THE EFFECT OF SEAT BELT USAGE RATES ON THE NUMBER OF MOTOR VEHICLE-RELATED FATALITIES

Richard A. Derrig, Ph.D.,[1]
Maria Segui-Gomez, M.D., Sc.D.,[2]
Ali Abtahi, M.P.H. [2]

[1]Automobile Insurers Bureau of Massachusetts
[2]Injury Control Research Center
Harvard School of Public Health

ABSTRACT

The effectiveness of seat belt usage in reducing mortality and morbidity among traffic accident victims has been well established. Population usage rates have been increasing from eleven percent in 1980 to sixty-eight percent in 1995, as measured by observational surveys sponsored by the National Highway Traffic Safety Administration (NHTSA). Safety incentive grants from NHTSA to the States with higher than average usage rates are expected to total $500 million during 1999-2003. Longitudinal annual motor vehicle-related fatality levels are analyzed by state to estimate the effect of the population seat belt usage rate on fatalities in the presence of known confounders such as alcohol use and youthful drivers. Consideration of alternative multivariate methodologies applied to fifteen years of data shows that the population usage rate is associated with a small effect on fatalities that for most methodologies is not statistically significant. Such a result calls into question the NHTSA policy of basing the incentive program on overall seat belt usage rates.

[1]To whom all correspondence should be addressed:
101 Arch St. Boston, MA 02110-1103
tel (617) 439-4542, fax (617) 439-6789
e-mail: richard@aib.org

March 17, 2000

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Introduction

The effectiveness of seat belt usage in reducing mortality among auto accident victims has been subject of many studies in the US (Campbell and Campbell, 1988, Rivera, *et al*. 1999) as well as in foreign countries (Campbell and Campbell, 1986). Estimates of mortality reduction vary from 22-75%, but all show a positive effect, a reduction in mortality for belted crash victims. Auto safety regulations, including those involving seat belts, are acknowledged to have contributed to decreased fatality rates since 1980 (Zlatoper, 1989). The National Highway Traffic Safety Administration (NHTSA) sponsored seat belt effectiveness studies in 1984 that concluded that there is a 40-50% reduction in risk of fatal injury to properly used lap and shoulder belts (NHTSA, 1984). Recently, using data from their CODES project (which merges data from: death certificates, hospital discharge, emergency departments or pre-hospital providers, and accident crash reports to create a population-based dataset), NHTSA analyzed data from seven states[1] and found continued support for their original estimates of the size of the favorable effect of seat belts on crash victim mortality (NHTSA, 1996).

The percentage of motoring population wearing safety belts has generally grown from 11% in 1980 to 68% in 1995. Installation of safety belts has been mandatory in the new cars sold in the US since 1968 (Rivera, *et al*. 1999). The current US private passenger auto fleet is estimated to have virtually 100% installation of seat belts. While seat belts may be installed in the vehicles, crash protection comes only from their active use by drivers and their passengers. While population seat belt usage rates have risen dramatically with the passage of mandatory seat belt laws, the Fatal Accident Reporting System (FARS) data reveal that front seat occupants involved in fatal crashes have much lower belt usage rates as shown in Figure 1 (Thompson, et. al., 1999).

[1] One year data from Hawaii, Missouri, Maine, Pennsylvania, Utah, Wisconsin and New York were analyzed. NHTSA found a 60% mortality effectiveness for safety belt use when adjusted for over-reporting by police.

[Figure 1 here]

Usage rates are affected by the passage (and repeal) of mandatory safety belt laws with primary or secondary enforcement (NHTSA, 1994, Rivera, *et al.* 1999). Figure 2 shows a pattern of increased belt use for primary enforcement states and for states with a mandatory seat belt law (NHTSA, 1994). Usage rates have been estimated by state under NHTSA sponsored grants since 1981. States use stratified statistical sampling methods in observational studies of cars on roadways to estimate usage rates by type of occupant. For example, in Massachusetts, the 1998 observational survey estimated 51% of drivers and front seat passengers were belted (Hingson, *et al.* 1998). These studies have an estimated direct cost of $40,000 per year per state. Safety incentive grants to states with higher than average observed usage rates totaling $500 million are to be provided by NHTSA during 1999-2003 under the TEA-21 funding. Presumably, the favorable outcome of the incentive grants will be further increased belt use and decreased fatalities.

Simple empirical or univariate model relationships of safety belt usage rates and motor vehicle crash fatalities are used to project lives saved (or lost) by increased (decreased) safety belt usage in the vehicle occupant population. For example, in the 1998 Massachusetts study, it was noted that were Massachusetts to increase its belt use from 51% of front seat occupants to meet the national average of 62%, an additional 10-15 deaths would be prevented (Hingson, *et al.* 1998).

The number of occupant fatalities in the US crashes depends not only on safety belt use, but on an array of other factors known to influence the likelihood of: (a) being in a crash, (b) the severity of the crash once a crash happens, and/or (c) the severity of the injuries sustained by the occupants, and (d) the health care provided. Some of the factors associated with one or several of these stages (besides use of safety belts) are: vehicle miles traveled, type of roads (e.g., urban vs. rural), alcohol use, age, educational status, availability of trauma medical centers, and insurance status (Zlatoper, 1989, Hu, *et al* 1998, Devlin, 1999, Cummins, Weiss and Phillips, 1999).

A wide variety of functional forms relating fatalities to potential explanatory variables have been studied (Zlatoper, 1989). While it is clear that a simple fatality/seat belt usage univariate functional relationship is inadequate, a precise functional relationship may be difficult to support absent a complete model of automobile accident involvement. Indeed, simultaneous equations or instrumental variables may be needed when variables exhibiting endogeneity are used (Cummins, *et. al*, 1999). In reviewing studies relating primary and secondary enforcement of mandatory seat belt laws, Rivera, *et al.* (1999) find substantial significance for the association of primary law enforcement and fatalities but not for secondary enforcement states, the majority of all states (Figure 2).

[Figure 2 here]

In this study we wanted to evaluate how general population safety belt use rates translate into changes in motor vehicle occupant fatalities while controlling for possible confounders. Also, we wanted to evaluate the differences in findings associated with alternative methodologies for evaluating such changes. Finally, we wanted to evaluate whether the NHTSA Traffic Safety Incentive program's dependence on statewide seat belt usage rates is warranted.

Data and Methods

We collected a pooled cross-sectional dataset of demographic, socioeconomic, political, insurance, and roadway variables on all fifty US states over a fifteen-year period (1982-1996) for a total of 750 state-years[2]. Our outcome of interest was the number of motor vehicle occupant crash fatalities per each state each year. This number was extracted from the Fatal Accident Reporting System (FARS) maintained by NHTSA. In order to be included in our study, the death had to occur to occupant (driver or passenger) of a passenger car, light truck or minivan.

Other variables to be used in our analysis included characteristics of the population in each state and year (e.g., proportion of population ages 18 to 24), characteristics of the road system, miles traveled, and insurance systems in each state each year, and information on the population safety belt use. Specifically, we created three variables that contained the total number of residents in each state each year, the percent of the state population between 18 and 24 years of age, and the percent of the population older than 65 years old using census data. Using data from the US. Census Bureau–Department of Commerce, we also created variables to indicate the proportion of the population in each state and year living in metropolitan areas as well as the proportion of the population with a college education or higher --although this information was only available for 1982, and hence held constant from the year observed Information regarding the real income per capita per each state year came from the Bureau of Economic Analysis (Dept. of Commerce). Income was transformed into 1982 constant US dollars using the Consumer Price Index. Using data from the National Institute on Alcohol Abuse & Alcoholism, we created a variable to indicate the per capita consumption of alcohol (including distilled spirits and beer). The number of hospitals (of any level) per square mile were obtained from the American Hospital Association (US Statistical Abstract, 1998). Data from the National Oceanic and Atmospheric Administration was used in compiling the information regarding the volume of precipitation (rain and snow) occurring in each state each year. The number of miles driven in rural non-interstate, interstate, and urban roads as well as the total miles available in each state (in each of the three types of road above mentioned) were obtained from the Federal Highway Administration. By dividing the total vehicle miles traveled by the total miles available we created a variable that reflects traffic density. Information on the insurance systems in each state and year available from the Insurance Information Institute and the Insurance Services Office (The Fact Book, 1999) was synthesized by whether the state had a no-fault, tort or mixed system and whether involvement in a crash is "penalized" with negative points in the insurance record of the driver. Last, data regarding the motor vehicle occupant safety belt usage were obtained from

[2] A portion of the data was provided by J. David Cummins and Mary A. Weiss from their study (Cummins and Weiss, 1998).

the state observational surveys through NHTSA. We also created dummy variables for each year (using 1982 as the reference year).

The analyses were done in five steps: (1) univariate analysis, (2) multivariable analysis using three alternative regression methods, (3) development of an instrumental variable to better handle insurance status, (4) multivariable analysis using the same previously used alternative regression methods but with the instrumental variable as one of the covariates, and (5) predicting the number of motor vehicle occupant fatalities using different state-level safety belt rate changes and the various parametrized models. Throughout our analysis, statistical significance was defined at $p<0.05$. Stata and SAS were the statistical software used.

First, the effect on the number of motor vehicle occupant fatalities per state and year of each covariate was evaluated using Pearson's correlation (r). Only those covariates that had statistically significant effects on our outcome were used in the multivariable regression models.

Second, three multivariable models were developed using the number of motor vehicle occupant fatalities per state and year as the dependent variables and a deterministic choice of possible confounders as the independent variables. We evaluated three alternative mathematical models, ordinary least squares (OLS), panel data methods (PD), and ordinary least squares with auto-correlation correction.[3] Ordinary least squares (in the form of linear regression), is one of the most common methods used in the evaluation of motor vehicle injury prevention interventions. In this method, each observation is considered to be independent of all other observations. In our dataset, this is clearly not the case, since data on the same 50 states over a 15-year time span are clearly correlated. However, since this is a method used by researchers with whose results we wanted to compare ours, we decided to include it in our work. Panel data methods are, theoretically at least, a much more refined tool to analyze the repeated measures data that we had (Hu, *et al*., 1998). Using this method, data from the same state is acknowledged as such. The ordinary least squares method with a correction for auto-correlation accommodates the within-state correlated time series. The overall performance of these models was evaluated using the Adjusted R2 (OLS and OLS autocorr), the Dubin-Watson (OLS autocorr) and the Wald X2 (PD) statistics.

Third, we evaluated the need for developing and using an instrumental variable to indicate the insurance tort system for each state and year. Instrumental variables are appropriate when the response variable (fatalities) may be a determinant of one of the covariates, in this case, the insurance system (Zohoori and Savitz, 1997, Newhouse and McClellan, 1998). Using variables that are highly correlated with the insurance status but have absolutely no relationship with our outcome of interest, motor vehicle occupant fatalities, one can build an instrumental variable that allows for making causal arguments. The appropriateness of the instrumental variable was tested here using the Hausmann Test (Cummins, *et al*. 1999).

Fourth, using the instrumental variable developed in step 3, we run the same three multivariable regression models described the two paragraphs above. Additionally, we simultaneously test for the influence of primary seat belt laws and high usage rates by performing the analyses separately for states with 1996 usage greater and less than 65 percent, the overall U.S. rates

[3] Greene (1993).

average. It seems reasonable that if population seat belt usage rates are to affect fatalities significantly, then that effect should be apparent in those states with high usage rates.

Results

The mean number of fatalities across state-years was 440, with a range between 16 in Rhode Island in 1982 and 2,179 in California in 1989. Motor vehicle occupant safety belt use, as reported by the observational surveys ranged from a low 10% in Indiana (1982 through 1985) to a high 87% in California in 1996. Regarding insurance status, among the 750 state years, 368 (50%) had a tort system, 171 (23%) had a mixed system, and the remaining 211 (28%) had no-fault systems. Only 3 states changed their insurance status in these years: Connecticut and Georgia changed from a no-fault state to a tort state in 1994 and 1992, respectively, Pennsylvania changed from a no-fault state to an add-on (mixed) state in 1985 and then back to a no-fault state in 1991. Among the 50 states, 37 (74%) assigned violation points throughout the study period for a total of 555 state years. This did not change over the years. Table 1 provides a descriptive summary of the mean, standard deviation and range of selected variables across state-years.

[Table 1 here]

Table 2 provides a list of the auto insurance systems of all 50 states over the years.

[Table 2 here]

1) Univariate analysis

All the evaluated variables, except two, had statistically significant effects on motor vehicle occupant fatalities by state and year. The exceptions were the political affiliation of the state governor in 1974 (a year concurrent with states adopting no-fault insurance) and in 1996 (the year of the most recent elections). Those two variables were subsequently used in defining instrumental variables for insurance.

2) Multivariable analysis

Table 3 presents the coefficients and statistical significance of the covariates in each of the three models used. Seat belt usage was associated with reduced fatalities at a rate of about one fatality per one to two percentage points of increased usage. Significance was achieved, however, only when the method used was for the panel data. Increases in for total population, proportion of youthful (18-24) population, real income and alcohol resulted in increases in fatalities as expected. Higher college education and annual precipitation levels were associated with decreased fatalities. No other variables achieved significance in both the panel data and auto-correlation correction models. The expected negative correlation of fatalities with the availability of hospitals and trauma centers appears significant only in the OLS model.

[Table 3 here]

3) Creating the instrumental variables

Whether the state governor in 1974 or 1996 was democratic was highly positively correlated with the existence of a no-fault insurance system. Political affiliation of the governor had, on the other hand, no relationship with the number of motor vehicle occupant fatalities occurring in the states, an ideal situation for a potential instrumental variable regressor.

To create the instrumental variable, we used a logistic multivariable regression model where the dependent variable was a dummy variable indicating whether a state year had a no-fault insurance system and the independent variables were dummy variables to indicate whether the state governor was democratic in 1974 and 1996. We then defined the instrumental variable with the predicted probability that any given state year would have a no-fault system given the information regarding the governor's political affiliation in 1974 and 1996. The instrument variable validity was confirmed using the Hausman Test. Table 2 summarizes the range of the instrumental variable values across the years per each state.

4) Multivariable analysis with an instrumental variable as covariate

Table 3 also presents the coefficients and statistical significance of the covariates in each of the three models used when the insurance system is replaced with a no-fault instrumental variable. Seat belt usage retained the expected sign but resulted in a lesser magnitude (one fatality reduction per three or four percentage points of increased usage) and without significance for any methodology. This result is similar to the non-significance of secondary seat-belt laws at reducing fatalities found by Rivera, *et al*. 1999. Total population and alcohol remained strongly positively correlated with fatalities while college education levels kept their strong negative correlation. The insurance system variables resulted in opposite correlations, no-fault instrument and violation points had positive and negative effects respectively, but significance is achieved only for the panel data method. The precipitation variable retains its strong negative correlation but only for the auto-correlation correction model.

5) States with High and Low Seat Belt Usage

The general non-significant relation of population seat belt usage rates to fatalities across all states may be the result of the failure of many states to achieve sufficiently high levels of usage. The finding by Rivera, et al (1999) that primary enforcement laws are effective at reducing fatalities while secondary laws are not points to a hypothesis that a minimum level of population usage may be needed in order to affect the fatal crash population (see Figure 2). Likewise, the notion that there are "good" and "bad" drivers with significantly different accident propensities (Venezian, 1980), argues for high enough population usage rates to cover a fair proportion of the "bad"drivers.

Tables 4a and 4b provide a first pass test of these hypothesis by segregating states into those states above (21) and below (29) 65 percent usage in 1996, the latest year of data. Primary enforcement states generally fall in the above 65 percent usage group while the no-effect secondary enforcement states generally fall below 65 percent.

[Table 4a here]

Table 4a shows, however, a pattern of seat belt coefficients across models similar to that for all states. Five of six models show small negative but insignificant coefficients. The panel data model with no-fault dummies shows a small but significant negative coefficient (-1.08) similar to that for all states (-1.15). Table 4b shows similar results indicating that primary enforcement, as it raises the observational population of seat belt usage, may not account for identified decreases in fatalities.

[Table 4b here]

6) Model Projections

Table 5 displays the state by state fatality reductions predicted by the six models in Table 3, given seat belt usage increases of 5 and 10 percent from the 1996 levels. At the 5 percent level of increased seat belt usage, fatality decreases of 35 to 184 were projected from a level of 21,001. The 10 percent usage increase doubles the decrease in fatalities to a high of 368, still only a 1.75 percent decrease.

[Table 5 here]

Conclusions

Across models and regardless of whether insurance is incorporated as a dummy or instrumental, variable alcohol, total population, and percent population age's 18-24 increase number of motor vehicle occupant fatalities, most of the times in a statistically significant manner. Higher proportions of the population with higher education always decrease in a statistically significant manner the total number of fatalities (and the magnitude of this effect is among the largest). Larger proportions of safety belt use as reported in observational surveys have also a beneficial effect in lowering the numbers of fatalities. Interestingly, these changes are only statistically significant in one of the 6 models evaluated. Even more interestingly, the magnitude of this effect is relatively low (at most, each increase of 1% in the occupant safety belt use in any given state year is associated with 1.15 fewer deaths). The vulnerability of older drivers and passengers to severe injuries appears not to be detectable at the statewide level, possibly because of their offsetting low driving volume.

All other covariates, including insurance status underwent huge changes in direction of sign, of magnitude of coefficients, and their statistical significance across models, most likely due to little variability in the data. The panel data method without the instrument supports the add-on or mixed tort system rather than the simple no-fault system as the source of positive correlation with fatalities. Table 2 shows that, while statistically more appropriate, the instrument variable for no-fault combined with the variable regarding "penalty" points merely shifts the collection of states considered as "no-fault", with little variation over time. Perhaps appropriate conclusion is that there is an omitted variable or unobserved heterogeneity (Zohoori and Savitz, 1997) that ties the instrument-valued states together rather than the insurance system. For example, the proportion of drivers that are uninsured could proxy risky behavior as well, if not better, than the style of compensation system.

Remarkably, no-fault insurance status (whether as a dummy or an instrumental variable) and a violation points policy always have opposite effects. When one is associated with increases in the number of fatalities, the other is associated with decreases in that number. However, changes associated with the violate points policy tend to be larger in magnitude that those associated with insurance status.

As a result of our findings we believe that recent increases in safety belt usage rates may not be primarily responsible for the observed decrease in road fatalities. The population safety belt usage increase may be due to risk adverse "good" drivers and their children occupants increase in their usage rate[4] while risky "bad" drivers (i.e. those who get into crashes) maintain their current behavior. Policy implications: target risky drivers e.g. (teenagers, drivers with violation and/or accident histories, urban drivers) rather than population seat belt usage: primary enforcement, and 100% usage target. For example, occupants wearing seat belts have been observed in less severe crashes than those that do not. (NHTSA, 1984).

Our analysis has some limitations. For example, except for our findings with regards to no-fault insurance when using the instrumental variable, one must remind the reader not to make any causal associations between our independent and dependent variables. In trying to circumvent this problem, we explored other models, which included dummy variables for each state. This would allow us to make causal inferences regarding the effects of the covariates. Changes within state drove the coefficients with no (or little) change within state to either become non-significant or drop out from the models, but given the little variability of the data over time, the state dummies were redundant.

[4] Hingson, *et al*. 1998 observe significantly higher seat belt usage rates for children when the adult driver is also observed using a seat belt.

Acknowledgements

We thank Meredith Rosenthal, Ph.D., for her suggestions regarding the modeling strategies.

Partial funding for this project was provided by the Center for Disease and Control through a grant to the Harvard Injury Control Research Center (R49/CCR115279-01).

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Table 1. Distribution of Selected Variable by State Year N=750 or 50 states per 15 years (1982-1996)				
	Mean	**Std. Dev.**	**Min**	**Max**
Motor Vehicle Occupant Fatalities (N)	440	403.2	16	2,179
Roadside observational safety belts use (%)	45.8	18.5	9.5	87.0
No-fault insurance (%)	28.1	44.9	0	1
Total population (N in thousands)	4941.9	5332.4	450.0	31857.7
Population between 18-24 years old (%)	11.0	1.3	8.0	14.3
Population over 65 years old (%)	12.2	2.2	2.9	18.5
Population living in metropolitan areas (%)	66.3	21.6	21.9	101.5
Population with college degree or higher (%)	13.0	2.3	8.0	18.0
Real income per capita (1982 US$)	12,942	2,196	8,082	20,898
Alcohol consumption per capita (gallons)	2.5	0.6	1.2	5.3
Hospitals per Square Mile (N)	2.9	3.0	0.0	15.2
Precipitation (inches)	36.6	15.0	7.0	81.0
Traffic density (VMT/ TRM)	0.6	0.4	0.1	2.0
VMT or Vehicle Miles Traveled (in millions)	40,845	42,723	3,358	276,371
TRM or Total Roadway Miles	77,717	50,155	3,939	305,951
Safe Driver Incentive Program	74.0	44.0	0	1
Democratic Governor in 1974 (%)	72.0	44.9	0	1
Democratic Governor in 1992 (%)	40.0	49.0	0	1

Table 2. Motor Vehicle Insurance Characteristics by States (and Year)			
	Safe Driver Incentive Program 1=Yes, 0=No	No fault=2; Tort=0; Mixed=1	Instrumental Variable (range)
Alabama	1	0	0.16-0.24
Alaska	0	0	0.001-0.004
Arizona	0	0	0.18-0.30
Arkansas	1	1	0.13-0.31
California	0	0	0.23-0.51
Colorado	1	2	0.86-0.94
Connecticut	1	0(1994-1996); 2 (1982-1993)	0.93-0.97
Delaware	1	1	0.61-0.86
Florida	0	2	0.41-0.65
Georgia	1	0 (1992-1996); 2 (1982-1991)	0.17-0.44
Hawaii	1	2	0.80-0.93
Idaho	1	0	0.009-0.16
Illinois	0	0	0.10-0.13
Indiana	1	0	0.21-0.46
Iowa	0	0	0.002-0.008
Kansas	1	2	0.53-0.87
Kentucky	1	2	0.005-0.13
Louisiana	0	0	0.006-0.001
Maine	1	0	0.10-0.16
Maryland	1	1	0.84-0.92
Massachusetts	1	2	0.84-0.95
Michigan	0	2	0.006-0.12
Minnesota	1	2	0.60-0.87
Mississippi	0	0	0.002-0.004
Missouri	0	0	0.006-0.33
Montana	1	0	0.003-0.007
Nebraska	1	0	0.50-0.79
Nevada	1	0	0.003-0.10
New Hampshire	1	1	0.004-0.10
New Jersey	1	2	0.70-0.91
New Mexico	0	0	0.007-0.002
New York	1	2	0.79-0.88
North Carolina	1	0	0.27-0.55
North Dakota	1	2	0.27-0.45
Ohio	1	0	0.40-0.56
Oklahoma	1	0	0.34-0.57
Oregon	1	1	0.51-0.75
Pennsylvania	1	1 (1985-1990); 2(1982-1984; 1991-1996)	0.55-0.76
Rhode Island	0	0	0.20-0.57
South Carolina	1	1	0.17-0.28
South Dakota	1	1	0.11-0.25
Tennessee	1	0	0.12-0.34
Texas	1	1	0.28-0.63
Utah	1	2	0.72-0.90
Vermont	1	0	0.005-0.12
Virginia	1	1	0.63-0.79
Washington	0	1	0.21-0.46
West Virginia	1	0	0.007-0.20
Wisconsin	1	1	0.19-0.40
Wyoming	1	0	0.001-0.007

Table 3. Covariates Coefficients and Statistical Significance in Alternative Modeling Strategies.						
	Models			Models with Insurance Instrument		
Covariates or independent variables	OLS	PD	OLS autocorr	OLS	PD	OLS autocorr
Population Seat Belt usage Rate	-0.46	-1.15*	-0.52	-0.42	-0.37	-0.22
Insurance:						
No Fault	-7.79	-2.96	27.5	N/A	N/A	N/A
MIXED	3.30	87.3*	19.02	N/A	N/A	N/A
INSTR	N/A	N/A	N/A	-8.63	318.11*	133.12
Total Population (N in thousands)	0.07*	0.06*	0.054*	0.07*	0.06*	0.06*
Population between 18-24 years old	14.29*	25.13*	24.84*	14.55*	5.23	17.4
Population over 65 years old	-1.62	4.80	4.02	-1.47	-11.05	-0.85
Population living in metropolitan areas	2.13*	1.40	0.67	2.19*	-1.09	-0.23
Population with college degree or higher	-13.24*	-43.25*	-51.32*	-12.89*	-58.26*	-56.24*
Real income per capita	-0.02*	0.02*	0.016*	-0.017*	0.007	0.01
Alcohol consumption per capita	4.69	49.21*	56.32*	4.87	109.38*	75.81*
Hospitals per square mile (n)	-15.77*	3.11	-6.02	-16.21*	9.2	-4.61
Precipitation (inches)	3.59*	-1.3*	-1.48*	3.65*	0.09	-0.97*
Traffic Density	-23.32	-69.42	31.15	-23.1	-102.9*	17.55
Safe Driver Incentive Plan	8.92	-46.04	-73.16	10.96	-108.56*	-93.67
Years dummy (1982 reference year)	* (5/14)	* (9/14)	* (0/14)	* (6/14)	* (12/14)	* (0/14)
N	750	750	700++	750	750	700++
Adj r2	93.1		34.06	93.1	--	34.8
Wald x2		810.9*			843.9*	
DubinWatson (Transformed)			2.17	--		2.19

+ N = 750, 50 states per 15 years
++ N = 700, 50 states per 14 years (1982 is used as reference year)
*Significance at p# 0.05

Table 4a. Covariates Coefficients and Statistical Significance in Alternative Modeling Strategies. States with SB use $ 65% in 1996 (n=21)						
	Models			Models with Insurance Instrument		
Covariates or independent variables	OLS	PD	OLS autocorr	OLS	PD	OLS autocorr
Population Seat Belt usage Rate	-0.13	-1.08*	-0.19	-0.62	-0.26	0.10
Insurance:						
No Fault	9.92	-18.0	-52.24	NA	NA	NA
MIXED	176.7*	100.0	-45.50	NA	NA	NA
INSTR	NA	NA	NA	-330.65*	478.01*	140.19
Total Population (N in thousands)	0.07*	0.05*	0.05*	0.06*	0.06*	0.05*
Population between 18-24 years old	55.6*	27.78*	24.32	77.57*	10.37	18.12
Population over 65 years old	-13.90*	20.43*	11.62	-8.54	0.38	6.18
Population living in metropolitan areas	0.76	-5.59	-2.13	6.31*	-3.44	-3.76
Population with college degree or higher	-47.92*	-20.06	-35.85	-1.72	-3.615*	-46.35
Real income per capita	-0.02*	0.03*	0.03*	-0.003	0.017	0.03*
Alcohol consumption per capita	-59.9*	6.7	50.30	-180.60*	68.36	68.32
Hospitals per square mile (n)	-20.82*	48.87*	-8.0	-21.84*	34.82	-11.33
Precipitation (inches)	-0.22	-2.31*	-1.96*	-1.30	-0.03	-1.41*
Traffic Density	56.44	-89.97	157.78	-60.61	-141.86*	144.63
Safe Driver Incentive Plan	29.46	-103.45	-124.17	177.30*	-201.49*	-164.29
Years dummy (1982 reference year)	*(6/14)	*(0/14)	*(0/14)	*(5/14)	*(0/14)	*(0/14)
N+	315	315	294++	315	315	294++
Adj r2	95.28		36.8	94.9		37.5
Wald x2		300.04*			364.3*	
DubinWatson (Transformed)			2.12			2.13

[+] N = 315, 21 states per 15 years

[++] N = 294, 21 states per 14 years (1982 is used as reference year)

*Significance at p# 0.05

Table 4b. Covariates Coefficients and Statistical Significance in Alternative Modeling Strategies. States with SB use < 65% in 1996 (n=29)						
	Models			Models with Insurance Instrument		
Covariates or independent variables	OLS	PD	OLS autocorr	OLS	PD	OLS autocorr
Population Seat Belt usage Rate	-0.66	-0.77*	-0.95*	-0.48	0.24	-0.41
Insurance:						
No Fault	13.60	28.88	38.90	NA	NA	NA
MIXED	43.43*	76.37*	-41.82	NA	NA	NA
INSTR	NA	NA	NA	79.68*	360.07*	221.81*
Total Population (N in thousands)	0.08*	0.07*	0.07*	0.08*	0.078*	0.07*
Population between 18-24 years old	24.75*	14.43*	15.88	20.10*	-11.30	1.95
Population over 65 years old	0.39	-19.07*	-16.36	-3.93	-40.94*	-25.13
Population living in metropolitan areas	2.39*	2.32*	3.82*	1.63*	-0.54	1.92
Population with college degree or higher	-20.18*	-59.47*	-64.77*	-21.58*	-74.10*	-68.93*
Real income per capita	-0.012*	0.01	0.012	-0.014*	-0.006	0.001
Alcohol consumption per capita	43.94*	119.65*	76.96*	39.03*	176.82*	107.61*
Hospitals per square mile (n)	-22.68*	-6.78	-4.24	-21.39*	4.94	-0.83
Precipitation (inches)	4.06*	-0.65	-1.14*	4.11*	0.61	-0.27
Traffic Density	-0.98	-62.24	-138.6	10.17	-104.6*	-144.55
Safe Driver Incentive Plan	17.92	-7.79	-34.18	-13.84	-113.02*	-83.06
Years dummy (1982 reference year)	*(12/14)	*(12/14)	*(4/14)	*(13/14)	*(13/14)	*(13/14)
N+	435	435	406++	435	435	406++
Adj r2	94.3		40.37	94.07		44.0
Wald x2		807.14*			812.0*	
DubinWatson (Transformed)			2.27			2.25

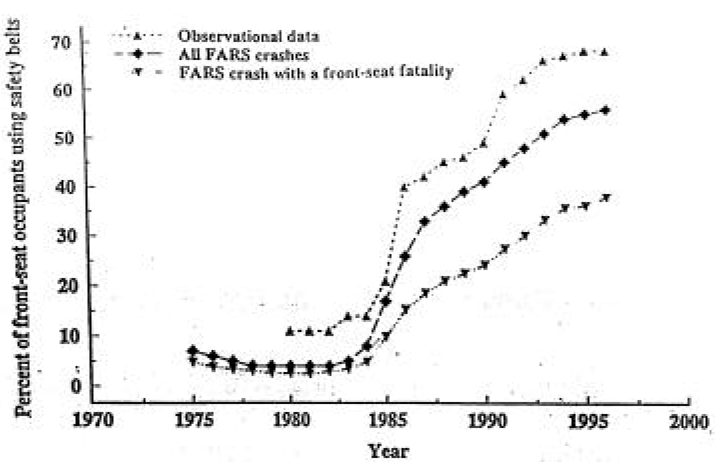
+ N = 435, 29 states per 15 years

++ N = 406, 29 states per 14 years (1982 is used as reference year)

*Significance at p# 0.05

Table 5			PROJECTED CHANGE IN FATALITY @ 5% increase in 1996 SBUSE							PROJECTED CHANGE IN FATALITY @ 10% increase in 1996 SBUSE					
			REG	PD	AUTOREG	REG	PD	AUTOREG		REG	PD	AUTOREG	REG	PD	AUTO
STATE	SBUSE-BASE	OCCFATAL	(NF&ADDON)	(NF&ADDON)	(NF&ADDON)	(INST NF)	(INST NF)	(INST NF)		(NF&ADDON)	(NF&ADDON)	(NF&ADDON)	(INST NF)	(INST NF)	(INST
ALABAMA	54	646	-1	-3	-1	-1	-1	-1		-2	-6	-3	-2	-2	
ALASKA	69	36	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
ARIZONA	56	369	-1	-3	-1	-1	-1	-1		-3	-6	-3	-2	-2	
ARKANSAS	48	303	-1	-3	-1	-1	-1	-1		-2	-6	-2	-2	-2	
CALIFORNIA	87	1968	-2	-5	-2	-2	-2	-1		-4	-10	-5	-4	-3	
COLORADO	56	300	-1	-3	-1	-1	-1	-1		-3	-6	-3	-2	-2	
CONNECTICUT	62	164	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
DELAWARE	68	64	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
FLORIDA	64	1237	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
GEORGIA	62	704	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
HAWAII	80	41	-2	-5	-2	-2	-1	-1		-4	-9	-4	-3	-3	
IDAHO	54	109	-1	-3	-1	-1	-1	-1		-2	-6	-3	-2	-2	
ILLINOIS	64	807	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
INDIANA	62	546	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
IOWA	75	280	-2	-4	-2	-2	-1	-1		-3	-9	-4	-3	-3	
KANSAS	54	241	-1	-3	-1	-1	-1	-1		-2	-6	-3	-2	-2	
KENTUCKY	55	473	-1	-3	-1	-1	-1	-1		-3	-6	-3	-2	-2	
LOUISIANA	68	438	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
MAINE	50	107	-1	-3	-1	-1	-1	-1		-2	-6	-3	-2	-2	
MARYLAND	70	358	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
MASSACHUSETTS	54	229	-1	-3	-1	-1	-1	-1		-2	-6	-3	-2	-2	
MICHIGAN	71	814	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
MINNESOTA	64	347	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
MISSISSIPPI	46	458	-1	-3	-1	-1	-1	-1		-2	-5	-2	-2	-2	
MISSOURI	62	628	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
MONTANA	73	89	-2	-4	-2	-2	-1	-1		-3	-8	-4	-3	-3	
NEBRASKA	65	157	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
NEVADA	71	101	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
NEW HAMPSHIRE	56	74	-1	-3	-1	-1	-1	-1		-3	-6	-3	-2	-2	
NEW JERSEY	60	409	-1	-3	-2	-1	-1	-1		-3	-7	-3	-3	-2	
NEW MEXICO	85	165	-2	-5	-2	-2	-2	-1		-4	-10	-4	-4	-3	
NEW YORK	74	864	-2	-4	-2	-2	-1	-1		-3	-9	-4	-3	-3	
NORTH CAROLINA	82	769	-2	-5	-2	-2	-2	-1		-4	-9	-4	-3	-3	
NORTH DAKOTA	43	51	-1	-2	-1	-1	-1	0		-2	-5	-2	-2	-2	
OHIO	62	847	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
OKLAHOMA	48	335	-1	-3	-1	-1	-1	-1		-2	-6	-2	-2	-2	
OREGON	82	215	-2	-5	-2	-2	-2	-1		-4	-9	-4	-3	-3	
PENNSYLVANIA	71	838	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
RHODE ISLAND	58	25	-1	-3	-2	-1	-1	-1		-3	-7	-3	-2	-2	
SOUTH CAROLINA	61	479	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
SOUTH DAKOTA	47	63	-1	-3	-1	-1	-1	-1		-2	-5	-2	-2	-2	
TENNESSEE	63	692	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
TEXAS	74	1442	-2	-4	-2	-2	-1	-1		-3	-9	-4	-3	-3	
UTAH	60	157	-1	-3	-2	-1	-1	-1		-3	-7	-3	-3	-2	
VERMONT	69	45	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
VIRGINIA	70	506	-2	-4	-2	-1	-1	-1		-3	-8	-4	-3	-3	
WASHINGTON	84	323	-2	-5	-2	-2	-2	-1		-4	-10	-4	-4	-3	
WEST VIRGINIA	58	207	-1	-3	-2	-1	-1	-1		-3	-7	-3	-2	-2	
WISCONSIN	61	425	-1	-4	-2	-1	-1	-1		-3	-7	-3	-3	-2	
WYOMING	72	56	-2	-4	-2	-2	-1	-1		-3	-8	-4	-3	-3	
ALL	3204	21001	-74	-184	-83	-67	-59	-35		-147	-368	-167	-135	-119	

Figure 1. Safety belt use for front-seat occupants. Observational data and FARS data.



Source: Thompson et al, 1999 [reproduced with permission]

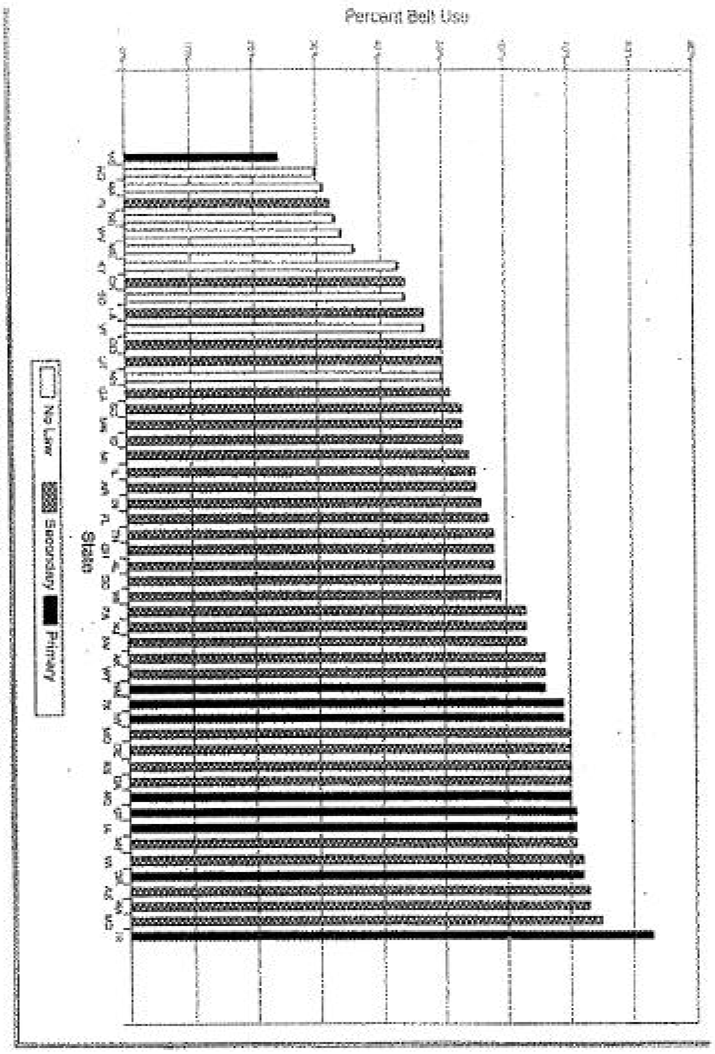


Figure 2 Belt Use Rates by State (Source: NHTSA December 1992).