A Look at the Zero Tolerance Law in Texas

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Abstract

The purposes of this study were: (1) examine the literature for statistics on young drivers and alcohol, (2) conduct a literature review on the effectiveness of the zero tolerance law and other alcohol related laws, (3) examine the effects of the zero tolerance law in Texas through an exploratory analysis of the data, a before and after study, and logistic regression, and (4) provide a discussion about the zero tolerance law.

An exploratory analysis was performed using data from the Fatality Analysis Reporting System (FARS) from 1994-2003 for underage (young) drunk driver fatalities (15-20) in Texas. Variables that were examined included: day of the week, first harmful event, holiday, month of year, type of roadway, occupancy, speeding, seatbelt usage, and gender. All of these variables were compared to the BAC level of the underage intoxicated driver.

The findings from the review of the literature and analysis were the following:

- Zero tolerance law appeared effective in reducing the proportion of underage drunk driving accidents.
- A reduction of 13 percent was experience in underage drunk driver fatalities.
- Seatbelt usage saves lives but underage drunk drivers tend to not wear them.
- Most drinking and driving is done by male drivers according to this analysis.
- Various other factors are important in predicting if an underage driver in a fatality has been drinking.
- By implementing the zero tolerance law Texas may have saved up to $29.7 million dollars.

Résumé

L’étude visait les objectifs suivant: 1) effectuer le recensement des écrits portant sur les statistiques d’accidents impliquant les jeunes conducteurs (15 à 20 ans) et l’alcool au volant ; 2) réaliser le recensement des écrits portant sur l’efficacité des lois du type « tolérance zéro » et autres lois visant à diminuer les incidences d’alcool au volant ; 3) évaluer l’efficacité de la loi en vigueur au Texas par l’utilisation de méthodes statistiques, telles que les analyses du type avant et après ainsi que le développement de modèles de régression logistique ; 4) présenter une discussion sur les lois du type « tolérance zéro ».

Afin de répondre aux objectifs de l’étude, une analyse exploratoire a été effectuée à partir des données d’accident disponibles dans la base de données Fatal Analysis Reporting System (FARS) pour les années 1994-2003 impliquant des jeunes conducteurs qui sont décédés dans l’État du Texas. Les variables qui ont été examinées inclus : la journée de la semaine, le premier événement qui a mené à une blessure corporelle, les journées fériées, le mois de l’année, la classification fonctionnelle de la route, l’excès de vitesse, l’utilisation de la ceinture de sécurité et le sexe du conducteur. Toutes ces variables ont été comparées au taux d’alcoolémie du jeune conducteur.

Les résultats de cette étude montrent que :

- Les lois du type tolérance zéro semblent efficaces pour réduire le nombre de décès des jeunes conducteurs en dessous de 21 ans.
• Une réduction de 13 pourcent a été observée suivant l’introduction de cette loi au Texas.
• L’utilisation de la ceinture de sécurité sauve beaucoup de vie ; toutefois, les jeunes conducteurs qui conduisent sous l’influence de l’alcool ont tendance à ne pas porter la ceinture de sécurité.
• Les jeunes hommes sont les plus souvent impliqués dans des accidents mortels où le conducteur était en état d’ébriété.
• Plusieurs autres facteurs importants contribuent à prédire si un jeune conducteur était ivre au moment de l’accident.
• En introduisant la loi du type tolérance zéro, l’Etat du Texas pourrait avoir sauver plus de 29.7$ millions en coûts sociaux.

Introduction

Motor-vehicle crashes are a serious health concern in the United States. As a result, numerous measures have been taken to lower the risk of becoming a fatality in a crash. These measures range from improving highway design elements to the introduction of new legislative initiatives and policies. Since 1994, an average of 41,962 fatalities has occurred each year in the U.S. (FARS, 2005\(^1\)) (see Figure 1). Although the crash rate is steadily going down due to the increase in miles traveled (VTM), fatal motor-vehicle crashes still remain a top ten cause of death in America. In 2001, motor-vehicle fatalities was ranked 9\(^{th}\) in leading cause of death in the U.S. (U.S. NCHS, 2003\(^2\)). This problem is particularly significant for young drivers below 21 years of age. As stated by the National Highway Traffic Safety Administration (NHTSA): “motor vehicle crashes are the leading cause of death for people from 15 to 20 years old” (NHTSA, 2003\(^3\)).

Alcohol-impaired driving greatly affects the incidences of motor-vehicle crashes. Between 1994 and 2003, alcohol-related fatal crashes accounted for 40 percent of fatalities (95% confidence interval [CI] = 39.13%-41.05%). During the same period, inebriated drivers who were killed accounted for on average 7,285 fatalities per year (95% CI = 7,066-7,502). As can be observed from Figure 2, alcohol-impaired drivers account for approximately 29 percent of the drivers killed or 17 percent of all fatalities. Even at a greater cost to society are that “drunk” drivers (approximately 1,000 are below 0.08 g/dl) kill on average 9,538 passengers per year (95% CI = 9,188-9,889). Figure 2 shows the top four age groups and the percentage of drivers who were involved in fatal accidents whose BAC level was above 0.08 g/dl; the highest percentage being people aged 21 to 24. Alcohol-impaired drivers between the ages 16 to 20 are a serious problem. These are underage drivers who should not be at risk (since they are not supposed to be able to drink), yet they are involved in a large amount of drinking and driving fatalities. A decrease in percentage can be observed between 1993 and 1997; however, statistics in 1994 to 1996 were unavailable due to the data being recorded in 0.10 g/dl.
In order to minimize the number of alcohol related fatalities among drivers below 21 years of age, Texas officials have enacted in September 1, 1997 a zero tolerance alcohol law aimed specifically at that age group. The goal of this law was to lower the amount of drinking and driving incidences among young drivers. Since the law was enacted, the effects on the number of fatalities involving young drivers have not been properly studied by researchers. Consequently, this study aimed at examining whether this law reduced the number of fatalities among drivers below 21 years of age in Texas using appropriate statistical tools.

To accomplish the objective of this study: 1) a review of the literature was conducted on current up-to-date statistics on alcohol and underage drivers; 2) a review of the literature was also performed on zero tolerance laws applied elsewhere; 3) statistical analyses, including a before-after study and the development of logistic regression models, were conducted on data obtained from FARS.

This paper is divided into three sections. The first section describes the literature review. The second section describes the results of the statistical analyses. The last section presents a discussion about the effects of the zero tolerance law in Texas and the number of fatal crashes involving young drivers and alcohol.

Literature review

This section describes the characteristics alcohol-related crashes in Texas, the key elements of the zero tolerance law, and previous work on the safety effects of such law respectively.

Alcohol related Crashes in Texas

The state of Texas has one of the largest drinking and driving problems in the nation. As stated above, more alcohol-related fatalities occur on Texas roads than any other state. Table 1 shows the total number of fatalities and fatality rates from 1982 to 2003 in Texas. As observed in this table, alcohol fatalities in Texas accounted on average for about 54.9 percent (95% CI = 52.24%-57.56%) of all traffic fatalities over the last twenty years. Looking at the time period 1994-2003, the proportion of alcohol fatalities was on average 49.9 percent (95% CI = 47.81%-51.99%). This value is 9.9 percentage points above the national average (40 percent). If the state of Texas could reduce its alcohol-related fatal crashes by 10%, the state may have saved $395 million dollars in 2003. It is estimated that each alcohol related fatality in Texas costs $3.3 million, of which $2.2 million is attributed to the quality of life lost cost while $1.1 million is designated as direct cost (NHSTA, 20034).

Young (underage) drivers have the highest fatality rate among any age group. As Figure 3 indicates, drivers aged 15-20 have a fatality rate of approximately 65 per 100,000 licensed drivers, yet this young age group only makes up around 6 to 7 percent of the licensed drivers. Based on the VMT, the fatality rate for teenage drivers is about 4 times as high as the rate for 25 to 69 year-olds (NHSTA, 20003). Drivers aged 15 to 20 are responsible for 3,514 fatalities per year (95% CI = 3,375-3,653). Comparing this number to Figure 1 would account for nearly 14 percent of driver fatalities, yet again
make up only 6 to 7 percent of the licensed drivers. Alcohol plays a part in nearly 21 percent of all underage drivers (15 to 20) fatal accidents. This represents 749 underage drivers who are killed in a motor-vehicle crash with alcohol in their blood stream (95% CI = 709-790). This is roughly 10 percent of drivers who die in a motor-vehicle crash with a BAC above zero, and yet none of these drivers should legally have been drinking.

Table 1. Fatality and alcohol fatality rates in Texas (NHTSA – Texas: Toll 2003)

<table>
<thead>
<tr>
<th>Year</th>
<th>TOTAL</th>
<th>Alcohol-Related</th>
<th>% Alcohol Related</th>
<th>Fatality Rate per 1 M VMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>3,912</td>
<td>2,457</td>
<td>63</td>
<td>2.84 1.78</td>
</tr>
<tr>
<td>1985</td>
<td>3,678</td>
<td>2,271</td>
<td>62</td>
<td>2.57 1.59</td>
</tr>
<tr>
<td>1986</td>
<td>3,567</td>
<td>2,206</td>
<td>62</td>
<td>2.4 1.49</td>
</tr>
<tr>
<td>1987</td>
<td>3,260</td>
<td>1,951</td>
<td>60</td>
<td>2.16 1.29</td>
</tr>
<tr>
<td>1988</td>
<td>3,392</td>
<td>2,011</td>
<td>59</td>
<td>2.17 1.29</td>
</tr>
<tr>
<td>1989</td>
<td>3,370</td>
<td>1,927</td>
<td>57</td>
<td>2.11 1.21</td>
</tr>
<tr>
<td>1990</td>
<td>3,250</td>
<td>1,989</td>
<td>61</td>
<td>2.08 1.27</td>
</tr>
<tr>
<td>1991</td>
<td>3,078</td>
<td>1,814</td>
<td>59</td>
<td>1.94 1.14</td>
</tr>
<tr>
<td>1992</td>
<td>3,059</td>
<td>1,818</td>
<td>59</td>
<td>1.87 1.11</td>
</tr>
<tr>
<td>1993</td>
<td>3,043</td>
<td>1,748</td>
<td>57</td>
<td>1.82 1.04</td>
</tr>
<tr>
<td>1994</td>
<td>3,187</td>
<td>1,725</td>
<td>54</td>
<td>1.79 0.97</td>
</tr>
<tr>
<td>1995</td>
<td>3,183</td>
<td>1,739</td>
<td>55</td>
<td>1.76 0.96</td>
</tr>
<tr>
<td>1996</td>
<td>3,742</td>
<td>1,967</td>
<td>53</td>
<td>2 1.05</td>
</tr>
<tr>
<td>1997</td>
<td>3,513</td>
<td>1,710</td>
<td>49</td>
<td>1.77 0.86</td>
</tr>
<tr>
<td>1998</td>
<td>3,586</td>
<td>1,745</td>
<td>49</td>
<td>1.74 0.85</td>
</tr>
<tr>
<td>1999</td>
<td>3,522</td>
<td>1,700</td>
<td>48</td>
<td>1.67 0.81</td>
</tr>
<tr>
<td>2000</td>
<td>3,779</td>
<td>1,841</td>
<td>49</td>
<td>1.72 0.84</td>
</tr>
<tr>
<td>2001</td>
<td>3,736</td>
<td>1,807</td>
<td>48</td>
<td>1.73 0.84</td>
</tr>
<tr>
<td>2002</td>
<td>3,823</td>
<td>1,810</td>
<td>47</td>
<td>1.73 0.82</td>
</tr>
<tr>
<td>2003</td>
<td>3,675</td>
<td>1,709</td>
<td>47</td>
<td>1.64 0.76</td>
</tr>
</tbody>
</table>

Drivers below 21 appear to be over-represented in alcohol-related crashes. Looking at Figure 4, an average of 69 underage drivers in Texas has alcohol in their blood stream when they were involved in a fatal accident. Approximately 326 underage drivers die in motor-vehicle crashes each year in Texas. Since approximately 69 out of 326 underage drivers have alcohol in their system, an astonishing 22 percent of underage driver fatalities in Texas were inebriated at the time of the collision (1997-2003). Comparing the percentage of 15 to 20 year old drivers in Texas who are killed in a fatal accident (1997-2003) and had alcohol in their blood stream (Figure 4) versus the percentage across the U.S. (Figure 2), the state of Texas is several percentage points above the national average. This state accounts for 9.2 percent of the deaths across the U.S. (326/3514) for both underage drivers and underage drivers with alcohol (69/749). This illegal phenomenon of underage drinking and driving can be attributed to three reasons: inexperience in driving, inexperience in drinking alcohol, and younger people tend to have a greater sense of being invincible and death is a foreign fact to them (Hanson, 20045).
Figure 4. Percentage of drivers, in Texas, involved in a fatal accident ages 15 to 20 with alcohol in their bloodstream (FARS, 2005)

Legislative Initiatives

Since drinking and driving are such an abundant problem in the United States, the federal government has initiated several initiatives to minimize this problem. In 1984, Congress passed a legislation that required highway construction funds to be withheld until a state changed their legal drinking age from 18 to 21. By 1988 (the Texas law was introduced in 1986) all states had adopted a minimum legal drink age (MLDA) of 21. In 1988, the Drunk Driving Prevention Act provided the right for a license to be seized if the driver had either a BAC over the legal limit or refused to take a breathalyzer/sobriety test. As a result of the Intermodal Surface Transportation Equity Act (ISTEA) in 1991, each state had to pass four of five mandate laws in order to receive grant money. These laws are as follows: create an administrative license suspension program, reduce the maximum BAC to 0.08 g/dl three years after grant is received, create sobriety checkpoints, develop procedures to keep minors from obtaining alcohol, and create educational programs for a convicted drunk driver. Texas has enacted all these laws with the exception of sobriety check points.

In 1995, a national highway bill again withheld highway construction funding until a 0.02 BAC (zero tolerance) law was adopted by each state. By July 1998 (Texas in Sept 1997) all states had adopted a zero tolerance law. In October 2000, President Clinton signed a bill that states would loose 2 percent of highway funds in 2003 if a 0.08 g/dl BAC was not adopted. The percent of highway funds withheld would have increased to 8 percent by 2006; however by 2003 (Texas in 1999) all the states had lower their BAC level to 0.08 g/dl. Other relevant laws recently introduced in Texas, which should impact the incidences of drinking and driving, include the open container law and the dram shop laws that hold alcohol servers liable for harm that intoxicated or underage customers inflict on themselves or other people.

Effectiveness Alcohol Related Legislation

In one of the first zero tolerance law studies, Blomberg (1992) examined the statewide data of Maryland. Maryland had adopted a 0.02 zero tolerance law in six trial counties. They announced this law throughout the state so that everyone would have knowledge of the law. Blomberg reported a statewide a reduction of 11 percent in underage drinking and driving accidents and a reduction of 21 percent in the six counties. After an emphasis was placed on enforcing and punishing drivers who violated the zero tolerance law, a reduction of 30 percent was seen in the six trial counties.

Hingson et al. (1994) and Martin et al (1996) noted that the zero tolerance law was effective in reducing the proportion of nighttime single-vehicle (NSV) crashes that involved underage drivers drinking alcohol. These studies compared 12 states that already had a zero tolerance law to those that had none such law. The proportion of NSV underage alcohol fatal crashes slightly increased in the states where no law was in effect, but in the states where there was a zero tolerances law experienced approximately a 16 percent reduction in NSV underage alcohol fatal crashes compared. Hingson (1996) used a similar study to prove the
effectiveness of the 0.08 g/dl law. In the states where no 0.08 g/dl law existed, an increase of 1.4 percent of alcohol related driver fatal crashes occurred while in states with a 0.08 g/dl law a decrease of 2.4 percent of alcohol related driver fatal crashes was observed.

Lacy et al. (2000) examined the zero-tolerance in four states. In Texas, it was found for the first year after the law was put into effect the arrest/suspension rate for the zero tolerance law was low, but in the second year rose significantly and was about 1.2% of licensed drivers in the 15 to 20 age group. Texas Government has initiated a large public education campaign for the zero tolerance law; however according to Lacy et al. (2000) no reduction was revealed in NSV crashes associated with the implementation of the law in the first two years of its enforcement. Although other states have had different experiences than the one seen in Texas just two years after the law was enforced. There was “as much as forty and thirty-six percent in (SVN crashes) Oregon and Maine about the time the laws were made more stringent to as little as five percent in Florida.”

Hedlund et al. (2001) issued a report for NHTSA describing why there are fewer underage alcohol impaired drivers. In this report, they listed several reasons. The first two reasons mentioned pertained to the legal area. The MLDA was the first law reviewed followed by the zero tolerance law. The zero tolerance laws “have definitely reduced youth drinking and drinking …for two reasons by deterring youth through the fear of losing their driver’s license if they drive after drink, and also by reinforcing the broad community disapproval of driving after drinking.” The zero tolerance laws may have brought an attitude of it is acceptable to drink but do not drink and drive.

Miller et al. (1998) performed a study of the zero tolerance law from an economic perspective. In their study, it was assumed that lowering BAC laws reduced underage driver alcohol crashes by 20 percent. In the cost-benefit analysis, Miller et al. reported that for every dollar invested four to eight dollars were returned when a violator of the law received a 6-month license suspension. Other findings that Miller came to regarding alcohol and underage drivers were underage drivers are overrepresented in crash and have estimated crash cost at $1.58 per mile driver compared to $0.17 by other drivers. The cost of drunk driving per a mile is $5.80 compared to $0.11 when sober.

Voas et al. (2002) assessed the effectiveness of the MLDA and the zero tolerance laws in the United States. Through an analytical method, the authors showed that both underage laws were significant in reducing the proportion of underage drinking drivers in fatal crashes. The MLDA law reduced fatalities by 14.9 percent and the zero tolerance law contributed to a reduction of 24.4 percent. The maximum BAC of 0.10 was significant and contributed to a reduction of 17.8 percent; however, the change to 0.08 was not a significant factor for underage drinking drivers in fatalities. In addition, both the administrative license revocation and seat belt laws significantly contributed to the reduction (p<5%).

Keall et al. (2004) fitted a conditional logistic model to estimate the risk of being fatally injured in a motor-vehicle crash in New Zealand. The variables used to explain this risk were BAC, driver gender, driver age, time of night, and number of passengers. The BAC and age were the two strongest variables in explaining risk. At the 5 percent level, only age, BAC level, and number of passengers were determined to have an effect of the risk model. The relative risk was calculate to be the risk associate with age multiplied by the risk associated with the BAC multiplied by the risk associated with the number of passengers. It was found through Keall et al’s (2004) analysis that the worst risk scenario would be a 15 to 19 year-old driver with a high BAC level carrying two or more passengers. A teenager with a BAC level equal to 0.03g/dl (legal limit in New Zealand) and who is carrying two or more passengers has 34 times the risk of a fatal accident than a sober 30+ year-old
driver driving with one passenger. It was shown that carrying one passenger had less of a risk than having no passengers, but carrying more than one passenger increased the risk to that above driving alone. Keall et al. stated that the high risk of young drivers relative to the risk of older drivers calls into question concerning the BAC legal limit of teenager drivers. The study indicates that a sober teenage carrying one passenger is still 5 times at a greater risk than a sober 30+ year-old carrying one passenger to be involved in a motor vehicle crash. Even a small amount of alcohol ingurgitated by a teenager causes his or her risk to increase more dramatically.

**Statistical Analysis**

This section presents the results of the exploratory analyses based on the FARS database, the before-after study and the logistic regression respectively.

**Exploratory Analysis of the Data**

The section looks into various factors that might play a role in underage drivers and alcohol related fatalities. Primarily, this section focuses on factors that could be used to reduce the alcohol related fatalities on Texas roadways. The information was obtained from the FARS database and only includes drivers who were killed in a motor vehicle collision. For some of the analyses, the summary was divided into pre-1997 (1994-1996) and post 1997 (1998-2003) time periods.

Figure 6 shows the characteristics of underage drivers who are killed in crashes on Texas roadways on average each month. The number of deaths occurring each month between Pre-1997 and Post-1997 is relatively the same with January and February being slightly lower. However, the percentage of alcohol-related fatalities for Post-1997 dropped for every month except for December. Also, the raw number of drinking and driving fatalities occurring each month for Post-1997 was the same or lower than Pre-1997 except for September or December.

Figure 7 shows the details of the average number of alcohol-related underage driver fatalities that occur on the day of the week. Saturday and Sunday compose over 50 percent of all underage driver alcohol fatalities. Sunday, since 1997, has experience a decrease in raw number and percentage of fatalities, but this number is still very high. Friday also sees its share underage fatalities and is considered by some part of the weekend. The overall total amount of accidents between the two time periods remained nearly the same. The main difference between Pre-1997 and Post-1997 is that Post-1997 shifted 7 percent of the accidents from Sunday to Thursday. An explanation for this could be the emphasis that college students (18-20 year-olds) have high incentives to go out on Thursdays that were not as prevalent in Pre-1997, or the fact that more 18-20 year-olds are in college and, therefore, “partying” on Thursday could have be the reason for the doubling fatalities on this day.
Figure 7. Day of the week and underage drunk driver fatalities (FARS, 2005)

Figure 8 illustrates the relationship between holidays and underage inebriated drivers. This figure shows that, if a 15 to 20 year-old driver is involved in a fatal crash on a holiday, there is greater likelihood that alcohol was a contributing factor to the crash than a non-holiday. Since there are far fewer holidays than typical days, the confidence intervals will be larger than non-holidays (in Figure 8). Combining all 10 years together, the likelihood that a crash involving alcohol occurs on a holiday is 9 percent greater than a than a typical day. One can note that the percentage dropped on holidays for the after period. This could be an effect of the zero tolerance law and/or the campaigns that are focused on the holiday seasons (e.g. Christmas).

Figure 8. Holidays and underage drunk driver fatalities (FARS, 2005)

Driving at excessive speeds increases the likelihood of being fatally injured in the event of a crash. Figure 9 shows that about the same number of alcohol-related fatal crashes occurs whether speeding or not was a contributing factor (31-37). However, it appears that, if a 15 to 20 year-old is involved in a fatal crash and the driver was speeding, this person is more likely to have been drinking than a person of the same age group who was not driving in excessive speed.
Figure 10 shows the characteristics of fatal and non-fatal injuries for drivers between 15 and 20 year-old as a function of the seatbelt use. The top trend line indicates the percentage of fatally injured drivers who were not wearing their seat belts. The bottom trend line illustrates the number of injured drivers not wearing their seat belts. As seen in Figure 10, many more injured drivers wear their seat belts. This figure also shows that more underage drivers are wearing their seat belts. The percentage of drivers not wearing their seat belts has decreased along with a slight increase in the number of total fatalities will result in a significant increase in seat belt usage among underage drivers. When alcohol is involved, about 71 percent of underage drivers do not wear their seat belts; and, unlike the trends below, this one has remained constant (roughly 50 percent underage drinking and driving fatalities not wearing seat belt versus 20 percent wearing seat belts each year).

Figure 11 explores the relationship between gender and drinking and driving. The pie chart shown in Figure 11 clearly indicates that male drivers in the state of Texas account for the majority of the underage drinking and driving motor vehicle collisions. In fact, 87 percent of the driver fatalities involving alcohol are attributed to males. Males ages 15 to 20 are involved in fatal crashes about twice as often as females and are much more likely to have been drinking.

Figure 9. Speeding and underage drunk driver fatalities (FARS, 2005)

Figure 10. Seatbelt usage of underage drivers (FARS, 2005)

Figure 11. Gender and underage drunk driving fatalities (FARS, 2005)
Figure 12 shows the relationship of underage drivers who have been drinking and the number of occupants in the motor vehicle. Most driver alcohol fatalities occur when the underage drunk driver is alone, roughly half of all fatalities. This outcome contradicts the findings of Keall et al. (2004) who reported that number of passengers influenced the chance of being involved in a fatal motor vehicle crash. It is important to point out that the number of occupants may include confounding factors. For instance, teenagers probably carry other people on weekends and, may also involve taking trips on rural roads during this time period (note: rural roads account for the majority of the transportation network in Texas). As the previous exploratory analysis has shown for weekends, it may hypothesize that the greater risk attributed to occupancy is in fact attributed to why, where, and when the intoxicated teenage driver is carrying passengers. Note how similar the numbers of fatalities based on occupancy both before and after the zero tolerance law was introduced. As shown in Figure 12, the percentage of alcohol-related accidents has decreased since 1997.

**Before-After Study**

In order to analyze whether or not the zero tolerance law has been effective, an analysis was carried out by examining the difference in proportion of fatal crashes for underage drivers involving alcohol before and after the enactment of the law in 1997. As before, the FARS database was used to analyze two different proportions. The first proportion evaluated was underage drivers who were fatally killed in an accident while the second proportion dealt with all underage drivers involved in a fatal collision. As expected, the proportion of alcohol-related crashes involving injuries is lower than those involving fatalities.

Table 3 summarizes the fatal crashes by age group. Of special interest are the 15 year-old drivers who are not yet legally allowed to drive without an adult, yet have a significant proportion of fatal accidents due to alcohol. There appears to be a noticeable difference in the percentage of teenager drunk driver fatalities between 15 and 18 year-old, and between 19 and 20 year-old. This difference might also be attributed young drivers currently in high school versus high school graduates. However, a gradual increase in percentage as the age increases even before high school graduation can be noticed in Table 3.

Figure 13 shows the various proportions of underage drinking and driving. This figure shows that the effects of the zero tolerance law appear to be lowering the proportion of underage driver and alcohol related accidents. In both cases, there appears to be a statistically significant reduction in the percentage of accidents that are occurring where a teenage driver has been consuming alcohol. To verify this statement, statistical hypothesis tests were performed.
Table 3. Age and % of drivers who died in a fatal crash who had been drinking (FARS, 2005)

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Number of Drivers (94-03)</th>
<th>Percentage with Alcohol (94-03)</th>
<th>Number of Drivers (94-96)</th>
<th>Percentage with alcohol (94-96)</th>
<th>Number of Drivers (98-03)</th>
<th>Percentage with alcohol (98-03)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>78</td>
<td>14.10%</td>
<td>30</td>
<td>20.00%</td>
<td>43</td>
<td>11.63%</td>
</tr>
<tr>
<td>16</td>
<td>401</td>
<td>11.22%</td>
<td>126</td>
<td>13.49%</td>
<td>234</td>
<td>10.68%</td>
</tr>
<tr>
<td>17</td>
<td>513</td>
<td>19.49%</td>
<td>131</td>
<td>25.19%</td>
<td>313</td>
<td>16.93%</td>
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<td>18</td>
<td>674</td>
<td>21.07%</td>
<td>169</td>
<td>27.81%</td>
<td>458</td>
<td>18.78%</td>
</tr>
<tr>
<td>19</td>
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<td>26.10%</td>
<td>167</td>
<td>35.33%</td>
<td>482</td>
<td>21.78%</td>
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<tr>
<td>20</td>
<td>688</td>
<td>30.96%</td>
<td>155</td>
<td>34.19%</td>
<td>462</td>
<td>29.87%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3059</td>
<td>22.33%</td>
<td>778</td>
<td>26.09%</td>
<td>1992</td>
<td>20.68%</td>
</tr>
</tbody>
</table>

Test 1: Underage Driver is Fatally Injured

\[ H_0 : p_{pre} = p_{post} \]
\[ H_A : p_{pre} > p_{post} \]
\[ \alpha = 0.05 \]

\[ T = \frac{\hat{p}_{post} - \hat{p}_{pre}}{\sqrt{\frac{\hat{p}_{post}(1-\hat{p}_{post})}{n_{post}} + \frac{\hat{p}_{pre}(1-\hat{p}_{pre})}{n_{pre}}} \]

where \( \hat{p}_{pre} = 0.2609 \), \( \hat{p}_{post} = 0.2068 \),
\( n_{post} = 1992 \), \( n_{pre} = 778 \)

REJECT \( H_0 : p_{pre} = p_{post} \) if \( Z > 1.96 \)
\( T \approx 3.42 \)

As a result the null hypothesis is rejected and the alternative is accepted meaning the proportion has decreased since 1997.

Test 2: Underage Driver is Involved in a Fatal Crash

\[ \hat{p}_{pre} = 0.1872 \], \( \hat{p}_{post} = 0.1452 \),
\( n_{post} = 4529 \), \( n_{pre} = 1961 \)

REJECT \( H_0 : p_{pre} = p_{post} \) if \( Z > 1.96 \)
\( T \approx 4.10 \)

As a result, the null hypothesis is rejected and the alternative is accepted meaning the proportion has decreased since 1997. Adding the injured underage drivers did not have an impact on the analysis even if the percentage of drivers is lower than fatal injuries.

It was of interest to determine if the proportion of underage alcohol drivers had decreased since 1997. The data was used from FARS from 1994-1996 and 1998-2003 to determine the effects. The first test compared only when the underage driver was killed while the second test was for any underage driver involved in a fatal crash.

Figure 13. Percentage of underage drunk driver fatalities (FARS, 2005)

Previously, it was shown that there was a reduction in the proportion of alcohol related crashes among underage drivers after the zero tolerance law was introduced. To verify this assessment, a before and after study was conducted using observed crash data. Consequently, a naïve before and after study was performed using the methodology proposed by Hauer (1997). As mentioned in the exploratory analysis, the number of fatalities remained the same for many variables examined after 1997, but the
proportion of drinking and driving fatalities was lower. To more accurately compare crashes occurring in the before and after periods, an adjustment factor $r_{tf}$ was applied to capture the change in exposure between both study periods. A factor $r_{tf} = 1.15$ was used and was estimated by determining the ratio of the average population of 15-20 year olds before (1994-1996) and after (1998-2003) (U.S. Census, 2005\textsuperscript{16}). Average population was used due to the unavailability of registered driver license holders. Table 4 shows the calculations following the application of the adjustment factors, including the difference in time period.

Table 4. Before and After study – data and calculating number of underage drunk driving fatalities

<table>
<thead>
<tr>
<th>Years Before</th>
<th>Years After</th>
<th>$K(j)$</th>
<th>$L(j)$</th>
<th>$r_{d(j)}$</th>
<th>$r_{d(j)i}$</th>
<th>$r_{d(j)i}K(j)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>6</td>
<td>203</td>
<td>412</td>
<td>2</td>
<td>466.9</td>
<td>812</td>
</tr>
</tbody>
</table>

Table 5 shows results of the before and after study. The outcome shows that approximately 467 crashes would have occurred if the zero tolerance law had not come into effect. This is a reduction of 54.9 fatalities in a six year period or on average 9.15 underage drivers lives are saved per year.

Table 5. Estimated Values of the before and after study

<table>
<thead>
<tr>
<th>Estimate of Parameters</th>
<th>Estimate of Standard Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\lambda} = 412$ (After)</td>
<td>$\sigma{\hat{\lambda}} = 20.3$</td>
</tr>
<tr>
<td>$\hat{\pi} = 466.9$ (Before)</td>
<td>$\sigma{\hat{\pi}} = 28.5$</td>
</tr>
<tr>
<td>$\hat{\delta} = 54.9$ (Change)</td>
<td>$\sigma{\hat{\delta}} = 35.0$</td>
</tr>
<tr>
<td>$\hat{\theta} = 0.87$ (Effectiveness Index)</td>
<td>$\sigma{\hat{\theta}} = 0.004$</td>
</tr>
</tbody>
</table>

Logistic Regression

In an attempt to better understand the effects of various variables that might be associated with an underage drunk driver involved in a fatal crash, a logistic regression model was estimated. In this analysis, the BAC level of the underage driver was modeled as a function the variables explored earlier. The model predicted the percentage of underage drivers that have a BAC = 0 given certain characteristics. The logistic model, estimated using SAS (SAS, 2002\textsuperscript{17}), takes the following form (Klienebaum, 2002\textsuperscript{18}):

$$P(x) = \frac{1}{1 + e^{-u}} \text{ where } u = \alpha + \sum \beta_i x_i,$$

Table 6 shows model output. From this output, one can directly estimate the odds ratio. The odds ratio is the probability that, given a specific variable, an event will occur. Table 6 shows that all the variables were found to be significant (p<5%) with exception of whether the accident occurred on a holiday or month of the year.
### Table 6. Logistic Regression Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>P-value</th>
<th>Odds Ratio</th>
<th>95% Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.9395</td>
<td>&lt;.0001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Weekend (y=1, n=0)</td>
<td>-0.5461</td>
<td>&lt;.0001</td>
<td>0.579</td>
<td>[0.477, 0.703]</td>
</tr>
<tr>
<td>Fixed Object (y=1, n=0)</td>
<td>-0.6844</td>
<td>&lt;.0001</td>
<td>0.504</td>
<td>[0.413, 0.616]</td>
</tr>
<tr>
<td>Urban Road (y=1, n=0)</td>
<td>0.3375</td>
<td>0.0013</td>
<td>1.401</td>
<td>[1.141, 1.721]</td>
</tr>
<tr>
<td>Driver only (y=1, n=0)</td>
<td>0.1934</td>
<td>0.0511</td>
<td>1.213</td>
<td>[0.999, 1.473]</td>
</tr>
<tr>
<td>Speeding (y=1, n=0)</td>
<td>-0.4153</td>
<td>&lt;.0001</td>
<td>0.660</td>
<td>[0.541, 0.805]</td>
</tr>
<tr>
<td>Seatbelt worn (y=1, n=0)</td>
<td>0.6902</td>
<td>&lt;.0001</td>
<td>1.994</td>
<td>[1.620, 2.454]</td>
</tr>
<tr>
<td>Male (y=1, n=0)</td>
<td>-0.9387</td>
<td>&lt;.0001</td>
<td>0.301</td>
<td>[0.301, 0.508]</td>
</tr>
<tr>
<td>After Zero Tolerance Law (1=after, 0=before)</td>
<td>0.3326</td>
<td>0.0012</td>
<td>1.395</td>
<td>[1.140, 1.706]</td>
</tr>
</tbody>
</table>

Table 6 shows similar trends as the ones observed in the exploratory analysis. For example, the weekend odds ratio of 0.579 shows that on weekends a driver is 0.579 times as likely to have a BAC = 0, if involved in an underage drinking and driving fatality. In other words, a driver is 1.72 more likely to be intoxicated if involved in a fatal crash during the weekend. Similarly, if a seatbelt is worn, it is nearly two times more likely the underage driver had not been drinking alcohol. Also, notice that the male variable is closest to zero. This shows that gender is the largest factor in drinking and driving. The occupancy variable shows interesting results. The confidence interval for the odds ratio dips to 1. Keall et al. (2004) showed that driver only, a driver and one passenger, and then two or more passengers all had different risk factors. According to these authors, the risk a single driver is higher than the risk for one passenger, but lower than for the risk for multi-passengers. The analysis shows that occupancy has a marginally significant effect. In this case, a driver traveling alone would more likely be sober. The variable of interest in this experiment was related for the after period. After 1997, the odds ratio is equal to 1.395, which implies that after the law was passed it is more likely that an underage driver who was fatally killed in an accident was not drinking. The case where the underage driver is most likely to have been drinking is when the fatal accident occurred while a male was driving on a weekend, hitting a fixed object, on a rural road, with passengers, speeding, not wearing a seat belt, and before the zero tolerance law was in effect. Also, it should be noted that the interaction between the variables can occur such as the exploratory analysis noted for occupancy. This could also exist with any of the above variables.

### Discussion and Conclusions

The outcome of the before and after study shows that a 13 percent reduction in fatal crashes was observed following the enactment of the zero tolerance law. This is comparable to the reduction of 16 percent for NSV that Hingson (1994) reported in the twelve states in which he examined the zero tolerance law. Voas (2002) noted a 24.4 percent reduction for the zero tolerance law, while Lacy (2000) found no effect in Texas. Lacy however had very little after data and half of the data used in Lacy’s study was considered the “adjustment” period in this study, and, therefore, due to limited data the true effects might have been missed. Miller assumed a 20 percent reduction for his economic analysis. All of these values seem relatively close to the value obtain in this study.

An important issue must be discussed with regards to the analysis carried out in this analysis. This issue is related to the effects of external causes on
the reduction observed in this study. Shen and Gen (2003\textsuperscript{19}) discussed this issue along with others in detail. Shen and Gen (2003\textsuperscript{19}) reported that numerous external factors could also have led to a reduction of underage drinking and driving. For example, the various media campaigns (Drink, Drive, Go to Jail campaigns, etc.) and the reduced BAC level from 0.10 to 0.08 that occurred in 1999 in Texas could have contributed to the observed reduction. Also, the state of Texas does not have a law requiring a BAC test at the site of a fatal crash and this could potentially lead to cases where the BAC level is unknown. Therefore, the stated change in safety might just partly reflect the zero tolerance law and may also include the effects of other factors. At this point, it is not known with certainty what part of the reduction is attributed to the zero tolerance law and what part is contributed to various other influences.

In conclusion, the zero tolerance law appeared to reduce the amount of underage drunk driver fatalities in Texas by approximately 9 deaths per a year (not including the number of occupants’ lives that might have been saved) when accounting for the population change. At a value of life of $3.3 million, the state of Texas saved $29.7 million\textsuperscript{4} ($9.9 million in monetary value) a year for passing a law. This is a conservative estimate since only driver fatalities were consider in the analysis. The cost of this law is obviously minimal compared to $29.7 million social benefits a year. Even allocating extra patrol officers for enforcing this law and launching a large media campaign such as “Shattered Dreams\textsuperscript{20}” far outweighs the benefits received in the lives that could potentially be saved by the zero tolerance law.

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