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RESEARCH NOTE

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BELTUSE Regression Model Update

Since 1994, NHTSA has used BELTUSE (Blincoe, 1994), a DOS version program, to estimate the benefits from increased safety belt usage. The core of the BELTUSE program is a statistical model (BELTUSE model) developed by a regression technique using 1983-1991 safety belt usage data collected in the 19-City Surveys. Basically, the BELTUSE model is used to predict safety belt usage in potentially fatal crashes (UPFC) from observed safety belt use rates among the general public in non-crash situations. The BELTUSE model is a refinement of an approach developed previously by Partyka (Partyka, 1988 & 1989).

The 19-City Surveys were conducted during a time of relatively low belt use. After implementation of Federal, state, and local belt use programs in early 1991, and with an increased emphasis on enforcement, public information and education, state safety belt use rates have steadily increased. In some states, the increase was over 10 percentage points in one year (NHTSA, 1999). In recent years, national belt use estimates derived from the State Observation Surveys or the National Occupant Protection Use Survey (NOPUS) have replaced the 19-City Surveys. The state surveys are now systemically stable because states have improved their survey sampling methodologies and recently adopted a uniform set of criteria. These surveys have been conducted during a time when belt usage has increased significantly beyond the levels reflected in the 19-City Surveys. To reflect the impact of these higher rates on the relationship between UPFC and the observed belt use rates, the BELTUSE model needed to be updated by including more recent data.

Although BELTUSE was derived using the 19-City Survey national belt use data, the model is used to predict UPFC and increased safety benefits both at the national and state levels. Therefore, it is not surprising that usage predicted by the BELTUSE model can vary significantly from rates reported in individual state police reports. The variations are caused not only by NHTSA’s Fatality Analysis and Reporting System (FARS) reporting difference but also by the sampling errors from observation surveys and inconsistent sampling methodologies and practices adopted among states (Utter, 2000). Beginning 1998, regulations implementing the TEA-21 Section 157 Grant Program required all state surveys to be probability based and to employ a uniform set of criteria. NHTSA recalculated 1996 and 1997 state observed belt use estimates under the same guidelines (Blincoe, 1998). There are thus four years of comparable state safety belt usage data that can be used to examine state level estimates and its variations. Recently, Salzberg *et al* (1998) developed a mathematical model (WA Model) which addressed the predicted variations among states. Their theorized model described the relationship between belt use rates reported in FARS and the state observed safety belt usage rates. Salzberg *et al* employed a parameter termed “relative risk” of unbelted to belted occupants in the model. Relative risk was a function of observed belt use, and thus varied state by state.

This research note describes an analysis based on newer and more comprehensive data to update the BELTUSE model for the purpose of future safety belt benefits assessments. The statistical procedure PROC REG developed by the SAS Institute (SAS, 1994) was used as the modeling tool. However, the modeling process is slightly different from the current model. The current BELTUSE model describes the relationship between “percent of lives saved” and the observed use rate based on a constant safety belt effectiveness rate of 45 percent. UPFC can be derived by a two-step process. First, use the current BELTUSE model to predict the “percent of lives saves” for a specific observed belt use rate. Then divide the “percent of lives saved” by the safety belt effectiveness rate to derive UPFC.

In contrast, the new BELTUSE method directly models the relationship between UPFC and the observed belt use rate. An advantage of the new model is that it eliminates the two-step process. Users can directly predict UPFC from a specific observed use rate. In addition, the safety belt effectiveness rates imbedded in the modeling process are the weighted effectiveness rates of passenger cars and light trucks. The weighted effectiveness rates (vs a constant 45 percent) reflect the real world passenger car-light truck/van population involved in the potential fatal crashes at the time. Safety belts are more effective against fatalities for light trucks (60 percent) than for passenger cars (45 percent). Due to the increasing number of light trucks/vans, the overall safety belt effectiveness rate against fatalities has risen to about 50 percent in recent years.

Several regression models using the SAS PROC REG program under different restricted conditions are examined. At the national level, a model based on the 19-City Survey and the State Observed Belt Use Surveys was compared to one based on the 19-City Surveys and NOPUS data. At the state level, the regression model was based on the State Observed Belt Use Surveys. This note discusses the differences among models and provides estimation of variations among states. Finally, this note compares the updated models to Salzberg’s WA Model and examines the fit of the models by using belt use information in the daytime hours to address the daytime bias from the observation surveys.

Data

The analysis includes the following data: 1983-1999 FARS, 1983-1991 19-City Surveys, 1992-1999 State Observed Belt Use Surveys, and National Occupant Protection Use Surveys (NOPUS). NHTSA has conducted a Full NOPUS biennially since the Fall of 1994. The Full NOPUS is composed of the Moving Traffic Study and the Controlled Intersection Study. Since 1998, NHTSA also conducted MiniNOPUS - a smaller scale of NOPUS using only the Moving Traffic Study - several times each year in 1998, 1999, and 2000 (Bondy, 2000) to measure the belt use progress.

National Observed Belt Use. The national observed use rates were based on two sets of data: 1) 19-City Surveys and 1992-1999 State Observed Belt Use Surveys (Blincoe, 2000) and 2) 19-City Surveys and Fall of 1994, 1996 and 1998 Full NOPUS and December 1999 MiniNOPUS. NHTSA's National Center for Statistics and Analysis (NCSA) provides the statistical methodologies and guidelines to estimate the national belt use from the survey data.

Belt use in FARS. Belt use in FARS is derived from 1983-1999 FARS. It was limited to front-outboard passenger vehicle occupant fatalities age 5 and older – the same group that is reflected in most survey data.

Use in Potentially Fatal Crashes (UPFC). UPFC is also derived from belt use in 1983-1999 FARS using the following formula:

$$U = \frac{U_f}{1 - e^*(1 - U_f)} \quad \text{- - - - (1)}$$

where U_f is belt use in FARS; e is the weighted safety belt effectiveness against front seat outboard fatalities.

Weighted Safety Belt Effectiveness Against Fatalities (e). The agency has estimated that the basic safety belt effectiveness against front seat outboard fatalities is 45 percent for passenger cars and 60 percent for light trucks and vans (Blincoe, 1994; Kahane, 2000). The weighted effectiveness (e) against fatalities was derived using potentially fatal front-outboard occupants in passenger cars and light trucks/vans as weights. These weights were applied to the basic safety belt effectiveness of 45 percent and 60 percent to derive the weighted effectiveness. For individual state results, the weights were derived at the state level and thus e varies by state (see Table 2 for the estimated effectiveness over time).

Methodology

Based on previous research and the graphic presentation of the relationship between UPFC and observed use rate, the current BELTUSE model format with a square term for observed belt usage was adapted to establish a relationship between UPFC and observed safety belt usage. In theory, if no one used safety belts then UPFC would be 0 percent (0 percent restriction) and if everyone wore safety belts, UPFC would be 100 percent (100 percent restriction). However, the models in this study were derived only under the 0 percent restriction (one-restriction model) for two reasons. One is that the observed safety belt use surveys were conducted during daytime hours. Nighttime traffic includes a disproportional number of alcohol impaired drivers who are both less likely to wear safety belts and more likely to be involved in a serious crash. Belt use among impaired drivers is 20 percent lower than the general population. The surveys were thus likely to overestimate true belt use in all driving conditions. Therefore, both the true overall safety belt use rate and UPFC would be less than 100 percent even if the observed daytime use was 100 percent. The other reason is that the model reflects more of the natural relationship between the dependent variable (UPFC) and the independent variable (observed rate) with fewer restrictions. The one-restriction model prevents extra modeling errors introduced by imposing more restrictions during the modeling process. The one-restriction models are called the National and State Models in the research note. In a later section, the note discusses the difference between the one-restriction and two-restriction models.

The regression model has the general form as follows:

$$U = a_1 * U_o + a_2 * U_o^{\,2} \text{ ---- } (2)$$

Where U is UPFC and U_o is observed belt usage. Both a_1 and a_2 are parameters to be estimated by fitting the model through the historic belt use data. The SAS PROC REG procedure with a restriction statement was used to estimate a_1 and a_2. UPFC is derived using equation (1).

Two regression models were developed through the above process: the National and the State models. The National model was best fitted into the 1983-1999 national safety belt use estimates, whereas the State model was best fitted into the 1996-1999 state observed belt use estimates. At the national level, there are two alternative sources of belt use survey data post 1991 that can be used for modeling: State Observed Use Surveys and NOPUS. The chosen model was based on the number of data points and continuity of the data. At the state level, each individual state estimate was treated as a data point. A total of 204 data points were used to maximize the State model. The best fit of the models was measured by the sum of the squared estimation errors (SSE). The estimation error is the percentage point difference between the actual and predicted values.

To compare these two models, the National model was then fitted into the state estimates and the State model was fitted into the national estimates. SSEs were calculated to quantify the difference between these models. Both the National and State models were derived under the 0 restriction regression process.

Results

National Model

Two sets of later years of observed belt use data were added to the 19-City Surveys to complete the model fit: (1) 1992-1999 State Observed Safety Belt Use or (2) 1994, 1996, and 1998 NOPUS and 1999 MiniNOPUS. Table 1 shows the national belt use estimates from these two surveys.

As shown in Table 1, there is a considerable difference between these two surveys in 1994 and 1996. The national belt use estimates derived from the State Observed Surveys have 4 more data points than NOPUS and the estimates show a continuity of belt use trend from 1992 to 1999.

Table 1 National Observed Belt Use Based on State Observed Belt Use Surveys and NOPUS

Year	From State Observed Surveys	NOPUS
1992	62	NA
1993	66	NA
1994	67	58
1995	68	NA
1996	66	61
1997	67	NA
1998	69	69
1999	70	67*

* from December 1999 MiniNOPUS - Moving Traffic Study

When the State Observed Belt Use Surveys were used, there were a total of 17 consecutive data points from 1983 to 1999. Even though these two types of surveys used different sets of survey criteria and applied different survey methodologies, the inclusion of all estimates presented a general and continuous safety belt use trend in the U.S. over time from 1983 to 1999. The corresponding UPFCs (dependent variable) were derived using belt use in 1983-1999 FARS and weighted belt effectiveness. Figure 1 shows the national belt use trends between 1983-1999.

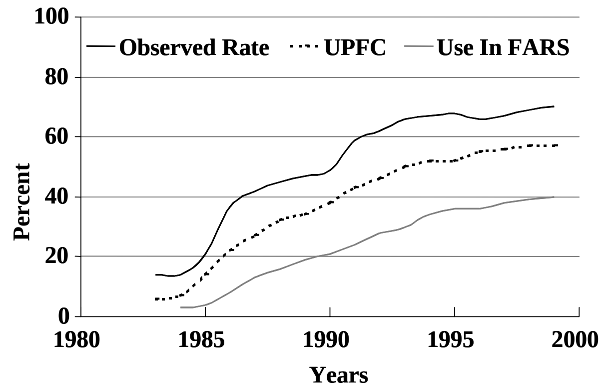

Figure 1 National Belt Use Trends From 1983-1999

Based on the graphic presentation of the relationship, we were confident that the chosen format is appropriate. The final National model had an adjusted R-square value (R^2) of 0.9976 and an SSE of 61. The value of R^2 indicated that the model described almost 100 percent of the variation between years. The regression model is:

$$U = 0.475195 * U_o + 0.477125 * U_o^2$$

The t-statistics for observed belt use (U_o) and its square term (U_o^2) were 9.068 and 5.679, respectively. Both t-values were significant at the 0.0001 alpha level. The model indicates that at 100 percent observed belt use rate, UPFC only reaches to 95 percent. Figure 2 depicts the curve relationship between the UPFCs and the observed belt use rate and the fitted curve.

Conversely, the observed belt use U_o can be derived from known UPFC (U) by solving the above quadratic equation (i.e., UPFC as predictor):

$$U_o = \frac{-0.475195 + \sqrt{(0.475195)^2 - 4 * 0.477125 * (-U)}}{2 * 0.477125}$$

i.e.,

$$U_o = \frac{-0.475195 + \sqrt{0.225810 - 1.908500 * (-U)}}{0.954250}$$

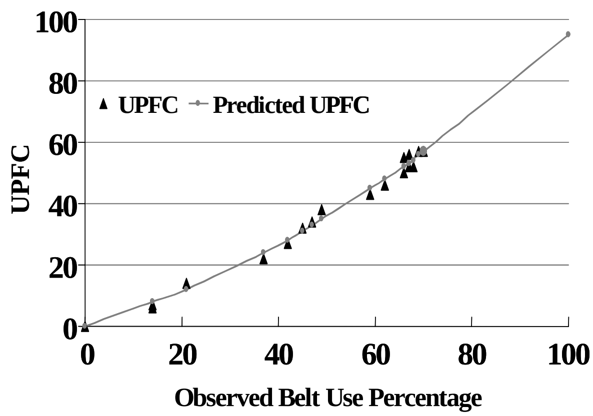

Figure 2 UPFC vs Observed Belt Use Rate 1983-1999

Percent lives saved can be calculated by taking the product of the predicted UPFC and e (weighted effectiveness rate against fatalities). Table 2 (page 11) lists the percent belt use in FARS, derived UPFC, observed belt use, estimated belt effectiveness, and model results for years 1983 to 1999.

When NOPUS data were used, there were a total of 13 data points to fit the model. The model became: $U = 0.430558 * U_o + 0.635038 * U_o^2$ (R^2=0.9930). The coefficient 0.63508 of the square term is larger than 0.477125 of the National model. This indicates that the curve rises faster (i.e., predicts a higher UPFC) than does the National model in the higher observed belt use range. Figure 3 shows these two curves. For example, at an 85 percent observed belt use,the NOPUS model predicts a 75 percent UPFC vs a 69 percent from the National model. At a100 percent observed belt use, the NOPUS model predicts a 106 percent UPFC vs 95 percent from the National model. For the above reasons, as well as for the added data points and continuity of data, the model (National) based on State Observed Surveys is preferable to the NOPUS based model. Only the National model will be referenced for the remainder of this research note.

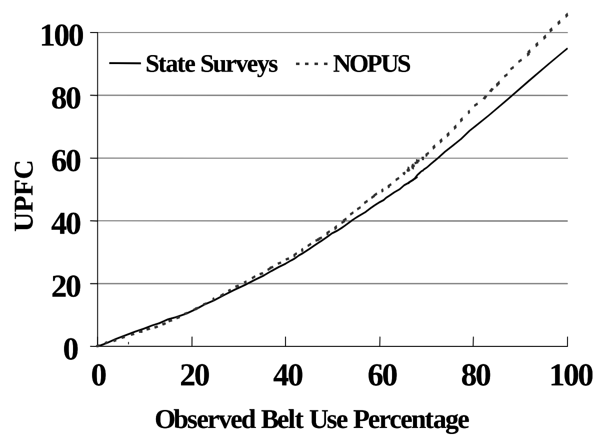

Figure 3 Predicted UPFCs, State Surveys vs NOPUS

State Model

This analysis uses 1996-1999 state (including the District of Columbia) belt use data to derive the State model. A total of 204 paired (UPFC, observed usage) data points were input into the SAS PROC REG procedure to estimate the parameters a_1 and a_2. The model had the form:

$$U = 0.942305 * U_o - 0.184602 * U_o^2$$

The model had an adjusted R-square value of 0.9826 and an SSE of 10,159 in predicting statewide results. Note that at 100 percent observed safety belt use rate, UPFC only reaches to 76 percent by this model. Table 3 (page 12) lists the state observed belt use, corresponding belt use in FARS, UPFC, and predicted UPFC. Figure 4 depicts the curve relationship between the state level UPFCs and the observed belt use rates and the fitted curve.

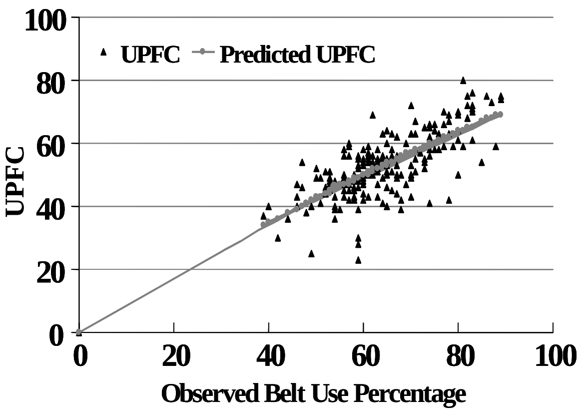

Figure 4 State Level UPFC vs Observed Belt Use Rate 1996-1999

National vs State Model

The two models were compared both at the national and the state levels. At the national level, the State model was fitted into the national historic data. The State model has an SSE of 497 in predicting the national UPFCs, compared to an SSE of 61 for the National model. Table 4 (page 14) shows the predicted results year by year between these two models.

At the state level, the National model was fitted into 1996-1999 state estimates. The National model has an SSE of 14,428 in predicting the statewide UPFCs, compared to an SSE of 10,159 for the State model. Table 5 summarizes the SSE results.

The State model, as expected, has a smaller SSE in predicting statewide UPFC than the National model. However, the State model was fitted only by the most recent four years of data and thus can't be considered as a good predictor over time. As shown in Figure 4, the observations were concentrated in the area between 55 and 70 percent. There was only one point (0,0) in the lower end of scale (< 40 percent) to complete the fit. The resulting curve has been perturbed to a convex shape rather than the natural concave shape that would reflect expected risk behavior. In addition, there is instability due to wide variation in police-reported belt use rates and large sampling errors in observed belt use surveys, particularly in states with small populations. These variations may be in part due to natural variations in the crash population within small states, but may also reflect reporting errors. For example, the predicting error for some states was large in one year, but very insignificant in others. The direction of error was frequently different among years, being negative in one year and positive in another. The fitting curve changed from concave to convex if different years of data were used or more restrictions were imposed.

Daytime Bias

The observed belt use surveys were conducted during daytime hours and thus were likely to overestimate actual belt use in all driving conditions. The daytime belt use in FARS was consistently about 8 percentage points higher than the overall FARS belt use during the 1990s. The above models linking UPFC directly to the state observed belt use survey inherited a daytime bias in the state observation surveys. To eliminate the bias, the above models were refitted to daytime data in FARS. The National model became $U = 0.717922 * U_o + 0.309463 * U_o^2$ (R^2 =0.9974).

This model predicts a daytime UPFC of 102 percent at a 100 percent observed belt use rate.

The daytime state model has the form
$U = 1.182162 * U_o - 0.360690 * U_o^2$ (R^2 =0.9833). It predicts daytime UPFC about 78 percent at the 100 percent observed belt use rate. In addition, limited to the daytime hour data, about 30 or so states (data points) had a higher UPFC than the observed belt use estimate compared to only 3-5 states with the same problem when daytime and nighttime were combined.

<u>One-Restriction vs Two-Restriction Model</u>

All the models (one-restriction and two-restriction) were developed by the SAS PROC REG program. The one-restriction models (National and State) were derived by forcing the intercept to be 0, i.e., 0 percent observed belt use rate would correspond to 0 percent UPFC. Theoretically, if an observed 100 percent belt use rate was representative of all vehicle occupants, the UPFC should also be 100 percent. If we impose both conditions into the regression modeling process (two restrictions), the two-restriction national model would be $U = 0.408314 * U_o + 0.591686 * U_o^2$ (R^2 = 0.9975, SSE=75).

Both the National model and two-restriction national models predict similar results. However, the National model has an SSE of 61 which is smaller than the 75 for the two-restriction model. In addition, the National model predicts a UPFC of 95 percent at a 100 percent usage, where the two-restriction model predicts 100 percent UPFC by design. The two-restriction model using NOPUS data would be $U = 0.505153 * U_o + 0.494847 * U_o^2$ (R^2 = 0.9931). The predicted results would be similar to that of the two-restriction National model. Both curves fall between the two curves (one-restriction) shown in Figure 3.

The two-restriction state model is
$U = 0.506852 * U_o + 0.493148 * U_o^2$ (R^2 = 0.9744, SSE= 15,011). Though, this model has a larger SSE in predicting state level results than the State model (15,011 vs 10,159), the model predicts a better UPFC result (SSE 142) at the national level than does the State model (one-restriction model, SSE 497). At 100 percent observed belt use, the two-restriction model predicts a 100 percent UPFC by design verses a 76 percent by the State model. The two-restriction model has preserved a natural concave shape, in contrast to the convex shape of the State model. For these reasons, the two-restriction model might be a better predictor than the State model in predicting state level results. However, both models are considered unstable as a long-term predictor because limited time history data were used and these data were all concentrated in the higher belt use area as shown in Figure 4.

<u>WA Model</u>

The WA model is similar to the one-restriction regression models. Both the national belt use data and the 1996-1999 state belt use data were used to fit the WA model. At the national level, the best fit was when the risk factor equaled 0.31. The model has an SSE of 191 which is more than three times the 61 from the National model. The WA model has a total SSE of 12,857 when used to predict the individual state UPFCs.

The best fit of the WA model to 4-year state belt use data was at the risk factor 0.22. The model has an SSE of 10,404 compared to 10,159 from the State model. However, the model has an SSE of 323 in predicting national

UPFC, which was lower than the 497 from the State model.

If data were limited to the daytime hours only, the risk factor would be 0.10 (SSE=164) and 0.07 (SSE=13,876) for the best national and 4-year state estimates, respectively. The risk factors in daytime hours were much smaller than those for daytime and nighttime combined. This also indicates that daytime belt use was generally higher than the nighttime use.

Discussion

The current algorithm was originally developed to enable predictions of usage rates in potentially fatal crashes in future time periods, so that users could estimate the potential impact of higher observed belt use rates on fatalities and injuries. The calculations that produce the safety impact are dependent on both the absolute usage level and the change in this level. However, the change is by far the more important factor in determining estimated benefits. The stability of the model is important because it anchors both the predicted current UPFC and the predicted future UPFC to a common basis, and allows a more accurate estimate of the likely change in UPFC than would be possible if the current rate was derived directly from FARS data. In a sense, this method sacrifices small levels of inaccuracy in the absolute rate for a more reliable estimate of the rate change, which is the larger concern. Thus, the failure to predict extremes of individual state variation in UPFC, whether they were due to inaccuracy in reported data or to genuine deviation from normal experience, is not a critical problem and the small difference in accuracy between the National and State models is of minimal consequence.

Of more importance is the overall reliability of the models as predictors of the general relationship between observed usage and UPFC. The National model is based on a historical series that includes a significant portion of the full value range of the independent variable. Only the upper end of this variable is lacking. The resulting model predicts an ultimate UPFC level that is consistent with the difference between daytime and overall belt use rates in FARS. The resulting model also describes a curve that is consistent with the concept that the least risk-adverse occupants will be those least likely to buckle up, and also most likely to be exposed to potentially fatal crashes. By contrast, the State model is based on data that only reflects a limited range of observed belt use experience. The resulting State model produces a curve that is counterintuitive to the concept of correlated risk aversion and high belt use, and predicts a maximum UPFC of only 76%, which is significantly different from what would be expected based on FARS data. Overall, the National Model provides a much more stable and acceptable basis for predicting future impacts.

If two restrictions were imposed to the regression modeling process, the derived best UPFC predicting models would have a larger SSE than the one-restriction model. Theoretically, the two-restriction models would be more appropriate if observed belt usage was representative of all driving conditions. However, the observed safety belt use surveys were conducted during daytime hours and thus excluded some high-risk persons at night time hours. The daytime survey results thus might overestimate the overall belt use rate. Under these circumstances, a 100 percent observed daytime use rate would not necessarily correspond to a 100 percent UPFC. The one restriction model is best to describe the relationship without introducing another dimension of error.

When restricted to belt use in daytime hours, the predicted UPFCs were close to the observed belt use level. However, UPFCs based on daytime FARS data in many states were higher than observed belt use levels. Uncertainty about the accuracy of the initial daytime data raised questions about the reliability of the daytime models. In addition, daytime models predict only the daytime UPFCs. Further development is needed to link the daytime UPFCs to the overall UPFCs. This two-step process would not reduce the predicting variability.

Clearly, neither national nor state data can fit the regression models perfectly, especially at the state level. Many sources of errors such as sample size, survey errors, modeling errors, and police-reported belt use would affect the fit and the reliability of the models. It is expected that larger predicted variations will exist among states. This variation is particularly great for smaller or less populated states. But, there are no discernible trends and it is difficult to isolate the factors that contribute to the modeling errors. For example, Rhode Island, Montana, New Mexico, Nebraska, and North Dakota had considerably larger predicted errors in some years. Rhode Island, particularly is interesting. The state's observed belt use rates were slightly lower than the national averages during 1996-1999. Yet, the state constantly had the lowest belt use rate (about 15 percent) in FARS for the first three years (1996-1998). The state belt use in FARS for 1999 was almost doubled to the 29 percent. This put Rhode Island the 12th lowest among reported states in FARS. The relationship between UPFC and the observed belt use in 1999 was closer to the regression model. However, it is difficult to decide what factors contributed to this result: was there improvement in the state's police-reporting system, or did belt use actually increase in the state so that it finally followed the predicted trend that is established by experience in most other states? In contrast, the predicted results for the big states such as California and New York were much more stable and had a consistent predicted variation.

The WA model, in practice, is more comparable to the one-restriction regression model, i.e., the National and State models. It has the same limitation as the regression models: no one model fits well at both the national and state level. The best fit risk factor at the national level was very different from that for the state level. In either case, the regression models produce a better fit than the WA models.

In summary, the National model showed a true time history curvilinear relationship between observed safety belt use and the UPFCs. The shapes of the National modeling curves, whether developed by one or two restriction rule, were similar. Although the National model $U= 0.475195*U_0 + 0.477125*U_0^2$ can't completely address all the variability of the state data, it is the best model to provide a stable basis for predicting future impacts.

Table 2 Historic Belt Use Data and Model Results at National Level

National Model $U = 0.475195*U_0 + 0.477125*U_0^2$

		UPFC as Predictor				Observed Belt Use as Predictor*				
Year	% Use in FARS	% Observed Belt Use	Model % Observed Belt Use	Difference in % Points	% Diff-erence	UPFC** (%)	Model UPFC (%)	Difference in % Points	% Diff-erence	Effec-tiveness
1983	3	14	11	-3	-21	6	8	2	33	48
1984	4	14	13	-1	-7	7	8	1	14	48
1985	8	21	24	3	14	14	12	-2	-14	48
1986	13	37	34	-3	-8	22	24	2	9	48
1987	16	42	40	-2	-5	27	28	1	4	49
1988	19	45	46	1	2	32	31	-1	-3	49
1989	21	47	48	1	2	34	33	-1	-3	49
1990	24	49	52	3	6	38	35	-3	-8	49
1991	28	59	57	-2	-3	43	45	2	5	49
1992	30	62	60	-2	-3	46	48	2	4	49
1993	34	66	64	-2	-3	50	52	2	4	49
1994	36	67	66	-1	-1	52	53	1	2	49
1995	36	68	66	-2	-3	52	54	2	4	49
1996	38	66	69	3	5	55	52	-3	-5	50
1997	39	67	69	2	3	56	53	-3	-5	50
1998	40	69	70	1	1	57	56	-1	-2	50
1999	40	70	70	0	0	57	57	0	0	50

Source: 1983-1999 FARS; 1983-1991 19-City Belt Use Surveys; 1992-1999 State Observation Belt Use Surveys.
* With Sum of squared Estimating Errors (SSE) =61
** Derived from belt use in FARS and belt effectiveness rate against fatalities.

Table 3 Percent Safety Belt Use and Belt Effectiveness* by State and Year

Predicted UPFC Using State Model $U = 0.942305*U_0 - 0.184602*U_0^2$

	1996					1997				
State	Use in FARS	Observed Use	UPFC **	Predicted UPFC	Effective-ness	Use in FARS	Observed Use	UPFC**	Predicted UPFC	Effective-ness
Alaska	29	53	45	45	50	31	56	49	47	53
Arizona	38	56	56	47	51	40	63	58	52	51
Arkansas	23	48	38	41	51	25	51	40	43	51
California	58	87	73	68	50	60	86	75	68	50
Colorado	33	56	50	47	51	31	60	48	50	51
Connecticut	25	59	39	49	48	33	60	49	50	48
Delaware	53	62	68	51	48	36	59	52	49	48
District of Columbia	32	55	48	47	48	33	64	49	53	49
Florida	38	63	55	52	49	41	60	58	50	49
Georgia	32	58	48	48	50	33	65	50	53	50
Hawaii	51	78	67	62	49	54	80	70	64	49
Idaho	32	50	49	43	51	25	49	41	42	52
Illinois	35	62	51	51	48	36	62	52	51	49
Indiana	35	53	51	45	49	33	53	49	45	49
Iowa	48	75	64	60	49	42	75	59	60	49
Kansas	25	54	40	46	50	29	56	45	47	50
Kentucky	28	54	44	46	50	31	53	47	45	50
Louisiana	38	59	56	49	51	37	64	55	53	51
Maine	35	50	52	43	50	38	61	54	51	48
Maryland	57	70	72	57	48	51	71	67	58	48
Massachusetts	23	54	36	46	47	32	53	48	45	48
Michigan	47	66	63	54	49	46	67	63	55	49
Minnesota	39	64	56	53	49	47	65	63	53	49
Mississippi	22	44	36	38	50	25	46	40	39	50
Missouri	27	58	43	49	50	31	63	47	52	50
Montana	34	71	52	57	52	34	73	52	59	53
Nebraska	30	65	46	53	50	35	63	52	52	50
Nevada	32	70	49	57	51	42	69	60	57	52
New Hampshire	41	56	57	47	48	27	58	42	48	48
New Jersey	38	59	54	49	47	38	60	54	50	48
New Mexico	36	85	54	67	52	40	88	59	69	53
New York	47	71	63	58	48	49	73	65	59	48
North Carolina	54	80	70	64	49	52	82	68	65	49
North Dakota	17	42	30	36	53	14	49	25	42	50
Ohio	38	60	54	50	48	38	63	54	52	48
Oklahoma	23	48	38	41	51	26	60	42	50	51
Oregon	56	82	72	65	51	60	82	75	65	51
Pennsylvania	37	65	54	53	49	31	65	46	53	48
Rhode Island	17	59	28	49	48	14	59	24	49	48
South Carolina	40	61	57	51	49	40	61	57	50	49
South Dakota	30	47	47	40	51	26	68	42	56	51
Tennessee	28	60	44	50	50	27	58	43	49	50
Texas	43	74	61	60	51	47	75	64	60	51
Utah	35	60	53	50	52	37	63	55	52	52
Vermont	32	69	48	56	48	41	71	58	58	50
Virginia	33	70	49	57	49	39	67	56	55	50
Washington	41	79	58	63	50	42	77	59	62	50
West Virginia	35	63	52	52	51	29	66	45	54	50
Wisconsin	39	59	56	49	49	31	52	47	44	49
Wyoming	29	59	46	49	53	30	60	48	50	53

Source: 1996-1999 FARS; 1996-1999 State Observation Belt Use Surveys; State Observation Belt use Surveys.

* Against fatalities

** Derived from belt use in FARS

Table 3 Percent Safety Belt Use and Belt Effectiveness* by State and Year - Continued
Predicted UPFC Using State Model $U = 0.942305*U_0 - 0.184602*U_0^2$

State	1998					1999				
	Use in FARS	Observed Use	UPFC**	Predicted UPFC	Effective-ness	Use in FARS	Observed Use	UPFC**	Predicted UPFC	Effective-ness
Alabama	30	52	46	44	50	33	58	50	48	50
Alaska	42	57	60	48	52	37	61	55	50	52
Arizona	33	62	50	51	51	37	71	55	58	51
Arkansas	29	53	46	44	52	28	57	45	48	53
California	60	89	75	69	50	59	89	74	69	50
Colorado	40	66	58	54	51	42	65	60	54	52
Connecticut	33	70	49	57	48	39	73	55	59	47
Delaware	38	62	55	52	50	27	64	41	53	49
District of Columbia	35	80	50	63	46	27	78	42	62	49
Florida	39	57	56	48	49	39	59	55	49	49
Georgia	45	74	62	59	50	41	74	58	60	50
Hawaii	66	81	80	64	51	47	80	64	64	51
Idaho	31	57	48	48	51	28	58	45	48	52
Illinois	39	65	56	53	49	39	66	56	54	49
Indiana	36	62	52	51	49	42	57	59	48	50
Iowa	49	77	66	62	50	46	78	63	62	50
Kansas	31	59	48	49	51	34	63	51	52	51
Kentucky	32	54	48	46	50	32	59	49	49	51
Louisiana	33	66	50	54	51	32	67	49	55	51
Maine	43	61	60	51	49	47	64	63	53	49
Maryland	57	83	72	65	49	54	83	70	65	49
Massachusetts	33	51	49	43	48	29	52	44	44	49
Michigan	46	70	63	57	50	47	70	63	57	49
Minnesota	38	64	55	53	50	40	72	57	58	50
Mississippi	26	58	41	48	50	24	55	39	46	51
Missouri	34	60	51	50	50	33	61	50	50	50
Montana	36	73	54	59	53	25	74	41	60	54
Nebraska	25	65	40	54	51	24	68	39	55	51
Nevada	41	76	59	61	51	43	80	61	63	51
New Hampshire	28	56	43	47	48	30	58	46	48	50
New Jersey	39	63	55	52	48	38	63	54	52	48
New Mexico	43	83	61	65	52	40	88	59	69	53
New York	50	75	66	60	49	47	76	63	61	49
North Carolina	55	77	71	61	49	53	78	69	62	50
North Dakota	25	40	41	35	52	36	47	54	40	52
Ohio	33	61	49	50	49	39	65	55	53	49
Oklahoma	30	56	47	47	51	36	61	54	50	51
Oregon	61	83	76	65	51	56	83	71	65	50
Pennsylvania	33	68	49	55	49	34	70	50	57	49
Rhode Island	18	59	30	49	48	29	67	44	55	48
South Carolina	38	65	55	53	50	37	65	54	54	50
South Dakota	30	46	47	39	51	23	39	37	34	51
Tennessee	27	57	43	47	50	27	61	43	51	50
Texas	47	74	64	60	51	48	74	66	60	52
Utah	33	67	51	55	52	35	67	53	55	53
Vermont	28	63	43	52	49	28	70	43	57	50
Virginia	39	74	56	59	50	36	70	53	57	50
Washington	42	79	59	63	50	41	81	59	64	51
West Virginia	30	57	46	47	50	34	52	51	44	50
Wisconsin	37	62	54	51	50	34	65	51	54	50
Wyoming	31	50	49	43	54	26	46	43	39	55

Source: 1996-1999 FARS; 1996-1999 State Observation Belt Use Surveys
* Against fatalities
** Derived from belt use in FARS

Table 4 Comparison Among Model Results for National Estimates

		National Model $U = 0.475195 * U_o + 0.477125 * U_o^2$			State Model $U = 0.942305 * U_o - 0.184602 * U_o^2$		
Year	**UPFC**	**Predicted UPFC**	**% Difference**	**% Changed**	**Predicted UPFC**	**% Difference**	**% Changed**
1983	6	8	2	33	13	7	117
1984	7	8	1	14	13	6	86
1985	14	12	-2	-14	19	5	36
1986	22	24	2	9	32	10	45
1987	27	28	1	4	36	9	33
1988	32	31	-1	-3	39	7	22
1989	34	33	-1	-3	40	6	18
1990	38	35	-3	-8	42	4	11
1991	43	45	2	5	49	6	14
1992	46	48	2	4	51	5	11
1993	50	52	2	4	54	4	8
1994	52	53	1	2	55	3	6
1995	52	54	2	4	56	4	8
1996	55	52	-3	-5	54	-1	-2
1997	56	53	-3	-5	55	-1	-2
1998	57	56	-1	-2	56	-1	-2
1999	57	57	0	0	57	0	0

Note: Sum of squared Estimating Errors (SSE) is 61 for the National Model and 497 for the State Model.

Table 5 Comparison of Predicting UPFC Results Measured by Sum of Squared Estimation Errors (SSE)

Estimated Level	**National Model** $U = 0.475195 * U_o + 0.477125 * U_o^2$	**State Model** $U = 0.942305 * U_o - 0.184602 * U_o^2$
National	61	497
State	14,428	10,133

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