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Understanding effect of traffic and driver related characteristics on seat belt usage in Mumbai city using random parameter logit approach and time series analysis

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ABSTRACT

Safety seat belt usage has been a great interest to the transportation community. Understanding factors that influence driver's decision of wearing a safety seat belt or not is essential in determining ways to enhance safety seat belt usage rate. A modeling approach is made to observe the trend of seat belt usage in Mumbai city and to understand the effect of vehicle type, ownership type, driver's sociodemographic, and environmental characteristics on safety seat belt usage in Mumbai City. Data were collected by roadside observational surveys at various locations in Mumbai during the years 2015 through 2018. The time series model estimate confirms declining trend of drivers not wearing safety seat belt. When vehicles are disaggregated into different build types, buses are found to be associated with no use of safety seat belt as compared to other type of vehicles, and even male drivers follow the same trend in the city. By using random parameter logit model unobserved heterogeneity was captured among individuals. Findings can be used by policymakers to develop intervention strategies to increase seat belt usage in Mumbai and other cities having similar traffic characteristics and social environment features.

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Time trend analysis; random parameter logit model; safety belt use; road safety

1. Introduction

Road transport is the dominant mode of transport in India, both in terms of traffic share and contribution to the national economy. To meet the demand for road transport, the number of vehicles and the length of road network have increased over the years. A negative externality associated with the expansion in road network, motorization, and urbanization in the country is increase in road accidents and road crash fatalities. As per the World Health Organization (WHO), 150,785 road traffic fatalities were reported in 2016 in India (WHO World Health Organization (WHO), 2018). In addition to the grief suffering, road traffic crashes constitute an important public health, and development problem with significant health, and socioeconomic costs. Moreover, the Ministry of Road Transportation and Highway accident data depicts that the proportion of fatal accidents has increased since 2005 from 19.0% to 28.3% in 2016 in which Mumbai has the highest number of road accidents (Ministry of Road Transport & Highways, 2016). Mumbai is one of the most populous cities in India, and being the economic headquarters of the country, the population is increasing at an alarming rate. According to a report from the Central Ministry of Road Transport and Highways, Mumbai saw 3160 road accidents in 2017, of which 467 were fatal, and 2603 were injury accidents (Ministry of Road Transport & Highways, 2017). In 2017, 26896 people died due to the non-usage of seatbelts in India. This is an exponential increase over last years' number (Ministry of Road Transport & Highways, 2017). In 2016, around 5638 road crash deaths were reported due to the non-usage of seatbelts (Ministry of Road Transport & Highways, 2016). In order to reduce such fatalities, use of safety seat belt must be practiced. Global Status Report on Road Safety 2018 by WHO suggest that wearing seat belt reduces the risk of fatalities among driver and front-seat occupants by 45-50% and the risk of minor and serious injuries by 20% and 45% respectively (WHO World Health Organization (WHO), 2018). Although India has a law on the use of safety seatbelt, implementation is a challenge due to lack of awareness and weak enforcement of the laws. In countries such as the United States, New York was one of the first states to enact safety belt use legislation in early 1980s and it has been noticed that safety belt laws are an effective way to increase safety seat belt usage. However, several sociodemographic characteristics of drivers and passengers have a huge impact on safety seat belt use (Gkritza & Mannering, 2008). Some previous studies depict that female drivers prefer wearing seat belt as compared to male drivers (Reinfurt et al., 1996; Wells et al., 2002; Nelson et al., 1998). Empirical evidence suggests that young adults are less likely to use seat belt due to forgetfulness, laziness, perceived low risk of injury and discomfort (Begg & Langley, 2000). Moreover, Michigan study depicts that

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commercial light vehicles tend to have lower safety belt usage rates (Eby et al., 2002a). In terms of vehicle type, pickup trucks, and other vehicles apart from passenger cars are correlated with non-usage of seat belt (Center of Applied Research & Inc, 2004). In addition, a study conducted by Nissan India and SaveLife foundation for Indian cities including Mumbai for seat belt usage concludes that most Indian drivers do not use seat belt which is due to lack of awareness, ignorance of the law, and weak law enforcement (SaveLife Foundations, 2019).

In terms of methodological approach, many studies depict that time series analysis can be used in road safety research to analyze trends at an aggregate level. Although, there are several techniques for the analysis of time-series data; classical linear regression, standard generalized linear, and nonlinear models; they usually cannot account for the dependencies in time series data (Commandeur et al., 2013). To bridge this gap, ARMA (autoregressive moving average) and ARIMA (autoregressive integrated moving average) models can be used. As they can describe the dynamics of a process over time and to extrapolate it into the future, without any call to additional variables and with the only assumption that the process dynamics will stay unchanged until the forecast horizon (Box et al., 1994; Brockwell & Davis, 1987; Brockwell & Davis, 1998). Another study examined the prevalence of drink driving and speeding in China using ARMA models and found that the commonness of both factors is relatively low in their study area. However, their findings indicate improvements and suggested that their results must be interpreted with caution (Li et al., 2017). In 2013, to understand the factors that influence the decision of wearing a seat belt or not in school bus several modeling techniques have been employed including multinomial, nested, and mixed logit modeling, and concluded that nested and mixed logit models are recommended to describe and predict seat belt usage (Mehta & Lou, 2013). In addition, to understand the effect of vehicle, roadway, and occupant characteristics on seat belt usage in single and multi-occupant vehicles random parameter (mixed) logit model was adopted (Gkritza & Mannering, 2008). As random parameter logit model addresses all the limitations of the multinomial logit model (random error terms are independent) and nested logit model (values of coefficients are considered the same across the individual decision-makers) (Mehta & Lou, 2013).

However, previous studies have not considered all possible correlations among unknown and unobserved factors that may contribute to seat belt usage. Following a new protocol, information at a disaggregated level about traffic and driver-related characteristic is obtained. Safety belt usage rate is affected by many confounding factors that need to be addressed. Moreover, due to the high population, Indian cities have heterogeneous traffic which is different from other countries. A heterogeneous traffic mix that includes high-speed vehicles sharing the road space with vulnerable road users as well as unsafe road infrastructure and vehicles that are in poor condition all contribute to the high fatality rates seen on Indian roads. Due to such traffic conditions, drivers are less cautious and compassionate on the roads. A rigorous analysis is conducted to detect the trend in safety seat belt usage in Mumbai city using time series analysis and to understand the effect that vehicle type, ownership type, driver and environmental characteristics have on the safety seat belt usage. This can be useful for taking a policy level decision on the implementation of seatbelt usage law.

2. Data collection process

Seat belt usage data are collected as a part of ongoing research project under the Bloomberg Initiative for Global Road Safety supported by John Hopkins International Injury Research Unit (USA) in collaboration with the Indian Institute of Technology, Bombay (IITB) for Mumbai city. In order to collect data seven rounds of observational surveys were made at ten selected locations in Mumbai during the years 2015 through 2018. The selected sites lie within the Mumbai city district and are near signalized intersections. The collection procedure, protocol, and design of survey form were prepared by the John Hopkins International Injury Research Unit, Baltimore, USA. The data were collected in two timeframes in a year, i.e. February – April, and June –September on weekends and weekdays at each location. The survey duration was divided into five equal intervals of one and a half hours starting from 7:30 AM to 7:00 PM. The data collected are rich and of high quality; two-day training was given to observers before data collection. Two data collectors were allotted to each site along with an observer who filled data in a survey form. The data were collected by observing vehicles that were waiting at the signalized intersection for green indication. The data were collected as per the survey form with entries like vehicle type, vehicle ownership type, gender, age, seatbelt usage category; i.e. yes/no. They were collected for each observation. In addition, details like number of occupants, weather conditions, visible presence of law enforcement, and survey days were recorded during the survey. In total, 257,056 observations were recorded during the seven rounds of observational survey. However, 90,578 observations reveal no association with seat belt usage and when disaggregated by vehicle type, 42% of bus drivers and 30% of sedan/saloon drivers did not wear seat belts during their trip as shown in Figure 1. In addition, 27% of private vehicle users and 37% of other vehicle users follow the same trend and are less likely to wear a safety seat belt as shown in Figure 2.

3. Methodological approach

3.1. Time series analysis: ARIMA modeling

Time series analysis is commonly used in road safety research and other fields. To understand the changes in prevalence of seat belt usage and effect of different interventions adopted by the city time trends analysis is required. In road safety research, most time series are constructed by aggregating or averaging some quantity over a specific period of time and then tabulating its value for subsequent periods (Dupont & Martensen, 2007). The autoregressive and

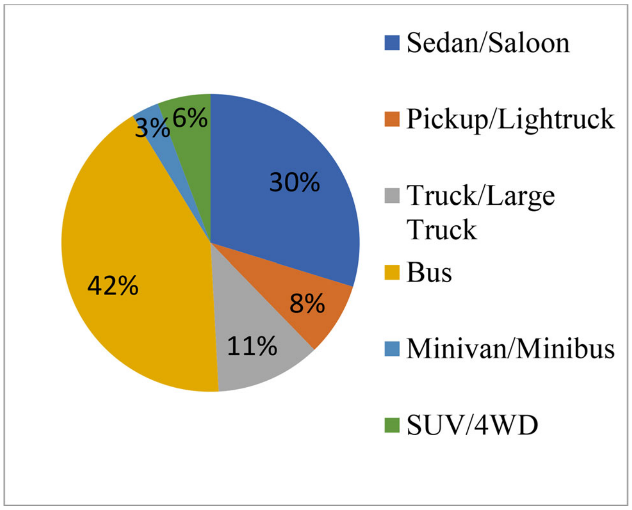

Figure 1. Non-usage of seat belt based on vehicle type.

moving average (ARMA) models describe the relationship between its values at different time points. It is often noticed that stationary series are usually not found in road safety. To make the series stationary so-called filter of differences is applied to the process y_t, removing the trend and seasonality making results of the process stationary (Box & Jenkins, 1976). First order of differencing was enough to obtain stationarity as autocorrelation function (ACF) plot showed no long-term trend, which implies that the series tends to return to its mean. In addition, to stabilize variance, data were systematically log-transformed. Hence, first-order autoregressive model with one order of non-seasonal differencing is used.

$$y_t = \mu + y_{t-1} + \phi(y_{t-1} - y_{t-2}) + \varepsilon_t \quad (1)$$

Where y_t is the outcome at time t, μ represents the constant and ϕ is the autoregressive coefficient and ε_t is a white noise disturbance. The percentage of drivers not wearing seat belt during the survey from the years 2015 to 2018 is considered for developing this model. IBM SPSS Statistics 23 statistical software was used to develop this model (*IBM SPSS Statistics 23 Brief Guide Product Information*, 2017).

3.2. Random parameter (mixed logit) logit model

The random parameter (mixed logit) logit modeling approach was carried out to understand the effect of vehicle type, ownership type, driver's sociodemographic and environmental characteristics on drivers' decision of wearing safety seat belt. Moreover, several other studies have adopted mixed logit models in transportation and road safety-related research. Safety seat belt function determining whether safety seat belts is used by the driver is defined as,

$$B_{in} = \beta_i X_{in} + \varepsilon_{in} \quad (2)$$

Where B_{in} is the safety seat belt use function determining the safety belt use category i, i.e. for driver using safety seat belt; driver not using safety seat belt, in vehicle n; X_{in} is a vector of explanatory variables, e.g. type of vehicles, type of vehicle ownership, environmental attributes, sociodemographic of the driver; β_i is a vector of estimator parameter

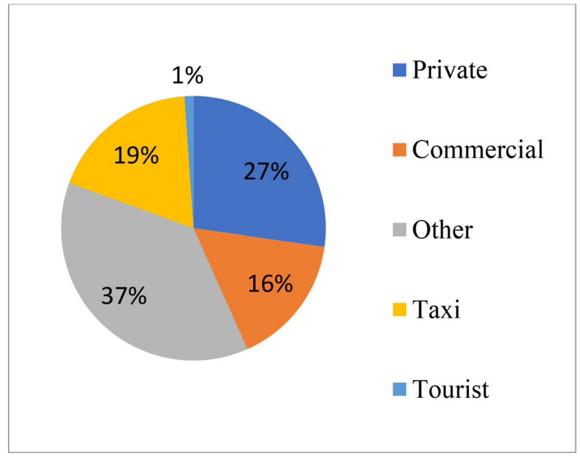

Figure 2. Non-usage of seat belt based on vehicle ownership.

for each category, and ε_{in} is an error term. McFadden (1981) has shown multinomial logit model results in the form of Equation 3:

$$P_n(i) = \frac{\exp[\beta_i X_{in}]}{\sum_I \exp[\beta_i X_{in}]} \quad (3)$$

Where $P_n(i)$ is the probability of safety seat belt option i from the set of all safety seat belt usage option categories I for vehicle n. In order to allow parameter variation across vehicle driver, a mixing distribution is introduced giving safety seat belt use probabilities (Train, 2003)

$$P_{in} = \int \frac{\exp[\beta_i X_{in}]}{\sum_I \exp[\beta_i X_{in}]} f(\beta|\varphi) d\beta \quad (4)$$

Where $f(\beta|\varphi)$ is the density function of β with φ referring to a vector of parameters of the density function, mean and variance. For this mixed logit model, β can account for vehicle-specific variations of the effect X on safety seat belt use probabilities, with density function $f(\beta|\varphi)$ which is used to determine β. Mixed logit probabilities are then a weighted average for different values of β across vehicles where some elements of β may be fixed and some may be randomly distributed. However, if the vectors are random, the mixed logit weights are determined by the density function $f(\beta|\varphi)$. Usually, a simulation-based approach is used to determine the maximum likelihood function in mixed logit modeling. As compared to standard random draws, Halton draws is more used as it can achieve convergence much faster than them (Train, 2000; Bhat, 2003). A simulation was conducted based on 200 draws which are adequate to produce accurate parameter estimates (Gkritza & Mannering, 2008; Milton et al., 2008). In order to develop this model, factors such as vehicle type, ownership type, driver characteristics, and environmental conditions were considered as they influence the driver's decision to wear safety seat belt or not. A total of 10226 observations were used, and Table 1 depicts all variables considered and dummy values assigned to each category. Majority of the drivers are male with a mean of 0.76. Moreover, sedan and private vehicle users belong to a dominant group as compared to other vehicle types and ownership types as listed in Table 1. The mixed logit model was estimated using a

Table 1. Descriptive statistics of variables.

Variables	Description	Mean	SD
Safety Seat Belt	Dummy, if driver is wearing safety seat belt =1, 0 otherwise	0.75	0.42
Type of Vehicle			
Sedan/Saloon	Dummy, if vehicle type is sedan/saloon =1, 0 otherwise	0.71	0.44
Pickup/Light Truck	Dummy, if vehicle type is pickup/light truck =1, 0 otherwise	0.08	0.27
Truck/Large Truck	Dummy, if vehicle type is truck/large truck =1, 0 otherwise	0.02	0.15
Bus	Dummy, if vehicle type is bus =1, 0 otherwise	0.04	0.21
Minibus	Dummy, if vehicle type is minibus =1, 0 otherwise	0.007	0.08
Sports Utility Vehicle/4 Wheel Drive	Dummy, if vehicle type is SUV/4WD =1, 0 otherwise	0.11	0.32
Type of Ownership			
Private Vehicle	Dummy, if vehicle's ownership is private based = 1, 0 otherwise	0.61	0.48
Commercial Vehicle	Dummy, if vehicle's ownership is commercial based =1, 0 otherwise	0.10	0.30
Government Vehicle	Dummy, if vehicle's ownership is government based = 1, 0 otherwise	0.04	0.21
Taxi vehicle	Dummy, if vehicle's ownership is taxi based =1, 0 otherwise	0.23	0.42
Tourist vehicle	Dummy, if vehicle's ownership is tourist based =1, 0 otherwise	0.005	0.07
Law Enforcement			
Camera	Dummy, if there is a presence of law enforcement camera along the route =1, 0 otherwise	0.19	0.39
Sociodemographic Characteristics			
Gender	Dummy, if driver's gender is male =1, 0 otherwise	0.76	0.42
Age	Dummy, if driver's age is within the range of 24 to 59 = 1, 0 otherwise	0.67	0.46

Note: SD = Standard Deviation.

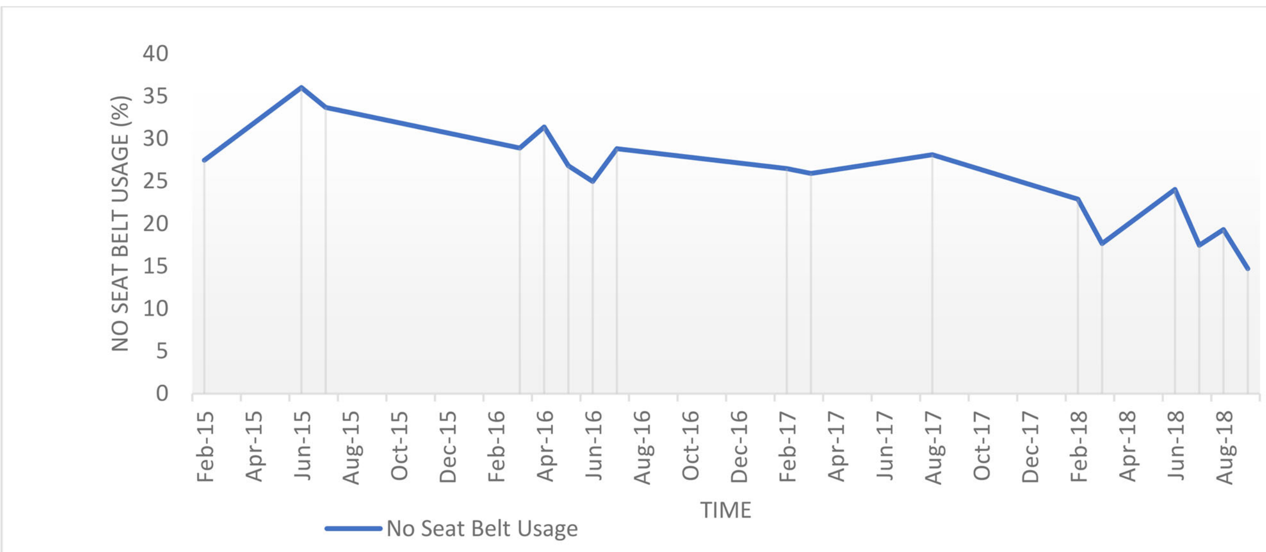

Figure 3. Trend of No Seat Belt Usage in Mumbai City 2015 to 2018.

mathematical software package (Econometric Software Inc, 2007). Initially, all variables were tested in the model but later variables found to be insignificant were dropped from the final model. During the model building process variables dropped in terms of vehicle type were trucks, minibus, and in terms of ownership type were commercial, other, and tourist vehicles, and lastly, weather. In addition, a similar approach was adopted where model development includes selection of random parameters, and log-likelihood value at convergence is used as a basis to identify the random parameters (Hensher et al., 2005; Goh et al., 2014).

4. Results and discussion

4.1. Modeling seat belt usage trend using time series analysis

The seven rounds of observational studies cover 17 months of survey at ten different locations in Mumbai during the years 2015-2018. Figure 3 depicts trend and percentage of drivers in Mumbai city not wearing safety seat belt during the observation period. On average, 74% of motorists were found to be using seat belt while making their trips. Approximately 36% of drivers are not likely to wear seat belt during May-August 2015 which gradually declined, and a substantial reduction was observed in March 2018. This low level was sustained until the end of the survey which reduced to 14.6% in September 2018. However, fluctuation in rate can be noticed between February – August 2016. From Table 2, the statistical significance of the overall declining trend can be confirmed using the time series model. For developing a model first-order autoregressive with one order of non-seasonal differencing structure was used and has the lowest Bayesian Information Criterion (BIC) value. The estimate of parameter is below one which indicates a declining trend of seat belt usage in the Mumbai city. This trend can be due to an increase in awareness regarding road safety and better law enforcement techniques adopted by the Mumbai Traffic Police.

Table 2. Time series model for Mumbai City.

	Estimates	t-statistic
L1.AR	−0.574	−2.484
Difference	1	NA
Constant	−0.022	−2.09
Number of observation (in Months)	17	NA

Table 3. Random parameter logit model results.

Variables	Parameter Estimate	Standard Error	t-statistic
Constant	1.437	0.171	8.40
Type of Vehicle			
Sedan/Saloon	0.649	0.081	8.00
Pickup/Light Truck	0.469	0.070	6.67
Bus	−0.825	0.095	−8.64
Sports Utility Vehicle/4 Wheel Drive	0.665	0.088	7.50
Type of Ownership			
Private	0.540	0.074	7.25
Taxi	0.361	0.076	4.71
Sociodemographic characteristics			
Gender_Male	−0.240	0.075	−3.20
Age_24 to 59 years (Random)	−0.082 (0.105)	0.035	−2.37
Law Enforcement			
Camera	−0.185	0.075	−3.19
Number of observations		10226	
Log-likelihood at constant		−5661.439	
Log-likelihood at convergence		−4821.162	
McFadden's Pseudo R^2		0.319	

Note: All parameters presented in the final model specification are significant at 95% confidence level. The value of the Akaike information criteria and Bayesian information criteria for model is 9664.35 and 9743.884 respectively. The adjusted R^2 value for the model is 0.148.

4.2. Modeling various factors affecting seat belt usage

Table 3. depicts the results of the random parameter logit model estimation of safety seat belt usage in vehicles. All estimated parameters are statistically significant, and the signs are plausible. For all the random parameters, the normal distribution was found to be providing the best statistical fit. From the results, it's quite evident that vehicle type affects seat belt usage. For instance, drivers travelling by sedan/saloon, pickup/light truck, and sports utility vehicle showed higher association with seat belt usage. On the other hand, bus drivers showed a negative relationship with seat belt usage, which might be due to the absence of driver's seat belt in bus which was observed during the survey. Also, a similar study depicts that truck and passenger van drivers are less likely to wear safety seat belt during their trips (Gkritza & Mannering, 2008). The next set of findings is related to the ownership type of the vehicles. The parameter estimates suggest that private and taxi owned vehicle drivers have higher likelihood of safety seat belt usage as compared to other ownership types. Moreover, sociodemographic characteristics of driver such as age and gender have a significant influence on safety seat belt usage. The indicator variable for male drivers was found to be fixed with a parameter estimate of −0.240, which indicates that female drivers prefer wearing safety seat belt as compared to male drivers. Wells et al., 2002 and Reinfurt et al., 1996 illustrate similar findings in their study. Interestingly, indicator variable of driver's age is estimated to be normally distributed with a mean of −0.082 and standard deviation of 0.105. This implies that drivers falling in the age range of 25-59 years old have lower value function for wearing safety seat belt during their trip. In terms of law enforcement related factors, variable indicating presence of camera at an intersection or on a stretch of road was found to be statistically significant. The parameter of the variable indicating presence of camera depicts that drivers do not prefer wearing safety seat belt in the presence of cameras for law enforcement. These findings indicate that there is a spillover effect of heterogeneous traffic mix in Mumbai city on seat belt usage and it may vary across the type of vehicle, ownership and also depends upon driver characteristics. High vehicular traffic and speeding vehicles show risk-taking behaviour of the driver as a significant amount of road users are not using safety seat belt which may increase the accident fatality rate. Overall findings depict that, on average 26% of motorists are not using seat belt in Mumbai which can be due to lack of awareness, ignorance of the law, and weak law enforcement.

5. Summary and conclusions

Increasing safety seat belt usage is an effort to reduce fatal and injury-related accidents. The trend of safety seat belt usage in Mumbai city during 2015-2018 is explored. Particularly, the effect of vehicle type and ownership type on safety seat belt usage is investigated. In addition, driver's sociodemographic and law enforcement indicators were also incorporated in this study. To investigate the relationship and understand the effect these attributes has on driver decision to wear seat belt or not, a random parameter logit model was developed, and a statistical confirmation of the trend of seat belt usage through time series analysis was conducted. The random parameter logit model accounts for unobserved heterogeneity among the sample individuals. Time series analysis indicates decreasing trend of non-usage of safety seat belt among drivers, which is statistically confirmed using an autoregressive integrated moving average model. However, as evident from Figure 3, a fluctuation exists in the non-usage trend of seat belt during February 2016 – August 2016, and in April - August 2018; a substantial reduction was observed.

The developed modeling approach can be used for estimating safety seat belt use as a function of the type of vehicle, type of ownership, driver's sociodemographic, environmental condition, and law enforcement indicator. Results from the random parameter mixed logit model depict that among vehicle types, sedan/saloon, pickup/light truck, and sports utility vehicle/4 wheel drive have a higher likelihood towards safety seat belt usage. Whereas, bus drivers showed the opposite results. Similar findings were reported where sports utility vehicle and passenger car drivers are more likely to wear safety seat belt as compared to other types of vehicles (Gkritza & Mannering, 2008). In addition, when disaggregated in terms of ownership, private vehicle driver and taxi driver tend to wear safety seat belt which is quite favourable towards higher level of road safety, since the majority of the vehicles in Mumbai city are privately owned or operate as a taxi. Moreover, parameter estimates for presence of camera as a measure of law enforcement illustrate that drivers do not use safety seat belts in their presence. However, these parameters vary across the population and thus might have opposite effects for some.

Among sociodemographic, an indicator variable for age depicts heterogeneity, however, results show that drivers within the range of 24 to 59 years old are less likely to use safety seat belt. This finding implies that younger, i.e. 18 to 23 year olds and elderly, i.e. 60 year olds or above drivers tend to wear safety seat belt while making the trip, as they are more cautious and aware of the law enforcement. Finally, parameter estimates depict that male drivers have lower association with safety seat belt usage as compared to female drivers. These findings contribute to the ability to understand and address the effectiveness of vehicle, driver, and traffic-related factors on seat belt usage in Mumbai city. The findings highlight the dominant group of motorists not using seat belt disaggregated in terms of vehicle type, ownership type, and based on gender, age which must be considered by policymakers while developing the intervention strategies to enhance law enforcement in the city and generate more awareness amongst the road users. With such useful information, these results may not be applicable everywhere due to various reasons. Firstly, the age range considered for this database is from 24 to 59, which covers the majority of the population and might give biased results. Secondly, certain driver behaviour attributes were not captured and considered. Moreover, the parameters are assumed to be normally distributed in a mixed logit model which might not be true for other areas. The results may only be unique to Mumbai because of certain distinctive features in its traffic and social environment but can be applicable to other cities having similar features. However, mentioned variabilities and limitations must be considered while developing intervention strategies and enhancing safety seat belt usage law.

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References

Begg, D. J., & Langley, J. D. (2000). Seat-belt use and related behaviors among young adults. Journal *of Safety Research*, *31* (4), 211–220. https://doi.org/10.1016/S0022-4375(00)00038-4

Bhat, C. R. (2003). Simulation estimation of mixed discrete choice models using randomized and scrambled Halton sequences. *Transportation Research Part B: Methodological*, *37* (9), 837–855. https://doi.org/10.1016/S0191-2615(02)00090-5

Box, G. E. P., & Jenkins, G. M. (1976). *Time series analysis: Forecasting and control* (Rev. ed.). Holden-Day.

Box, G. E. P., Jenkins, G. M., & Reinsel, G. C. (1994). *Time series analysis. Forecasting and control* (3rd ed.). Prentice Hall.

Brockwell, P. J., & Davis, R. A. (1987). *Time-series: theory and methods*. Springer-Verlag.

Brockwell, P. J., & Davis, R. A. (1998). *Introduction to time series and forecasting*. Springer-Verlag.

Center of Applied Research, Inc. (2004). *Rural pickup truck drivers and safety belt use: Focus group report* (Report No. DOT HS 809 711). National Highway Traffic Safety Administration, U.S. Department of Transportation.

Commandeur, J. J. F., Bijleveld, F. D., Bergel-Hayat, R., Antoniou, C., Yannis, G., & Papadimitriou, E. (2013). On statistical inference in time series analysis of the evolution of road safety. *Accident; Analysis and Prevention*, *60* (2013), 424–434. https://doi.org/10.1016/j.aap.2012.11.006

Dupont, E., Martensen, H. (Eds.). (2007). Multilevel modeling and time series analysis in traffic safety research – Methodology. Deliverable D7.4 of the EU FP6 project SafetyNet.

Eby, D. W., Fordyce, T. A., & Vivoda, J. M. (2002a). A comparison of safety belt use between commercial and noncommercial light-vehicle occupants. *Accident; Analysis and Prevention*, *34* (3), 285–291. https://doi.org/10.1016/S0001-4575(01)00024-0

Econometric Software Inc (2007). Nlogit version 5.0.

Gkritza, K., & Mannering, F. L. (2008). Mixed Logit analysis of safety-belt use in single- and multi-occupant vehicles. *Accident; Analysis and Prevention*, *40*(2), 443–451. https://doi.org/10.1016/j.aap.2007.07.013

Goh, K., Currie, G., Sarvi, M., & Logan, D. (2014). Factors affecting the probability of bus drivers being at-fault in bus-involved accidents. *Accident; Analysis and Prevention*, *66* (2014), 20–26. https://doi.org/10.1016/j.aap.2013.12.022

Hensher, D., Rose, J., & William, G. (2005). *Applied choice analysis: A primer*. Cambridge University Press.

IBM SPSS Statistics 23 Brief Guide Product Information (2017).

Li, Q., He, H., Duan, L., Wang, Y., Bishai, D. M., & Hyder, A. A. (2017). Prevalence of drink driving and speeding in China: a time series analysis from two cities. *Public Health*, *144* (2017), S15–S22. https://doi.org/10.1016/j.puhe.2016.11.024

McFadden, D. (1981). Econometric models of probabilistic choice. In: Manski, C., McFadden, D. (Eds.), *A Structural Analysis of Discrete Data with Econometric Applications*. The MIT Press.

Mehta, G., & Lou, Y. (2013). Modeling school bus seat belt usage: Nested and mixed logit approaches. *Accident; Analysis and Prevention*, *51*(2013), 56–67. https://doi.org/10.1016/j.aap.2012.10.008

Milton, J. C., Shankar, V. N., & Mannering, F. L. (2008). Highway accident severities and the mixed logit model: An exploratory empirical analysis. *Accident; Analysis and Prevention*, *40* (1), 260–266. https://doi.org/10.1016/j.aap.2007.06.006

Ministry of Road Transport & Highways. (2016). Road Accidents in India 2016. Government of India.

Ministry of Road Transport & Highways. (2017). Road Accidents in India 2017. Government of India.

Nelson, D. E., Bolen, J., & Kresnow, M. (1998). Trends in safety belt use by demographics and by type of state safety belt law, 1987 through 1993. *American Journal of Public Health*, *88* (2), 245–249. https://doi.org/10.2105/ajph.88.2.245

Reinfurt, D., Williams, A., Wells, J., & Rodgman, E. (1996). Characteristics of drivers not using seat belts in a high belt use state. Journal *of Safety Research*, *27* (4), 209–215. https://doi.org/10.1016/S0022-4375(96)00026-6

SaveLife Foundations. (2019). Study on rear seat belt usage and child road safety.

Train, K. (2000). *Halton sequences for mixed logit department of economics*. Berkeley.

Train, K. (2003). *Discrete choice methods with simulation*. Cambridge University Press.

Wells, J. K., Williams, A. F., & Farmer, C. M. (2002). Seat belt use among African Americans, Hispanics, and Whites. *Accident; Analysis and Prevention*, *34*(4), 523–529. https://doi.org/10.1016/S0001-4575(01)00050-1

World Health Organization (WHO). (2018). Global status report on road safety.