Chapter 40
Rear Seat Belt Usage Models Using FARS and Field Data

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Abstract Little research has been performed to evaluate the factors that impact seat belt usage for rear seat occupants. Because of the difficulties to collect rear seat belt data in the field, most researches have to rely on crash data, however, has its limit. Seat belt usage passengers not seriously hurt in a crash would typically not be recorded in the police officer filling report. In this study, Rear seat belt models using logistic regression analysis were performed using both FARS data and observational data. The resulting models were then analyzed to determine differences between using crash data and field data in identifying factors associated with the seat belt usage of rear seat occupants. The research showed both similar and differing results between the models produced using FARS data and field data. All the models using the FARS data showed a strong correlation between the back seat passenger's seat belt usage and the driver's seat belt usage. The research shows there are differences obtained in the factors that influence seat belt usage using field data and FARS data. The research demonstrates that care must be taken in the use of this data with regard to safety research looking at passenger restraint.

Keywords Rear seat belt · FARS

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Society of Automotive Engineers of China (SAE-China), *Proceedings of SAE-China Congress 2016: Selected Papers*, Lecture Notes in Electrical Engineering 418,
DOI 10.1007/978-981-10-3527-2_40

40.1 Introduction

Seat belt usage is one of the most effective strategies available to avoid death and injury in a crash. Today, however, nearly 40 years since the federal government required all passenger cars to be equipped with seat belts, the nationwide seat belt usage is at 83%. According to a National Highway Traffic Safety Administration [1] report, an estimated 13,250 lives were saved by seat belt use in 2008 [2]. Although the seat belt usage rate in the US increases each year, this usage still lags behind some other developed countries, such as Canada, Australia and some European countries, especially for rear seat belt usage.

Based on the statistics provided by Occupant Restraint Use in 2010 [2], seat belt usage for rear passengers stood at 74% in 2010. In addition, in states where rear seat belt use was not required in 2008, only 66% of adult passengers buckled their seat belts while seating in the back seat [1]. In New Jersey, a study conducted by New Jersey Institute of Technology showed the rear seat usage rate was only 47.9%.

Much research has been performed demonstrating seat belt use by vehicle occupants during crashes can result in lower injury severities with seat belts and airbags the most effective strategies to protect occupants [3, 4]. While most of vehicles are not equipped with back seat airbags; the seat belt seems to be the only protection for back seat passengers. In some cases, the unrestrained rear seat occupants can injure the driver or front seat passenger even if the front seat occupants are buckled. Therefore, using seat belts for rear seat occupants is not only beneficial for protecting rear seat occupants, but also reduces the risk of a second injury for the driver and front passenger.

In 2009, the majority of US states have primary or secondary Seat Belt Laws. Primary state laws allow motorists to be stopped and cited solely for violating a seat belt law, while secondary state laws are applicable when the motorists is stopped for another offense and are found violating the seat belt law. These laws play an important role in increasing seat belt usage and prove to be one of the most effective measures.

The State of New Jersey has a primary Seat belt Law, furthermore, NJ government recently tried to strengthen the state seat belt laws. On January 18, 2010, legislation was signed into law requiring all passenger vehicle occupants, regardless of their seating position, to wear their seat belts (NJS 39:3-76.2f). As a secondary law, the new law allows law enforcement to issue summonses to unbuckled back seat occupants, 18 years of age and older, when the vehicle they are riding in is stopped for another violation.

40.2 Problem Statement and Objectives

Factors influencing seat belt usage have been researched in safety analysis. Most research has focused on factors influencing the seat belt usage for drivers and front seat passengers. Little research has been performed to evaluate the factors that impact seat belt usage for rear seat occupants. In addition, because of the difficulties associated with collecting rear seat belt data in the field, most research in this area has relied on crash data, particularly the Fatal Accident Reporting System (FARS), to obtain seat belt usage data. Crash data, however, has its limits. Seat belt usage for vehicle occupants not seriously hurt in a crash would typically not be directly observed by the police officer filling out the report.

A rear seat belt model using logistic regression analysis was performed using both FARS data and also using observational data. The variables used from the FARS data and the field data, included vehicle type, age of rear seat passenger by seating position, vehicle occupancy and other variables. The resulting models were then analyzed to determine differences between using crash data and field data in identifying factors associated with the seat belt usage of rear seat occupants. In this paper, we analyze the two data sets, show the differences and try to examine whether the FARS data can be used to make a general conclusion of seat belt usage.

40.3 Literature Review

The methodology for collecting rear seat belt usage has not been clearly documented in the literature. However, gathering rear seat belt usage is increasing becoming an important role for safety agencies. Rear seat occupants are difficult to observe on highways due to high speeds on this roadway and visibility is difficult from a distant location. Surveyors are also unable to stand close to the traffic for their own safety and to avoid distracting drivers. Even when vehicles are stopped at an intersection, it is often still difficult to observe seat belt usage for rear seat occupants, especially when many vehicles have tinted windows also made difficult under dark conditions. Another complication is the lack of vehicles with back seat passengers. For this reason crash data is often used to determine seat belt usage in model development.

Data on seat belt usage, both front and rear, is obtained through a variety of methods including: phone interviews, observation and through crash records. NHTSA's *Traffic Safety Facts: Seat Belt Use in Rear Seats in 2008* reports on seat belt usage data collected by sending trained observers to probabilistically sampled intersections controlled by stop signs or stoplights, where vehicle occupants are observed from the roadside. Data is collected between 7 a.m. and 6 p.m. Only stopped vehicles are observed to permit time to collect the variety of information required by the survey, including subjective assessments of vehicle occupants' age and race. Most observational seat belt data collection use similar approaches for collecting data. Some of data collection use random dialed telephone surveys to report seat belt usage [5], some others conduct questionnaire survey to acquire seat belt usage rate [6, 7].

Research to identify factors that influence seat belt usage has primarily relied on data from crash records, particularly the Fatal Accident Reporting System (FARS) crash database. The Fatal Accident Reporting System (FARS) provides a wealth of data that is usable by researchers to better understand many crash related factors. To be included in FARS, a crash must involve a motor vehicle traveling on a traffic way customarily open to the public and result in the death of a person (occupant of a vehicle or a non-motorist) within 30 days of the crash. Since it only lists those crashes where there is at least one fatality, the problem of sample selection becomes obvious. Sample selection arises because a given individual's seatbelt usage affects his or her probability of death, which in turn influences whether the crash is included in the data [8]. If the death not occurred, the crash would not be recorded in FARS database. Furthermore, the same people may perform different behavior in different situations. For example, people have the awareness of fatal crashes have more chance occurred on highways with high speed, which is reasonable for more occupants choose to buckle up. The same one could be less likely to use seat belt when they are on local road for a quick trip. This affected the observation field seat belt usage data, while not showed from FARS data. Although providing a wealth of information on fatal crashes, obtaining seat belt usage from this data is limited.

FARS provides only those crashes where there is at least one fatality, which may lead to some bias in the sample selection [8]. Research performed by Salzberg and Yamada [9], indicate that FARS data may underestimate seatbelts usage when compared to estimates obtained from observational data. Salzberg et al. [9] investigated differences in seat belt use by the general public and belt us by motor vehicle occupants fatally injured in crashes. The study indicated that seat belt use rates obtained from FARS are much lower than the use rates found in observation surveys. A "straw man" model, describing the empirical relationship between FARS and observed usage rates, was developed. To examine the fit of the model, the state's FARS use rate was compared to the model's predicted rate. Corrections were made to the initial model to provide a more reasonable fit. The study concluded that unbelted occupants are over-represented in fatal collisions because these types of occupants have a greater likelihood of being involved with potentially fatal collisions in the first place, and because they are unbelted, the crash has a greater likelihood of being fatal.

Islam et al. [8] showed that FARS data can be a comparable alternative to the observational annual National Occupant Protection Use Survey (NOPUS) data. NOPUS is an annual survey providing the only probability-based observed data on seatbelt use in the United States. Although NOPUS is considered to be a reliable dataset, the data also has limitations because it is observational and based on the observer's ability to capture seat belt usage in a relatively short amount of time. The study found that NOPUS data can be used in estimating seat belt use once corrected for sample selection bias. Once the sample selection bias was corrected, the corrected FARS data can be applied as a comparable alternative to NOPUS estimates.

Factors influencing seat belt usage has been comprehensively studied. Common factors that have been identified are gender, age, income, time, familiarity of roadway, and geometric factors, such as [10, 11]. Very little work has been done to determine these factors that impact seat belt usage for back seat passengers. Some research reveal that the rear seat occupants' belt usage impact front occupants' injury severity. Mayrose et al. [12] studied the influence of unbelted rear seat passenger on driver mortality; logistic regression model disclosed that the probability of fatality for a belted driver in a head-on crash was 2.27 times greater with an unbelted rear seat passenger than if seated in front of a restrained passenger. However, the study was limited to whether unbelted left rear seat passenger increases the risk of death of belted driver involved in fatal crashes. The author applied FRAS data 1995–2001 involving belted driver with a left rear seat passenger.

40.4 Methodology

In this research, seat belt usage models are developed to examine the contribution of several variables to seat belt usage of back seat occupants in motor vehicles. Separate models were developed for back-left (behind the driver), back-middle and back-right (behind the front passenger) occupants. In these models seat belt usage is the dependent variable and is a binary or dichotomous variable with two categories, usage and non-usage.

Logistic regression was used to develop the seat belt usage models. Logistic regression falls in the class of models called generalized linear models. Generalized models are extensions of general linear models in which the assumptions of normality, linearity, and constant variance (Homoscedasticity) are removed. Maximum likelihood estimation is used after transforming the dependent variable into a logit variable (the natural log of the odds of the dependent variable occurring or not). The logistic function is given by:

$$F(Z) = \frac{1}{1+e^{-z}} \quad or \quad P = \frac{e^{a+bX}}{1+e^{a+bX}} \tag{40.1}$$

The "input" is Z and the output is F(Z). The output F(Z) takes values between 0 and 1. The variable Z represents the exposure to some set of risk factors. F(Z) represents the probability of a particular outcome, given a set of risk factors. The variable Z is the measure of the total contribution of all the risk factors used in the model and is known as the Logit. Z is defined as:

$$Z = \alpha + \beta_k X_k \tag{40.2}$$

where α is called the intercept and the β_k are the regression coefficient of the X_k. That is β_1, β_2, β_3… β_k are coefficients of X_1, X_2, X_3, …, X_k. The intercept is the value of Z when the values of all the risk factors are zero (i.e. the value of Z with no risk factors).

Substituting Eq. (40.2) into Eq. (40.1) yields:

$$F(Z) = \frac{1}{1 + \mathrm{e}^{-(\alpha + \beta_k X_k)}} \tag{40.3}$$

Suppose F(Z) is denoted as Y, then Eq. (40.3) becomes

$$Y = \frac{1}{1 + \mathrm{e}^{-(\alpha + \beta_k X_k)}} \tag{40.4}$$

Each represents the size of the contribution of that risk factor. A positive regression coefficient implies that the risk factor increases the probability of the outcome, while a negative coefficient implies the risk factor decreases the probability of that outcome. A large regression coefficient implies the risk factor strongly influences the probability of that outcome; while a near zero value implies that the risk factor has little or no influence on the probability of that outcome.

The specific form of the logistic regression model in Eq. (40.1) is

$$\Pi(x) = \frac{\mathrm{e}^{\alpha + \beta_1 \mathrm{X}}}{1 + \mathrm{e}^{\alpha + \beta_1 x}} \tag{40.5}$$

where Eq. (40.5) is transformed by using the natural log to develop a linear relationship between the dependent variable and the independent variables. The transformation of the function is known as the logit transformation:

$$g(x) = \ln\left[\frac{\Pi(x)}{1 - \Pi(x)}\right] = \alpha + \beta_1 x \tag{40.6}$$

The importance of transformation of the logit model (40.5) into (40.6) is that g (x) has most of the properties of a linear regression model. The logit, g(x) is linear in its parameters, may be continuous, and may range from − to +.

In logistic regression the slope coefficient, is equal to the difference between the values of the independent variable at x + 1 and x, for any value x. That is

$$\beta_1 = g(x+1) - g(x) \tag{40.7}$$

Therefore the slope coefficient represents the change in the logit for a change of one unit in the independent variable x.

Logistic regression calculates the probability of success over the probability of failure. Results are in the form of odds ratio. Odds ratio is the ratio of an event occurring to the likelihood of not occurring. An odd ratio also provides knowledge of the relationships and strengths among variables.

SPSS version 16.0 Statistical Software is used to develop the seatbelt usage model. In the SPSS result output for a logistic regression, the odds ratio for each independent variable is calculated as the exponential of the coefficient of that variable.

40.5 Data Collection

40.5.1 Field Data

Seat belt usage data were collected for drivers, front seat outboard passengers, and rear-seat passengers in passenger motor vehicles. Seat belt usage was obtained separately for three passenger motor vehicle types including: passenger cars, vans and sport utility vehicles (SUVs). Pick-up trucks were no included as these vehicles hardly have rear-seat passengers. For FARS data models, pick-up trucks were also not included to make sure that all models have the same variables.

The rear seat belt data is part of New Jersey “Click It or Ticket” campaign field survey conducted by New Jersey Institute of Technology graduate students in March 2010. NBA Games and pop-star concerts were selected because these events will attract more family members or friends. Two locations were identified to conduct the survey. One is Izod Center, East Rutherford, NJ. Another is Prudential Center, Newark, NJ. The data were collected two hours before the event starts. Eight surveyors divided into four groups, two people per group, one people observe whether the vehicle occupants use seat belt or not; another one recorded what were observed. Surveyors stood at the toll booths of parking decks or parking lots to observe the occupants seat belt usage when the vehicle stopped and rolled the window down to pay toll fees. Stopped vehicles are observed to permit time to collect the variety of information required by the survey. Observers do not interview vehicle occupants, so that the undisturbed behavior of vehicle occupants can be captured.

New Jersey’s Child Passenger Law requires the following:

- Children up to age 8 or 80 lb must ride in a safety or booster seat in the rear-seat of the vehicle. If there is no rear-seat, the child must sit in the front seat secured by a child safety seat or booster seat.
- Children under age 8 who weigh more than 80 lb must wear a seat belt anywhere in the vehicle.
- Passengers age 8–18 (regardless of weight) must wear a seat belt anywhere inside a vehicle.

For this reason, rear-seat passenger data were collected for three types of passengers: adults (older than 18), young (between 8 and 18) and child (under 8 years old). The age of the occupant was determined through observation by the data collector. Data were also collected by seating position of the rear-seat passengers including the left position (behind the driver), middle and right position (behind the front-seat passenger).

A total of 2923 vehicles were observed at two locations in New Jersey. Of these vehicles, 1915 back seat passengers were observed. Of the observe back seat passengers, 657 adults were observed with 178 or 27.09% using seat belts. A total of 516 youths were observed with 209 (40.5%) using seat belts. A total of 742 children were observed with 531 (71.56%) using seat belts. As the data shows, children have the highest seat belt usage and adults have the lowest among other age groups, probably because the safety of teenagers and kids are guarded by their parents. Most of adults go with their friends or adult family numbers who lack of the safety supervision. In addition, the usage rate of left back and right back seat occupants are relatively equal with the usage rate for the middle back seat lower than that of the other two back positions. This may be due to the fact that there almost 4 times more observations for right and left-back seat occupants compared to middle-seat occupants. Also, the seat belt usage of middle back seat passengers is more difficult to observe because for some vehicles, the middle seating position is a lap belt only, not a shoulder belt. In some cases, middle back seat passengers are conditioned to unbuckle when seated in the middle or with other back seat occupants.

40.5.2 FARS Data

Seat belt usage data were pulled out from the Fatality Analysis Reporting System (FARS) from 2004 to 2006 for New Jersey. FARS is a national wide database which contains data for all motor vehicle crashes that result in at least one fatality within 30 days of the crash. The database was created and maintained by the National Highway Traffic Safety Administration (NHTSA). The database records the crash information related to the environment, road conditions, circumstances of the crash, characteristics of the involved vehicles, and data on all related people involved in the crash.

FARS database was selected for this study for the reason that it contains many detail factors during the crash. In addition, it also contains restraint usage information for occupants during the crash. On the other hand, other existing databases, such as the New Jersey Department of Transportation Crash Database, are not suitable because it does not have information on restraint use for all occupants involved in the crash.

Three separate datasets were obtained from FARS database in developing the rear seat belt usage models. The datasets contain crash data factors for back-left, back-middle and back-right occupants in passenger cars, sport utility vehicles

Table 40.1 Model variable description

Variable	Description
Vehicle type	1 if passenger car; 2 if mini-van; 3 if SUV
Driver seat belt usage	1 if belted; 0 otherwise
Front passenger seatbelt usage	1 if belted; 0 otherwise
Left back passenger age	1 if Adult(>18); 2 if Youth (8–18); 3 if Child(<8)
Left back passenger seatbelt usage	1 if belted; 0 otherwise
Middle back passenger age	1 if Adult(>18); 2 if Youth (8–18); 3 if Child(<8)
Middle back passenger seatbelt usage	1 if belted; 0 otherwise
Right back passenger age	1 if Adult(>18); 2 if Youth (8–18); 3 if Child(<8)
Right back passenger seatbelt usage	1 if belted; 0 otherwise
Vehicle occupancy	2 if two people; 3 if three people; 4 if four people; 5 if five people

(SUV) and minivans. Crashes involved in large trucks, pedestrians, bicycles, motorcycles were not included in the study in order to consistent with field data. Variables used in the logistic regression models are obtained from the FARS database. These variables are treated as independent variables in the models. Table 40.1 gives a description of the variables used and how categorized in the models. A total of 10 independent variables are used in the models. The dependent variable—seat belt usage—is derived from the FARS data called "restraint system".

A total of 1954 vehicles were recorded in New Jersey FARS data from 2004 to 2006. Of these vehicles, 3981 back seat passengers were recorded. Of the FARS data back seat passengers, 1600 adults were observed with 751 or 46.93% using seat belts. A total of 1206 youths were recorded with 687 (56.97%) using seat belts. A total of 1175 children were recorded with 789 (67.15%) using seat belts. As the data shows, all age group have similar usage rate, but children have the highest seat belt usage and adults have the lowest among other age groups which is the same as field data showed.

40.5.3 Data Comparison

Table 40.2 shows the seat belt usage rate comparison between observational data and FARS data. The overall usage rate for field data is 47.94% while the rate for FARS data is 55.94%. The figure below indicates that all FARS data categories have higher usage rate than field data by age groups and rear seat seating positions except children's usage rate in left back seat. When compared the increase rate between two data sets, the rate of adult and youth have significant increase while the rate of children are in same level. The reason for the difference is the data collection strategies; FARS data only recorded the accidents that involve death which cannot represent the general seat belt usage in all circumstances. In addition, the sample size should be another reason that has to be considered. In our case, we select similar sample size for both field data and FARS data (BL Field 822 vs. FARS 800; BM Field 225 vs. FARS 274; BR 870 vs. FARS 880, for example, "BL Field 822" means 822 vehicles that have passengers seating in left back seat in field data).

Table 40.2 Usage rate comparison

Back left						
	Adult		Youth		Child	
	Field	FARS	Field	FARS	Field	FARS
Usage rate (%)	26.06	48.83	43.87	57.88	72.09	62.29
Increase rate (%)	87.37		31.95		−13.60	
Back middle						
	Adult		Youth		Child	
	Field	FARS	Field	FARS	Field	FARS
Usage rate (%)	12.28	34.54	23.61	44.08	55.91	58.74
Increase rate (%)	181.24		86.71		5.05	
Back right						
	Adult		Youth		Child	
	Field	FARS	Field	FARS	Field	FARS
Usage rate (%)	30.70	48.51	42.67	63.04	75.54	77.65
Increase rate (%)	58.03		47.74		2.79	

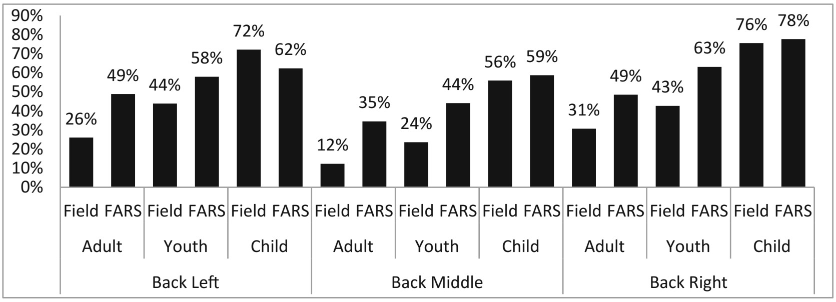

Table 40.3 Rear seat back seat belt usage models developed

Model number	Model description	
1	Field data	Left-back occupant seat belt usage
2	FARS data	
3	Field data	Middle-back occupant seat belt usage
4	FARS data	
5	Field data	Right-back occupant seat belt usage
6	FARS data	

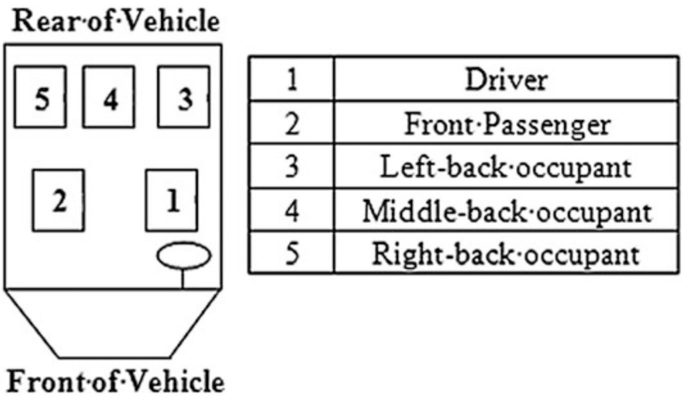

Fig. 40.1 Passenger positions

40.5.4 Analysis

Using the methodology described above for the seat belt usage model, models for left-back, middle-back and right-back seat passenger are developed. Models for each back seat position are developed using both field and FARS data. These models are described in Table 40.3 and Fig. 40.1. SPSS version 16.0 Statistical Software is used to develop the model.

The models examine the contribution of several variables that impact seat belt usage for each back seat occupant in a vehicle. The dependent variable is the back seat passenger seatbelt usage in the six models. Seatbelt usage in these models is a binary or dichotomous variable with two categories: usage and non-usage.

The variables used in the development of the logistic models are obtained from the field survey, and the FARS data variables are selected and coded as the same value of field data. Table 40.1 gives a description of the variables used and how they are coded in the models.

Results from these models are interpreted by examining the odds ratio and *p*-value for each of the model's independent variable. Table 40.4 provides the coefficients and *p*-values for each model variable. The confidence level for all models is 90%.

Table 40.4 Model coefficients and *p*-values

Field data						
Variables	Left back seat		Middle back seat		Right back seat	
	Model 1		Model 3		Model 5	
	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
BLAge		0.026		0.095		0.057
BLAge(1)	−3.216	0.013	3.003	0.030	−2.140	0.065
BLAge(2)					−2.476	0.047
BLUsage			4.419	0.000	1.933	0.032
BMAge		0.045		0.040		0.013
BMAge(1)	2.726	0.025	−3.077	0.012	3.046	0.014
BMAge(2)	2.646	0.041				
BMUsage	5.916	0.000			3.019	0.002
BRAge		0.078				0.002
BRAge(1)					−2.999	0.009
BRAge(2)	−3.563	0.025			2.844	0.038
BRUsage			2.873	0.002		
Constant	−2.929	0.001	−5.682	0.001	−1.573	0.005
FARS data						
	Left back seat		Middle back seat		Right back seat	
	Model 2		Model 4		Model 6	
Variables	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
VehicleType		0.049				0.075
Driver	−1.884	0.068	−1.618	0.061	−2.028	0.072
BLUsage					−3.277	0.000
BMAge		0.001		0.000		
BMAge(1)	3.302	0.001				
BMAge(2)	4.731	0.000	−1.782	0.001		
BMUsage	−4.781	0.001			−2.303	0.000
BRAge		0.000				0.000
BRAge(1)	−3.825	0.001			−1.238	0.000
BRAge(2)	−6.621	0.000			−0.043	0.012
BRUsage			3.062	0.000		
Constant	−35.553	0.998	20.444	0.998	25.588	0.999

Vehicle Type

The vehicle type was found to be an insignificant factor for all models except left and right back passenger seat belt usage models using FARS data. However, when the different levels are considered and compared with the reference level “3” which is SUV, this variable is found to be insignificant as well. The result indicates that people choose to buckle no matter what kind of vehicle he or she is in.

Driver Seat Belt Usage

In this research, the driver's seat belt usage was considered for all back seat occupants using the FARS data. For the left-back occupant using the FARS data, model 2, the odds ratio for the driver seat belt usage is 0.152. Thus the odds of left back seat passenger using a seat belt are 0.152 times less when the drivers are not using their seat belt than when the driver is using a seat belt. For the middle back seat occupant using the FARS data, model 4, the odds ratio for the driver seat belt usage is 0.198 and coefficient estimated as −1.618. Thus the odds of a middle back seat passenger using a seat belt are 0.198 times less when the driver is not buckled than when they are buckled. The odds of the right back seat passenger using a seat belt are 0.132 times less when the driver is not buckled. The result of FARS data indicates that driver seat belt usage has an impact on whether the back seat occupant will wear a seat belt.

The models developed using field data, however, did not show the same result with the driver's seat belt usage significant only for the middle back occupant model, model 3. Unlike the FARS data, the coefficient for this model is positive, 1.978.

Front Passenger Seatbelt Usage

The Front Passenger Seatbelt Usage variable is insignificant for all models using both FARS and field data. This indicates that the front passenger seat belt use does not have an impact on the whether the back seat passengers use their seat belts.

Back Passenger Age

The back passenger age variable was categorized into three levels: 1 for adult; 2 for youth and 3 for child, with the child level as the reference level. For the Left Back Passenger, age was found to be a significant factor for all the back seat occupant seat belt usage models using field data. This variable was not significant using FARS data. In Model 5, right back seat occupant seat belt model, the level 1 and level 2 coefficients of −2.14 and −2.476 variables are significant with p-values of 0.065 and 0.047, respectively. The odds ratios for these two levels are 0.118 and 0.084, therefore the odds of a middle back adult passenger using seat belt are 0.118 times less than children, while a middle back teenager passenger using seat belt are 0.084 times less than a child. Children have higher seat belt usage rate than adult and youth because children under 12 are required, under law, to be in a booster seat.

The Middle Back Passenger Age variable is significant in all models except for Model 6, right back seat occupant belt usage model. So both the FARS and field data showed this variable to be significant except for the right back seat occupant where the field data showed the middle back passenger age to be significant and the FARS data showed it was not significant. The middle passenger age variable was not significant by level for all the models. For the left back seat usage models, both the FARS and field data were significant at levels 1 and 2 with positive coefficients indicating that the odds for a left back seat occupant using their seat belt is more than a child.

For the middle back seat occupant field data model, Model 3, the odds of a middle back adult passenger using seat belt are 0.046 times less than a child. This is different to the middle back seat occupant FARS data model, Model 4, which shows that the odds for a middle back seat occupant using a seat belt are more than a child.

The Right Back Passenger Age variable is significant for both the FARS and field data for the left back seat usage models and for the right back seat usage models. In addition, looking at the coefficients for the right back passenger age variable at its levels, the coefficients are generally consistent in sign between the FARS and field data models. For the left back seat model, all of the coefficient variables are negative. For the right back seat models, all but one of the coefficients is negative. For example, the Right Back Passenger Age variable is significant in Model 2 overall and for both levels with the reference level of "child". For level 1, p-value is 0.001 and an estimate value of −3.825. The odds ratio is 0.022. This shows that the odds of adult seating in right back side that will buckle seat belt are 0.022 times less than child in the right back seat.

In general, back seat passengers' age is significantly impact their seat belt usage in most cases in this research. Adults have lower seat belt usage in the back seat than youth and children; this is proved both by the models and the data. Thus, measures that could improve back seat adult seatbelt usage will be considered in the future studies.

Back Passenger Seat Belt Usage

This variable determines whether one back seat passenger using a seat belt will impact the seat belt usage for the other back seat passengers. As the models are predicting the seat belt usage for the back seat passenger, only the remaining back seat belt usage not being predicted is used as independent variables.

The Left Back Passenger Seat Belt Usage variable was found to be significant in Model 3, middle back seat belt usage, and Model 5, right back seat usage, which is both models, developed using field data. In Model 5, the p-value is 0.032 and the coefficient estimate is 1.933. The reference category is the right back occupant being belted. Therefore, the odds of right back occupant being belted are 6.907 times more when the left back passenger is belted than not belted.

The Middle Back Passenger Seat Belt Usage variable was found to be significant in both the FARS and field data left back seat usage models, Models 1 and 2, and in the right back seat usage models, Models 5 and 6. In both the left back seat models and in the right back seat models, the coefficient for the FARS data is negative and the coefficient for the field data is positive. In Model 5, the right back seat model using the FARS data, the p-value is 0.02 and the coefficient estimate is 3.019. The reference category is the middle back occupant being belted. Therefore, the odds of right back occupant being belted are 20.47 times more when the middle back passenger is belted than not belted. A similar result could be found in Right Back Passenger Seat Belt Usage variable. It can be concluded that the seat belt usage of back seat passengers is interact each other if more than one back seat occupants.

Vehicle Occupancy

This variable was found to be insignificant in all of the models and indicates that the number of people in a vehicle will not impact whether a back seat occupant uses their seat belt.

40.5.5 Predicted Logistic Regression Model

The predicted logistic regression model for left back seatbelt usage model using field data, model 1 is given as:

$$\text{Log}\left(\frac{p}{1-p}\right) = -2.929 - 3.216\text{BLA}(1) + 2.726\text{BMA}(1) + 20.646\text{BMA}(2) + 50.916\text{BMU}30.563\text{BRA}(2)$$

where,

p	Probability of wearing a seat belt
BLA(1)	Left back seat adult passenger
BMA(1)	Middle back seat adult passenger
BMA(2)	Middle back seat youth passenger
BMU	Middle back seat passenger seatbelt usage
BRA(2)	Right back seat youth passenger

The predicted logistic regression model for left back seatbelt usage model using FARS data, model 2 is given as:

$$\text{Log}\left(\frac{p}{1-p}\right) = -35.553 - 1.884\text{DR} + 3.302\text{BMA}(1) + 40.731\text{BMA}(2) - 4.781\text{BMU} - 30.825\text{BRA}(1) - 6.621\text{BRA}(2)$$

where,

p	Probability of wearing a seat belt
DR	Driver seatbelt usage
BMA(1)	Middle back seat adult passenger
BMA(2)	Middle back seat youth passenger
BMU	Middle back seat passenger seatbelt usage
BRA(1)	Right back seat adult passenger
BRA(2)	Right back seat youth passenger

The predicted logistic regression model for middle back seatbelt usage model using field data, model 3 is given as:

$$\text{Log}\left(\frac{p}{1-p}\right) = -5.682 + 3.003\text{BLA}(1) + 4.419\text{BLU} - 3.007\text{BMA}(1) + 2.873\text{BRU}$$

where,

p	Probability of wearing a seat belt
BLA(1)	Left back seat adult passenger
BLU	Left back seat passenger seatbelt usage
BMA(1)	Middle back seat adult passenger
BRU	Right back seat passenger seatbelt usage

The predicted logistic regression model for middle back seatbelt usage model using FARS data, model 4 is given as:

$$\mathrm{Log}\left(\frac{p}{1-p}\right) = 20.444 - 1.618\mathrm{DR} - 1.782\mathrm{BMA}(2) + 3.062\mathrm{BRU}$$

where,

p	Probability of wearing a seat belt
DR	Driver seatbelt usage
BMA(2)	Middle back seat youth passenger
BRU	Right back seat passenger seatbelt usage

The predicted logistic regression model for right back seatbelt usage model using field data, model 5 is given as:

$$\begin{aligned}\mathrm{Log}\left(\frac{p}{1-p}\right) = & -1.573 - 2.14\mathrm{BLA}(1) \\ & - 2.476\mathrm{BLA}(2) + 1.933\mathrm{BLU} + 3.046\mathrm{BMA}(1) + 3.019\mathrm{BMU} \\ & - 2.999\mathrm{BRA}(1) - 2.844\mathrm{BRA}(2)\end{aligned}$$

where,

p	Probability of wearing a seat belt
BLA(1)	Left back seat adult passenger
BLA(2)	Left back seat youth passenger
BLU	Left back seat passenger seatbelt usage
BMA(1)	Middle back seat adult passenger
BMU	Middle back seat passenger seatbelt usage
BRA(1)	Right back seat adult passenger
BRA(2)	Right back seat youth passenger

The predicted logistic regression model for right back seatbelt usage model using FARS data, model 6 is given as:

$$\begin{aligned}\mathrm{Log}\left(\frac{p}{1-p}\right) = & \ 25.588 - 2.028\mathrm{DR} - 3.277\mathrm{BLU} - 2.303\mathrm{BMU} - 1.238\mathrm{BRA}(1) \\ & - 0.043\mathrm{BRA}(2)\end{aligned}$$

where,

p	Probability of wearing a seat belt
DR	Driver seatbelt usage
BLU	Left back seat passenger seatbelt usage
BMU	Middle back seat passenger seatbelt usage

BRA(1) Right back seat adult passenger
BRA(2) Right back seat youth passenger

40.6 Conclusions

The research showed both similar and differing results between the models produced using FARS data and those produced using field data. All the models using the FARS data showed a strong correlation between the back seat passenger's seat belt usage and the driver's seat belt usage. This may be due to the fact that a large proportion of back seat occupants are children and teenagers who required buckling by the laws which may be why age in influences these occupants' seat belt usage. Only the middle back seat usage model developed using the field data showed significance and the results were opposite, different coefficient signs, compared to the coefficients developed using the FARS data.

Mixed results were obtained between FARS data and field data for the back seat occupant age variable. In some cases the results between the models produced by the two data are similar, in other cases it is not. Similar mixed results were also found for the back seat passenger usage as an independent variable. It is also found that back seat occupants' seatbelt usage was influenced by the other back passengers' usage. This indicates the presence of interaction among back seat occupants. The result shows that a single back seat passenger is less likely to be belted than if more than one back seat passenger is belted. In addition, New Jersey passengers are more aware of using their seat belts when seated in the back row due to the secondary state law.

The research shows there are differences in the factors that influence seat belt usage using field data and FARS data. The models developed were limited in the variables used as the primary focus of the field data collection was to obtain the back seat belt usage. Although further research is warranted to understand the limitations of FARS in looking at overall passenger restraint, the wealth of data provided through FARS still makes this data to be a valuable tool for safety research. Care must be taken, however, in the use of this data with regard to safety research looking at passenger restraint. Future studies are needed to find a better approach to obtain back seat belt usage data and to include additional factors not traditionally used in back seat belt usage models that may influence the seat belt usage for back seat occupants.

Acknowledgements This study was funded by the New Jersey Division of Highway Traffic Safety and New Jersey Institute of Technology as a part of the research project Seat Belt Study. The authors would like to thank Mr. Robert Gaydosh who served as the Project Manager.

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