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The Effect of Macroeconomic Conditions on Traffic Fatality Rates across the United States

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THE EFFECT OF MACROECONOMIC CONDITIONS
ON TRAFFIC FATALITY RATES ACROSS THE UNITED STATES

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Social and Applied Economics

By

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B.S., Wright State University, 2005

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ABSTRACT

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The Effects of Macroeconomic Conditions on Traffic Fatalities Across the United States.

This study uses state-level data to estimate the effects of macroeconomic conditions on traffic fatality rates. Data was averaged over a five year period (1999-2003) and regression analysis was used to estimate a model to explain the impact of unemployment rates and income on traffic fatalities per vehicle mile traveled across the 50 United States. Variables were also included to control for other factors that affect state fatality rates. These factors include per capita alcohol consumption, speed limits, the percentage of teenage drivers, the relative strength of teenage driving laws, and average state temperature. A dummy variable was also included for the state of Utah. The results of this study indicate that income, temperature, and the dummy variable for Utah are inversely related to traffic fatality rates. Alcohol consumption, speed limits, the percentage of teenage drivers, and the relative strength of teenage driving laws were found to be positively correlated with state traffic fatality rates.
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INTRODUCTION

According to the United States Department of Transportation, there were 42,636 motor vehicle fatalities in the United States in 2004. Traffic fatalities vary considerably from state to state. According to the National Highway Traffic Safety Administration, in 2004, Wyoming had the highest per capita rate of fatalities at 32.38 per 100,000 people, while Massachusetts had the lowest rate at 7.42 per 100,000 people.\(^1\) Massachusetts also had the lowest fatality rate per million vehicle miles traveled (0.0085290), while Mississippi had the highest fatality rate per million vehicle miles traveled (0.0241931).

Numerous studies have examined the impact of regulatory safety policies such as speed limits, DUI laws, seatbelt enforcement, and teen driving laws on traffic fatality rates across states.\(^2\) However, few cross-sectional studies examine the impact of macroeconomic factors, such as income and unemployment rates, on state traffic fatalities. Economic factors are likely to impact traffic fatalities because people will demand more safety, including public safety, at higher income levels. The purpose of this study is to estimate the cross-sectional relationship between economic conditions and traffic fatalities among states.

Several economic studies have analyzed the relationship between macroeconomic factors and traffic fatalities over time. Some articles have concluded that national traffic


fatality rates tend to increase in initial industrialization phases, but later decrease as the country’s economy expands. For example, Kopits and Cropper (2005) showed that while per capita fatalities have been increasing considerably for developing countries, they have been decreasing for high-income nations. They found that fatality rates are likely to increase as a developing nation’s income increases due to an increase in the number of automobiles on the road. As income continues to grow, however, the fatality rate begins to fall because governments invest in better road infrastructure and individuals invest in safer cars.

Van Beeck, et al (2000) also examined the nonlinear relationship between traffic fatalities and economic growth over time. They found that traffic fatalities in industrialized nations have decreased as income has increased since the 1960’s. They partly attributed this reduction to declines in mobility growth (the per capita growth in vehicles). Mobility growth tends to increase rapidly at the onset of industrialization, but then it tends to level off. These findings were also echoed by Wang, et al’s (2003) time series analysis of economic growth and traffic fatalities in China. This study found that China, a newly developing country, has seen a rapid rise in the absolute number of traffic fatalities. They acknowledged that this was caused a 266-fold increase in the number of automobiles during the 1990’s, which occurred without corresponding updated infrastructure.

Similarly, Scuffham and Langley (2002) examined the time series relationship between real gross domestic product and traffic fatalities in New Zealand between 1970 and 1994. They found real GDP per capita and automobile crashes to be negatively
correlated. They believed that this trend was potentially caused by “supply side effects,” such as better road infrastructure.

There have also been some cross-sectional studies analyzing the impact of income on traffic fatalities. For instance, Peltzman (1975) showed that per capita traffic death rates were negatively correlated with disposable personal income among U.S. states.\(^3\) Moreover, he found that increased income, rather than increased safety regulation, was responsible for declines in traffic fatalities because the demand for vehicle safety features is greater at higher income levels. Hasselberg and Laflamme (2004) also found that Swedish children from families with higher disposable incomes were less likely to experience traffic accidents than their lower income counterparts. Likewise, Van Beeck, et al (1991) demonstrated that higher levels of income correspond to lower fatality rates among regions of the Netherlands.

The time-series impact of unemployment on traffic fatalities has also been examined, but the results have been mixed. For example, Wagenaar (1984) found the lagged unemployment rate and traffic fatalities to be positively correlated in a study which used monthly time series data for Michigan between 1972 and 1982. He believed this relationship was caused by the increased stress associated with negative economic conditions and unemployment. Schuffham (2003) analyzed the impact of the unemployment rate on quarterly traffic fatalities in New Zealand from 1970 to 1994. However, he found that reductions in unemployment (lagged one quarter) were associated with increases in the number of traffic fatalities. He believed this could be attributed to the reduction in vehicle miles traveled for both work and leisure associated with unemployment. It is unclear which of these factors is dominant.

\(^3\) Peltzman’s empirical model was specified to evaluate the impact of safety regulations on fatality rates.
This study uses a cross-sectional approach for examining the relationship between economic conditions and traffic fatalities across the 50 United States. More specifically, this study examines the impact of per capita total income and state level unemployment rates upon fatalities per vehicle mile traveled. Traffic fatalities per vehicle mile traveled are believed to be a better measure than simply the number of fatalities because it controls for differences in driving distances. Traffic fatalities and their determinants are statistically modeled using averages of annual data for the years 1999 through 2003. This will help control for any anomalies that might have occurred in some states during a single year.4

The estimates presented herein support the hypothesis that economic conditions are indeed negatively associated with traffic fatalities across the 50 U.S. states. The following sections provide a detailed description of the econometric model, the data, and resulting estimates. The limitations of the analysis, suggestions for further research, and policy implications are also discussed.

MODEL

Economic conditions are likely to affect traffic fatality rates for several reasons. First, states with higher incomes should have better road infrastructure such as improved lighting and wider lanes. Those states are also more likely to have better equipment, resources, and employees for clearing snow and ice from roads. Furthermore, they should be able to have a larger police force to enforce traffic laws, thereby reducing the

4 An attempt was made to use panel data to estimate the model. However, this approach yielded poor goodness of fit characteristics, possibly due to the spurious variation in single year state fatality rates.
prevalence of unsafe driving. One reason for these increased expenditures is that states with better economic conditions should have a larger tax base. It is also expected that the demand for public safety should be greater at higher income levels if it is a normal good.5

Secondly, individuals should purchase more safety at higher income levels if safety is perceived as a normal good. Thus, individuals earning higher incomes are expected to purchase newer, safer cars. Johnson and Witt (1986) found that there was a significant positive correlation between new vehicle demand and personal disposable income. Increased income should also increase an individual's demand for automobile safety features. For example, Boulding and Purohit (1996) showed that individuals are more willing to pay for airbags and antilock breaks when they have higher earning potentials. Additionally, individuals with higher incomes should be expected to exhibit more caution in driving and safety device use because they have more to lose if they are prevented from working due to an accident. Indeed, Blomquist (1979) found that individuals with higher expected future incomes were more likely to use safety belts.

Thirdly, more affluent regions are likely to have better medical facilities and Emergency Medical Services (EMS). These regions should have more highly trained physicians, nurses, and paramedic crews. Furthermore, newer and more advanced medical technologies and procedures are more likely to be found in prosperous regions. Better medical care is likely to reduce the number of fatalities seen in crash victims. Additionally, more emergency rooms in a region means shorter travel distances for traffic accident victims. This markedly increases their chance of survival. For instance, Noland (2003) found a significant inverse association between the number of doctors per capita and fatalities rates in OECD nations.

5 Pradhan and Ravallion's empirical analysis showed that public safety was, in fact, a normal good (1999).
The following econometric model was developed to evaluate the impact of income on traffic fatalities across states.

\[ FR_i = \beta_0 + \beta_1INC_i + \beta_2UR_i + \sum_{j=5}^{n} \beta_jX_{ji} + \epsilon_i \]

The 1999-2003 average annual state traffic fatality rate is measured by \( FR_i \). This variable represents annual state fatalities per 1,000,000 vehicle miles traveled (VMT). Economic conditions at the state level are represented by two variables: the per capita total income in dollars \((INC_i)\) and the unemployment rate \((UR_i)\). For the reasons stated earlier, if increased income does in fact reduce the fatality rate, the sign of \( B_1 \) should be negative. The sign of the coefficient for the unemployment rate is expected to be positive because states with higher unemployment rates should yield a higher fatality rate.

The \( X_i \) variables represent the control factors that impact the state fatality rate. These factors include the alcohol consumption, speed limits, the percentage of teenage drivers, the relative strength of teenage driving laws, and state temperature.

Alcohol consumption \((ALC)\) is measured by the 1999-2003 average annual ethanol alcohol consumption in gallons per capita. Alcohol consumption is likely to vary by state due to lifestyle differences or variations in religious or moral values. It is hypothesized that states with higher per capita alcohol consumption will have higher traffic fatality rates because alcohol consumption increases unsafe or reckless driving behavior. Alcohol can impair a person’s motor coordination skills, depth perception,
vision, and judgment (CAMH). Therefore, the coefficient of ALC should have a positive sign.  

Traffic crashes are the leading public health threat for teenagers. Teenagers are more likely to be involved in fatal traffic crashes because they lack experience and maturity. They are not able to handle dangerous situations as well as more experienced drivers, and they may underestimate the impact of careless or reckless driving.

Therefore, it is likely that states with a higher proportion of teenagers drivers will have higher traffic fatality rates.

Largely because of the risks to teenage drivers, many states have restricted teenage driving. Teen driving laws vary substantively from state to state. The IIHS measured the strength of state teen driving laws using a 1-4 scale, with 4 meaning a state’s teen driving laws significantly restrict teen driving, while a 1 means that a state’s teen driving laws do not restrict teen driving. The following criteria were used to evaluate the laws: learner’s entry age, learner’s permit holding period, practice driving certification, nighttime driving restrictions, passenger restrictions, the presence of driver’s education, and the duration of the restriction period. These laws attempt to limit the distractions and/or extend driving practice times for teenage drivers, thereby promoting safer driving habits.

---

6 States with lower incomes or higher unemployment rates are more likely to have alcohol use rates. Ruhm (1995) found that increased in both alcohol consumption and traffic fatalities corresponded to lower income levels in the 48 contiguous states. Therefore, there is possibly of an interaction effect between alcohol consumption and economic conditions. However, an interaction variable was included to account for this effect, but it was found to be statistically insignificant. Thus, the interaction term was excluded from the final model.

7 Insurance Institute for Highway Safety, 2004

In order to estimate the impact of teenage driving on state traffic fatality rates, a variable that combined the number of teenage drivers and the relative strength of teen driving laws was produced. This variable (TEEN) is defined as:

\[
\text{TEEN} = \frac{(\text{Teen Drivers/ Total Drivers}) \times 100}{\text{IIHS Teen Driving Law Value}}
\]

Thus, TEEN divides the percentage of drivers that are teenagers by the relative strength of the state’s teen driving laws in order to adjust for differences in the quality of teenage driving from state to state. The coefficient for TEEN is expected to be negative; having a larger percentage of teenage drivers and/ or weaker teenage driving laws should increase a state’s traffic fatality rate.

It is expected that states with higher speed limits will have more severe traffic crashes, and thus, more traffic fatalities. Additionally, most high-speed driving occurs on interstate highways. Therefore, the variable SPEEDMILE was included to control for differences in interstate speed limits and the frequency of travel on interstate roads. SPEEDMILE is the percentage of each state’s total miles driven on interstate highways, weighted by the mileage and speed limit differentials for urban versus rural highways.

\[
\text{SPEEDMILE} = \frac{\text{Urban Speedmile}^9 + \text{Rural Speedmile}^{10}}{\text{Total Miles Driven}}
\]

\[^9\text{Urban Speedmile} = (\text{Urban Interstate Speed Limit} \times \text{Urban Interstate VMT}) \times (\text{Urban Interstate VMT/ Total VMT})\]

\[^{10}\text{Rural Speedmile} = (\text{Rural Interstate Speed Limit} \times \text{Rural Interstate VMT}) \times (\text{Rural Interstate VMT/ Total VMT})\]
The coefficient of this variable is expected to be positive, since driving more miles at higher speeds is likely to yield a higher traffic fatality rate.

A variable was also included to control for differences in state temperatures. All other factors equal, states with lower average annual temperatures should expect less traffic fatalities than states with higher average temperatures. This idea was empirically established by Koshal (1976), Zlatoper (1987), and Zlatoper (1991). In states with higher temperatures, drivers are likely to be less comfortable, and therefore, have poorer performance. Hot temperatures are also linked to higher levels of driver aggression\(^{11}\). Driver aggression or road rage causes drivers to engage in risky driving behaviors, which causes more traffic crashes. Finally, states with colder temperatures typically have more snowfall, which slows driving spends and reduces fatalities\(^{12}\).

For this study, temperature was measured by the variable \textit{DEGREEDAYS}. This variable was calculated by subtracting the annual population-weighted cooling degree days\(^{13}\) from the annual population-weighted heating degree days.\(^{14}\) Thus, states with lower average annual temperatures have a higher value for this variable. As a result, the coefficient of this variable is expected to be negative.

Finally, a dummy variable, \textit{UTAH}, was included for the state of Utah. Utah was an outlier in this analysis, as it had a low fatality rate and a relatively low per capita income for each of the five years examined. Thus, the coefficient for \textit{UTAH} is likely to be negative.

\footnotesize
\(^{11}\) Kenrick and MacFarlane (1986), for instance, recorded the number of times cars honked their horns at a car stopped at a green light at various temperatures. They found a direct linear relationship between temperature and the number of honks.

\(^{12}\) Snowfall is not measured by state. Therefore, it could not be included in the model. Evans (2004) examines regional differences in snowfall and its effect on fatality rates.

\(^{13}\) \(\Sigma_{i=365}^{n} (\text{Mean daily temperature} - 65 \text{ degrees Fahrenheit})\)

\(^{14}\) \(\Sigma_{i=365}^{n} (65 \text{ degrees Fahrenheit} - \text{mean daily temperature})\)
In order to determine the aggregate effect of income on traffic fatalities, variables related to the state healthcare expenditures and the size of the police force were purposely excluded from the model. Although these factors are likely to impact the number of traffic fatalities in a state, they were primarily functions of state economic conditions. For instance, Jacobs and Helms (1997) found that there was a direct relationship between the tax base, as measured by GDP per capita, and police force strength. Similarly, Newhouse (1977) showed that over 90 percent of country-level cross-sectional differences in per capita medical expenditures could be explained by differences in per capita incomes. Thus, in order to examine the total effect that income has on traffic fatalities, these variables were excluded from the model.

DATA

State data was collected for the years 1999-2003. Yearly observations were then averaged to produce one observation per state for each variable. Calculating five year averages reduces the possibility of spurious outliers, thus providing a more accurate representation of typical state conditions. All fifty states were included.

State traffic fatality totals were produced by the U.S. Department of Transportation. State total per capita income data was calculated by the Bureau of Economic Analysis, and state unemployment rates were published by the Bureau of Labor Statistics. State per capita alcohol consumption data was calculated by the National Institute on Alcohol Abuse and Alcoholism, an agency of the National Institutes of Health. Data regarding state vehicle-miles traveled by functional system was
produced by the U.S. Department of Transportation’s Federal Highway Administration. State speed limits and teen driving laws were provided by the Insurance Institute of Highway Safety. State heating and cooling degree days were computed by the National Oceanic and Atmospheric Administration. Finally, data regarding the number of teen and total licensed drivers was produced by the U.S. Department of Transportation. Teenage drivers were recognized as those 19 years of age and younger.

The descriptive statistics of the data are included in Appendix A. The mean fatality rate is 0.01573 crash fatalities per million vehicle miles traveled annually. State traffic fatality rates ranged from 0.0085290 per million annual vehicles miles traveled (Massachusetts) to 0.0241931 per million vehicle miles traveled (Mississippi). State income per capita ranged from $22,134.00 (Mississippi) to $42,267.00 (Connecticut), with an average of $29,359.46. State unemployment rates ranged from 6.8 percent (Alaska) to 3.2 percent (North Dakota and South Dakota), with an average of 4.738 percent.

Ethanol alcohol consumption ranges from 1.08 gallons per capita (Utah) to 3.35 gallons per capita (New Hampshire). The mean value of per capita alcohol consumption is 1.8902 gallons. Hawaii has the smallest value (-3,522) for DEGREE DAYS, since it did not have any heating degree days. Predictably, Alaska had the largest value for DEGREE DAYS (10,373). The average value for DEGREE DAYS is 3997.86, which most closely approximates the climates of states such as Maryland, West Virginia, Missouri, and New Jersey.\textsuperscript{15}

\textsuperscript{15} Data regarding state DUI laws and penalties, seat belt laws and penalties, nighttime driving speed limit differentials, average annual precipitation, urban to rural driving ratios, and population density were collected, but were found to be statistically insignificant when included in the empirically estimated model. Therefore, these variables were excluded from the model.
ESTIMATES

The model was empirically estimated using ordinary least squares. The estimates are summarized in Appendix B. The results indicate that state level economic conditions significantly impact the traffic fatality rate. More specifically, a 1,000 dollar increase in the per capita state GDP decreases state traffic fatalities by 0.000542 per million vehicle miles traveled, on average. Similarly, a one percentage point decrease in the state unemployment rate leads to 0.00113 fewer traffic accidents per million vehicle miles traveled, on average.

The parameter estimates are statistically significant at the 95% confidence level for two-tailed tests. All of the parameter estimates also have the expected signs as determined by the previous theoretical discussion. The regression results show that a one gallon increase in per capita ethanol alcohol consumption causes the traffic fatality rate to increase by 0.00222, ceteris paribus. States with a higher ratio of teen to total drivers and/or less strict teen driving laws also experience more traffic fatalities per vehicle mile traveled. In fact, a one percentage point in the number of teen drivers, adjusted for differences in teen driving laws, increases state traffic fatalities by 0.00111 per million vehicle miles driven.

Increases in interstate speed limits or the frequency of travel on interstate roads also significantly increases state traffic fatality rates. A one unit increase in SPEEDMILE increases traffic fatalities per by 0.00106 for every one million vehicle miles driven. Furthermore, as expected, states with warmer temperatures experience more traffic fatalities than states with cooler climates. The regression results indicate that a
100 degree increase in net degree days decreases the traffic fatality rate by .000033.\textsuperscript{16} Finally, there are -0.00551 fewer traffic fatalities per million vehicle miles traveled in Utah, with other factors held constant.

The model’s goodness-of-fit measures are fairly strong for a cross-sectional analysis. The $R^2$ value is 0.7421, indicating that the model explains 74.21 percent of the variation in the traffic fatality rates across the states. Furthermore, the model shows no signs of multicollinearity. There is also no evidence of heteroskedasticity, as determined by the White’s Test for heteroskedasticity.\textsuperscript{17} Thus, the model is statistically valid and appears to adequately represent the determinants of traffic fatalities.

**DISCUSSION**

This analysis shows that economic conditions do in fact influence cross-sectional state level fatalities per vehicle mile traveled, after controlling for several demographic, policy, and geographic factors also linked to traffic fatalities. States with higher per capita income levels and lower unemployment rates should see fewer traffic fatalities, ceteris paribus.

It is important to remember that this study does not address the time series impact of economic conditions on traffic fatalities. Therefore, it is not possible to determine any lagged effects of the independent variables. However, cross-sectional estimates may be useful to Federal and state policymakers that wish to reduce fatality rates because they present a more general analysis of the determinants of fatality rates. Nevertheless, future

\textsuperscript{16} A 100 increase in net degree days could mean 100 days out of the year with temperatures decreased by 1 degree Fahrenheit, for example.

\textsuperscript{17} The White’s Test Statistic is equal to 0.414.
researchers might consider using panel data to view time series and cross-sectional effects simultaneously

In order to reduce fatality rates, policy makers at both the federal and state levels should consider economic conditions when budgeting for goods and services such as road infrastructure, law enforcement, and medical services. For instance, if a less affluent jurisdiction’s goal is to decrease traffic fatalities, perhaps a higher percentage of that jurisdiction’s tax revenue should be used for these goods. Additionally, poorer states might consider adopting stricter teen driving/licensing laws or increasing expenditures for alcohol awareness programs in order to compensate for low levels of income or high unemployment rates. Federal policy makers might also consider giving states larger grants to spend on road infrastructure and traffic safety. However, it is beyond the scope of this analysis to determine which of these goods or services is most important for reducing traffic fatalities. Additional research should be conducted in this area.

There are three main limitations associated with this analysis. First, economic conditions may vary significantly among counties or regions within states. However, this study does not account for intrastate differences in economic conditions. Secondly, this study only measures the fatalities associated with traffic crashes. Since it neglects non-fatal crashes, it may not capture the total impact of economic conditions on overall traffic safety. Further research should be conducted to determine if better economic conditions reduce all traffic crashes. Finally, this model is unable to account for time series affects. Therefore, it cannot be used to determine the relationship between economic conditions and traffic fatality rates overtime.
## APPENDIX A
### DESCRIPTIVE STATISTICS

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<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
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<tr>
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</tr>
<tr>
<td>INC</td>
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<tr>
<td>UR</td>
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</tr>
<tr>
<td>ALC</td>
<td>1.89020</td>
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<td>1.96361</td>
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</tr>
<tr>
<td>SPEEDMILE</td>
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<td>1.02439</td>
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<tr>
<td>DEGREE DAYS</td>
<td>3997.86</td>
<td>2978.15</td>
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### APPENDIX B

PARAMETER ESTIMATES

<table>
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</tr>
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<td>1.039687E-7</td>
<td>-5.22</td>
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<tr>
<td>UR</td>
<td>0.00113</td>
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<td>ALC</td>
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<td>0.00093137</td>
<td>2.38</td>
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<td>TEEN</td>
<td>0.00111</td>
<td>0.00042690</td>
<td>2.60</td>
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<td>DEGREEDAYS</td>
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<td>1.153819E-7</td>
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<tr>
<td>UTAH</td>
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<td>-2.27</td>
</tr>
</tbody>
</table>

N = 50

$R^2 = 0.7421$

Root MSE = 0.00218
REFERENCES


Centre for Addiction and Mental Health, 2003. *Do You Know: Alcohol, Other Drugs, and Driving*.


