

The comparison of regional and urban transit bus driver distraction

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Abstract

This paper compares the distraction risks and factors causing such distractions between regional and urban transit bus drivers. The objective is to ascertain if the nature and intensity of driver distraction and associated distraction factors are common at the different types of transit agencies. To establish this, an independent driver distraction study was conducted at a regional transit agency and an urban transit agency located at different areas in the Commonwealth of Virginia, USA. Using accident databases and bus driver surveys, the distracting activities were classified into risk zones according to their severity. Furthermore, multinomial logistic regression models were applied to establish relationships between a set of dichotomous and continuous distracting factors and intensity of the multi categorical levels of driver distraction based on risk zones.

Among the useful findings was similarity in the highest risk distracting activities for regional and urban transit bus drivers which were mainly due to passengers, pedestrians and other road users. While many of the distraction related factors such as the service area (regional/urban), driver attributes (age, gender, driving experience, educational level, marital status etc.), driving pattern (driving schedule, driving hours per week, service location etc.), and type and age of the buses were significant in either regional and urban models, there were few that impacted both the transit agencies concurrently. The reasons for the resulting differences could be due to significant variations in driver attributes, driving pattern, type and age of buses between the transit agencies. Hence, training needs and policies to curb distracted driving may differ at both agencies. *Keywords: transit bus driver distraction, analysis of transit accident databases, distraction survey of bus drivers, classification of distracting activities, application of multinomial logistic regression, Distraction Risk Index, distraction risk zone.*



1 Introduction

Cities and metropolitan areas around the world depend on efficient and convenient transit systems (including buses) for moving persons and goods from one place to another. Transit systems utilizing motor buses operating on public roads or, sometimes, special roadways are mostly managed by local transit agencies. Transit agencies face continuous challenges of controlling traffic accidents as injuries from accidents are generally higher because buses carry many passengers. The National Transit Database (NTD) maintains accident statistics that reveal important information regarding incidents (e.g. bus collision, passenger injury, and vehicle damage and theft) reported by transit agencies [1]. Analysis of accident databases has found driver distraction to be a significant cause of total motor vehicle crashes [2]. The distraction occurs when a driver's attention is diverted away from driving by a secondary task that occurs approximately 30% of the vehicle movement time [3].

The risks of distraction are generally higher in the case of transit buses due to the driver performing added secondary tasks and attending to many passengers. Yet, research work on transit bus driver distraction in the US is very limited [4, 5] and comparison of driver distraction between transit agencies serving different regions and localities is not available. Many factors, including driver attributes, driving pattern, service location, and type and age of bus are known to affect driver distraction and expected to vary based on the characteristics of locality.

This paper compares the types of distraction between regional and urban transit bus drivers in the Commonwealth of Virginia along with factors causing such distractions. The regional agency covers a larger area in and out of several connected cities and counties. The urban agency covers a smaller compact area mostly serving commuters and metro passengers on fixed routes and with fixed schedules. Using two to three years of accident data along with a self-administered driver survey for each driver group, descriptive and inferential statistical analysis was carried out. Tabular and graphical models, together with the generalized linear model of multinomial logistic regression (MLR), were used in the data analysis. The objective was to ascertain if the nature and intensity of driver distraction and associated distraction factors were similar for regional and urban drivers in different areas of the Commonwealth of Virginia. An understanding of differences between factors impacting regional and urban distraction risks is required to assess the bus drivers' training needs [5] and to guide policymakers in crafting counter measures to curb distracted driving [6].

The categorical distracted driving risk was measured in three levels: Not Distracted, Slightly Distracted, and Distracted (including Very Distracted). Using the MLR model, this multi-categorical response variable was linked to the predictor variables so as to provide information on the magnitude and direction of each variable's coefficient on driver distraction.

The results of the statistical analysis provided valuable information that distinguishes both types of agencies based on causes and level of bus driver distraction and the factors which impact distractions. Three out of the five highest risk distracting activities are internal passenger-related for both type of

transit agencies. The factors causing these same distractions had different impacts on the level of distractions due to varied driver attributes, driving pattern, service location, and type and age of vehicles at both agencies. The results from the statistical models provide useful insight into the types of transit bus driver distractions that are highly risky, along with the estimated coefficients that impact these distractions at the agencies.

2 Literature review

Driver distraction represents a significant problem in the personal and public transport sector and has been studied by several national and international researchers, and governmental agencies [2–9]. The source of bus driver distractions at a major Australian public transit company was investigated using ergonomics methods through which, a taxonomy of the sources of bus driver distraction was developed, along with countermeasures to reduce their effects on driver performance [7]. In a pioneering study, Salmon *et al.* [8] ranked the distraction sources, duration, and perceptions of bus drivers at the State Transit Authority New South Wales, Australia. In this study, a taxonomy of the sources of distraction was developed and a descriptive statistical analysis was conducted. D'Souza and Maheshwari [5] expanded the work of Salmon *et al.* [8] using multivariate statistical models to study the impact of driver attributes, driving pattern, type and age of the bus, and service location on distracting activities.

Past studies on the impact of driver attributes and driving patterns on driving performance have produced mixed results. The impact of age, gender, driving experience, and driving demands on driving performance suggests that younger (below 25 years) and older (above 70 years) drivers tend to be more vulnerable to the effects of distraction than middle-aged drivers [9, 10]. Factors such as location, driving hours/week; and driver age, gender, and experience have an impact on public bus driver distraction [5]. A driving route running through a densely populated area would service a larger number of passengers and experience higher distraction due to external sources like more frequent stops, higher traffic, and/or pedestrians [5].

Multivariate statistical models are widely used in transportation to study the relationship between the categorical response or dependent variable (DV) consisting of a set of categories and a set of continuous and categorical predictor or independent variables (IVs). The multivariate model applied by Yan *et al.* [11] utilized multinomial logistic regression (MLR) to study the impact of potential factors such as driver characteristics, road layout, and environmental conditions on rear-end truck to car, car to truck, and car to car crashes. Washington *et al.* [12] developed a multinomial logit (MNL) model consisting of 18 independent variables covering driver factors, traffic flow, distance, and number of signals etc. to study factors that influence drivers' selection of route on their morning commute to work. The nominal outcome variable represented the mode of travel (an arterial, a two-lane road, or a freeway) and the covariates consisted of categorical variables (for example, number of signals) and

continuous variables (for example, travel distance). A MLR model was developed by Morfoulaki *et al.* [13] to identify the factors contributing to service quality and customer satisfaction (*very satisfied, satisfied, somewhat dissatisfied, and very dissatisfied*) with a public transit service in Greece. Following the approach of Washington *et al.* [12] and Morfoulaki *et al.* [13], D'Souza and Maheshwari [5] proposed an MLR model to analyze public transit bus driver distraction that included five predictor variables linked to a categorical response variable.

Independent driver distraction studies have been conducted at different locations and at different types of transit agencies. But to the best of the author's knowledge, none have compared distractions at these different areas for assisting in formulation of regulatory policies. Khorashadi *et al.* [14] compared accident severity in large trucks and found several significant differences with respect to risk factors between urban and rural locations. Although the risk factors were related to accident severity, it closely resembles this study since driver distraction is one of the significant cause of accidents and hence, the methodologies [14] provide useful inputs for this research.

3 Analysis and results of regional and urban bus drivers' distraction

Historical accident data was collected from the past two to three years accident databases and current distraction data was collected from self-administered surveys for the regional and urban transit bus drivers. The distracting activities from the surveys were ranked according to ratings, duration, and driver's perception of distraction [5]. Each activity was graded relative to the maximum rating, and duration and perception of distraction that was used to compute the Distraction Risk Index (DRI). The DRIs were then used to classify the distracting activities into four risk zones: Risk Zone I *Very High Risk*, Risk Zone II *High Risk*, Risk Zone III *Moderate Risk*, and Risk Zone IV *Low Risk* [5].

3.1 Data analysis

The accident database and survey results are summarized for the regional and urban drivers in Table 1. The accident rates have been computed on an annual basis per million riders to account for ridership difference. The total number of regional annual accidents per million riders is over 75% higher compared to the urban drivers with preventable accidents over seven and half times higher. Since accidents due to driver distraction account for 17% of the total accidents, it can be concluded there is a higher distraction accidents in the regional agency (6.29) as compared to urban agency (3.52) which also accounts for the higher rate of preventable accidents.

3.2 Multivariate statistical analysis

The Risk Zone I activities were further analyzed using multivariate statistical models [5] to elicit the factor(s) causing distraction. The generalized linear model (GLM) technique of multinomial logistic regression (MLR) was applied to relate discrete, dichotomous, and continuous predictors or independent variables (IVs), and nonlinear categorical outcome or dependent variables (DV) [16]. The outcome is the distraction activity having risk-levels experienced differently by the drivers with specific attributes, driving pattern, and type of equipment. The distracting activities had three categories of risk-levels: *Not Distracted*, *Slightly Distracted*, and *Distracted*.

Table 1: Summary of accident database and survey results.

Annual/Million Riders	Regional	Urban	Attributes	Regional	Urban
Total Accidents	37.0	21.0	Gender: Males	45%	74%
Preventable	5.24	0.69	Females	55%	26%
Non-Preventable	25.41	13.71	Mean Age (Years): (49.5, 9.5)	(47, 9.69)	
Total Accident/Driver	0.77	0.48	Driving Exp (Years): (11.4, 8.6)	(8, 8.35)	
Accidents due to Driver Distraction	6.29	3.52	Driving Hrs/Wk	(38.9, 10.7)	(37.1, 15.2)
Other Causes	30.64	17.05	Avg. Age of Bus (Yrs)	6.1	9.5
Comparison of risk zone distracting activities					
Risk Zone	Type of risk	Regional distracting activities	Urban distracting activities		
I	Very High	Passengers Using Mobile Phone, Unruly Kids, Passengers (moving around, standing next to driver's cabin and talking)	Pedestrians, Passengers (moving around, standing next to driver's cabin and talking), Other Road Users, Unruly Kids		
II	High	Passengers not following etiquette, Passengers Trying to Talk to Driver, Other Road Users, Pedestrians, Ticket Machine, Passengers with Infants	Passengers Using Mobile Phone, Mobile Data Terminals, Passengers not following etiquette (eating, drinking, smoking, noisy), Ticket Machine/Fare Box		
III	Moderate	Food and Other Smells, On-board rattles, Fatigue/Sickness, Climate Controls, Audible alerts, General Broadcasts, Disabled passengers, Reading (e.g. Route Sheet), Personal Broadcasts	On-board rattles, Communication with Dispatch, Looking at Advertisements, Passengers Trying to Talk to Driver, Fatigue/Sickness, Climate Controls, Driver's Mobile Phone, Disabled Passengers, Announcing Bus Stops, Reading (Route Sheet)		
IV	LOW	Driver's Mobile Phone, Looking at Advertisements	Dispatch Broadcasts, Food and Other Smells, Passengers with Infants, General Broadcasts/ Other, Audible Alerts		

3.2.1 Theoretical framework of the MLR model

The MLR model developed as an extension of the logistic regression [17, 18], generates a relationship between dichotomous outcomes and one or more continuous or categorical predictors. The model developed as a type of GLM, comprised of three components [16]. The *random component* Y is the random DV of the logistic regression having an independent set of observations ($Y_1, \dots, Y_n$). In a logistic regression, Y is binary (*distracted* or *not distracted*) and assumed to follow a *binomial distribution*. Y can represent the occurrence (success) of a distraction activity level (for example, *Slightly Distracted*, and *Distracted* with reference to *Not Distracted*). The *systematic component* represents right hand side of the GLM called *linear predictor* [16]. It is constructed by combining the explanatory variables as follows:

$$Y_{ij} = \beta_0 + \beta_1 \text{SEX} + \beta_2 \text{AGE} + \beta_3 \text{EXP} + \beta_4 \text{MARITAL} + \beta_5 \text{EDU} + \beta_6 \text{DRIVING/WK} + \beta_7 \text{LOCAT} + \beta_8 \text{DAY} + \beta_9 \text{PEAK} + \beta_{10} \text{EQUIP} \quad (1)$$

where:

SEX: Gender of driver, 1 = Male, 0 = Female;

AGE: Reported age of driver in years;

EXP: Number of years of experience driving a bus;

MARITAL: Marital Status, 1 = Married, 0 = Others (Separated, Divorced, Never Married, etc.);

EDU: Educational Level, 1 = HS or Equivalent, 0 = Others (Some College, 2, 4 year degree, etc.);

DRIVING/WK: Weekly driving hours;

LOC: Location of transit agency service area, 1 = Northside, 0 = Southside (regional); 1 = Commuter, 0 = Others (Local, Metro etc.) (urban);

DAY: Driving Schedule, 1 = Day, 0 = Night;

PEAK: Driving Time, 1 = Peak, 0 = Non-Peak;

EQUIP: Type of Equipment* Driven, 1 = MCI, 0 = Others (Gillig, Orion etc.)

β_0 is the model constant (Y intercepts) and $\beta_1, \dots, \beta_K$ are the regression coefficients corresponding to the $\{x_k\}$ which may be continuous or categorical. The model constant and coefficients $\beta_0, \beta_1, \beta_2, \dots, \beta_K$ are estimated by the *maximum-likelihood* method that estimate coefficients that make the observed values most likely to have occurred [17]. The coefficients β_K represents the change in the probability per unit change in x_k [16]. When β_K are positive values, increasing explanatory variables will increase the logit of Y and conversely, when β_K are negative values, increasing these variables will decrease the logit of Y . For both cases, the reverse is true when the variable is decreasing. The third component called the *link component* is necessary to connect the *random component* to the *systematic component*. The principle mathematical theory behind logistic regression is the non-linear function called the logit that is used as the link function. The *logit* is the natural log (ln) of the odds ratio. The odds

are defined as the ratio of the probability that an event will occur divided by the probability that the event will not occur.

Let π = probability of success of the response variable and x are fixed variables,

$$\text{Odds} = \left[\frac{\pi(x)}{(1-\pi(x))} \right] \quad (2)$$

The general MLR model proposed by Moutinho and Hutcheson [17] is expressed as:

$$\ln \left[\frac{\pi(Y=j)}{\pi(Y=j')} \right] = \beta_0 + \beta_1 \text{SEX} + \beta_2 \text{AGE} + \dots + \beta_{10} \text{EQUIP} \quad (3)$$

where j is the identified distraction level (*Slightly Distracting, Distracted/Very Distracted*) and j' is the reference distraction level (*Not Distracted*).

The MLR model was applied to the five Very High Risk distracting activities in Zone I and the significant estimated coefficients were computed along with the odds ratios. Due to space restrictions only three distracting activities shown in Table 2 will be discussed further.

4 Discussion of results

The literature discusses several methods of interpreting the results of the MLR model. Khorashadi *et al.* [14] have argued that interpretation of the model's estimated coefficients are insufficient in explaining the impact of the explanatory variables on the outcome probabilities and have recommended the use of elasticities to measure the marginal effects. However, in this study, an approach proposed by other researchers [16–18] who interpreted the estimated coefficients (Table 2) one at a time and keeping the rest unchanged is followed in the discussion to explain the impact of predictor variables on distraction risks.

The proportion of males is higher at the urban agency (74%) as compared to the regional agency (45%). There is no conclusive evidence that driver distraction is related to gender and no difference was found in reaction time for males or females performing multitasks [10]. The positive coefficients (6.24 and 5.79) associated with GENDER implies that male (code = 1) regional drivers were more likely than female (code = 0) drivers to get Slightly Distracted followed by Distracted by passengers, but less likely (-3.81) to get Slightly Distracted by Passengers Using Mobile Phones. While, the male urban driver is less likely (-24.6) to get Distracted by Passengers.

The average age of a regional driver (49.5 years) was not significantly different ($t = 1.98$, $p > 0.05$) from the urban driver (47.9 years). The average ages in both agencies falls within the 45 to 55 age group which is considered “safe” age since, younger drivers (less than 25 years) and older drivers (more than 70 years) are more vulnerable to distractions than middle age drivers [9, 10]. The positive coefficients (0.21) associated with AGE implies that the higher the

regional driver's age, the more likely the driver would get Slightly Distracted by Passengers.

A driver's experience in driving transit buses influences her/his driving performance. Analysis of the accident databases revealed that less experienced drivers have higher accidents than the more experienced drivers (Figure 1). The average driving experience of the regional driver (11.4 years) was significantly higher ($t = 1.98$, $p < 0.05$) than the urban driver (8.00). The MLR model's estimated coefficients have mixed results. An urban driver with more experience will get less Slightly Distracted by Passengers (-1.36) but more Slightly Distracted by Passengers Using Mobile Phones (1.91). Although the regional drivers have significantly more driving experience than the urban drivers yet, the accident rate and corresponding distraction is much higher leading to the suspicion that there must be other factors causing this to happen.

There was no significant difference ($t = 1.99$, $p > 0.05$) between the hours driven per week by regional (38.9) and urban (37.1) drivers which were close to the normal 40 hour week. Hence, differences in the distraction level caused by fatigue due to longer driving hours could be ruled out for regional/urban drivers.

Table 2: Zone I distracting activities with significant variables*. (Internal passenger-related).

DISTRAC. FACTORS	PASS MOB PH SD ($\chi^2 = 31.71$, $p > 0.10$) ($\chi^2 = 52.15$, $p < 0.01$)		PASSENGERS SD ($\chi^2 = 49.12$, $p < 0.05$) ($\chi^2 = 42.81$, $p < 0.01$)		PASSENGERS D/VD ($\chi^2 = 49.12$, $p < 0.05$)		UNRULY KIDS SD ($\chi^2 = 31.92$, $p > 0.10$) ($\chi^2 = 31.95$, $p < 0.05$)	
	REG	URB	REG	URB	REG	URB	REG	URB
INTERCEPT/CONSTANT	29.74	101.35	3.56	8.87	2.22	7.25	-6.75	17.23
AGE	-	-	0.205	-	-	-	-	-
DRIVE HRS/WK	-	-1.97	-	-	-	-	-	-
DRIVE EXPERIENCE	-	1.91	-	-1.36	-	-	-	-
GENDER	-3.81	-	6.24	-	5.79	-24.6	-	-
EDUCAT STATUS	-	-	3.53	-	3.47	4.44	-	-
MARITAL STATUS	-	-	-6.58	-	-	-	-	-
LOCATION	-	-223	-4.49	-	-4.45		-	-
DRIVE SCHEDULE	4.69	-	6.57	-	5.92	-8.07	4.13	-6.67
DRIVE TIME	-	-	-	-5.01	-	-8.06	-	-
TYPE OF EQUIP	-	-	26.4	-	-	-	-	-
AGE OF EQUIP YRS	-	-	-	-	-	-	0.73	

* $p = 0.000$ to 0.10 . REG – Regional; URB – Urban.

Around 44% of the regional drivers reported that they drive during the day and 30% drive during peak hours, while 62% of the urban drivers typically drive during the day and 22% drive during peak times (Figure 2). The regional drivers do more of nighttime and peak time driving. The risk of accidents is generally higher at night and during peak time. Hence, this could possibly be the reason for a higher accident rate at the regional agency.

Marital separation or divorce has been reported to be associated with an increased risk of a serious accident and recent separation and divorce are associated with an increase in serious traffic accidents [19]. Figure 3 show that urban drivers have a higher number of married drivers who have a lower accident rate and correspondingly low distraction. The estimated coefficient for regional drivers was negative (-6.58) indicating that married drivers (code = 1) are less likely to get Slightly Distracted by Passengers. Extending this result to urban drivers, where around 65% are married could be the reason for lower the risk of distraction related accidents.

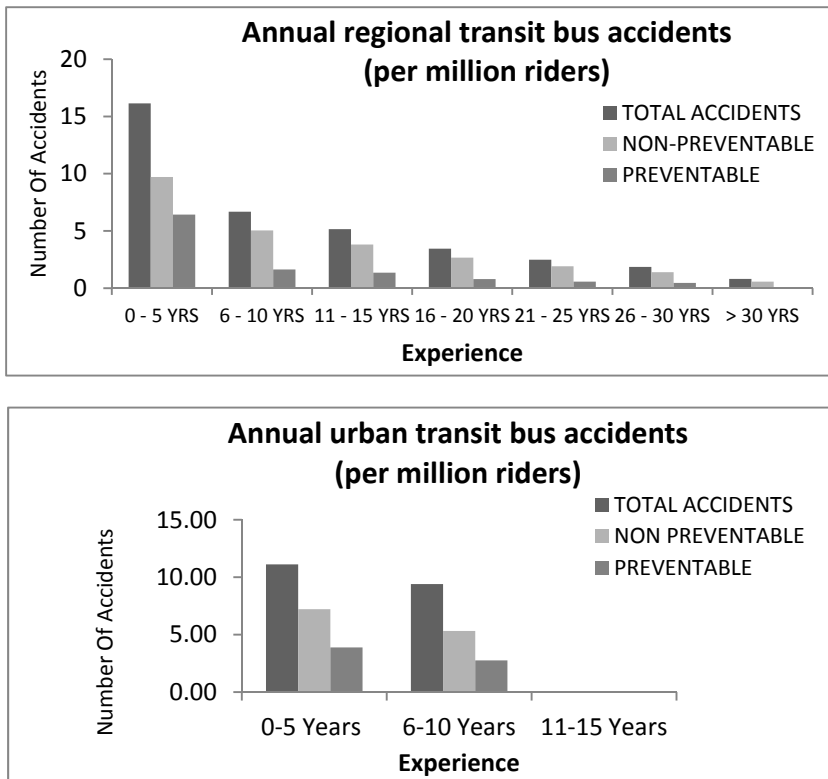


Figure 1: Impact of driving experience on number of accidents.

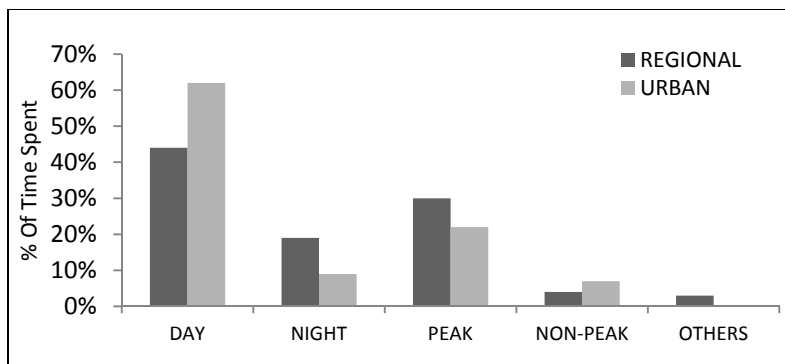


Figure 2: Time spent on various driving schedules.

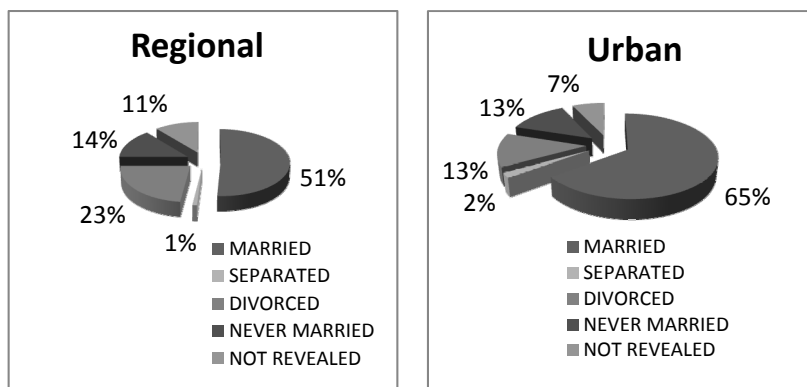


Figure 3: Marital status of regional and urban bus drivers.

Location of the service routes has an impact on the distraction of bus transit drivers. For example, if the route to be driven is located in a densely populated area, there would be a greater number of passengers and a greater number of external sources of distraction as a result of more frequent stops, traffic congestion, and pedestrians. The MLR model's estimated coefficients for LOCATION are negative for regional (-4.49, -4.45) and urban (-22.3) implying that drivers operating in the regional Northside routes (code = 1) and urban commuter routes (code = 1) are less likely to get distracted by Passengers Using Mobile Phones and Passenger.

The above study results suffer from limitation related to small sample sizes (77 regional and 53 urban drivers). The *linear predictor* in Equation 1 has ten covariates some of which are dichotomous variables. According to Hosmer *et al.* [18], the MLR model developed in Section 3.2 for the analysis of Risk Zone I activities having ten covariates (totally 17 variables) would require at least 170 survey cases each as per the *Rule of 10* to prevent numeric *instability*, *multicollinearity*, large coefficient estimates (Table 2) and high standard errors.

5 Conclusions and recommendations

In this study, the very high risk (Zone I) distracting activities reported by the agency's bus drivers were mostly passenger-related (Table 1). Among the very high risk distracting activities, the two (Passengers and Unruly Kids) that were common to both types of transit agencies were also passenger-related. The descriptive statistics and MLR results show that some of the distraction factors were found significant in both the agencies. For example, the regional and urban drivers with high school or equivalent education were more likely (3.47, 4.44) to get Distracted by Passengers. But in other cases, there were differences. The likelihood of getting Slightly Distracted by Unruly Kids was higher for regional drivers (4.13) driving during the day but lower for urban drivers (-6.67). Significant differences in the regression covariate coefficients were found with reference to driver attributes, driving pattern, and location. The covariates having an impact on the driver distraction differed widely in each group.

Distractions from Passengers and Unruly Kids are an annoyance to other passengers and the driver. Hence, a growing number of cities and states have banned the use of personal mobile phones in the transit system, forbids drivers talking to passengers, and require an adult to accompany kids. It is a challenge for the transit agency to develop effective policies for handling passenger behaviour so that they are less likely to stand next to the driver's cab, talk to the driver, use cell phones, and indulge in non-etiquette and noisy behavior.

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