

# Safety-Restraint Use Rate as Function of Law Enforcement and Other Factors

## Preliminary Analysis

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**Persistent use of safety restraints prevents deaths and reduces the severity and number of injuries resulting from motor vehicle crashes. However, safety-restraint use rates in the United States have been below those of other nations with safety-restraint enforcement laws. With a better understanding of the relationship between safety-restraint law enforcement and safety-restraint use, programs can be implemented to decrease the number of deaths and injuries resulting from motor vehicle crashes. Does safety-restraint use increase as enforcement increases? Do motorists increase their safety-restraint use in response to the general presence of law enforcement or to targeted law enforcement efforts? Does a relationship between enforcement and restraint use exist at the countywide level? A logistic regression model was estimated by using county-level safety-restraint use data and traffic citation statistics collected in 13 counties within the state of Florida in 1997. The model results suggest that safety-restraint use is positively correlated with enforcement intensity, is negatively correlated with safety-restraint enforcement coverage (in lane-miles of enforcement coverage), and is greater in urban than rural areas. The quantification of these relationships may assist Florida and other law enforcement agencies in raising safety-restraint use rates by allocating limited funds more efficiently either by allocating additional time for enforcement activities of the existing force or by increasing enforcement staff. In addition, the research supports a commonsense notion that enforcement activities do result in behavioral response.**

Despite research that shows safety restraints prevent deaths and reduce injuries sustained in motor vehicle crashes (1), in 1997 the safety-restraint use rate was 69 percent nationwide, and 41,967 people were killed in motor vehicle crashes (2). To underscore the importance of this statistic, President Clinton's administration initiated the Buckle Up America campaign, which included commitments to raise the safety-restraint use rates nationwide to 85 percent by 2000 and 90 percent by 2005 (3).

To increase safety-restraint use rates, numerous states implemented mandatory use laws (MULs). Although these laws increased use, use rates still are not comparable with the significantly higher use rates in other countries that have MULs (4, 5). In an effort to elevate use rates, some states implemented selective traffic enforcement programs (STEPs) (5–8). These programs consist of intensified enforcement of a particular traffic offense, such as the nonuse of safety restraints, combined with heightened publicity about the program through media outlets. Agencies justify the intent of these programs as public education services.

The state of New York enacted the first mandatory safety-restraint use law on December 1, 1984. By the end of 1998, 48 additional states and the District of Columbia had mandatory safety-restraint laws (2). A MUL can be either primary or secondary. A primary safety-restraint law enables law enforcement officers to stop vehicles and issue citations solely on safety-restraint law violations. A secondary safety-restraint law permits enforcement only after a driver has committed another violation. Florida's secondary enforcement law was enacted July 1, 1986, and enforcement began January 1, 1987. In 1997, Florida had a safety-restraint use rate of 60 percent (2), and the fine for a safety-restraint citation in Florida was \$30.

A number of jurisdictions have successfully increased safety-restraint use with programs ranging from enforcement alone (6, 9, 10) to enforcement combined with public information, education, and incentives (4, 5, 8, 11, 12).

Although research has shown that the number of belted drivers increases with heightened enforcement, several specific research questions have not been addressed:

- To what extent do motorists increase their safety-restraint use when safety-restraint enforcement is increased? That is, what change in safety-restraint use is associated with a marginal change in law enforcement?
- Do motorists increase their safety-restraint use in response to the general presence of law enforcement or to targeted law enforcement? In other words, do motorists respond to the mere presence of law enforcement, who enforce many laws including moving violations, criminal activities, and safety-restraint use, or do they respond only to targeted ticketing of safety-restraint violations? The former would imply that the presence of law enforcement motivates motorists to buckle up, whereas the latter would imply that word of mouth and publicity of heightened safety-restraint enforcement are what motivates motorists to buckle up.
- Are relationships between enforcement and restraint use present at the county level? This question will help inform the preceding question. Will countywide policies of enforcement affect safety-restraint use rates across the county? A "yes" answer provides support for an impact of word of mouth and publicity of safety-restraint ticketing, and a "no" answer suggests that these relationships exist only at the corridor level and that presence and localized law enforcement are what motorists respond to when considering whether to use safety restraints.

Because most STEPs have limited budgets, determining what works most efficiently and effectively can result in maximum returns from targeted enforcement efforts. Also, states can receive additional

funds from the federal government through incentive clauses by increasing safety-restraint use among motorists. Through the use of a logistic regression model, this paper strives to provide answers to these research questions (at least for the state of Florida).

## REVIEW OF RELATED MODELING EFFORTS

Several analytical methods have been implemented to determine what factors affect the use of safety restraints by motor vehicle occupants. A logistic regression analysis and categorical data analysis revealed that safety-restraint use was related to socioeconomic and demographic factors (13). Low use rates were related to lower-income families, nonwhite drivers, and drivers younger than 25 years old; however, the model accounted for less than 5 percent of the variability in safety-restraint use. Linear regression analysis for both primary and secondary enforcement states showed a direct statistical association between safety-restraint use and enforcement, and primary enforcement states had higher belt use rates at constant levels of enforcement; see the work of Campbell (9). Campbell did not examine the spatial influence of enforcement on safety-restraint use rates (9). In another study, Kim used a linear regression model to model the relationship between enforcement and safety-restraint use (6). The number of belted drivers increased with heightened enforcement from both a monthly and cumulative monthly perspective. Although reporting that enforcement of the safety-restraint law had been strong, consistent, and uniform, Kim did not address the spatial relationships between enforcement and safety-restraint use. In addition, a linear regression on a continuous variable that is bounded by 0 and 1 (safety-restraint use rate) is not the best choice of modeling approaches and cannot limit predictions within the appropriate range of values.

Other modeling efforts included the use of a binary logit model of driver beliefs as a random variable in ordered probability safety-restraint use models for both urban and rural trips (14), the development of binary logit models for both safety-restraint beliefs and safety-restraint use (15), and stepwise multiple regression analysis to identify factors that influenced safety-restraint use.

In general, studies have shown that safety-restraint use rates are affected by factors that include gender (15–17), race (15, 18, 19), income (19), and age (15, 17, 19). In addition, level of education, place of residence (15, 19), facility where ticket was issued (17), beliefs about safety (20), and type of enforcement law (9, 15) affect rates of safety-restraint use. These studies revealed factors that affect safety-restraint use but provide little information regarding the relationship between safety-restraint use and law enforcement.

## RESEARCH HYPOTHESIS

Research hypotheses were constrained because of the data available for analysis. Thus, nothing can be postulated about sociodemographic factors and their relation to safety-restraint use. The research hypotheses were used to guide the modeling effort and to provide insight into new aspects of safety-restraint use not explored previously. Specific research hypotheses were as follows:

- Increases in total citations and safety-restraint violations written will positively affect safety-restraint use rates.
- Countywide total violations written will be a better predictor of restraint use rates than will countywide safety-restraint violations written.

- For a given level of law enforcement intensity (ticketing rate), safety-restraint use will decrease with increased enforcement coverage.
- Rural motorists will have lower safety-restraint use than urban motorists on average.

The first hypothesis reflects the a priori belief that increased law enforcement will indeed motivate motorists to buckle up. The second hypothesis reflects the a priori beliefs that motorists are more sensitive to law enforcement presence than word of mouth and advertising of targeted ticketing, and that countywide enforcement campaigns will have a trickle-down effect on residents in that county. Support for the second statement comes from the belief that to some extent word of mouth and advertising of enforcement have impact, and that law enforcement agencies know how best to allocate resources to be highly visible and affect the greatest number of motorists. The third hypothesis comes from the a priori belief that for a given law enforcement intensity (resources and ticketing rate), increased area of enforcement coverage will be associated with reduced safety-restraint use rates. This assertion provides support for the notion that visibility is a key component of law enforcement and that as the transportation system is less dense, visibility is decreased, frequency of ticketing per facility is decreased, and motorist sensitivity is lessened. Finally, the fourth hypothesis represents the a priori belief that surveyed rural motorists are less apt to be observed wearing safety restraints than surveyed urban motorists on average. There are many reasons to suspect that this difference exists, including differences in sociodemographic factors, perception of safety and level of security, duration and speed of travel, and other differences between the average rural and urban motorist.

## DESCRIPTION OF DATA

Data employed in this analysis were obtained from sponsored research by Florida State University for the Florida Department of Transportation (FDOT) State Safety Office (21). The data were collected during May and June 1997 as part of the state observational survey of safety-belt use done for NHTSA (22). The data include observations from 13 of 67 counties in Florida and were collected at 25 sites in each county for a total of 61,499 observations at 325 observation sites (Figure 1).

The counties represented in the data were Brevard, Broward, Dade, Escambia, Hillsborough, Leon, Marion, Orange, Palm Beach, Pasco, Pinellas, Polk, and Volusia. Escambia and Leon Counties are in the northern part of the state, and Palm Beach, Broward, and Dade Counties are in the south. Data collection procedures including site selection, observation times, and observation methods, and data analysis relied on guidelines established by NHTSA (23).

Survey sites included roads with average daily traffic of at least 500 vehicles and were selected from the FDOT transportation statistics database. County population, land use (urban, rural), and highway functional classification (principal arterial, minor arterial) stratified the sample. Observation times included all daylight hours for all days of the week for a predetermined period at each site. Only stopped or slow-moving vehicles in the near curb lane were observed, and observations included restraint use by front-seat occupants of passenger cars, trucks, vans, and sport utility vehicles. Weighted estimates of safety-restraint use with one standard error and a 95 percent confidence interval were reported. Also, the surveys were probability based, met a precision requirement specified by NHTSA, and represented at least

FIGURE 1 Florida counties in seat belt survey.

85 percent of the state’s population. The variables used in the development of the logistic regression model are shown in Table 1. In addition to safety-restraint use, other summary statistics of the data are shown in Table 2. The variation in both restraint use rates and tickets issued per month by county is displayed in Figure 2.

MODELING RESULTS

The resulting model is a grouped logistic regression model wherein the dependent variable is safety-restraint use rate, BeltUse. The S-Plus statistical software program (24) was used to produce estimates of coefficients, standard errors, and *t*-statistics. Table 3 shows the results of the final model, which was obtained after many starter specifications and various forms of the variables as shown in Table 1. The table shows that both LandUse and SBTicketRate.Month positively influence safety-restraint use, and PALaneMiles influences safety-restraint use negatively. The *t*-statistics for all coefficients are significant. Although there were only 13 sites in the model, the grouped nature of the model accounts for the fact that many observations were used to derive BeltUse, hence the large *t*-statistics. The table also shows that the mean absolute deviation or mean error of prediction is about 2.5 percent. Table 4 shows the odds ratio of the results of the final model.

Figure 3 shows a scatter plot of observed BeltUse versus fitted BeltUse for the 13 counties. Although it appears that a potential curvature exists in this plot, the curvature did not exist in any partial correlation plots. In other words, nonlinear patterns were not found between BeltUse and the independent variables in the model.

The estimated model, transformed back into probability units, is shown in Equation 1:

$$\text{BeltUse}_i = \frac{\exp[0.4206 + X_1(-0.0022) + X_2(0.1176) + X_3(0.0053)]}{1 + \exp[0.4206 + X_1(-0.0022) + X_2(0.1176) + X_3(0.0053)]} \quad (1)$$

where

- BeltUse<sub>*i*</sub> = average seatbelt use in county *i*,
- X<sub>1</sub> = PALaneMiles,
- X<sub>2</sub> = LandUse, and
- X<sub>3</sub> = SBTicketRate.Month.

Note that the model shown in Equation 1 is multiplicative in parameters. In addition, the marginal effect of a variable is a function of the value of other variables in the model, unlike a linear regression equation.

The model depicted in Table 3 shows that the logit of BeltUse increases with SBTicketRate.Month, decreases with PALaneMiles, and is higher for urban areas (LandUse = 1). Because parameters are multiplicative, and because marginal effects depend on the level of other explanatory variables in the model, an example can be used to best illustrate use of the model. For best results, the model should be used only within the range of observations (joint distribution of independent variables).

Suppose a rural county with 6 million daily vehicle miles traveled (VMT) (9.66 million km) wants to increase safety-restraint use at monitoring stations from 47 percent to 60 percent through increased enforcement. Assume that this county has 300 lane-mi (483 lane-km) of principal arterials to enforce, and their current safety-restraint ticket rate is 25 tickets per daily million VMT. Solving Equation 1 for SBTicketRate when UseRate = 60, PALaneMiles = 300, and

TABLE 1 County-Level Variables

Variable Name	Description
UseRate	Driver seatbelt use percentage observed during a survey period in May or June, 1997, at 25 survey stations in 13 counties in Florida
County	County where data were collected
PcWhiteMale	Percent of white males observed wearing seatbelts
PcWhiteFemale	Percent of white females observed wearing seatbelts
OtherMale	Percent of other males observed wearing seatbelts
OtherFemale	Percent of other females observed wearing seatbelts
LandUse	1 if survey station in urban location, 0 otherwise
PcAADTPA	Percent annual average daily traffic on principal arterials
PcAADTMA	Percent annual average daily traffic on minor arterials
NumPA	Number of principal arterial survey stations
NumMA	Number of minor arterial survey stations
Sbtickets	Number of seatbelt tickets issued in May and June, 1997, in county
Movtickets	Number of moving violations tickets issued in May and June, 1997, in county
AADTTot	Average annual daily traffic measured at all survey sites
DMVTTot	Average daily vehicle miles traveled on all facilities in county
DMVPA	Average daily vehicle miles traveled on principal arterials in county
TotLaneMiles	Centerline lane miles of all facilities in county
PALaneMiles	Centerline lane miles of principal arterials in county
BeltUse	Seatbelt use rate in decimal (UseRate/100) in county
SBTicketRate	Number of seatbelt tickets issued in May and June, 1997, in county per DMVTTot
SBTicketRate.Month	Number of seatbelt tickets issued in May and June, 1997, in county per DMVTTot per month

Public Road Mileage and Miles Traveled, 1997; source: Transportation Statistics Office, FDOT.

TABLE 2 County Variables in Model

Variable	Range Units	Description
BeltUse*	.49 - .68	Observed driver rate of safety restraint use compliance
SBTicketRate.Month	14 - 109	Number of seat belt tickets issued per DMVTTot
LandUse	0 - 1	Urban or rural county designation
PALaneMiles	107 - 308	Lane-miles of principal arterials
DMVTTot	5.06 - 39.1	Daily million vehicle miles of travel on all facilities in county

\*Measured at randomly selected survey sites (25 sites per county) at urban and suburban locations.

1 mi. = 1.61 km.

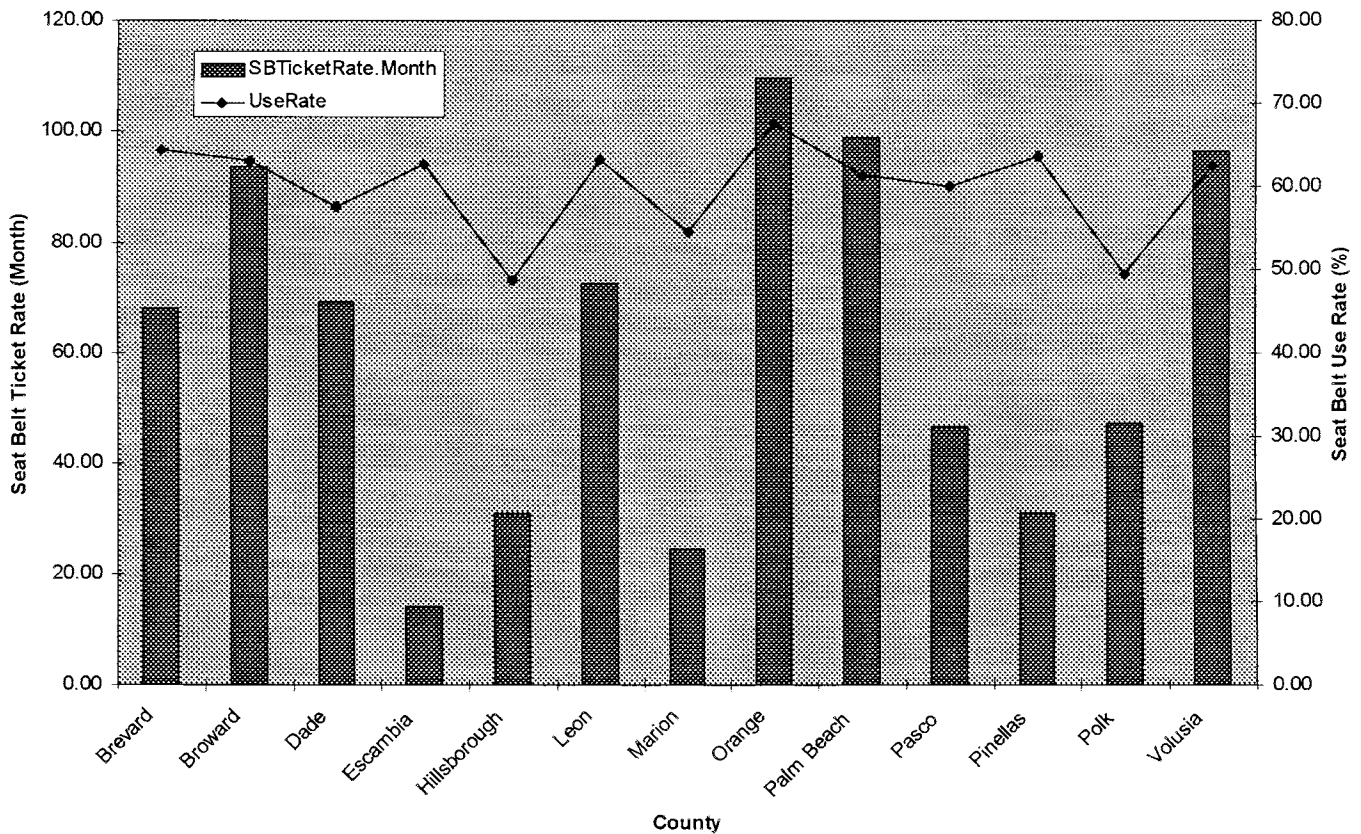


FIGURE 2 Florida safety-restraint data for 1997.

LandUse = 0, one gets SBTicketRate = 122, or equivalently 582 additional tickets per month on average. Thus, an almost fivefold increase in ticketing would result in an increase of BeltUse by 13 percent.

**DISCUSSION OF RESULTS**

The results of the logistic regression modeling can now be used to assess the research hypotheses stated previously.

Hypotheses 1 and 2. Increases in total citations and safety-restraint violations written will positively affect safety-restraint use rates, and

countywide violations written will be a better predictor of restraint use rates than will countywide safety-restraint violations written.

Early attempts to estimate a logistic regression model by using total citation ticketing rates instead of safety-restraint ticketing rates failed. The models that resulted from use of the total violation ticket rate did not suggest a significant relationship, and only when safety-restraint ticketing rates were used did a defensible and logical model emerge. This result suggests that observed motorists respond to targeted ticketing most likely through word of mouth and advertising campaigns such as TV commercials. This result opposed the a priori hypothesis, which presumed that law enforcement pres-

TABLE 3 Estimation Results of Logistic Model of Safety-Restraint Use

Variables	Coefficient	Standard Error*	t-value*
(Intercept)	0.420685	0.00781177	53.85280
PALaneMiles	-0.002204	0.00003682	-59.86497
LandUse	0.117598	0.00387656	30.33575
SBTicketRate.Month	0.005331	0.00008636	61.7315

\*t-values and standard errors reflect attributes of grouped data through the use of a weighting variable; i.e., AADT/12 was used as grouping weights at sites, which assumes a 2-hour collection period at each site. Null Deviance = 10108.3 on 12 degrees of freedom. Residual Deviance = 2167.8 on 9 degrees of freedom. Mean Square Prediction Error = 8.38%. Mean Absolute Deviation = 2.56%.

TABLE 4 Odds Ratio of Results of Logistic Model of Safety-Restraint Use

Variables	Odds Ratio	Standard Error	95% C. I. for Odds Ratio
PALaneMiles	0.997798	0.000037	0.9977–0.9979
LandUse	1.124791	0.004361	1.1163–1.1333
SBTicketRate.Month	1.005345	0.000087	1.0052–1.0055

ence alone would prompt motorists to buckle up. The results also suggested that counties have varying levels of enforcement across ticket categories that are not highly correlated, at least between safety-restraint and total ticket rates, and that total ticketing rate generally is not a good indicator of rate of safety-restraint ticketing.

The data and resulting model suggest that increasing safety-restraint enforcement, even with a secondary safety-restraint law, results in an increase in safety-restraint use. It was interesting to observe that county-level statistics resulted in a reasonable model. This provides further support for the notion that law enforcement agencies do well at targeting influential sites for enforcement and that word of mouth and other forms of advertising carry across a county.

Hypothesis 3. For a given level of law enforcement intensity (ticketing rate), safety-restraint use will decrease with increased enforcement coverage.

The third hypothesis could not be rejected with the data observed in this study. The model suggested that for a given level of enforcement, the number of principal arterials in the county is negatively related to safety-restraint use rates. In other words, as VMT is more dispersed in a county, law enforcement officers conduct enforcement

less frequently at a given site and time of day. This affects both law enforcement presence and word of mouth and other advertising of law enforcement. As would be expected, the larger the county (in terms of road mileage) to enforce, the lower the impact of a given intensity of enforcement.

Total county lane mileage also was tested; this proved inferior (statistically) to principal arterial lane mileage for predictive purposes. This probably is because survey sites are primarily located on principal arterials, and motorists are likely to be more sensitive to enforcement on arterials than on Interstates.

Hypothesis 4. Rural motorists will have lower safety-restraint use than urban motorists on average.

The fourth hypothesis could not be rejected with the sample of data obtained in Florida. Unfortunately, the database lacked sociodemographic variables, and so the variable LandUse is believed to correlate with those variables that were known to affect safety-restraint use in previous studies. As suspected, those variables associated with suburban locations (relative to urban), higher minority population, lower educational levels, greater sense of security, and greater mileage on non-Interstates are thought to account for the negative relation with LandUse, as shown in the model.

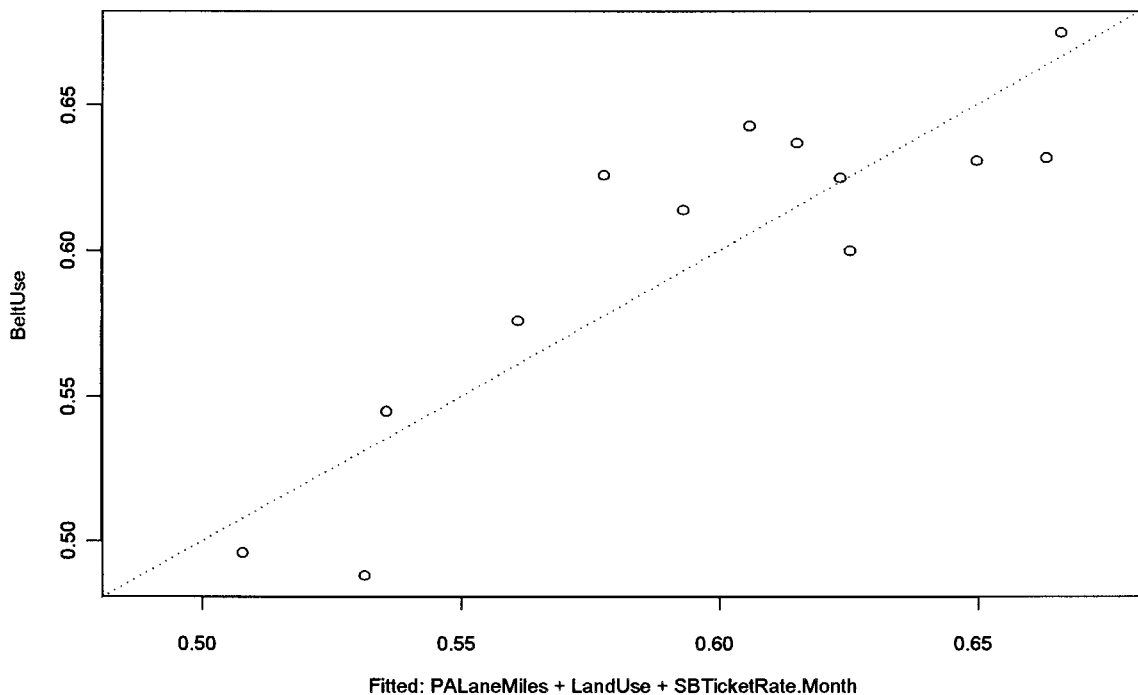


FIGURE 3 Observed belt use rate versus fitted model.

## CONCLUSIONS AND FUTURE WORK

A model relating safety-restraint use and enforcement intensity, land use designation, and enforcement coverage was estimated by using a logistic regression methodology. In general, the modeling results agreed with a priori hypotheses, and the signs and magnitudes of the explanatory variables are reasonable. The model can be used in the state of Florida and perhaps other states to assess the payback for increased enforcement intensity. However, the model is considered preliminary, and a carefully designed study, which uses panel data with changes in enforcement intensity, controls for safety-restraint counts stations, and survey of sociodemographic factors, should be conducted to validate the results postulated here.

Whether the model is generalizable to other states depends on many factors. Florida has a secondary safety-restraint enforcement law, and motorists in states with primary laws may exhibit different behavior. An assumption underlying the model is that data came from randomly selected survey sites throughout a county—nonrandom selection of sites in Florida or future comparison sites would render the results suspect. It is possible that greater enforcement as reflected through SBTicketRate.Month may have been conducted simultaneously with other public information and education programs, thus overestimating the effect of SBTicketRate.Month in the current model. In addition, the size of counties and extent of principal arterial mileage may be markedly different in other states. Perhaps most important are the potential effects of other programs related to safety-restraint use, such as educational campaigns, advertising, news coverage, and short-term intensified enforcement programs, such as check points, which were not accounted for in this model. The sociodemographic distribution of people, which was partly accounted for by a land use variable in this model, may differ across other states and thus render the effect of the land use variable incorrect. Finally, the model presented here is estimated on cross-sectional data; however, inferences are being made in a dose-response way: if ticketing is increased by an amount  $x$ , then safety-restraint use will increase by  $y$ . It is presumed that the most important elements leading to safety-restraint use are captured in the model; however, some obvious omitted variables could not be included. Because of the paired in space and time nature of the data, and because of the omitted variable bias potential, follow-on studies to validate these findings need to be conducted.

Similar data collection and analysis could be done in other states to determine the spatial stability of the model estimated in this research. In subsequent efforts, variables such as the frequency of programmed enforcement efforts, price of safety-restraint violation, frequency or extent of advertising campaigns, and age, ethnicity, alcohol use, and number of prior citations of the driver should be included to the extent possible.

Future work should also include a microanalysis of enforcement and rates of safety-restraint use to study the relationship between safety-restraint use and enforcement at the link level by using link-level travel, ticketing, and sociodemographic variables.

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