Explaining State-to-State Differences in Seat Belt Use: An Analysis of Socio-Demographic Variables

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16. Abstract

Despite the extensive evidence about the benefits of seat belt use, there is a great deal of variation in use within the US. For example, the national average for seat belt use in 2009 was 84 percent while the state-level averages ranged from 68 percent in Wyoming to 98 percent in Michigan. The overarching goal of this project was to gain a better understanding of the socio-demographic variables (or factors) that influence statewide belt use rates. To the extent that these vary among states, they can partially account for differences in statewide belt uses. Previous studies have already identified some important factors that affect belt use rates: gender, age, race, vehicle type, seat-belt enforcement laws, and amount of fine for belt-use law violation. This project studied the influence of additional socio-demographic factors on state-level use rates. These factors were: education (percentage of high school educated population), racial composition (percentage of White), median household income, political leaning (percentage of Democrats), and a measure of religiosity. The analysis was based on data from the 2008 Fatality Analysis Reporting System (FARS) which has information on seat belt use on all vehicle crashes that resulted in at least one fatality. The use rates in FARS data were lower than that for the general population. However, our interest is on differences in rates between the states. To the extent that the state-to-state differences in FARS data are consistent with those in the general population, the findings are likely to hold for the population-at-large. Exploratory analysis showed that many of the use rate patterns in FARS data were in fact consistent with those found in other data sets. Of the five socio-demographic factors that were considered, three were identified as important: religiosity, race (percentage White), and political leaning (percentage Democrat). The other two – income and education – were not significant. Hold-out analyses confirmed that this conclusion was consistent across different subsets of data. A regression model that included these new factors accounted for a substantial amount of the state-to-state variation in seat belt use rates, providing further evidence of the usefulness of the results. The findings from this study are preliminary and have to be confirmed on other data sets. Nevertheless, they demonstrate that socio-demographic factors can be used to effectively explain state-to-state variation in seat belt use rates. If factors such as religiosity are indeed important, they can be used to develop appropriate programs for increasing belt use.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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1. Introduction

Traffic crashes are the leading cause of death in the United States (US) for people age 4-34 (Subramanian, 2006). The National Highway Traffic Safety Administration (NHTSA, 2010a) estimates that almost 34,000 people died in traffic crashes in the US in 2009. Increasing safety belt use has been shown to be the simplest and most effective way to decrease traffic fatalities and injuries (Automotive Coalition for Traffic Safety, 2001). NHSTA (2010b) estimates that seat belts have saved about 75,000 lives from 2004 to 2008. Indeed, when lap and shoulder belts are used, they reduce the risk of fatal injury to front-seat passenger car occupants by 45 percent and reduce the risk of moderate-to-critical injuries by 50 percent (NHTSA, 1996). For occupants of light trucks, the benefits of seat belt use are even greater.

Despite the clear benefits of using seat belts, there is still a lot of variation in belt use rates within the US. According to the latest National Occupant Use Study (NOPUS), seat belt use in the US was 84 percent in 2009 (Chen & Ye, 2010), while state-level rates ranged from 68 percent in Wyoming to 98 percent in Michigan. A number of factors are known to influence belt use and thus partially account for differences in statewide belt use. For example, studies have found that statewide belt use is higher in states with primary seat belt enforcement laws compared to states with secondary enforcement (see e.g., Beck et al., 2007; Chen & Ye, 2010; Eby, Vivoda, & Fordyce, 2002; Nichols et al., 2010; Wortham, 1998). Recent work has also shown that belt use is higher in states with belt-use-law-violation fines that are greater than $25 (Nichols et al., 2010). When fines are increased from $25 (which is the current national average) to $60, belt use increases by as much as 4 percentage points. Even greater increases in belt use are found in states with fines up to $100.

Demographic and environmental factors have also been found to be related to use of seat belts, which in turn could influence statewide rates. For example, belt use among females is higher than among males (Preusser, Lund, & Williams, 1991; Pickrell & Ye, 2009a; Vivoda et al., 2004). If a state has a higher percentage of men than women, belt use might be lower for that state compared to another state that is comparable except with regard to gender balance. Other variables that could have a similar influence on statewide belt use include: age—young people (teens and early 20s) are less likely to use belts than older people (Pickrell & Ye, 2009a; Lee & Schofer, 2003; Vivoda, et al., 2004; Lerner et al., 2001); race—African Americans are less likely to use belts than Whites (Pickrell & Ye, 2009a; Vivoda et al., 2004); socioeconomic status (SES)—those individuals with higher SES are more likely to use seat belts than individuals with low SES (Colgan et al., 2004; Fhaner & Hane, 1973b; Lerner et al., 2001; Romano et al., 2005; Shinar, 1993; Shinar et al., 2001); and vehicle type—belt use is significantly lower among occupants of pickup trucks than among occupant of other vehicle types (see e.g., Eby, Fordyce, & Vivoda, 2002; Glassbrenner & Ye, 2006; Boyle & Vanderwolf, 2004). There is also building evidence that seat belt use is lower in rural areas when compared to suburban and urban areas (Glassbrenner, 2004; Nichols et al., 2009). Finally, studies have found that obese vehicle occupants (as defined by the Body Mass Index, BMI) are less likely to use seat belts than those who are of normal weight or underweight (see e.g., Beck et al., 2007; Lichtenstein, Bolton, & Wade, 1989).

The overarching goal of this project was to gain a better understanding of the socio-demographic variables that influence statewide belt use rates, so that more effective belt use promotion programs can be developed.

The report is organized as follows. Section 2 discusses the various sources of data that were considered and provides background information on the dataset that was used (the Fatality Analysis Reporting System, FARS). Section 3 describes the initial analyses that were conducted to verify that the patterns in FARS data were consistent with those found from other data sources in the literature. Section 4 deals with the analyses and findings for the new socio-demographic variables. Section 5 provides some concluding remarks.

2. Sources of Data

Various sources of data were examined for the availability and usefulness of data on statewide belt use rates: a) self-reports (the 2007 Motor Vehicle Occupant Safety Survey, MVOSS [NHTSA, 2010c]); b) direct observation (the 2009 National Occupant Protection Use Survey, NOPUS [Pickrell & Ye, 2009b]); and c) crash reports (the 2008 , FARS [NHTSA, 2010d]. MVOSS data were found to be inadequate because there were too few respondents in several states to allow us to derive reasonable estimates of belt use on a state-by-state basis. The project team requested and received from NHTSA raw data from the 2009 NOPUS survey. Unfortunately, there were no identifiers in the data for the exact location of seat belt observation sites. We further requested this location information and were told that only regional locations were available. Since state-specific data were not available for estimating statewide belt use, we could not utilize NOPUS data in our analyses. FARS data, on the other hand, were found to be useful.

FARS data contain information on all vehicle crashes that resulted in at least one fatality for all 50 states, the District of Columbia, and Puerto Rico. Trained analysts code FARS records from police crash reports, other information including witness statements, and autopsy reports (NHTSA, 2002a, 2003a). This database was the best source of information available for those interested in traffic fatalities and the use of seat belts in this type of crash. Because unbelted drivers in crashes are more likely to die, belt use derived from FARS data are likely to underestimate actual use. However, we would not expect the magnitude of such underestimation to be dramatically different across states. Therefore, because this project focused on understanding variations in use among states rather than actual use rates, FARS data were utilized in this project to estimate statewide belt use rates.

The project analyzed 2008 FARS data, the most recent that were available. Attention was restricted to data on *drivers* of automobiles and pickup trucks. If a driver was using either lap belt or shoulder belt (or both), he or she was deemed to be using a seat belt. All others drivers were deemed as not using a seat belt. If data on belt use for a particular driver were missing, that record was excluded from the analysis. Because FARS did not have the exact location of crashes, we used the state in which the vehicle was registered to assign a state.

3. Analysis of FARS Data to Verify Existing Findings

Figure 1 shows the extent to which belt use varied by state in the 2008 FARS dataset. The values shown are the differences between state use rates and the overall average of 62.2 percent (see Table A.2 in Appendix A for the actual values). Note that the District of Columbia and Hawaii were removed from all analyses in the study as they were markedly different from other states in terms of two key socio-demographic variables analyzed later in the study. The District of Columbia was 92.9% Democrat and Hawaii was 75.3% non White. (See Table A.1 in Appendix A). These extreme values had an undue influence on the regression analyses and fitted models.

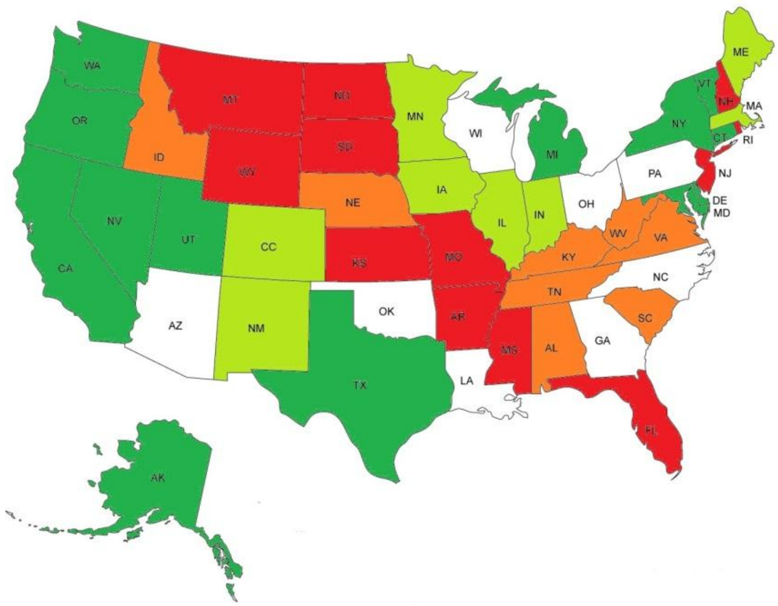

Figure 1: Distribution of Seat Belt Use Rates: Statewide Average Minus National Average
Red: < -10%; Orange: [-10%, -5%); White [-5%, +5%]; Light Green: (+5%, -10%], Green: > +10%)

The colors represent the magnitude and direction of deviation of the statewide rates from the national belt use rate: Red: < -10%; Orange: [-10%, -5%); White [-5%, +5%]; Light Green: (+5%, -10%], Green: > +10%). States in white have use rates that are within +/- 5 percent of the overall average. There is a clear clustering of the differences among geographic locations. States on the West coast, Great Lakes, and Northeast areas (except for New Hampshire and New Jersey) have higher than average use rates. States in the NW-SE corridor, starting from Montana and North Dakota and going down to Florida, have lower than average rates. The values for the states in the Appalachian and Southeastern region are in between.

The next set of analyses explored the extent to which factors that are known to be related to belt use were also found in FARS data. Seven possible factors were available in FARS: driver age; BMI (calculated as weight in kilograms divided by height in meters squared); driver gender (male/female); urbanicity of accident location (rural/non rural); passenger vehicle type (pickup truck/non-pickup truck); type of seat belt law (primary/secondary); and fine amount for first violation of seat belt law.

Variable		Belt Use (%)	Number of Drivers
Gender	Female	75.4	5,651
	Male	62.3	13,439
Vehicle Type	Automobile	69.1	12,742
	Pickup	60.3	6,348
Urbanicity	Rural	60.7	11,133
	Urban	73.8	7,957
Law Type	Primary	58.3	5,911
	Secondary	69.7	13,179
Fine Amount	<= $30	64.3	15,998
	> $30	76.1	3,092

Table 1: Distributions of Seat Belt Use Percentages and Number of Drivers by Categories

Table 1 shows the distributions of seat belt use rates in the FARS data for the four dichotomous factors: gender, vehicle type, urbanicity, and type of seat belt law. The patterns are consistent with findings from previous studies. For example, belt use for females is greater than for males; belt use for passenger vehicle occupants not driving a pickup truck is higher than for drivers of pickup trucks; and belt use is higher in non-rural than in rural areas. Belt use is also higher in states with primary enforcement and in states whose fines for violating the mandatory belt use law were higher than $30.

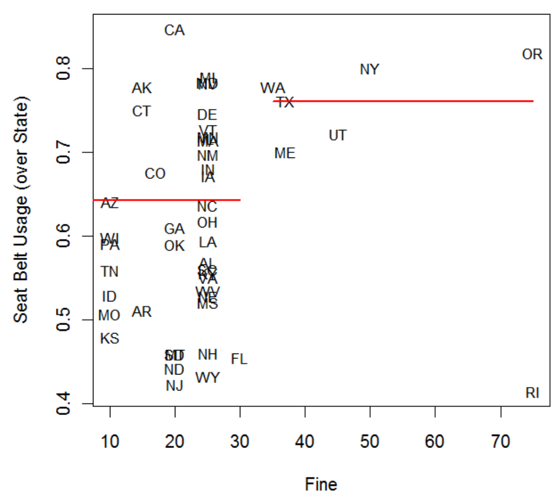

Figure 2: Proportion of Statewide Seat Belt Use (y-axis) Against Fine Amount for First Violation (x-axis)

The amount of fine for first violation varied considerably across states. Figure 2 shows a plot of the actual proportion of seat belt use in each state, *r*, against the fine amount in that state. While there was no consistent relationship, states with fines more than $30 generally had higher usage values. For the purposes of fitting a regression model of seat-belt use, fine amounts were grouped into two categories: <= $30 and > $30[1].

The two panels in Figure 3 show the relationships between *r* and the remaining two factors: age and BMI of the driver[2]. The belt use data were binary (driver used seat belt or not) and correspond to the values of 0 and 1 on the y-axis. A *local smoother*[3] was applied to the binary responses to get the estimates (solid curves) of the relationships between belt use and the factors. For BMI, the relationship looked approximately linear. The effect of age, on the other hand, was a bit more complex. It increased roughly linearly until age 60 and then was approximately constant for age >= 60. Therefore, we coded this variable in the regression model as follows: Age = actual age if driver's age is < 60 and = 60 if driver's age is >= 60.

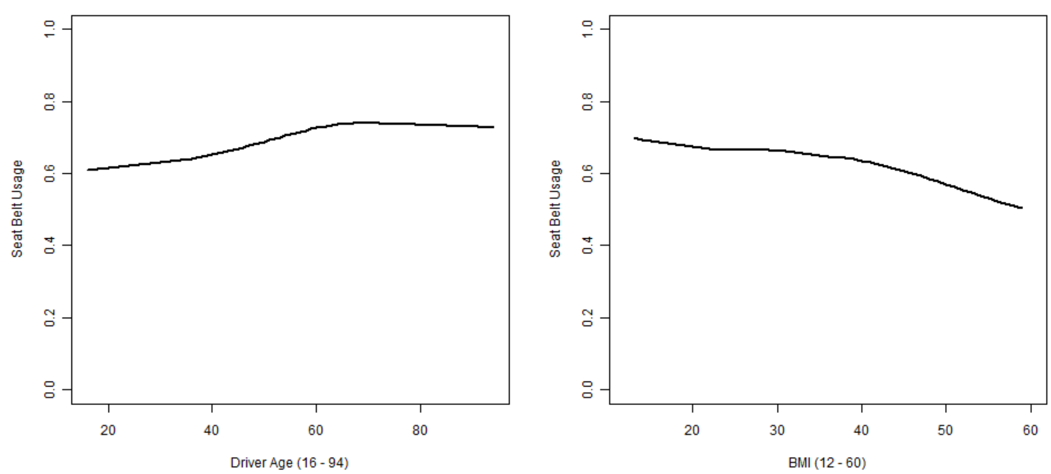

Figure 3: Left Panel: Proportion of Statewide Seat Belt Use against Driver's Age. Right Panel: Proportion of Statewide Seat Belt Use against Driver's BMI

[1] Figure 2 shows the relationship between *r*, actual proportion of statewide seat belt use, against various factors. However, the logistic regression models in the report fit logit(*p*) = log(*p/(1-p*)) as a function of the factors, rather than *p* = probability of seat-belt use. (Note: *r* should be interpreted as an estimate of *p* at the state level.) A version of these figures showing the relationship with logit(*r*) is given in Appendix B. Figure B.1 in Appendix B corresponds to Figure 2 with logit(*r)* on the y-axis. The conclusions are the same.

[2] Figure B.2 in Appendix B is the version of Figure 3 with logit(*r*) in the y-axes.

[3] A two-stage smoothing was used where the proportions of use were first estimated by grouping the binary responses within small windows of the factor (x-axis). A local smoother was then applied to the estimates. The smoother used was LOWESS which uses locally weighted polynomial regression. See Cleveland (1979) for more information. The bandwidth (proportion of points in the plot which influence the smooth at each value) was ½.

We then fitted the following logistic regression model to the binary data on driver-level seat belt use:

Model A

$$\log(\tfrac{p}{1-p}) = \beta_0 + \beta_U(Urbanicity) + \beta_F(Fine) + \beta_L(Law) \\ + \beta_G(Gender) + \beta_V(Vehicle) + \beta_A(Age) + \beta_B(BMI)$$

Logistic regression is the most common approach for fitting a regression model to binary data. It models logit(*p)*, where *p* is the probability of seat belt use, as a function of various factors. Here logit(*p*) = log(*p*/(*1-p*)). The factors were coded as follows. For the dichotomous factors, the `1' code was assigned to the settings where seat belt use was expected to be higher (for example, 1 = female).

- Urbanicity = 1 if urban or suburban, 0 if rural
- Fine = 1 if fine amount > 30, 0 if fine amount <= 30
- Law = 1 if primary enforcement, 0 if secondary enforcement or no law
- Gender = 1 if female, 0 if male
- Vehicle = 1 if automobile, 0 if pickup truc
- Age = actual age if driver's age is < 60 and = 60 if driver's age >= 60
- BMI is the centered value of the driver's BMI index (BMI – overall average)

Model A does not include any interactions among the factors; i.e., terms like Gender-by-Age, etc. Clearly, such interactions are possible and need to be investigated in future studies. However, in order to keep interpretation of the results simple, they were not considered in this study.

	Regression Coefficient	Std. Error	z-value	p-value
Baseline	-0.66			
Urbanicity	0.56	0.03	17.02	0.00
Fine	0.51	0.05	10.86	0.00
Law	0.40	0.03	11.83	0.00
Gender	0.54	0.04	14.28	0.00
Vehicle	0.26	0.03	7.45	0.00
Age	0.02	0.00	14.75	0.00
BMI	-0.01	0.00	-1.92	0.06

Table 2: Estimated Coefficients and p-values for Model A

The p-values in the last column show that all the factors except BMI had a strong influence on seat belt use rates for the FARS data. The conclusions based on FARS 2008 data are consistent with findings in the literature, i.e., fine amount, type of law, urbanicity, age, gender, and type of vehicle were all important factors in explaining state-to-state seat belt variation. The effect of BMI, on the other hand, was border-line. Previous studies have found that seat belt use does vary with measures of obesity (see e.g., Beck et al., 2007; Lichtenstein, Bolton, & Wade, 1989). Some of these studies are marginal analyses where the relationships between seat belt use and the factors were studied one-factor-at-a-time. The analysis here uses multiple regression where the effects of all the factors are studied simultaneously. It appears that the effect of BMI is mediated by the presence of two other factors: gender and vehicle type. When these two factors were not included in the model, BMI was much more significant.

The interpretation of the coefficients associated with the logistic regression analysis (Model A) is as follows: the term $p/(1-p)$ is called the odds or odds-ratio, and $\log(p/(1-p))$ is called the log-odds. Consider the estimated coefficient for the variable *Fine* in Table 2. Recall that the variable Fine = 0 if the fine amount is <=$30 and 1 if it is > $30. The estimated coefficient for this variable is 0.51 in Table 2. This implies that the odds are multiplied by a factor $e^{0.51} = 1.67$ or increased by 67% when one goes from states with Fine <=$30 to states with Fine >$30. A similar interpretation holds for other dichotomous factors.

For Age, recall that the variable equals driver's age if age <=60 and = 60 if age > 60. In this case, the odds ratio is multiplied by a factor $e^{0.02} = 1.02$, i.e., it increases by 2% if driver's age increases by one year up to age 60, after which there is no increase.

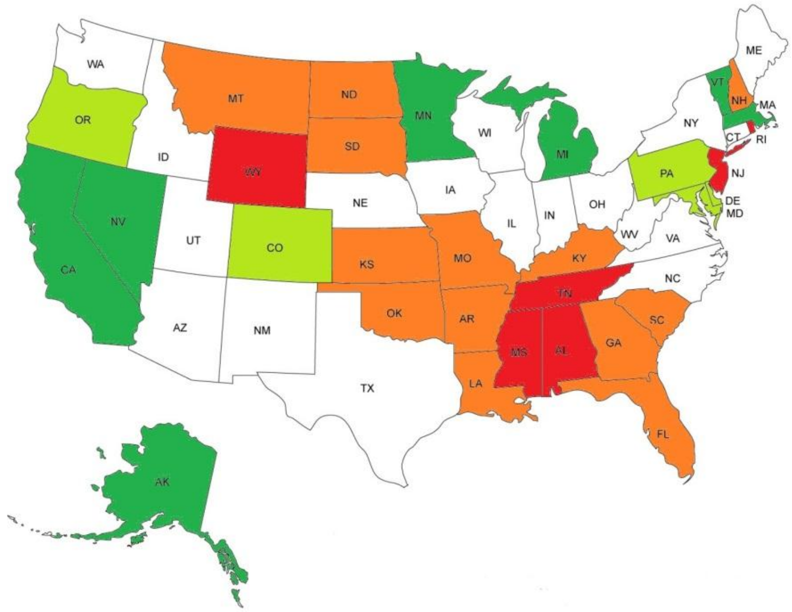

Figure 4: Difference among Statewide Belt Use Proportions: Observed Minus Predicted Proportions from Model A. Red: < -10%; Orange: [-10%, -5%); White [-5%, +5%]; Light Green: (+5%, -10%], Green: > +10%).

Figure 4 shows the remaining variation in seat belt use after fitting Model A. The values shown are differences in actual proportions minus the predicted proportion (using Model A) for the various states (see Table A.2 in Appendix A for the actual values). The state-to-state variation is much less compared to Figure 3—now 18 states are within +/- 10 percentage points of their predicted values. However, there are quite a few states in dark green and red which indicate differences bigger than +/- 10%. There is still geographical clustering of the states with higher than predicted (light and dark green) and lower than predicted (orange and red) use rates.

The next section examines whether additional socio-demographic factors can be used to effectively explain state-to-state variation in belt use.

4. Using Socio-Demographic Variables to Model State-to-State Variation

It is known that the unique set of socio-demographic factors that characterize a state or even a country (sometimes referred to as the state's or country's culture) can influence traffic safety behaviors (AAA Foundation for Traffic Safety, 2007). In this study, state culture was measured through a set of socio-demographic factors that included education, race, income, political leaning, and religiosity. Publically available databases were examined for state-specific measures of these socio-demographic factors. Several other factors of potential interest could not be pursued, given the limited resources and the exploratory nature of this project. The following state-specific factors, however, could be easily located and were analyzed, alongside the person-level factors that were considered in Model A.

Potential Socio-Demographics Factors

- *Education* – Percentage of the state's population 25 years and older that had a high school education or higher, based on 2000 US Census Bureau (2010) data.
  GCT-P11. Language, School Enrollment, and Educational Attainment: 2000
  Data Set: Census 2000 Summary File 3 (SF 3) - Sample Data
  http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=datasets_2&_lang=en&_ts=

- *Race*. Percentage of White population in the state[4] (based on 2000 US Census Bureau data). GCT-P6. Race and Hispanic or Latino: 2000
  Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data
  http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=datasets_2&_lang=en&_ts=

- *Income* – State's median household income, based on 2005-2007 American Community Survey 3-Year Estimates.
  GCT1901. Median Household Income (In 2007 Inflation-Adjusted Dollars)
  http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=datasets_2&_lang=en&_ts=
  (Note that the following FARS-based variables also fall in this category: *age* and *sex*.)

[4] Detailed data on percentage of African American, Hispanic, and other racial groups were available. After examining the distributions of these percentages and conducting exploratory analyses, we decided to use just the percentage of White population in the states as a surrogate for racial composition.

- *Political leaning* – Percentage of people who voted for the Democratic Party candidate[5] in the 2008 national election.
  http://www.factmonster.com/us/government/presidential-election-vote-summary.html
  Note also that the type of belt use *law* and *fine* amount also are a part of this category.

- Religiosity: Percentage of people in the state who responded "yes" to a straightforward question that asks: "Is religion an important part of your daily life?" – data collected throughout 2008 from Gallup.com
  http://www.gallup.com/poll/114022/State-States-Importance-Religion.aspx#1

The five factors – Democratic, Religiosity, Education (High school and above), White, and Income – were used as potential factors in the next set of analyses (see Table A.1 in Appendix A for the actual values for each state). These factors have obvious limitations in measuring the underlying latent traits of interest: level of education, social and political preferences, etc. Further, the available data are state-level averages and do not account for the variation from person-to-person or even region to region within the states. Ideally, it would be desirable to have data at the individual level, similar to the information on age, vehicle type, etc. in FARS.

	Religiosity	Education	White	Income
Democratic	-0.60	0.17	-0.05	0.54
Religiosity		-0.66	-0.39	-0.62
Education			0.55	0.49
White				-0.11

Table 3: Correlations among the Socio-Demographic Factors

Table 3 shows the correlations between the five new socio-demographic factors. Many of the values are over 0.5, indicating a high-degree of correlation among these factors. Since this can cause instability in the regression analysis, multiple hold-out analyses were conducted to examine the robustness of the findings within subsets of the data. These are described later.

[5] Data on percentages of people who voted for Republicans and Independents were also available. As to be expected, there were strong negative correlations between the percentages who voted Democrat and Republican, so we decided to keep just one of them and ignore the percentage who voted Independent.

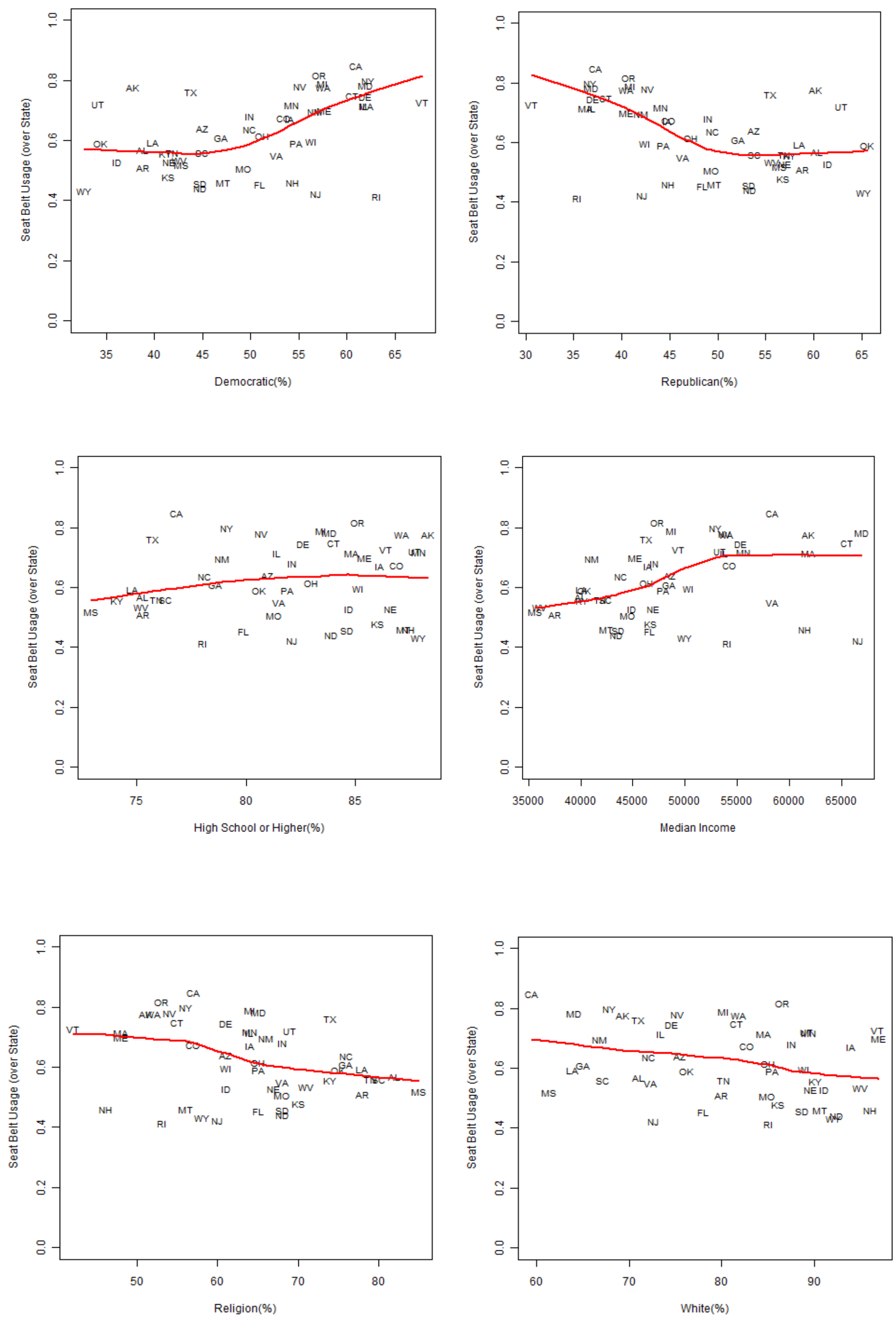

Figure 5: Relationship between Proportion of Statewide Seat Belt Use and Various Factors: Top Left – Percent Democratic; Top Right – Percent Republican; Middle Left – Percent with High School Education; Middle Right – Median Income Bottom Left – Religiosity; Bottom Right – Percent White

Figures 5 show the relationships between the new socio-demographic factors and statewide seat belt use proportions[6]. The lines in red are locally smooth fits to the data. These looked linear for the most part, except for Percent Democratic (Percent Republican) and State-level Income. The non-linearity for income was not severe, so a linear relationship was fitted to income. Since Percent Democratic and Percent Republican were highly correlated, only one factor (Percent Democratic) was used in the model. The factor was coded as Percent Democratic if the actual percentage was > 50 and = 50 if Percent Democratic was <=50.

A logistic regression analysis with the full model (all the new factors) was conducted. Note that some of the factors in this model are at the individual driver level while others are at the state-level (i.e., they have a single value for all drivers in that state). Recall also that the state affiliation refers to where the driver was from rather than where the accident occurred.

Full Model:

$$\begin{aligned}\log(\tfrac{p}{1-p}) = \beta_0 &+ \beta_U(Urbanicity) + \beta_F(Fine) + \beta_L(Law)\\ &+ \beta_G(Gender) + \beta_V(Vehicle) + \beta_A(Age)\\ &+ \beta_R(Religiosity) + \beta_W(White) + \beta_D(Democratic)\\ &+ \beta_E(Education) + \beta_I(Income)\end{aligned}$$

Table 4 provides the fitted values and other relevant results for the Full Model. The last column indicates that the effects of Education and Income were not significant even at the 0.1 level. However, several of the new factors are strongly correlated, so one has to be cautious in examining just the estimated coefficients as the effects can be masked by correlations.

	Regression Coefficient	Std. Error	z value	p-value
Baseline	1.02			
Urbanicity	0.45	0.03	13.17	0.00
Fine	0.54	0.05	10.45	0.00
Law	0.40	0.05	7.96	0.00
Gender	0.57	0.04	15.08	0.00
Vehicle	0.21	0.04	6.02	0.00
Age	0.02	0.00	14.92	0.00
Religiosity	-0.03	0.00	-7.14	0.00
White	-0.01	0.00	-3.24	0.00
Democratic	0.02	0.01	3.15	0.00
Education	-0.01	0.01	-1.28	0.20
Income	0.00	0.00	1.40	0.16

Table 4: Fitted Values and p-values (to two decimal places) for the Full Model

[6] The corresponding plots with the y-axis in logit scale are given in Figure B.3 in Appendix B.

Therefore, a systematic model selection process was used to determine the final model. A common technique used in the statistical literature is the Akaike's information criterion (AIC)[7]. One can add new variables into an existing model or drop variables in the model by examining the differences in the AIC criterion. Small differences in AIC values indicate that there is not much gain in using the model with more factors. For reasons of parsimony, there is a preference for models with fewer factors. Both forward and backward selection methods were used to examine the four candidate models in Table 5. There was very little difference in the AIC values between the Full Model and Model 5 (without Education and Income). The intermediate models (3 and 4) that included Education or Income also did not yield much improvement.

	AIC	Difference
Model 2: Full Model	22716.18	
Model 3: Model 2 minus Education	22715.83	0.35
Model 4: Model 2 minus Income	22716.14	0.04
Model 5: Model 2 minus Education and Income	22714.69	1.49

Table 5: Model Selection Criteria AIC on the Training Set

To further validate the findings, the analysis was redone by randomly splitting the 19,090 records into a 70% training set and a 30% test set 50 different times. If the p-value of the estimate was smaller than 0.05, we concluded that the variable had a significant effect on seat belt use and was chosen as the potential predictor. Among the 50 regression models, the previous set of factors (fine amount, enforcement law, urbanicity, age, gender, and vehicle type) was always chosen. Among the new factors, Religiosity was also picked all 50 times. Percent White was picked 45 times and Percent Democratic was picked 33 times. On the other hand, Education was only chosen 3 times, and Income was never chosen. This provides additional confidence in the choice of Model 5 as the Final Model (Model B).

Final Model

$$\begin{aligned}\log(\tfrac{p}{1-p}) = \beta_0 &+ \beta_U(Urbanicity) + \beta_F(Fine) + \beta_L(Law) \\ &+ \beta_G(Gender) + \beta_V(Vehicle) + \beta_A(Age) \\ &+ \beta_R(Religiosity) + \beta_W(White) + \beta_D(Democratic)\end{aligned}$$

The estimated coefficients and relevant summaries of the Final Model are given in Table 6. The z-values show that, of the new factors, Religiosity and Percent Democrat were the most significant. This model also shows that state-to-state variation in belt use are also partially explained by the urbanicity of the state, the states' laws and fines, the mix of age and gender of the drivers in the states, as well as the percent of pickup truck drivers.

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[7] AIC is defined as:

$$AIC = 2k + n\log(RSS),$$

where k is the number of parameters in the model, n is the total number of observations in the data set and RSS is the residual sum of squares from the Model.

	Regression Coefficient	Std. Error	z-value	p-value
Baseline	1.03			
Urbanicity	0.46	0.04	11.33	0.00
Fine	0.54	0.06	8.89	0.00
Law	0.36	0.06	6.22	0.00
Gender	0.59	0.05	12.92	0.00
Vehicle	0.22	0.04	5.34	0.00
Age	0.02	0.00	12.92	0.00
Religion	-0.03	0.00	-6.80	0.00
White	-0.01	0.00	-6.04	0.00
Democratic	0.03	0.01	2.86	0.00

Table 6: Fitted Values and p-values (to two decimal places) for the Final Model

Discussion

Percent Democrat had a positive effect on belt use, indicating that an increase in this factor (provided it is more than 50%) leads to an increase in statewide seat belt use. On the other hand, Religiosity and Percent White had negative coefficients, suggesting that an increase in these factors leads to a decrease in statewide seat belt use. Previous studies have found that belt user is higher among Whites when compared to African Americans (see for example, Vivoda, Eby, & Kostyniuk, 2004). As far as we know, no previous study has considered Religiosity as a factor in belt use.

Note that the factors `racial composition', `political leaning', and `religiosity' are correlated, so one cannot draw causal relationships between any one of these factors and seat belt use rate. Further studies are needed to determine the causal nature of any relationships. However, if such a relationship indeed holds, one can use it to develop effective programs to encourage drivers to use seat belts.

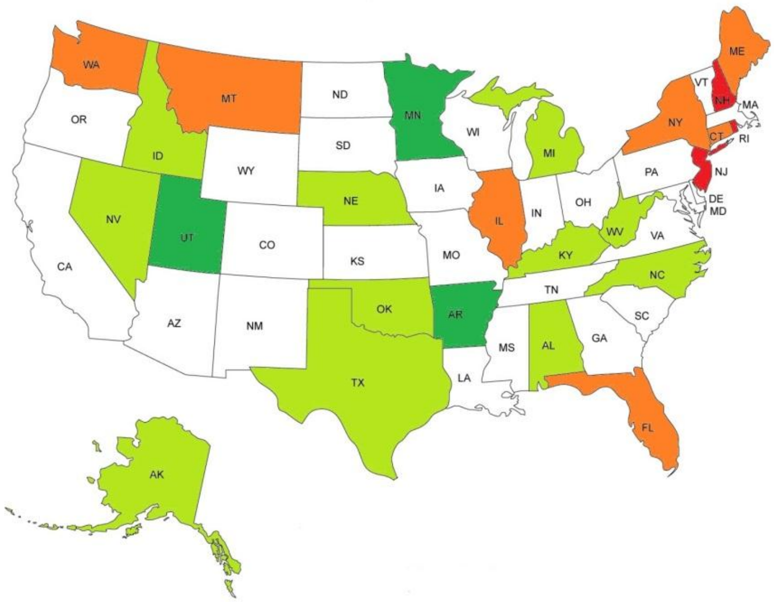

Figure 6: Difference among Statewide Belt Use Rates: Observed Minus Predicted Rates from Model B. Red: < -10%; Orange: [-10%, -5%); White [-5%, +5%]; Light Green: [+5%, -10%], Green: > +10%).

Returning to the assessment of state-to-state variation, Figure 6 shows the magnitude and direction of the deviations of statewide proportions from the predicted values using Model B (see Table A.2 in Appendix A. for the actual values). Now there is no obvious geographic clustering of positive and negative deviations. There are 25 states with statewide averages close to what the values should be, as predicted by this model. More importantly, there were very few states with a deviation of greater than 10% from the predicted use rates. Of the two states still in red, New Hampshire does not have a mandatory law on seat belt use. This fact was not used in the model and might be a plausible explanation for the large deviation. For New Jersey, the use rate may be artificially low in the FARS 2008 data (see Table A.1 in Appendix A). Utah, Minnesota, and Arkansas have use rates that are 10% or more than the values predicted from Model B. We have no plausible explanation for these large deviations.

5. Concluding Remarks

The conclusions from these analyses are clearly preliminary. There is the obvious question of generalizability of the conclusions from FARS data to general seat belt use. Second, even restricting to FARS data, we have analyzed data for just one year, and there can be considerable year-to-year variation in the data. Nevertheless, our study shows that there is potential in identifying important socio-demographic variables and using them effectively to develop programs for increasing seat belt use.

Further research should focus on teasing out the effects of the three key socio-demographic factors that emerged in this study: political leaning, religiosity, and racial composition. In addition to exploring causal relationships between belt use and these specific variables, it would be of interest to identify other variables that may be better measures of these factors. For example, instead of measuring political leaning by the percent of a state's population that voted for the Democratic (or Republication) presidential candidate, are there other measures that are more effective and available at the state or even individual level? To this end, one could expand the notion of political leaning to include individual preferences with respect to gun control, the role of government, and so forth. Similarly, instead of using percent of people reporting religion to be an important part of their daily life as the measure of religiosity, one could identify better measures that provide insights into religiosity. Exploring multiple dimensions of the socio-demographic factors that were found to affect belt use in this study will provide a better understanding of the mechanism of influence that these factors appear to exert, leading ultimately to the development of more effective countermeasures for increasing seat belt use.

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Appendix A: Data Tables

State	Abbreviation	Total	Belt Use (%)	Democratic	Religiosity	Education	White	Income
Alabama	AL	682	56.9	38.8	82	75.3	71.1	40052
Alaska	AK	45	77.8	37.7	51	88.3	69.3	61766
Arizona	AZ	526	64.1	45.0	61	81.0	75.5	48609
Arkansas	AR	401	51.1	38.8	78	75.3	80.0	37555
California	CA	2284	84.8	60.9	57	76.8	59.5	58361
Colorado	CO	330	67.6	53.5	57	86.9	82.8	54262
Connecticut	CT	4	75.0	60.5	55	84.0	81.6	65496
Delaware	DE	75	74.7	61.9	61	82.6	74.6	55303
District of	DC	11	72.7	92.9	61	82.6	74.6	55303
Florida	FL	33	45.5	50.9	65	79.9	78.0	46602
Georgia	GA	879	61.0	47.0	76	78.6	65.1	48540
Hawaii	HI	66	71.2	71.8	57	84.6	24.3	62543
Idaho	ID	157	52.9	36.1	61	84.7	91.0	44901
Illinois	IL	698	71.6	61.8	64	81.4	73.5	53745
Indiana	IN	553	68.0	49.9	68	82.1	87.5	47034
Iowa	IA	268	67.2	54.0	64	86.1	93.9	46399
Kansas	KS	265	47.9	41.4	70	86.0	86.1	46669
Kentucky	KY	624	55.6	41.1	74	74.1	90.1	40138
Louisiana	LA	603	59.4	39.9	78	74.8	63.9	40160
Maine	ME	107	70.1	57.6	48	85.4	96.9	45211
Maryland	MD	392	78.3	61.9	65	83.8	64.0	66873
Massachusetts	MA	7	71.4	62.0	48	84.8	84.5	61785
Michigan	MI	693	78.9	57.4	64	83.4	80.2	48642
Minnesota	MN	295	71.9	54.2	64	87.9	89.4	55616
Mississippi	MS	496	52.0	42.8	85	72.9	61.4	35632
Missouri	MO	634	50.6	49.3	68	81.3	84.9	44545
Montana	MT	122	45.9	47.2	56	87.2	90.6	42425
Nebraska	NE	142	52.8	41.5	67	86.6	89.6	46954
Nevada	NV	211	78.2	55.1	54	80.7	75.2	53753
New Hampshire	NH	100	46.0	54.3	46	87.4	96.0	61459
New Jersey	NJ	26	42.3	56.8	60	82.1	72.6	66509
New Mexico	NM	185	69.7	56.7	66	78.9	66.8	41042
New York	NY	15	80.0	62.2	56	79.1	67.9	52944
North Carolina	NC	22	63.6	49.9	76	78.1	72.1	43867
North Dakota	ND	52	44.2	44.7	68	83.9	92.4	43442
Ohio	OH	839	61.7	51.2	65	83.0	85.0	46296
Oklahoma	OK	493	59.0	34.4	75	80.6	76.2	40371
Oregon	OR	259	81.9	57.1	53	85.1	86.6	47385
Pennsylvania	PA	22	59.1	54.7	65	81.9	85.4	47913
Rhode Island	RI	29	41.4	63.1	53	78.0	85.0	54060
South Carolina	SC	575	56.0	44.9	80	76.3	67.2	42405
South Dakota	SD	85	45.9	44.7	68	84.6	88.7	43586
Tennessee	TN	770	55.8	41.8	79	75.9	80.2	41821
Texas	TX	2164	76.1	43.8	74	75.7	71.0	46248
Utah	UT	144	72.2	34.2	69	87.7	89.2	53324
Vermont	VT	55	72.7	67.8	42	86.4	96.8	49382
Virginia	VA	620	55.0	52.7	68	81.5	72.3	58378
Washington	WA	374	77.8	57.5	52	87.1	81.8	53940
West Virginia	WV	204	53.4	42.6	71	75.2	95.0	36088
Wisconsin	WI	443	59.8	56.3	61	85.1	88.9	50309
Wyoming	WY	88	43.2	32.7	58	87.9	92.1	50009

Table A.1: State-Level Data: Number of Records, Seat Belt Use Rates, and Factors

State	Abbreviation	Belt Use %	Deviation % from National Average	Deviation % from Model A	Deviation % from Model B
Alabama	AL	56.9	-5.31	-10.10	6.67
Alaska	AK	77.8	15.58	11.88	7.82
Arizona	AZ	64.1	1.87	3.41	3.78
Arkansas	AR	51.1	-11.08	-5.72	10.86
California	CA	84.8	22.56	14.67	2.45
Colorado	CO	67.6	5.38	8.17	2.33
Connecticut	CT	75.0	12.80	2.23	-6.19
Delaware	DE	74.7	12.47	7.20	-1.78
Florida	FL	45.5	-16.75	-9.56	-9.92
Georgia	GA	61.0	-1.22	-7.54	-1.69
Idaho	ID	52.9	-9.33	-2.85	6.51
Illinois	IL	71.6	9.43	1.80	-5.21
Indiana	IN	68.0	5.79	0.36	4.97
Iowa	IA	67.2	4.96	2.56	3.24
Kansas	KS	47.9	-14.28	-7.97	3.03
Kentucky	KY	55.6	-6.59	-9.55	5.30
Louisiana	LA	59.4	-2.83	-6.86	4.58
Maine	ME	70.1	7.89	2.19	-8.33
Maryland	MD	78.3	16.12	7.96	-0.24
Massachusetts	MA	71.4	9.23	12.48	-3.44
Michigan	MI	78.9	16.73	10.69	6.73
Minnesota	MN	71.9	9.66	13.91	13.49
Mississippi	MS	52.0	-10.18	-13.76	-0.19
Missouri	MO	50.6	-11.57	-6.54	-2.20
Montana	MT	45.9	-16.30	-7.92	-9.88
Nebraska	NE	52.8	-9.38	-2.98	6.41
Nevada	NV	78.2	16.00	16.18	6.42
New Hampshire	NH	46.0	-16.20	-10.00	-21.15
New Jersey	NJ	42.3	-19.89	-31.24	-37.08
New Mexico	NM	69.7	7.53	4.00	-1.89
New York	NY	80.0	17.80	1.60	-8.12
North Carolina	NC	63.6	1.44	1.71	7.36
North Dakota	ND	44.2	-17.97	-9.69	-1.01
Ohio	OH	61.7	-0.46	3.29	4.35
Oklahoma	OK	59.0	-3.17	-6.94	9.06
Oregon	OR	81.9	19.65	5.78	-1.94
Pennsylvania	PA	59.1	-3.11	6.31	4.91
Rhode Island	RI	41.4	-20.82	-34.26	-43.57
South Carolina	SC	56.0	-6.20	-7.55	2.44
South Dakota	SD	45.9	-16.32	-8.14	-0.35
Tennessee	TN	55.8	-6.36	-12.16	3.03
Texas	TX	76.1	13.91	-0.60	5.41
Utah	UT	72.2	10.02	2.96	17.53
Vermont	VT	72.7	10.53	16.78	-3.56
Virginia	VA	55.0	-7.20	-2.95	-3.89
Washington	WA	77.8	15.61	0.29	-7.93
West Virginia	WV	53.4	-8.77	-4.08	9.29
Wisconsin	WI	59.8	-2.38	2.00	-1.81
Wyoming	WY	43.2	-19.02	-10.39	-0.96

Table A.2: Difference among Observed and Estimated Statewide Belt Use Rates

Appendix B: Supplementary Figures

Figures 2, 3, and 5 in the body of the report show the relationships between *r*, actual proportion of statewide seat belt use, and various factors. However, the logistic regression models in the report fit logit(*p*) = log(*p/(1-p*)) as a function of the factors, rather than *p* = probability of seat-belt use. (Note: *r* should be interpreted as an estimate of *p* at the state level.) Therefore, we provide version of these figures showing the relationship with logit(*r*) in this Appendix. The conclusions are the same.

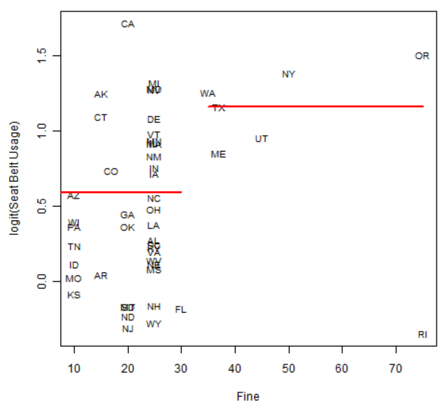

Figure B.1: Statewide Seat Belt Use as a Function of Fine Amounts for First Violation with the Proportion of Statewide Seat Belt Use (y-axis) in Logit Scale (*log(p/(1-p)*)). This Figure Corresponds to Figure 2 of the Report.

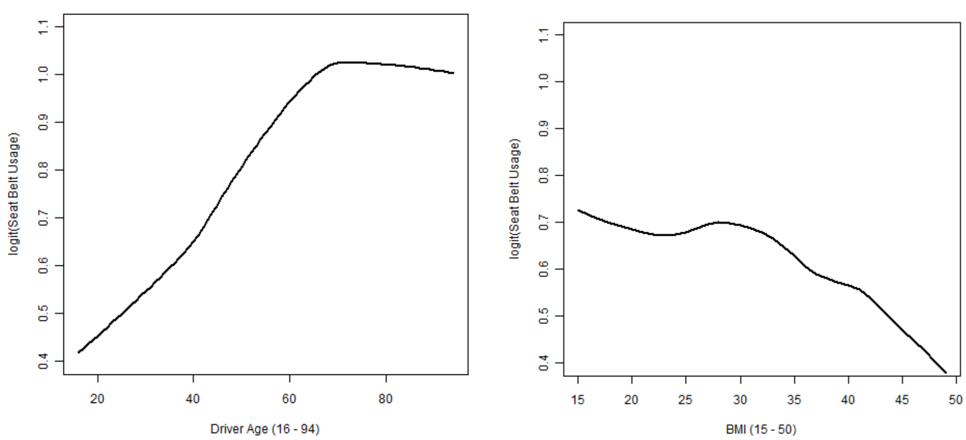

Figure B.2: Left Panel: Relationship between Belt Use and Driver Age (y-axis in logit scale); Right Panel: Relationship between Belt Use and BMI (y-axis in logit scale). These Panels Correspond to those in Figure 3 of the Report.

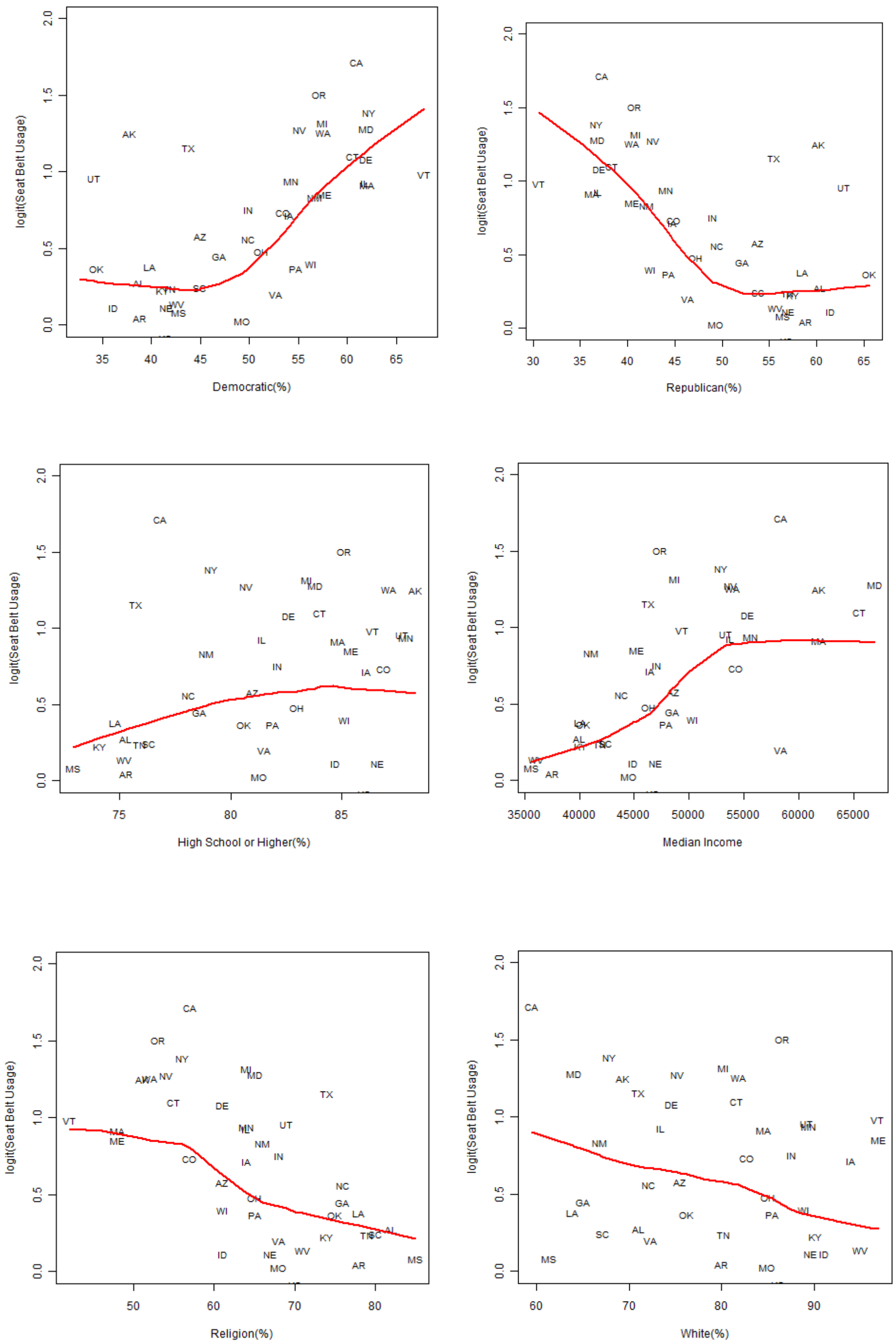

Figure B.3: Relationship among Statewide Seat Belt Use Rate and Factors with the y-axes in Logit Scale. Top Left – Percent Democratic; Top Right – Percent Democratic; Middle Left: Percent with High School Education; Middle Right – Median Income Bottom Left – Religiosity; Bottom Right – Percent White These Plots Correspond to those in Figure 5 of the Report.