Earlier research demonstrated the immediate effect of Michigan's raised legal age in reducing motor vehicle crash involvement among young drivers. The current study examined 6 years of post-law traffic crash data, using Box-Jenkins intervention analysis methods to assess the long-term effects of the raised drinking age. Results revealed long-term effects of the law similar to the initial effects identified earlier. Over the 6-year follow-up period, the rate of involvement in injury-producing single-vehicle nighttime crashes among drivers age 18-20 was 16% lower than the level expected, had the drinking age law not changed. Police-reported drinking driver crash involvement was down 19%. In contrast to many alcohol-impaired driving countermeasures, the raised legal drinking age appears to have a long-term effect in reducing motor vehicle crash involvement among young drivers.

The legal minimum age for purchase and consumption of alcoholic beverages continues to attract a high degree of public policy attention in the United States. The National Transportation Safety Board

(1982), National Council on Alcoholism (1982), The Presidential Commission on Drunk Driving (1983), American Medical Association (1986), and numerous other organizations and individuals have recommended that all states with a legal drinking age below 21 for any category of alcoholic beverages raise the age to 21. Federal legislation was enacted in July 1984 that withholds a portion of federal highway grants to states that have not implemented a minimum drinking age of 21. In order to avoid losing highway construction funds, many states with drinking ages below 21 are now considering legislation to raise their legal

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age. Recent actions in support of a drinking age of 21 are based on considerable evidence indicating that an increase in the legal drinking age results in a significant decline in the number of young drivers involved in alcohol-related motor vehicle crashes.

Numerous studies of the lowered drinking age appeared in the 1970s, and several studies of increases in legal age have appeared in the past few years. Based on studies using controlled scientific methods, lowering the legal age for alcohol consumption is frequently associated with an immediate increase in alcohol-related traffic crash involvement among the group affected by the law, and raising the legal age is associated with an immediate decrease in such crashes. Although discussion continues on the exact size of the estimated effects, it is now well established that increasing the legal drinking age from 18 to 20 or 21 typically leads to 5 to 30% reductions in motor vehicle casualties among youth.

The literature on the effects of the drinking age on youth crash involvement has been reviewed in detail elsewhere (Wagenaar, 1983). Two recent studies, not included in previous literature reviews, will be noted here. The National Highway Traffic Safety Administration (Arnold, 1985) examined raised legal drinking ages in 13 states and found a 13% reduction in fatal crash involvement among drivers affected by the legal changes. A similar study of 26 states conducted by The Insurance Institute for Highway Safety (DuMouchel, Williams, & Zador, 1985) found a 13% reduction in nighttime fatal crash involvement in the affected age groups.

One question that requires follow-up research is whether the immediate effect of the raised drinking age in reducing traffic crashes is sustained over the long term. There are three basic possibilities regarding the long-term effects of raising the drinking age. The short-term effects already demonstrated may: (a) continue unchanged as a permanent crash reduction, (b) dissipate over time as young drinkers gradually identify alternative sources of alcohol, or (c) become even larger as new cohorts of young drivers emerge that have never had legal ac-

cess to alcohol and have not developed a pattern of regular drinking and driving after drinking.

Michigan is one state in which the effects of legal drinking age changes have been carefully evaluated. Lowering the legal age for all alcoholic beverages from 21 to 18 in January 1972 was followed by a 17 to 35% increase in alcohol-related crash involvement among youth (Douglass & Freedman, 1977). The increase in legal age for all beverages from 18 to 21 in December 1978 was followed by a 22 to 28% reduction in the number of young drivers involved in alcohol-related crashes over the subsequent 12 months (Wagenaar, 1982, 1983.) After subtracting reductions in crash involvement across all age groups that were due to other factors, a significant 11 to 28% reduction in alcohol-related crash involvement remained attributable to the raised drinking age.<sup>1</sup> Analyses of control states in which the legal drinking age was not changed revealed no comparable changes in crash involvement.

The current follow-up study was designed to determine whether the short-term effects of Michigan's raised legal drinking age were maintained 6 years later.

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## METHOD

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Data were collected on all injury-producing traffic crashes that occurred in the State of Michigan from January 1976 through December 1984. Frequency of injury crash involvement was stratified by age, to permit comparisons of 18–20 year olds (the group directly affected by the higher drinking age) with motorists age 21 and over. Such comparisons ensured that broader changes in crash involvement in the early 1980s — due to non-age-specific alcohol-impaired driving programs and a major economic recession, for example — were controlled when estimating the effects of the legal drinking age.

The legal age change is expected to reduce the incidence of alcohol impairment in drivers under 21. Two indicators of alco-

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<sup>1</sup>Exact estimates of the drinking age effect vary depending on the indicator of alcohol-related crashes and analytic model used.

hol-related crash involvement were therefore examined. The first was based on the responses of investigating police officers to an item on the standardized report form asking whether or not the driver "had been drinking" (HBD). This item is independent of any judgment by the officer that alcohol contributed to or caused the crash. Moreover, it is not dependent on an arrest for driving under the influence or on the results of a chemical test.<sup>3</sup> The item therefore has a high degree of face validity as a measure of the presence of alcohol in a crash. However, the HBD indicator relies on police judgments and therefore is potentially unreliable. For example, increased public attention to alcohol-impaired driving in recent years, policy changes such as the raised drinking age, and other events may affect the propensity of police officers to record the presence of alcohol.

To control for the potential unreliability of the HBD measure, an indirect indicator of alcohol-related crashes was also examined: single-vehicle nighttime (SVN) crashes. Single-vehicle crashes occurring at night have a high probability of involving an alcohol-impaired driver and are therefore frequently used as a surrogate indicator of alcohol-related crashes (National Highway Traffic Safety Administration, 1985). The indicator is not perfect, however, because a number of alcohol-impaired drivers are involved in crashes that do not fall into the SVN category and a number of SVN crashes do not involve drinking drivers. Nevertheless, the SVN measure is valuable because of its consistency over time; there is little chance that the recording of time of day and number of vehicles involved will change during the period examined.

Time-series intervention analysis methods were used to estimate changes in crash rates associated with the raised drinking age, controlling for long-term trends and cycles in crash rates (McCleary & Hay, 1980). Auto-Regressive Integrated Moving Average (ARIMA)

models were developed using the iterative identification, estimation, and diagnosis strategy suggested by Box and Jenkins (1976). Transfer functions for the drinking age intervention were added to the ARIMA models and simultaneously estimated using the non-linear Gauss-Marquardt backcasting estimation algorithm implemented in BMDP2T (Dixon et al., 1983). All of the final models reported here meet the multiple criteria for model adequacy suggested by Box and Jenkins (significant noise model parameters, low correlations among parameters, and insignificant residual autocorrelations).

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## RESULTS

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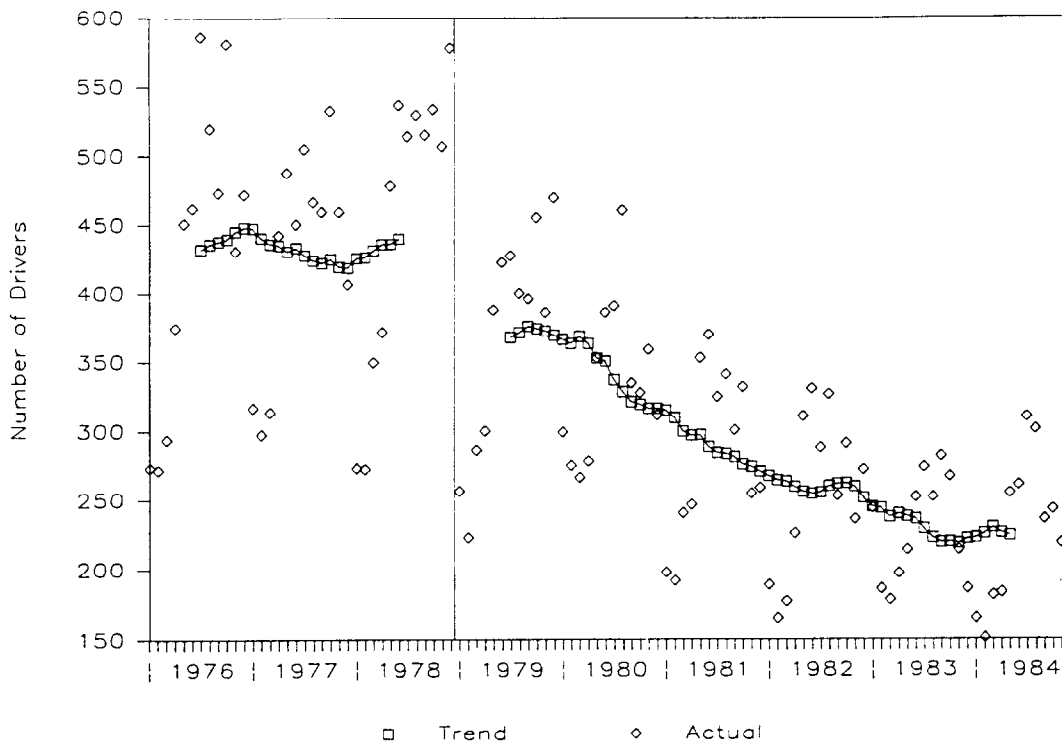
The immediate declines in youth crash involvement following implementation of the higher drinking age (Wagenaar, 1982, 1983) are evident in Figures 1 and 2. Both figures also indicate a downward trend from 1979 through 1984. This downward trend does not mean that the safety benefits of the raised drinking age were larger in the early 1980s than in 1979. Drivers of all ages experienced fewer traffic crashes in those years (Figures 3 and 4). Such overall crash reductions probably resulted from reduced travel and the other effects of a major economic recession (Wagenaar, 1984), as well as from renewed efforts to promote highway safety and reduce injuries, such as April 1983 legislation increasing penalties for alcohol-impaired driving (Michigan Public Acts 309, 310, and 311 of 1982). In contrast to the overall reductions in the early and mid-1980s, reductions in HBD and SVN crashes beginning in January 1979 were limited to 18–20 year olds—the focus of the change in legal drinking age.

To control for changes over time in the number of young drivers, the amount of motor vehicle travel, and other factors influencing the total number of crashes, the percent of all 18–20-year-old HBD drivers involved in injury-producing crashes was analyzed, instead of simply the number of HBD drivers. Because of reporting of drinking drivers by police officers investigating crashes improved considerably during the early 1970s, only data after January 1976 were included in the time-series models. The iterative specification, estimation, and diagnosis intervention analysis

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<sup>3</sup>Whether an arrest is made and a chemical test administered is a function of a number of factors in addition to the mere presence of a driver who has recently consumed alcohol.

FIGURE 1  
 NUMBER OF 18-20-YEAR-OLD POLICE-REPORTED DRINKING DRIVERS INVOLVED IN  
 INJURY-PRODUCING MOTOR VEHICLE CRASHES, STATE OF MICHIGAN



strategy produced the following final model for the rate of young HBD drivers:

$$(1 - B^{12}) \text{Ln}Y_t = (1.88B^{12}) (1 + .33B)a_t -$$

$$(.035) \quad (.097)$$

$$.063I_t(1 - B^{12}) - .27X_t(1 - B^{12})$$

$$(.033) \quad (.036)$$

where B is the backshift operator such that  $B(Y_t) = Y_{t-1}$ ,  $\text{Ln}Y_t$  is the natural logarithm of the youth HBD driver rate,  $a_t$  is random (white noise) error,  $I_t$  is a drinking age intervention step function, and  $X_t$  is a step function controlling for the effects of the April 1983 strengthened DWI legislation. Standard errors are shown in parentheses below each parameter estimate.

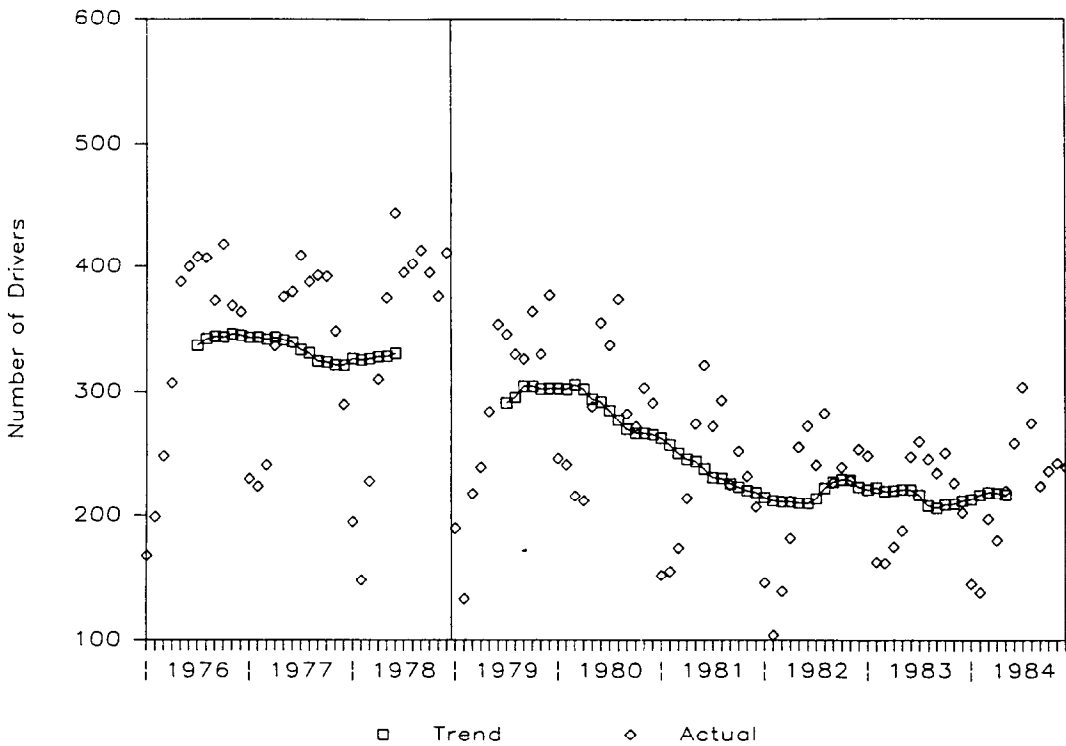
Conversion of the intervention parameter in the logarithm metric to percent change revealed a statistically significant decrease of 6.1% in the rate of 18-20-year-old HBD driver involvement in injury-producing

crashes over the 6 years following implementation of the higher legal drinking age.

In addition to factors influencing overall crash involvement (controlled by examining the rate of alcohol-related crash involvement), other factors may have influenced the rate of alcohol-related crashes in recent years. To control for such alcohol-specific factors, the rate of HBD drivers age 21 and over who were involved in injury-producing crashes was compared with the 18-20-year-old group. In contrast to the drinking age, which affects only drivers under 21, the impact of citizen action groups, increased publicity, and related events is expected to influence alcohol-impaired driving in all age groups. Comparisons between young and older drivers prevented these factors from confounding the observed effects of the raised drinking age.

Analysis produced the following model for the rate of HBD drivers age 21 and over involved in injury-producing crashes:

FIGURE 2  
 NUMBER OF 18-20-YEAR-OLD SVN DRIVERS INVOLVED IN INJURY-PRODUCING  
 MOTOR VEHICLE CRASHES, STATE OF MICHIGAN



$$(1 - B^{12}) \text{Ln}Y_t = (1 - .91B^{12}) (1 + .32B)a_t +$$

$$(.034) \quad (.097)$$

$$.12I_t(1 - B^{12}) - .26X_t(1 - B^{12})$$

$$(.024) \quad (.025)$$

indicating that drinking drivers 21 and over experienced a significant 13.4% increase in their rate of involvement in injury producing crashes in the early 1980s. Thus, the raised drinking age apparently prevented 18-20-year-olds from experiencing the same 13.4% increase in the rate of HBD crash involvement that occurred among those 21 and over. The difference between the intervention parameter estimates for the 18-20 and 21-and-over age groups is clearly significant ( $Z = 4.64$ ) and represents a 19% (6% plus 13%) reduction in the rate of drinking-driver crash involvement attributable to the increase in legal alcohol purchase age.

Time series analyses produced the follow-

ing model for the SVN rate among 18-20-year-olds:

$$(1 - B^{12}) \text{Ln}Y_t = (1 - .89B^{12}) (1 + .58B)a_t +$$

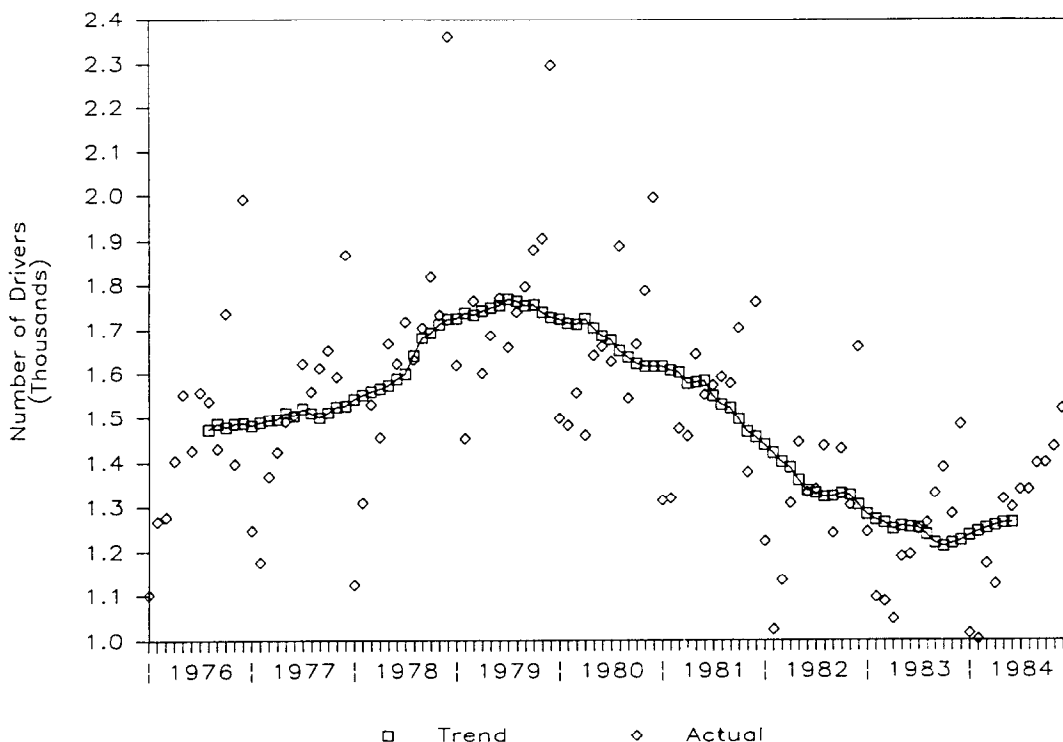
$$(.038) \quad (.082)$$

$$.008I_t(1 - B^{12}) - .11X_t(1 - B^{12})$$

$$(.046) \quad (.050)$$

indicating no significant change after the drinking age was raised from 18 to 21. The lack of a significant change in SVN crash involvement among 18-20-year-olds contrasts with the significant 6.1% decline in HBD crashes noted above. Concluding that the legal age had no effect on youth SVN crash involvement would be premature, however, because drivers age 21 and over experienced a significant 16.6% increase in the rate of SVN crashes at the time 18-20-year-olds showed no change. Thus, it appears that the raised legal age prevented the

FIGURE 3  
 NUMBER OF POLICE-REPORTED DRIVERS AGE 21 AND OVER INVOLVED IN  
 INJURY-PRODUCING MOTOR VEHICLE CRASHES, STATE OF MICHIGAN



increase in SVN crash involvement that occurred among motorists age 21 and over from occurring among those age 18-20. The time-series model for the SVN rate among those 21 and over is:

$$(1 - B^{12}) \text{Ln}Y_t = (1 - .91B^{12}) \left( \begin{matrix} (1 + .45B) a_t - \\ (.035) \quad (.087) \end{matrix} \right) + \begin{matrix} .15I_t(1 - B^{12}) - .20X_t(1 - B^{12}) \\ (.039) \quad (.040) \end{matrix}$$

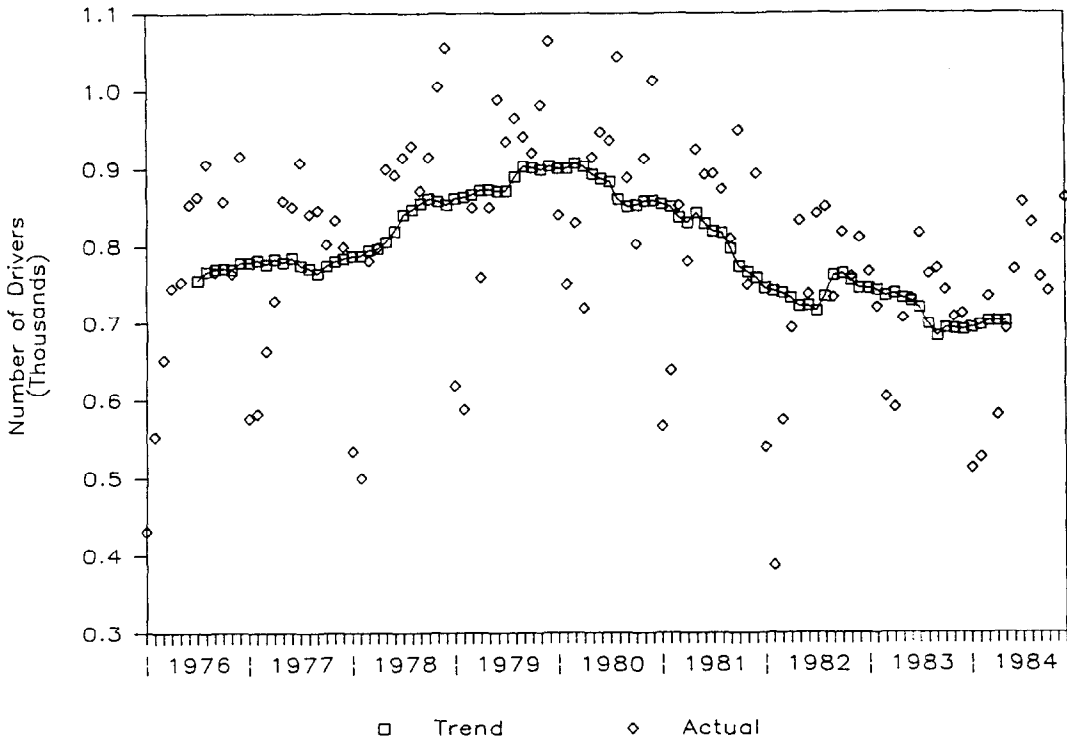
Results for the SVN analyses are similar to those for the HBD analyses when the differences between the 18-20 and 21-and-over groups are taken into account. The difference between the two groups is significant ( $Z = 2.40$ ) and represents a net 16% reduction in the rate of 18-20-year-old SVN crash involvement from the levels expected, had the legal age not been changed. The difference between the two age groups is smaller for SVN crashes than for HBD crashes (16% versus 19%), in-

dicating that a small part of the observed HBD effect may be due to a decrease in reporting after the drinking age was raised.

#### DISCUSSION

The long-term effect of Michigan's increase in legal drinking age should be compared with the short-term effect identified in previous research. Earlier time-series analyses revealed a 28% reduction in HBD drivers involved in injury-producing crashes and an 11% reduction in SVN injury-producing crashes during the first 12 months after Michigan raised its drinking age (Wagenaar, 1983). Because both measures of crash involvement have their limitations, the midpoint of these two estimates, 19.5%, is a reasonable overall estimate of the short-term reduction in alcohol-related crash involvement attributable to the increase in the legal age. In the current study, time-series analyses of baseline and 6 years of post-law-change data revealed reductions of 19% in

FIGURE 4  
 NUMBER OF SVN DRIVERS AGE 21 AND OLDER INVOLVED IN INJURY-PRODUCING  
 MOTOR VEHICLE CRASHES, STATE OF MICHIGAN



the rate of HBD drivers involved in injury-producing crashes and 16% in the rate of SVN injury-producing crashes, both attributable to the drinking age increase. The similarity of findings from analyses of two admittedly imperfect measures of alcohol-impaired driving increases confidence in the validity of each.

Ninety-five percent confidence intervals for the estimated long-term effect of the drinking age in reducing youth crash involvement are 12 to 26% for the HBD measure and 9 to 29% for the SVN measure. Based on these results, two conclusions can be made. First, the long-term effects of Michigan's increase in legal drinking age are not significantly different from the short-term effects identified in earlier research. Second, the results for the State of Michigan are consistent with the experiences in numerous other states.

Evidence to date clearly indicates the existence of an effect of raised legal drinking ages on youth crash involvement. The exact

magnitude (i.e., point estimate) of that effect varies from study to study, but most frequently is in the 10 to 20% range. A few recent studies appear to indicate that a raised legal age has little effect on motor vehicle crash involvement (Hingson et al., 1983; Smith et al., 1984; Bolotin & DeSario, 1985a, 1985b). The apparent inconsistency between these studies and the results of most of the drinking age literature may be due to the different levels of statistical power of the research designs and analytic methods used. In some cases, a conclusion of "no significant effect" of the drinking age is a result of a study design with inadequate statistical power to detect an effect within the range expected. Given the results presented here and the findings of other recent studies (Arnold, 1985; DuMouchel et al., 1985), the best estimate of the long-term effects of a higher legal drinking age is a decline in SVN crash involvement of about 15%. If the research design used to measure the effects of a legal age change requires a

decline in youth crash involvement larger than 15% to achieve statistical significance, it is unlikely that a significant effect of the drinking age will be found.<sup>3</sup>

A conclusion of "no statistically significant effect" is interpreted by many policy-makers as "no effect," when it really means that no effect of a specific magnitude was found. Therefore, researchers should state clearly the smallest effect that could be measured by their study. In the study of Michigan's long-term experience reported here, a drinking age effect smaller than a 7% decline in crash involvement could not be detected.<sup>4</sup>

Continuing research is needed to fully understand the nature of the effects of higher drinking ages. Nevertheless, available evidence clearly indicates that a higher drinking age reduces injuries and damage. If the goal is to reduce alcohol-related traffic casualties, a legal age of 21 is recommended. Despite the safety benefits of a higher drinking age, some argue in favor of a lower drinking age based on equity, difficulty in enforcement, and other considerations not related to health and safety. Numerous such arguments can reasonably be made. For example, interviews with a sample of Massachusetts police officers found little support for the higher age among some officers, high variability in enforcement levels, and minimal enforcement in some areas (Hingson et al., 1983). Given such low enforcement levels, some argue that the higher drinking age may foster disrespect for the law among youth, and that the lack of resolve to enforce this law indicates that other strategies may be more effective in reducing crashes among drivers of all ages. Despite the paucity of policies and programs that have a demonstrated long-term effect in reducing alcohol-related traffic crashes, many individuals favor using

approaches other than the minimum age to reduce alcohol-impaired driving.

Although all of these issues deserve attention in the policy debates surrounding the drinking age, they should not obscure the research evidence that an increase in drinking age from 18 to 20 or 21 lowers the incidence of traffic crashes among young alcohol-impaired drivers. Whether the injury-prevention benefits of a higher legal age are worth more than the perceived benefits of easy access to alcohol for youth is a value judgment. Recent events suggest that health professionals, policy-makers, and the public clearly believe the benefits outweigh the perceived costs of a legal drinking age of 21.

Finally, and perhaps most importantly, the legal age for drinking should not be viewed as an isolated policy. Rather, it is one example of an approach to the prevention of alcohol-related problems that focuses on restricting the availability and distribution of alcoholic beverages. An increase in the legal drinking age makes it more difficult for young people to acquire and use alcoholic beverages; that is, it reduces alcohol availability. Many states have experimented with various levels of alcohol availability as reflected by changes in the legal age—21 for many years, 18 for several years, then back to 21 (or some intermediate age). These changes in availability of alcohol to youth have significantly affected the extent of at least one major alcohol-related health problem—automobile crash-related injuries. Public policies on other dimensions of alcohol availability not limited to one specific age group (e.g., retail price of alcohol; design, location, number, and density of alcohol outlets; and selling, serving, and marketing practices) should be examined for their utility in the prevention of alcohol-related health and social problems. A combination of numerous regulatory, policy, and programmatic efforts is required to achieve the ultimate goal of a society in which the operation of a motor vehicle after the consumption of alcoholic beverages is taboo.

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<sup>3</sup>For example, the study design used by Hingson et al. (1983) required a drinking age effect of at least a 25% decline in SVN crash involvement to reach statistical significance at the 0.05 level. Any effect smaller than that could not be detected.

<sup>4</sup>The 7% minimum detectable effect of the research design used here is based on comparisons between the 18-20 and 21-and-over age groups. Analyses of the 18-20 group alone could detect crash reductions as small as 5%.



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