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Analysis of Non-Motorized Vehicles Characteristics Considering Patterns of Overtaking and Critical Lateral Distance in Heterogeneous Traffic Flow

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Abstract **- In India most common kind of traffics we can find on the road are mixed traffic which can also be termed as heterogeneous traffic where bikes, cars, even heavy vehicles like buses and trucks all move in the same lane. The objective of this study is to model the overtaking behavior and lateral interactions between Motorized Vehicles (MV) and Non-motorized Vehicles (NMV). Critical lateral distance (the shortest distance to initiate avoidance maneuvers) is used as the lateral interaction. Bikes have more interaction probability than other vehicles. Four sites were selected where two lanes were divided by median and two lanes were not divided by median. The sites not divided by median were Chota Bharwara, Gomti Nagar Extension and Sector 8, Jankipuram Vistar and sites divided by median were Padera, Raebareli Road and Kathauta Lake, Gomti Nagar. The data was collected of one hour for each site and a total of 3270 overtaking interactions were noted considering all sites. Lateral Interactions were modeled using parametric accelerated failure time (AFT) model.**

Keywords - Heterogeneous traffic, Non-motorized Vehicles (NMV), Motorized Vehicles (MV).

1. INTRODUCTION

In India history of bicycles goes way back and till slowly but surely the demand remains in the market. Bicycles and e-bikes are eco-friendly, sustainable and even beneficial for health. In some countries separate lanes are made for NMV's and many countries promote use of NMV to travel short distance so that both traffic congestion and environment pollution can remain in check. But sometimes NMV becomes major source of traffic congestion because of their different motion dynamics and behavior in comparison to MV's which include both bicycles and tricycles. Tricycles are mainly used to carry passengers and goods and in India and it is called rickshaws. We can clearly observe that in India not only the motorized vehicles (MV) moving on road are in majority but also the demands are increasing as time passes. Even after all the craze about bikes and cars, non-motorized vehicles (NMV) holds their fort strongly and mostly students who go to school or people travelling for short distance prefer bicycles. Nowadays research works regarding the microscopic parameters are mainly focused instead of macroscopic. While travelling no one notices or even cares but just overtaking a vehicle involves a chain of complex thought process and its proper implementation, acceleration, deceleration, maintaining proper distance between vehicles, etc. In Highway Capacity Manual (HCM) there are is no clear provisions about the effects of non-motorized vehicles on road and thus research regarding bicycles (NMV) attracts many researchers whether the conditions are of either heterogeneous traffic or homogeneous traffic.
The research work related to NMV and MV was conducted using many methods like statistical techniques, stimulation models, non-parametric analyses and parametric analyses. These methods can be categorized further for e.g. logistic regression model, cellular automata model, social free model, etc. These kind of research helps in designing traffic especially lane width and if necessary separation forms between NMV and MV can be provided.

2.LITERATURE REVIEW

Yan Liu et al. (2021) [1] paper conducted experiment to model lateral interactions between motorized vehicle and non-motorized vehicle and two sites were selected from Harbin, China. In this research mixed traffic is used for data collection and lateral interactions were modeled using parametric equation with Weibull distribution, also the data were extracted using computer vision techniques. The results show that the interaction rate was higher for bikes than e-bikes and decrease with the NMV or MV yaw rate. the model shows that the lateral interaction possibility increases as speed of MV increases.

Wei Wang et al. (2021) [2] paper focus on model the durations of overtaking behavior in the non-motorized vehicle exclusive lane. A total of 3010 overtaking events of non-motorized vehicles were extracted from two locations in Chengdu, China. The nonparametric survival analysis was conducted to model the overtaking duration of non-motorized vehicles. The categorical variables that significantly influence the overtaking duration were examined by the Log-rank test. The results show that the overtaking durations of female riders is longer than that of male riders. Moreover, it takes less time to overtake the non-

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motorized vehicle with load than to overtake the one without load. When there is a wrong-way driving phenomenon or under higher traffic volume, the duration is longer compared to the normal traffic and lower traffic volume conditions.

Manish Patkar and Ashish Dhamaniya (2020) [3] studied effect of NMV at six different urban mid-block arterial section. Speed-flow data has been collected through video graphic surveys at six urban arterial midblock sections. Among these sections, three have mixed motorized traffic; whereas, the remaining three sections have a significant proportion of NMVs mixed with motorized traffic. The data has been extracted from five-minute videos, which are further utilized to develop mathematical models relating the speed of each type of vehicle with the corresponding densities of all other vehicle present in the traffic mix. These models are solved for any predefined volume and proportions of traffic mix, and speed flow plots are developed to infer the capacity values. The results showed that with NMVs range between 5% - 25% capacity of urban arterials reduced by 3.60% - 35.82%.

Qiyuan Liu et al. (2019) [4] paper discuss problem created by non motorized vehicles where without the restriction of lane markers or physical barriers, they may disperse into adjacent lanes and thus lead to complex interactions with motorized vehicles. The model is calibrated and validated using 1,490 high-definition sets of trajectory data for go-straight, non-motorized vehicles during 43 cycles at two typical mixed flow intersections. The Particle Dispersion Model (PDM) is compared with the social force model (SFM) on their dispersion characteristics that are used to describe the non-motorized bicycles' behavior. The results show that the PDM performs better than the SFM with regard to depicting the dispersion characteristic indices of the non-motorized vehicles, such as the travel time, the dispersion intensity of heterogeneous non-motorized vehicles, the sectional dispersion degree, and other dispersion characteristics.

Shiddharth Purohit and Mahabir Panda (2014) [5] done an experimental study to observe the fundamental diagram from the data obtained from various roads of Rourkela city in Odisha and It was observed that with increase in NMV % the flow versus density graph is adversely affected. Density decreases at a particular flow rate when NMV % increases. Along with this a study on pattern of lateral occupancy of NMVs and MVs is done with respect to various percentages of NMV and total density. Also the variation of speed with respect to various parameters is studied and it was seen that all the parameters have a significant impact on the speed of a non-motorized vehicle in a mixed traffic.

Chetan R. Patel and G. J. Joshi (2014) [6] study is carried out on six lane divided urban arterial road in Patna and Pune city of India. Speed flow relationship is developed and capacity is determine. Arterial road in Patna city has 33% of non-motorized mode, whereas Pune arterial road dominated by 65% of Two wheeler. Also road side parking is observed in Patna city. The field studies using videography techniques are carried out for traffic data collection. Data are extracted for one minute duration for vehicle composition, speed variation and flow rate on selected arterial road of the two cities. Speed flow relationship is developed and capacity is determine. Equivalency factor in terms of dynamic car unit is determine to represent the vehicle is single unit.

Xiao-Mei Zhao et al. (2009) [7] paper mainly focused on mixed traffic between motorized and non-motorized vehicles near bus stop. The non-lane based behavior of non-motorized vehicles were considered which was seldom taken topic at that time. Cellular Automation model and Nagel-Schreckenberg Model were taken account to generate model using other parameters. Also the passenger transport capacity of both MV and NMV were investigated. A bus-stop near Jimen Bridge Beijing, China was taken for observation and data collection.

Tri Basuki Joewono and Hisashi Kubota (2005) [8] paper analyzes paratransit and non-motorized vehicles characteristics in Bandung, Indonesia. A survey was conducted to analyze the peoples opinion about non-motorized vehicles and paratransit and their willingness to pay. The main experiment conducted in questionnaire and data collected targeting different age group and their need. The result determined at the paratransit were 61.24% of total public transportation in Bandung which is very in number and the minimum load factor is 29.17% (in afternoon trip) and the maximum load factor is 82.34% (in noon or mid-day trip).

Md Mizanur Rahman and Fumihiko Nakamura (2003) [9] paper conducted survey considering relationship between fundamental traffic parameters which is speed, flow and density. Macroscopic parameters were main focus of this paper. Overtaking was divided in different categories and then with the help of graphs observation including passing and overtaking were concluded. Number of vehicles and their types were considered their flow in non-median divided road were investigated.

Dr Timothy Oketch (2003) [10] analyzes performance characteristics of non-motorized vehicles. The traffic stream was divided into two categories as standard and non-standard vehicles and lateral movement was modeled. A 500m lane was considered for the data collection and both interrupted flow and non-interrupted flow were taken. The model predicts a maximum capacity of about 3600 vehicles per hour for the two lanes or about 1800 per lane. It has shown that such heterogeneous traffic streams generally have lower capacities and saturation flows.

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3. DATA COLLECTION AND PRELIMINARY ANALYSIS

3.1. Study Location and Data Collection

For this study four different sites were selected in Lucknow, India considering lane is divided by median or not. Chota Bharwara, Gomti Nagar Extension and Sector 8, Jankipuram Vistar were the sites without median and sites divided by median were Padera, Raebareli Road and Kathauta Lake, Gomti Nagar. In this project data collection refers to the video collected from the sites stated above one hour video recording was done in December 2020. The data collected was between 12 pm to 3pm time period which represents the noon peak hours thus a total of 4 hours data was collected.

Figure 1. Study Sites (a) Chota Bharwara, Gomti Nagar Extension (b) Sector 8, Jankipuram Vistar (c) Kathauta Lake, Gomti Nagar (d) Padera, Raebareli Road

3.2. Extraction of Overtaking Behavior and Users Trajectories

The video data was played by KM player and two analyst observed to extract data. To reduce error and increase reliability both analysts were trained to have better understanding to note down the overtaking time duration of vehicles and to practice one short piece of same video was given to both to extract data and extracted data was compared afterwards. Both analysts data was same and average difference was less than 3%.

Number of vehicles passing through each lane and site were extracted along with their classification and tracking NMV and MV interactions were conducted. The set of variables between NMV and other types of vehicles considered were road user speed, NMV load state, type of vehicles, type of lane (divided by median or not).

3.3. Traffic Composition and Flow rate Analysis

Traffic composition of different sites are represented through pie chart in this section and for the sites where lane were divided by median half hour data for each lane were calculated to give one whole hour data for that site. Traffic composition of different sites are represented through pie chart in Fig.2,3,4 and 5.

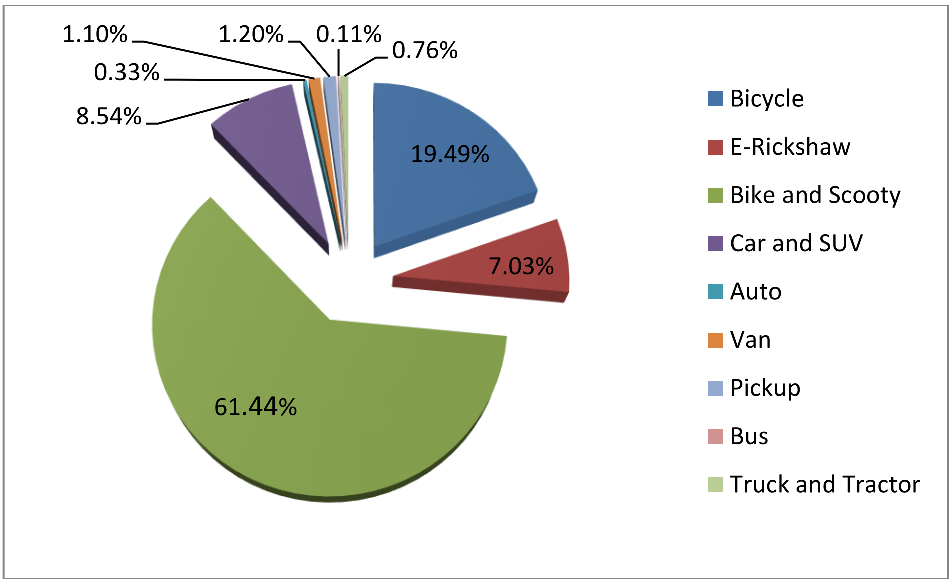


Figure 2. Chota Bharwara, Gomti Nagar Extension

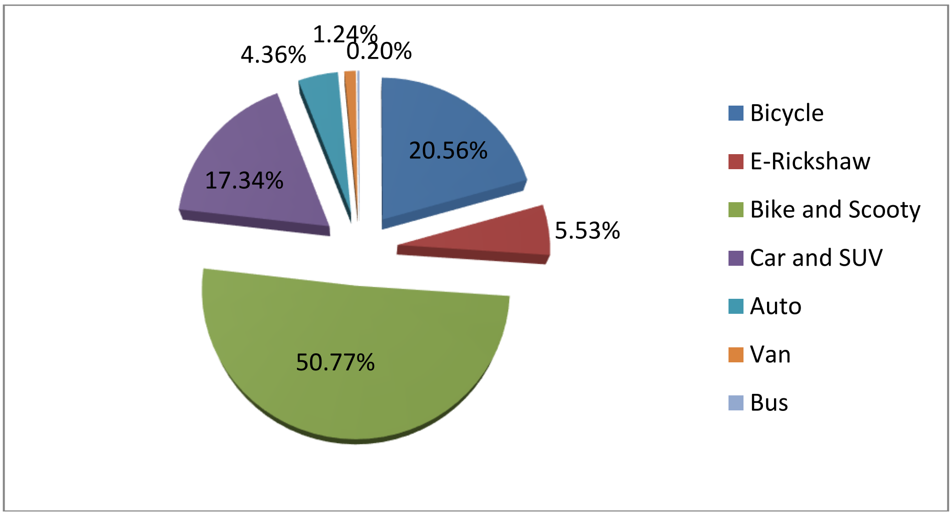
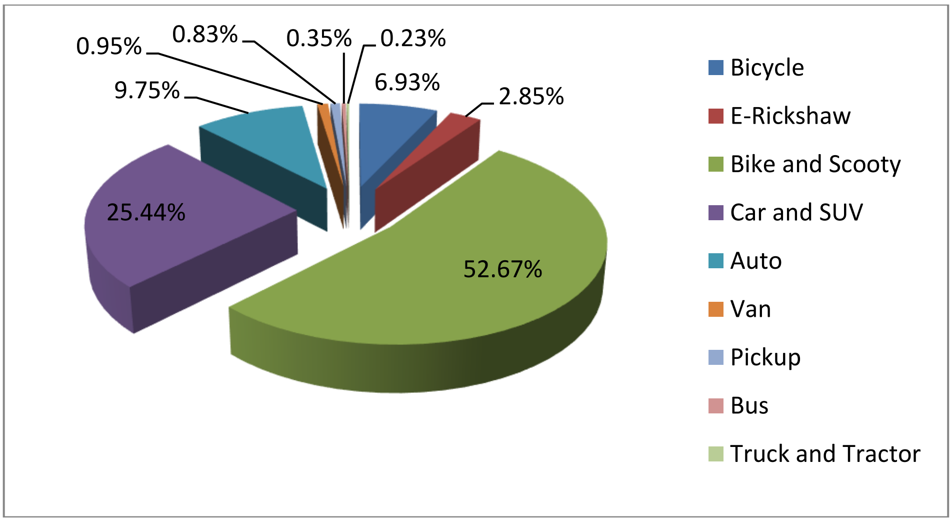
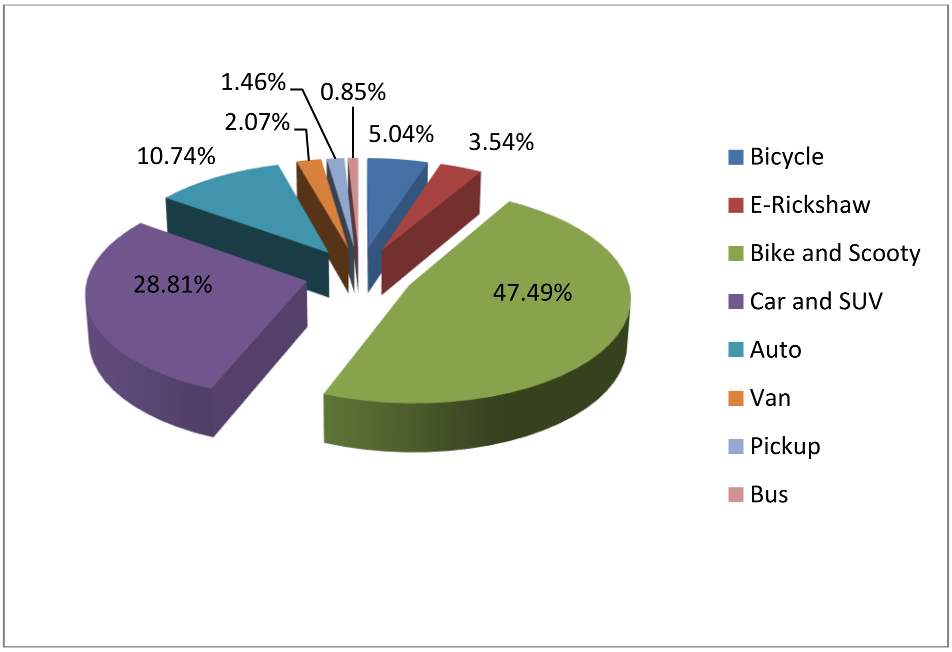


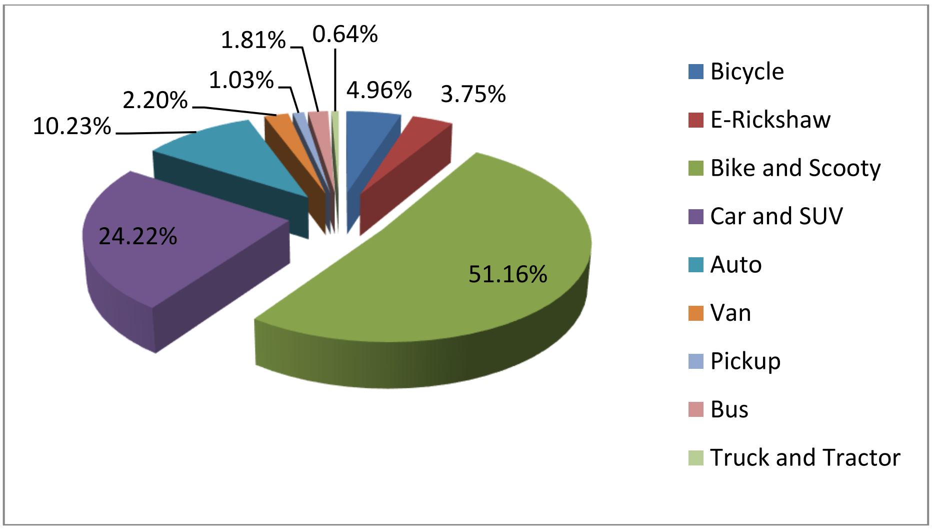
Figure 3. Sector 8, Jankipuram Vistar



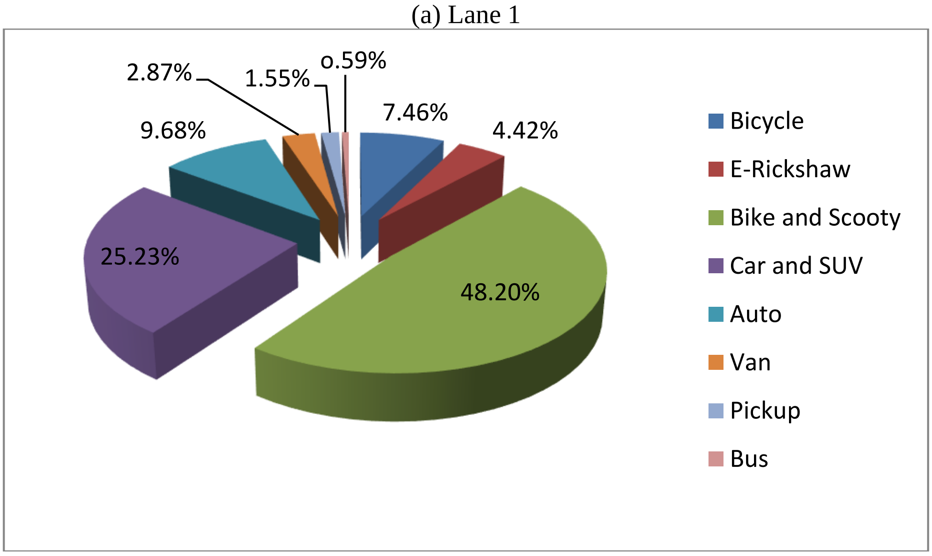
(a) Lane 1



(b) Lane 2
Figure 4. Kathauta Lake, Gomti Nagar



(a) Lane 1



(b) Lane 2
Figure 5. Padera, Raebareli Road

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4. METHODOLOGY

The accelerated failure time (AFT) model describes response variable and survival time. Here events are generally referred as failure because the event may be accident and even results in death. In lifetime data analysis a specific event occur during time T, while in lateral interaction data analysis an evasive maneuvers takes place with the decrease in critical lateral distance. A comparison between lifetime data analysis and lateral interaction data analysis is shown in table 1.

when the lateral distance is shorter than equal to some specified distance:

$$F(d) = Pr(D > d) = 1 - Pr(D \leq d) = 1 - S(d) \quad (1)$$

where F(d) is the failure function that gives the probability of an interaction taking place before the lateral distance between the road users reaches some specific specified distance.

	Lifetime analysis	Lateral Interaction Analysis
Parameter	Specified time t	Critical lateral distance d
Variable	Lifetime T	Lateral distance D
Failure event	Death at t	Evasive maneuver at d
Censored state	Dead when T > t	Evasive maneuver when D < d
Survival function	S(t) = 1-F(t)	S(d) = 1-F(d)
Distribution function	F(t)	F(d)

Table 1. Comparison between lifetime data analysis and lateral interaction analysis

The assumption of AFT model can be expressed as -

$$s(t/x) = s_0(\exp(\beta'x)t) \ldots\ldots\ldots\ldots\ldots\ldots \text{ for } t \geq 0 \quad (2)$$

where s(t/x) is the survival function at time t and $s_0(\exp(\beta'x)t)$ is the baseline survival function at time t. The factor $\exp(\beta'x)$ is known as the acceleration factor.

For distribution fitting of curve Weibull distribution was used. The Weibull AFT model (WAFT) and corresponding hazard function are expressed as given equations -

$$S(d) = \exp(-\lambda d^P) \quad (3)$$

$$h(d) = \lambda P(\lambda d)^{P-1} \quad (4)$$

where P is the scale parameter and λ is the location parameter and critical lateral distance is d. If P > 1, the hazard function ascends monotonically as d decreases. If P = 1, hazard function becomes constant. If P < 1, the hazard function descends monotonically as d decreases.

4.1. Descriptive Statistics of Overtaking Behavior

Considering all sites, a total of 4 hour recording was conducted and 3270 overtaking incidents were recorded. Tables mentioned below shows distribution of overtaking duration of vehicles at different sites.

Table 2. Chota Bharwara, Gomti Nagar Extension

Overtaking Duration (sec)	No. of Observation	Percentage (%)
1-2	147	26.92
2-3	224	41.02
3-4	96	17.58
4-5	56	10.25
5-6	23	4.21

Table 3. Sector 8, Jankipuram Vistar

Overtaking Duration (sec)	No. of Observation	Percentage (%)
1-2	196	31.71
2-3	301	48.70
3-4	83	13.43
4-5	33	4.36
5-6	11	1.77

Table 4. Kathauta Lake, Gomti Nagar

Overtaking Duration	Lane 1		Lane 2	
	No. of Observation	Percentage (%)	No. of Observation	Percentage (%)
1-2	188	34.24	133	22.50
2-3	202	36.79	289	48.90
3-4	99	18.03	117	19.79
4-5	47	8.56	33	5.58
5-6	13	2.36	19	3.21

Table 5. Padera, Raebareli Road

Overtaking Duration	Lane 1		Lane 2	
	No. of Observation	Percentage (%)	No. of Observation	Percentage (%)
1-2	103	33.88	167	30.03
2-3	138	45.43	207	37.58
3-4	43	14.14	103	18.52
4-5	17	5.59	54	9.71
5-6	3	0.98	23	4.13

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4.2. Equivalent Factor

There are various methods to determine equivalency factor such as Walker's method, Homogenization method, Headway method multiple regression method and stimulation techniques. The approach used here seems more suitable because of its simplicity and speed of vehicle which is prime influencing factor of vehicle in traffic used here to determine Dynamic Car Unit (DCU).

Mathematically,

$$DEFc = (V_c/V_y)/(A_c/A_y) \quad (5)$$

where, DEFc - Dynamic Car Equivalent Factor considering 'car' as reference vehicle, A_c/A_y - Area Ratio, V_c/V_y - Speed Ratio, A_c - Projected area of 'car' as reference vehicle, A_y - Projected area of 'y' reference vehicle, V_c - Spot speed of 'car' as reference vehicle, V_y - Spot Speed of 'y' vehicle.

4.2.1. Area Ratio

Computed area ratio of each vehicle category is shown in table 6.

Table 6. Computed area ratio of vehicles

Sr.No.	Vehicle	Projected Area of Vehicle (m^2)	Area Ratio
1	Two Wheeler (2W)	1.48	3.86
2	Three Wheeler (3W)	3.28	1.74
3	Car	5.72	1.00
4	Pickup	15.18	0.38
5	Bus	30.47	0.18
6	Light Commercial Vehicle (LCV)	7.50	0.76
7	Truck	33.32	0.17
8	Cycle	0.86	6.65
9	E-Rickshaw	2.57	2.23

4.2.2. Speed Ratio

Here speed ratio is the only dynamic parameter because area ratio remains constant. Speed ratio of different sites are in tables below.

Table 7. Sped Ratio of site Chota Bharwara, Gomti Nagar Extension

Vehicle	Speed Ratio (Car as Reference vehicle)							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	1.46	1.88	2.07	1.83	2.60	1.87	3.87	3.14
Min	0.58	0.78	0.82	0.71	0.48	0.90	1.26	1.19
Average	0.92	1.13	1.40	1.18	1.22	1.29	3.09	2.25
Std. Dev.	0.12	0.14	0.26	0.24	0.29	0.29	0.68	0.42

Table 8. Sped Ratio of site Sector 8, Jankipuram Vistar

Vehicle	Speed Ratio (Car as Reference vehicle)							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	1.62	1.91	-	1.70	1.28	-	4.22	2.77
Min	0.74	0.94	-	0.98	0.94	-	1.80	1.03
Average	1.06	1.27	-	1.26	1.19	-	2.68	1.85
Std. Dev.	0.16	0.21	-	0.22	0.26	-	0.67	0.36

Table 9. Sped Ratio of site Kathauta Lake, Gomti Nagar

(a) Lane 1

Vehicle	Speed Ratio (Car as Reference vehicle)							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	1.32	1.56	2.08	1.56	1.16	1.17	3.37	2.99
Min	0.52	1.03	0.70	0.69	0.78	1.06	1.06	1.04
Average	0.88	1.36	1.14	1.13	0.99	1.12	2.09	1.76
Std. Dev.	0.17	0.15	0.32	0.27	0.14	0.09	0.38	0.29

(b) Lane 2

Vehicle	Speed Ratio (Car as Reference vehicle)							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	1.35	2.43	2.91	1.57	2.57	1.49	4.86	3.68
Min	0.78	1.09	0.98	0.91	0.84	1.62	2.32	2.04
Average	1.06	1.39	1.63	1.29	1.42	1.66	3.19	2.88
Std. Dev.	0.12	0.22	0.55	0.23	0.38	0.08	0.56	0.43

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Table 10. Sped Ratio of site Padera, Raebareli Road

(a) Lane 1

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	1.30	1.46	1.95	1.83	2.91	1.20	3.92	2.53
Min	0.74	0.68	0.70	0.70	0.63	0.44	1.07	1.49
Average	0.92	1.09	1.02	1.06	1.18	0.91	2.11	1.88
Std. Dev.	0.12	0.19	0.24	0.28	0.33	0.17	0.73	0.39

(b) Lane 2

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	1.42	1.68	1.32	1.84	1.58	-	3.81	2.29
Min	0.81	0.92	0.82	0.76	0.59	-	2.06	1.20
Average	1.10	1.28	1.09	1.11	1.20	-	2.74	1.79
Std. Dev.	0.11	0.16	0.17	0.21	0.28	-	0.46	0.27

4.2.3. Dynamic Car Unit (DCU)

the area ratio for each vehicle type considering car as reference is shown in section 4.2.1 and speed ratio for different vehicles considering car as reference for different sites is shown in section 4.2.2. DCU is calculated using equation (5) and represented in tables below.

Table 11. Dynamic Car Unit of site Chota Bharwara, Gomti Nagar Extension

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	0.35	0.90	5.47	7.18	1.50	4.86	0.50	1.40
Min	0.14	0.61	1.82	3.08	1.03	3.35	0.15	0.53
Average	0.22	0.78	2.84	4.87	1.17	3.55	0.25	0.78
Std. Dev.	0.05	0.10	0.82	1.23	0.99	0.29	0.06	0.10

Table 12. Dynamic Car Unit of site Sector 8, Janakipuram Vistar

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	0.39	0.89	-	6.09	2.93	-	0.86	1.24
Min	0.24	0.54	-	4.27	1.17	-	0.23	0.46
Average	0.28	0.69	-	5.46	1.54	-	0.51	0.91
Std. Dev.	0.03	0.08	-	0.79	0.21	-	0.11	0.23

Table 13. Dynamic Car Unit of site Kathauta Lake, Gomti Nagar

(a) Lane 1

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	0.46	0.98	4.31	6.37	2.82	5.44	0.63	1.34
Min	0.24	0.41	2.82	2.08	1.73	3.89	0.19	0.46
Average	0.32	0.68	3.84	4.33	1.91	4.12	0.34	1.18
Std. Dev.	0.11	0.16	0.98	1.21	0.36	0.20	0.09	0.21

(b) Lane 2

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	0.45	1.10	4.79	6.78	1.65	-	0.64	1.65
Min	0.19	0.51	1.98	4.44	1.10	-	0.21	0.91
Average	0.27	0.73	2.44	5.62	1.38	-	0.40	1.27
Std. Dev.	0.16	0.12	0.69	1.19	0.14	-	0.24	0.32

Table 14. Dynamic Car Unit of site Paera, Raebareli Road

(a) Lane 1

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	0.41	0.90	5.20	8.73	3.86	6.84	0.63	1.13
Min	0.18	0.41	1.85	2.47	0.63	1.38	0.13	0.66
Average	0.27	0.62	2.73	4.83	1.42	4.58	0.32	0.84
Std. Dev.	0.13	0.14	0.55	1.33	0.44	0.84	0.11	0.19

(b) Lane 2

Vehicle	**Speed Ratio (Car as Reference vehicle)**							
Category	2W	3W	Pickup	Bus	LCV	Truck	Cycle	E-Rickshaw
Max	0.37	0.99	3.51	8.35	2.08	-	0.57	1.02
Min	0.21	0.54	2.18	3.38	1.06	-	0.31	0.53
Average	0.29	0.74	2.73	5.04	1.55	-	0.42	1.69
Std. Dev.	0.06	0.09	0.40	0.94	0.94	-	0.17	0.11

4.3. Statistical Analysis of Critical Lateral Distance

A total of 3270 interaction were taken from all four sites and the data extracted from it were used to determine the critical lateral distance which divided mainly two categories, one where the lane is divided by median and the other where the lane is not divided by the median. Road where the lane is divided by median had less average critical distance than the lane divided by median. The average critical lateral distance for lane divided by median was 0.967m and 1.284m for lane not divided by median. Weibull AFT was determined with the help of equation (3) and (4) and t-test was conducted for curve fitting. It was found that increase in the number of NMV causes adverse effect on mixed traffic.

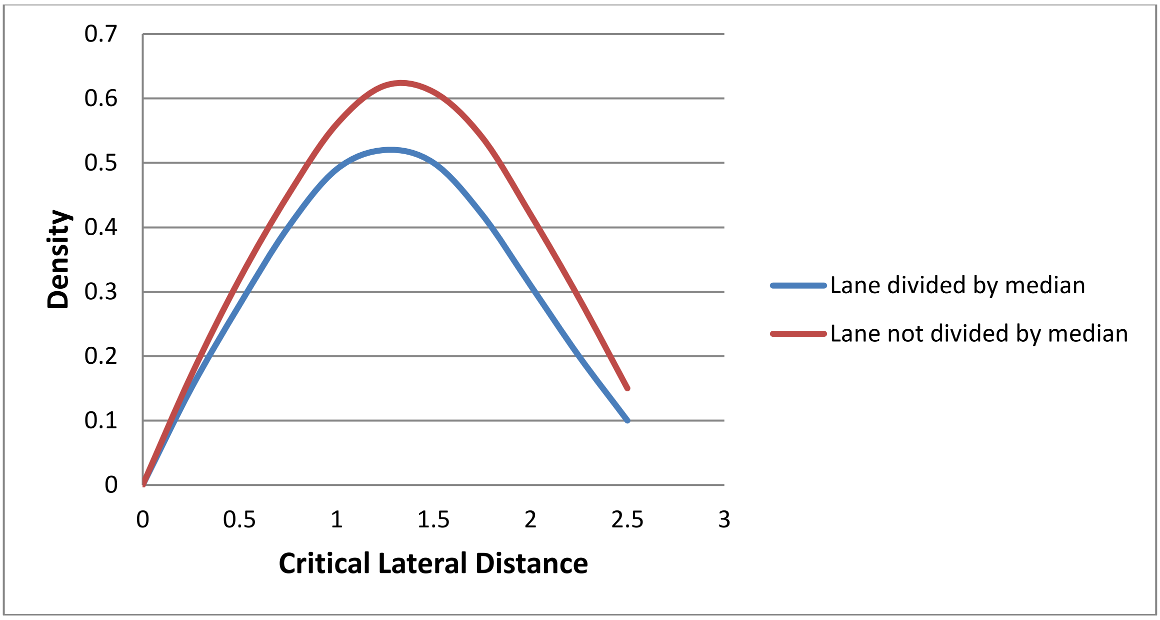

Figure 6. Weibull AFT distribution Curve

5. RESULTS AND DISCUSSION

The Weibull AFT is used to draw survival curve which compares the effects of parameters on lateral interactions between NMV and MV. The data collected was not for long duration and thus partial density for regions was observed. The 10th, 15th, and 50th percentile of one of the location where median was present were 0.441, 0.552, 0.913 respectively and same values for one of the sites without lane were 0.607, 0.812, and 1.321 respectively. To get more clear view of interactions, the survival probability of avoidance maneuvers at 1m and 2m of critical lateral distance were computed. The results show that the survival probability of adopting avoidance maneuvers at critical lateral distance of 1m and 2m are 72.1% and 14.4% respectively. This shows as the critical lateral distance increases the survival probability of failing decreases and less chances of interaction between NMV and MV occurs. Computing the survival probability at critical lateral distance of 3m shows almost zero percent (0.89%) chances of interaction.

This result was in expectations as critical lateral distance increases there will be less chance of users behavior get interrupted. After comparing the data it was shown that without the median on lane the users behavior get more interrupted and critical lateral distance is also more in comparison to lane with median. This model suggests that with the increase in the speed of MV lateral interaction probabilities increases.

6. CONCLUSION

This paper aims to model the interaction between NMVs and MVs interaction in heterogeneous traffic. Parametric Accelerated Failure Time model was used to determine the survival probabilities and lateral interaction. The critical lateral distance of lane with median was less than lane without median which shows overtaking is more comfortable in lane with median. A total of 3270 overtaking behavior observed from all four sites to get accurate results. In lateral occupancy study increase in number of NMV causes change in lateral occupancy was observed and state of congestion become unavoidable which shows adverse effects of NMV on same lane as MVs. In India we follow left hand side drive and thus vehicles try to overtake each other from right side but with the increase in number of NMVs left side of road get occupied by them and also in some cases NMV's travel in parallel to each other which left less space to overtake. Also some cases observed in lane without median was that both side NMV occupy sides of road and that creates a haywire situation as in the middle part of road vehicle from both sides are coming and overtaking space become less for MV and accidents chances due to overtaking increases.

7. FUTURE SCOPE

There are some shortcomings of this study. The speed parameters such as yaw rate can be considered and also vehicle travelling in wrong direction disrupts traffic can be set as one of the parameters. More observation sites and data can be considered for more study. Advanced 3D object tracking can be used to capture accurate width of tracked object.

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