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Correlates of front-seat passengers' non-use of seatbelts at night

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ABSTRACT

When properly worn, seatbelts can save lives. They are designed to prevent occupants from hitting objects inside their vehicle and from being ejected out of their vehicle in the event of a crash. Despite their proven effectiveness in reducing the severity of injuries, seatbelt non-use among passengers still remains a problem, especially at night. Although the factors associated with not using a seatbelt have been widely studied, research studies documenting this behavior at night are limited in the literature. The primary objective of this paper is to explore the factors related to front-seat passengers' seatbelt non-use at night using a 2015–2016 longitudinal observation survey conducted in five counties in East Tennessee. The Generalized Estimating Equation, a rigorous modeling technique, is employed for the data analysis.

The findings show that front-seat passengers who are most likely to not wear seatbelts at night are males, traveling in passenger cars and pickup trucks, traveling during the first half of the year (January to June), traveling late at night (after 10 p.m) and on local streets. The findings also indicate that drivers may have the greatest influence on their accompanying passengers' seatbelt use. That is, when drivers fail to wear seatbelts at night, their accompanying front-seat passengers are more likely to fail as well.

The model results show that there are many consistent correlations between the non-use of seatbelts and personal, vehicle and environmental characteristics. Accounting for these factors may be important when developing intervention strategies that promote nighttime seatbelt use.

1. Introduction

When properly worn, seatbelts can save lives. They are designed to prevent occupants from hitting objects inside their vehicle and from being ejected out of their vehicle in the event of a crash. Seatbelts saved an estimated 12,802 lives among passenger vehicle occupants over the age of 4 and 252 children (age 4 and under) in the United States in 2014 (National Center for Statistics and Analysis, 2015). An additional 2814 lives would have been saved in 2014 if unrestrained vehicle occupants (age 5 and over) had worn their seatbelts (National Center for Statistics and Analysis, 2015). It is estimated that nearly half (48%) of passenger vehicle occupants involved in fatal crashes in 2015 were unrestrained (National Highway Traffic Safety Administration, 2016). Despite their proven effectiveness in reducing the severity of injuries, seatbelt non-use still remains a problem especially among some high-risk populations including males and rural residents.

Seatbelts are intended for all motor vehicle occupants - drivers and passengers. However, studies have demonstrated a lower usage rate among passengers compared to drivers. In 2014, the nationwide seatbelt use rate in the U.S. for drivers was 87% and that of front-seat passengers was 85% (Pickrell and Choi, 2015). The difference in seatbelt use between drivers and passengers has led researchers to investigate whether unbelted occupants pose any risk to other occupants in the same vehicle. Previous studies have shown that in a frontal crash, drivers and front-passengers are at increased risk of injury from unbelted back-seat passengers (MacLennan et al., 2004; Bose et al., 2013). Similarly, in a side-impact crash, unbelted passengers are likely to pose an increased risk of injury to other passengers sitting adjacent to them (MacLennan et al., 2004; Bose et al., 2013). MacLennan et al. found that exposure to unbelted occupants increases the risk of injury to other occupants in the vehicle by 40% (MacLennan et al., 2004).

Although the average seatbelt use rate among drivers and passengers in the U.S. has increased significantly from 70% in 2000 to 90% in 2016, the proportion of unrestrained occupants in motor vehicle crashes still remains a concern (Pickrell and li, 2016). The increasing trend in seatbelt use is largely attributed to increases in safety educational

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programs by state and private agencies (Pickrell and Choi, 2015; Stanley et al., 2015; Geary et al., 2005), seatbelt laws (Beck and Shults, 2009; Strine et al., 2010), and enforcement programs including Click it or Ticket (CIOT) campaigns and saturation patrols (Reinfurt, 2004; Solomon et al., 2004; Thomas et al., 2011; Thomas et al., 2008; Tison and Williams, 2010; National Highway Traffic Safety Administration, 2010).

In addition to safety belt laws, enforcement and educational campaigns, socio-demographics (e.g. age, gender, race, education, socio-economic status, and marital status, etc), the environment (e.g. weather, road type) and psychosocial factors (e.g. young drivers traveling with parents) have been identified as having impacts on driver and passenger seatbelt use in previous studies. For instance, research suggests females are more likely to use seatbelts than males (Milano et al., 2004; Lipovac et al., 2015; Chaudhary et al., 2004). (Lipovac et al. (2015)) and (Preusser et al. (1991)) found that older adults are much more likely to use seatbelts than younger age groups. (Vivoda et al. (2004)) and Wells et al (Wells et al., 2002) found that African Americans are less likely to always wear seatbelts compared to Whites or Hispanic ethnicities. Moreover, past studies have reported that higher educational attainment is positively associated with seatbelt use (Wells et al., 2002; Reinfurt et al., 1996). In a study to evaluate rear-seatbelt use in Malaysia, Ng et al. found that married passengers are more likely to wear seatbelts compared to singles (Ng et al., 2013). They explained that this finding may be due to married passengers showing greater social and economic responsibilities than singles.

With regard to psychosocial factors, Williams and Shabanova (2002), and (Cooper et al. (2005)) found that the presence of other passengers and their seatbelt use has a significant positive influence on the driver's seatbelt use. Specifically, (Williams and Shabanova (2002)) reported that seatbelt use among teenage drivers increased when parents or older adults accompanied them. However, the usage rates decreased when the accompanying passengers were young (i.e. their peers). Additionally, seatbelt use of both front-seat occupants has been found to be highly correlated. Previous studies showed that when drivers wear their seatbelts, their accompanying front-seat passengers are much more likely to do so and vice versa (Nambisan and Vasudevan, 2007; Lehto and James, 1997; Şimşekoĝlu and Lajunen, 2008).

Driver and passenger seatbelt use differ across geography (e.g urban vs rural), at different times of day, and under different weather and traffic conditions. For example, Strine et al. found that rural residents have lower seatbelt use rates than urban residents (Strine et al., 2010). (Gkritza and Mannering (2008)) found that single vehicle occupants are less likely to be restrained in the morning as well as multi-vehicle occupants in the afternoon. Several studies have also reported that nighttime seatbelt use rates are significantly lower than daytime rates (Chaudhary et al., 2005; Chaudhary and Preusser, 2006; Solomon et al., 2007; Tison et al., 2010; Vivoda et al., 2007). Further investigation by (Chaudhary and Preusser (2006)) showed that the difference in seatbelt use rates between daytime and nighttime is higher on urban roads than rural roads. Many past studies have consistently demonstrated lower seatbelt usage rates among occupants of pickup trucks compared to those of other vehicle types (sedans, SUVs, and minivans) (Solomon et al., 2004; Reinfurt et al., 1996; Solomon et al., 2007; Nichols et al., 2009; Begg and Langley, 2000). In other studies, individuals traveling in newer car models have been found to be more likely to buckle up than those in older vehicles (Milano et al., 2004; Reinfurt et al., 1996). Though driving in rural areas on weekends and for shorter distance has been found to be negatively associated with seatbelt use, a positive relation has been found for people driving in bad weather, in bad road conditions, in heavy traffic, and on high speed roads (Lipovac et al., 2015; Williams and Shabanova, 2002; Chliaoutakis et al., 2000).

Although factors associated with passenger seatbelt non-use have been broadly researched in the literature, the majority of studies have focused on daytime and not nighttime evaluations. It is important to note that the seatbelt use rates reported in the National Occupant Protection Use Survey (NOPUS) by NHTSA are from daytime (7:00 a.m to 6:00 p.m) observations. As reviewed in the literature, nighttime seatbelt use rates are significantly lower than daytime rates (Chaudhary and Preusser, 2006; Tison et al., 2010; Vivoda et al., 2007). The nighttime fatality rate is about three times higher than the daytime rate accounting for the fact that about one-quarter of total traveled miles occur during dark hours (Varghese and Shankar, 2007). Moreover, among fatally injured passenger vehicle occupants, the proportion of unrestrained occupants is much higher during the night than the day time (Varghese and Shankar, 2007). It is also interesting to note that the percentages of alcohol and speed related crashes are higher during dark hours than during the daytime (Varghese and Shankar, 2007). So one may want to ask "why are risky driving behaviors more prevalent during the night than the daytime hours?" A possible reason could be that the driving population at night may be different from the daytime population. In this regard, studies must be conducted to account for such differences.

Understanding the factors associated with seatbelt non-use by passengers at night is crucial for the development of appropriate interventions that support prevention measures. There are still many gaps in our knowledge of nighttime seat belt use. Research studies examining nighttime seatbelt use for different personal, vehicle and environmental characteristics are needed in order to identify specific traffic safety problems that warrant immediate attention. The primary objective of this study is to explore factors that impact front-seat passengers' seatbelt use at night using longitudinal nighttime seatbelt observation surveys conducted in East Tennessee. With a clear understanding of drivers' and passengers' seatbelt use behavior, it will be possible to develop intervention programs that are persuasive and have the greatest potential for effectiveness.

2. Methodology

2.1. Empirical setting

Each year, with the support of the Tennessee Highway Safety Office (THSO), the Center for Transportation Research (CTR) at the University of Tennessee conducts and evaluates a statewide observational safety belt survey using guidelines developed by NHTSA (Chaudhary et al., 2010). Past studies have solely focused on daytime observations and did not address nighttime seatbelt usage. In 2015, as part of a research effort sponsored by the Centers for Disease Control and Prevention (CDC), CTR conducted a series of nighttime seatbelt observations in East Tennessee. Tennessee, a primary seatbelt law state requires that all drivers and front-seat passengers wear a properly fastened seatbelt at all times when a vehicle is in motion (Tennessee Seatbelt Laws §55-9-603). Since the provisions of this law only apply to front-seat occupants, rear-seat passengers were not considered in this study. Data from the observation surveys in 2015 and 2016 are used to evaluate the relationship between front-seat passengers' seatbelt non-use and other factors.

The nighttime surveys were conducted at 36 sites in five counties (Blount, Knox, Loudon, Roane and Sevier) in East Tennessee (see Fig. 1). East Tennessee was selected for this study because of its representative sample sociodemographic characteristic similar to the entire state's population, the mix of urban and rural settings, linkages to past seatbelt observational surveys, and the strength of existing partnerships between CTR and key community groups and stakeholders. The Uniform Criteria for State Observational Surveys of Seat Belt Use (23 CFR Part 1340), used for selecting the sites of past daytime seatbelt observation surveys, served as a starting point for the selection of the 36 sites used for nighttime observations. As shown in Fig. 1, some of the nighttime observation sites were the same or close to the daytime observation sites. Other sites were located away from the daytime sites due to visibility limitations and for the safety of observers. The sites were distributed by functional classification proportional to each county's annual vehicle miles traveled. Observations were conducted at

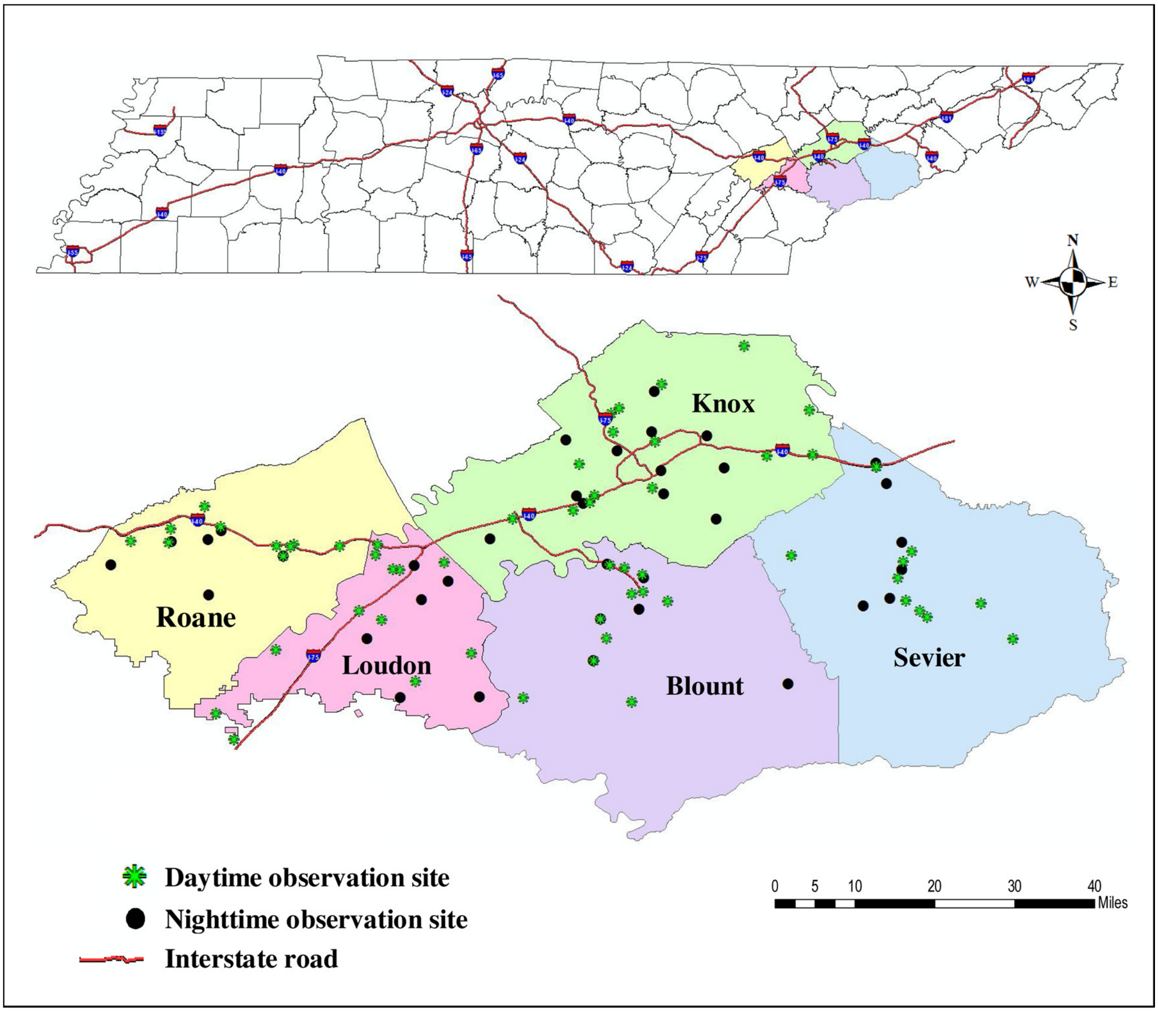

Fig. 1. Study location and sites.

both rural and urban settings at roadway intersections, freeway exit ramps, and road segments (refer to (Tennessee Department of Safety, 2010) for detail criteria for site selection).

2.2. Data collection

A series of nighttime seatbelt observations were conducted between March 2015 and November 2016 at the study locations. At each of the 36 sites, 12 waves (unevenly spaced) of data collection were conducted throughout the study period. Prior to the data collection, observers were trained and given the necessary safety guidance. Nighttime observations were enhanced by using a lighting setup that provided sufficient illumination, especially at locations where clear night visibility was not easy. To minimize any potential influence of the experimental set-up on passengers' seatbelt use, two considerations were important. First, a low-beam light was selected in order not to distract drivers as they approach the observation sites. Secondly, the lighting was set-up at a reasonable distance from the edge of the traveled lane with the intent to minimize the possibility of drivers easily noticing the observers from afar. At locations where there was enough lighting (e.g., street lighting), the lighting setup was not used. Data were collected at each site by two observers, one made seatbelt observations and the other recorded the results as stated by the observer. The trained staff observed the shoulder belt use, gender, the type of vehicle (passenger cars, sport-utility vehicles (SUVs), pickup trucks, and minivans), and the seating position of the vehicle occupants (driver and right front-seat passenger). Data collection efforts were randomly conducted on week days and weekends during dark hours between 8:00 p.m and 2:00 a.m. In the months of April through to August, observations did not start until 9:30 p.m (longer daylight hours). Observations lasted for one to two hours depending on the traffic intensity at site. Prior to analyzing the data, quality control and assurance checks were performed to ensure the data were valid.

2.3. Measures

Methodological approaches to determine the factors that affect passenger seatbelt use include analyses that ranges from simple descriptive analysis to more complex models including logistic regression, mixed logit, and time series. While these statistical techniques have certainly provided important new insights about the factors determining passenger seatbelt use, we need applications of more rigorous methods especially when data are clustered in a longitudinal study.

In this study the outcome variable is passenger seatbelt use (Yes or No). The word "Passenger(s)" in this study refers to the right front-seat passengers in all vehicles observed. Driver seatbelt use was used as an exposure variable since past studies have indicated a high correlation between driver seatbelt use and passenger seatbelt use (Nambisan and Vasudevan, 2007; Han, 2017). Information about vehicle, roadway, time, day, month, geographic location, driver and passenger characteristics associated with the observations was also considered for the analysis.

In this study, roadway types were classified as freeways (observations were made at exit ramps), arterials, collectors or local streets.

Table 1
Passenger seatbelt non-use.

Variable	Category	Passenger Seatbelt Non-use		
		Total	No	% Seatbelt Non-Use
Data	2015 (7 waves)	11,438	1925	17%
	2016 (5 waves)	14,120	1785	13%
	Total (12 waves)	25,558	3710	15%
Passenger Gender	Male	9138	1913	21%
	Female	16,420	1797	11%
Driver Gender	Male	17,129	2473	14%
	Female	8429	1237	15%
Driver Seatbelt Use	Yes	22141	1812	8%
	No	3417	1898	56%
Vehicle	Car	11,391	1517	13%
	Pickup	4192	988	24%
	SUV	7588	892	12%
	Van	2387	313	13%
Month	1 st quarter (Jan-Mar)	2175	371	17%
	2nd quarter (Apr-Jun)	12,163	1758	14%
	3rd quarter (Jul-Aug)	4549	558	12%
	4 th quarter (Sep-Dec)	6671	1023	15%
Day	Weekday (Mon-Fri)	24,340	3561	15%
	Weekend (Sat-Sun)	1218	149	12%
Nighttime	Early (before 10 p.m)	16,451	2259	14%
	Late (after 10 p.m)	9107	1451	16%
County	Blount	3378	438	13%
	Knox	10,577	1565	15%
	Loudon	2329	328	14%
	Roane	2044	376	18%
	Sevier	7230	1003	14%
Location	Urban	14,886	2057	14%
	Rural	10,672	1653	15%
Road	Arterial	19,130	2736	14%
	Collector	5183	803	15%
	Freeway (exit ramp)	648	91	14%
	Local	597	80	13%

Sites were classified as either rural or urban depending on the population size and the level and intensity of commercial activities in the study area. Seatbelt use was observed for a variety of vehicles but they were broadly categorized as passenger cars, sport-utility vehicles, pickup trucks and passenger mini-vans. The time of observation variable included in the analysis was dichotomized as early night (from 8:00 p.m to 10:00 p.m) and late night (from 10:00 p.m to 2:00 a.m). Though observations were made on all seven days of the week, the days were collapsed into weekdays and weekends for reasonable interpretation of results. Likewise, the monthly observations were collapsed into quarters; January to March as first quarter, April to June as second quarter, July to September as third quarter and October to December as fourth quarter.

A total of 66,375 vehicles were observed during the 12 waves, out of which 25,558 vehicles had both drivers and front-seat passengers present. The average seatbelt non-use of front-seat passengers is presented in Table 1 by driver and passenger characteristics, vehicle type, month (quarterly), day, time, county, location and road type.

As shown in Table 1, the proportions of passengers observed at night not wearing seatbelts in 2015 and 2016 were 17% and 13%, respectively. The overall non-use rate averaged 15% for all the study waves. With regard to gender, males showed a higher non-use rate (about 21%) compared to females (11%). The proportion of passengers unrestrained when the drivers were males compared to when drivers were females was almost the same. From Table 1, you can see that when drivers did not use seatbelts, about 56% of their accompanying passengers did not use seatbelts as well. Among vehicle types, pickup trucks have the highest seatbelt non-use. The average seatbelt non-use rate for passengers was the highest (about 17%) in the first quarter. As shown in Table 1, the seatbelt non-use rates were slightly higher during weekdays and late nights (after 10:00 p.m) compared to the rates during weekends and early nights (before 10:00 p.m). Passengers' seatbelt non-use rates across the five-county study area ranged from 13% to 18%, with the lowest rate in Blount County and the highest rate in Roane County. Seatbelt non-use among passengers in urban and rural areas was 14% and 15%, respectively. The average passenger seatbelt non-use rate was lowest on local streets and highest on collector streets.

2.4. Statistical analysis

In this study, a "rigorous" modeling technique suitable for the analysis of data was employed. A binary logistic regression with backward variable selection criteria was initially used as a statistical technique to establish the relationship between the outcome variable (passenger seatbelt use: No) and significant explanatory variables. Like all regression analyses, the logistic regression is a predictive analysis method used to explain the relationship between one dependent variable (it can be binary, ordered or multinomial) and one or more nominal, ordinal and interval or ratio-level independent variable. In logistic regression, the unknown probability π

is estimated using a set of regressors or explanatory variables $(X_1, X_2, \ldots X_k)$. In this study, passenger seatbelt non-use was modeled as follows (Agresti, 2009):

Y be a binary response varible

$Y_i = 1$ *if passenger does not wear seatbelt*

$Y_i = 0$ *if passenger wears seatbelt*

$X_i = (X_1, X_2, \ldots X_k)$ *be a set of explanatory variables*

Then the binary logistic model is formulated as;

$$logit\,[\Pr(Y_i = 1|\ X_i = x_i)] = \text{logit}(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \alpha + \beta_1 x_i + \ldots + \beta_k x_k \quad (1)$$

where α is an estimate of the intercept term and β_i $(i = 1, 2, \ldots, k)$ is an estimate vector of k coefficients.

Generalized linear models including logistic regression work under the assumption that the data are independent, but this is not always the case (Agresti, 2009). Usually data are clustered, especially when making seatbelt observations from sites that are close to each other or making multiple observations from the same site over time as was the case in this study. These clustered data may potentially be correlated and so must be accounted for when analyzing the data. There are many extensions of the generalized linear model that can handle data that are correlated. One of these models are the Generalized Estimating Equations (GEE) which work under the quasi-likelihood method (Agresti, 2009). The GEE method provides a semi-parametric approach to longitudinal analysis of categorical response data; it can also be used for measurements that are continuous. For correlated and clustered responses, the GEE method assumes a distribution for each subject (Y_i) and determines a relationship between the variance $[Var(Y_i)]$ and the mean $[E(Y_i)]$. The GEE method is formulated as follows:

Let $Y = Y_{ij}$ *be the response for each subject i (county), measured at different times*

(e. g. waves), $j = 1,2, \ldots k$.

$X_i = (X_1, X_2, \ldots X_k)$ *be a set of explanatory variables*

Then the GEE model is given as (Agresti, 2009):

$$g(\mu_{ij}) = x_{ij}^{'}\beta \quad (2)$$

where β is a $p \times 1$ vector of unknown regression coefficients and $g(\bullet)$ is the link function. The link function can be identity, log, logit, etc.

In using the GEE method, the covariance structure of the correlated responses (Y_{ij}) must be assumed apriori. This is called the working correlation matrix. There are four correlation structures that are typically used, with each one assuming something different about the data: autoregressive, exchangeable, independent and unstructured. The autoregressive structure assumes that observations that are further apart in time are less correlated. The independent structure treats all observations as if they are unrelated while the exchangeable structure assumes that the correlation is the same for all pairs. The last, unstructured correlation matrix allows the correlation to differ between every pair. The working correlation matrix is just a starting point for the GEE method. GEE estimates of model parameters are valid even if the wrong correlation structure is chosen (because they depend on the first moment, e.g., mean.). However, if the correlation structure is wrong, the standard errors will be affected, which will require some adjustments of the data to get more appropriate standard errors. (Agresti (2009)) noted that more efficient estimates can be achieved by carefully choosing a working correlation structure. If one is unsure about which type of structure to use, the exchangeable structure is usually recommended. The analysis was completed with SAS software using PROC GENMOD with the repeated statement and the exchangeable correlation type option. The GEE method for the average nighttime seatbelt use was used to account for clustering of observations within the study area.

3. Model estimation and results

3.1. Model estimation analysis

A sensitive analysis with and without the correlation effect was performed. Table 2 shows the results for both standard logistic regression (without considering correlation) and the GEE model (considering correlation). As shown in this table, the estimates for both models are similar in terms of magnitude and direction. However, the GEE method produces more reasonably accurate standard errors when compared to the regular logistic method. The difference in standard errors between the two models is a result of the GEE method accounting for the within-subject/cluster correlations, which the regular logistic method is unable to capture. This is the rationale for adopting this method in the analysis for this paper. To better understand the magnitude of the effects of the explanatory variables on passengers' seatbelt non-use at night, odds ratios were calculated for the variables of interest.

3.2. Discussion of results

Fatally injured passenger vehicle occupants have a significantly lower nighttime seatbelt use rate and this statistic remains a public health concern. Despite the consensus in the literature regarding the effectiveness of seatbelt use in reducing severe injuries in crashes, the seatbelt use rate among fatally injured passenger vehicle occupants is not encouraging. Increasing seatbelt use is a national priority. Over the past years, the United States has made several efforts to promote the use of seatbelts including the enactment of primary enforcement seatbelt laws and behavioral interventions (e.g. public education on seatbelt laws). Though these strategies have proven to be effective, compliance to such programs or technologies is associated with relevant environmental factors, person factors, and their interactions. To address the problem of passenger seatbelt non-use at night, it is imperative that we understand how these factors affect passenger seatbelt behavior. Once the critical factors related to seatbelt non-use behavior are identified, appropriate interventions best suited to the problems can be implemented. In this study, the authors explore passenger seatbelt use through a number of factors related to driver and passenger socio-demographic characteristics, vehicle type, roadway characteristics and environmental characteristics.

The results and findings discussed here refer to the GEE parameter estimates presented in Table 2 as they provide a better fit and reasonable standard errors. As shown in Table 2, the coefficient of the intercept is negative and significant, implying that the probability of observing a front-seat passenger without a seatbelt a night is about 4 percent. As expected and discussed previously in Table 1, a majority of passengers buckled up at night but a few passengers (about 15%) exhibited non-compliance. In order to reach these small group of part-time or persistent seatbelt non-users, specific or special intervention programs are needed especially in regions or states with high seatbelt use rates (Pickrell and li, 2016).

Seatbelt use with regard to gender showed that the odds of male passengers not wearing seatbelts at night were 2.24 times greater than the odds for females. This finding is consistent with previous nighttime evaluation studies (Chaudhary et al., 2005; Vivoda et al., 2007). The differences in seatbelt use may be due to the differing societal behaviors of genders. Males generally tend to make riskier decisions in order to show how self-confident they are in being the "stronger" sex.

Besides passenger self-demographic characteristics, driver demographics and their seatbelt use behavior had significant impacts on passenger seatbelt use at night. The results show that passengers were less likely to be unrestrained at night if their drivers were males compared to female drivers. This shows that male drivers have a greater influence on their accompanying passengers with regard to seatbelt use. The results also show that if drivers fail to wear seatbelts, their accompanying passengers are much more likely not to wear seatbelts as well. (Nambisan and Vasudevan (2007)), and (Şimşekoĝlu and Lajunen (2008)) reported similar findings in a daytime observational study. The results in this study confirms that such behavioral phenomenon exists at night.

Important differences in seatbelt use behavior were also found among passengers of different vehicle types. For example, the analyses showed that occupants of passenger cars and pickup trucks were more likely not to wear seatbelts at night compared to occupants traveling in SUVs. The results are also consistent with previous studies where occupants of pickup trucks were observed to have lower seatbelt use rates (Solomon et al., 2007; Vivoda et al., 2007). The myth that "you are safer in a pickup truck compared to other vehicles, so wearing a seatbelt is unnecessary" may be one of the reasons for lower seatbelt usage among occupants of pickup trucks. In order to overcome such a false perception of increased safety in pickup trucks, special educational efforts are needed in order to persuade non-users in pickup trucks. In fact, Nichols et al. demonstrated that combining media campaigns and high visibility programs such as "Buckle up in your truck" are effective at getting occupants of pickup trucks to use safety belts (Nichols et al., 2009).

New findings in this study show that seatbelt use varies quarterly. As shown in Table 2, the results indicate that passengers are more likely to not use seatbelts at night in the first and second quarters of the year. Front-seat passengers observed between the months of January and March were about 40% more likely to be unrestrained compared to those observed between July and September. Likewise, those observed between April and June were about 12% more likely to be unrestrained compared to those observed between July and September. No significant difference in usage rates were observed between the third and fourth quarters. The potential reasons behind this finding may be due to recurring seasonal fluctuations in vehicle miles traveled. Traffic patterns in the United States over the calendar year appear to be bell-shaped with an all-time volume low occurring in February. The rates slowly rise in the summer months until peaking in August and then

Table 2
Results of the analysis of maximum likelihood estimates and GEE parameter estimates.

Parameter	Category	Analysis of Maximum Likelihood Estimates				Analysis of GEE Parameter Estimates (Empirical SE Estimates)			
		Estimate	Odds Ratio	SE	Pr > |Z|	Estimate	Odds Ratio	SE	Pr > |Z|
Passenger Seatbelt Use	No = 1								
	Yes = 0	*	*		*	*	*	*	*
Intercept		−3.180	0.04	0.11	< **.0001**	−3.181	0.04	0.07	< **.0001**
Passenger Gender	Male	0.806	2.24	0.04	< **.0001**	0.806	2.24	0.03	< **.0001**
	Female	*	*		*	*	*	*	*
Driver Gender	Male	−0.187	0.83	0.05	< **.0001**	−0.187	0.83	0.03	< **.0001**
	Female	*	*	*	*	*		*	*
Driver Seatbelt Use	No	2.649	14.14	0.04	< **.0001**	2.649	14.14	0.06	< **.0001**
	Yes	*	*	*	*	*	*	*	*
Vehicle	Car	0.128	1.14	6.34	**0.012**	0.128	1.14	0.06	**0.033**
	Pickup	0.483	1.62	0.06	< **.0001**	0.483	1.62	0.07	< **.0001**
	Van	0.070	1.07	0.78	0.377	0.070	1.07	0.15	0.638
	SUV	*	*	*	*	*	*	*	*
Month	1st quarter (Jan-Mar)	0.335	1.40	14.80	< **.0001**	0.335	1.40	0.03	< **.0001**
	2nd quarter (Apr-Jun)	0.114	1.12	3.54	0.060	0.114	1.12	0.06	**0.049**
	4 th quarter (Sep- Dec)	0.082	1.09	1.52	0.218	0.082	1.09	0.08	0.304
	3rd quarter (Jul-Aug)	*	*	*	*	*	*	*	*
Day	Weekend (Sat-Sun)	−0.026	0.97	0.06	0.808	−0.026	0.97	0.17	0.884
	Weekday (Mon-Fri)	*	*	*	*	*	*	*	*
Nighttime	Late (after 10 p.m)	0.190	1.21	0.04	< **.0001**	0.190	1.21	0.02	< **.0001**
	Early (before 10 p.m)	*	*	*	*	*	*	*	*
County	Knox	0.236	1.27	8.54	**0.004**	0.235	1.27	0.04	< **.0001**
	Loudon	0.144	1.15	2.19	0.139	0.144	1.16	0.03	< **.0001**
	Roane	0.292	1.34	9.60	**0.002**	0.293	1.34	0.02	< **.0001**
	Sevier	0.059	1.06	0.56	0.456	0.060	1.06	0.03	0.054
	Blount	*	*	*	*	*	*	*	*
Location	Rural	0.076	1.08	1.81	0.179	0.076	1.08	0.08	0.348
	Urban	*	*	*	*	*	*	*	*
Road	Collector	0.095	1.10	2.35	0.125	0.095	1.10	0.08	0.246
	Freeway (exit ramp)	0.044	1.04	0.10	0.757	0.044	1.04	0.09	0.629
	Local	0.102	1.11	0.43	0.514	0.102	1.11	0.04	**0.006**
	Arterial	*	*	*	*	*	*	*	*
Summary Statistics	N	25,558				25,558			
	AIC/QIC	16698.22				16693.813			
	−2 log likelihood	16658.22				–			
	Working Correlation	–				5.45E-06			

[*] Referenced category.

declining through the Fall and Winter before reaching the all-time calendar year low in February (Bureau of Transportation Statistics, 2018). With this background information, we hypothesize that some passengers observed in first and second quarters may have a lower risk perception under low-volume conditions and may not see the need to buckle up during such periods. In a daytime seatbelt observational study, (Gkritza and Mannering (2008)) found that front-seat vehicle occupants were more likely to be unrestrained if the hourly traffic count was less than 1200 vehicles. Hence, the lower seatbelt use during the first and second quarters may be due to lower traffic intensity. Further analysis of nighttime observations showed that vehicle occupants after 10:00 p.m (late) are less likely to wear seatbelts compared to those observed during the early hours of the night (i.e. before 10:00 p.m). Seatbelt non-use for late-night travelers may be due to other confounding factors such as the perception of not being caught in the dark or forgetfulness because of driving impairment. Though no significant difference in seatbelt use was found between weekday and weekends in this study, prior studies have indicated otherwise for daytime observations (Lipovac et al., 2015; Williams and Shabanova, 2002; Chliaoutakis et al., 2000).

Several studies have also reported that the prevalence of seatbelt use differs across states, regions, metropolitan areas, cities and human settlements (rural vs urban) (Beck et al., 2007; Shults and Beck, 2012; Huang et al., 2011). Findings from this study support prior studies. The results showed that passengers observed in Knox, Loudon, and Roane Counties were more likely to be unrestrained at night compared to those observed in Blount County. The differences in seatbelt use among the counties may be due to the level of urbanization in each county. Blount, Knox, and Sevier Counties have more clusters of urbanized areas compared to Loudon and Roane Counties, each with population a little over 50,000. It is not surprising that the seatbelt use rates of Loudon and Roane counties are lower as these two counties have consistently showed lower daytime seatbelt rates below the state average. The attitude of motorist towards seatbelt use in these areas may also be a significant factor. In 2014, Loudon and Roane recorded more seatbelt violation citations than any of the other counties in this study. Previous studies have established that seatbelt use rates of rural residents, as is the case Loudon and Roane, tend to be lower than those living in urban localities (Beck et al., 2007; Shults and Beck, 2012). In this study, even though the seatbelt non-use rate in rural areas was slightly higher than that in urban areas, statistical analysis failed to confirm such a descriptive finding.

The parameter indicator variable for road type facilities showed that front-seat passengers traveling on local streets were more likely to be unrestrained at night compared to those traveling on arterials. Local streets are low-speed, short distance road facilities and so there is a perception of lower risk, which may be a reason for a lower usage rate. In a daytime observational survey, (Gkritza and Mannering (2008)) found that front-seat passengers were more likely to be restrained when traveling on an interstate (high-speed facility) compared to lower-speed facilities.

3.3. Limitations of study

This study has several limitations. Collecting data at night is challenging. The nighttime seatbelt observations occurred between 8:00 p.m and 2:00 a.m. It is possible that if the observations had been carried out through the entire night, the nighttime seatbelt use rates may have been different. Additionally, observers were unable to identify the seatbelt use status of occupants in vehicles with tinted windows or vehicles traveling at speeds above the posted speed limit. We are uncertain whether occupants of such vehicles are among the few persistent non-seatbelt users. Common theory is that people who engage in riskier driving behavior such as speeding and drunk-driving are likely to be unrestrained (Kweon and Kockelman, 2010). The data were collected at certain periods surrounding seatbelt use campaigns (e.g. national CIOT, saturation patrols). We think that such interventions may have impacted the seatbelt use rates of vehicle occupants considered in this study.

Besides the issues related to data collection efforts, there is also a limitation on the statistical technique employed here. Although GEE methods are computationally simple and produce consistent results even with a wrong specification of the working correlation structure, there is no likelihood-based methods for testing model fit and comparing with other models. One caveat also is that this method is limited to large sample size and so may not be appropriate for cases where sample data is small. In this study the sample size is large enough to warrant the use of the GEE method.

4. Conclusion

Increasing seatbelt use among drivers and passengers has been a national safety priority. There have been several efforts to reducing fatal and serious injury-related crashes in which occupants are unrestrained. However, such efforts have been limited to daytime observations. This study used longitudinal data to examine factors related to passenger seatbelt non-use at night. The study is original in terms of new and unique data collection as well as addressing the timely issue of nighttime seatbelt non-use.

Through a modeling approach, this paper investigated seatbelt use of front-seat passengers as a function of socio-demographic characteristics of drivers and passengers, vehicle type, roadway type, location, and time. The findings show that front-seat passengers who were more likely to be unrestrained at night were males, occupants traveling in passenger cars and pickup trucks compared to those in SUVs, traveling during the first half of the year, traveling late at night (after 10:00 p.m) and driving on local streets. The findings also indicate that drivers have the greatest influence on their accompanying passenger's seatbelt use. The analyses confirm that when drivers fail to wear seatbelts, there is a higher probability that their accompanying front-seat passengers will not wear seatbelts as well.

The model results show that there are many consistent correlations between the use of seatbelts and occupant characteristics, vehicle types, road classification, and other environmental factors. The effects of these factors vary across the motorist population, so considering these variabilities may be of significant importance when developing intervention strategies to promote nighttime seatbelt use. Enforcement programs combined with earned or paid media campaigns and community-based educational outreach programs may be considered for some of the strategies implemented for increasing seatbelt use for both drivers and their accompanying passengers.

The findings in this study will provide useful information to practitioners to support their decision-making processes regarding the development and implementation of road safety programs aimed at increasing seatbelt use for all drivers and their accompanying passengers especially at night. Moreover, this study will help researchers by quantifying the problem (seatbelt use at night) and the various correlates. Additionally, this study used a data collection and analysis methodology that is comprehensive and may easily be replicated by researchers in other contexts.

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