

Pedestrian Crossing Behaviour Influences Injury Severity in Urban Cities of India

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Abstract: *Safety of pedestrian is a major concern in urban cities due to growth of vehicular traffic and non - availability of proper pedestrian road crossing. Due to heavy population with the increase of vehicular growth rate, there is impose of regulation on motor vehicles but enforcing laws on pedestrian is completely deserted. The number of accidents in India is three times higher than that prevailing in developed countries. Age and Gender are major factors which influences the pedestrian crossing behaviour. The sex wise distribution revealed that males are predominantly affected with male: female ratio 5.67: 1. In this study the more number of Road Traffic Accidents cases among male in the age group of 15 - 54 years. Pedestrian crossing behaviour is analysed and some conclusions are drawn from model: (1) age and gender are the important factors when pedestrian involved in a crossing, (2) literacy is a factor which influences crossing behaviour of pedestrian.*

Keywords: Pedestrian Behaviour; vehicular growth; Age and Gender; Crossing Behaviour; Road Traffic Accidents

1. Introduction

Motor vehicle accidents with pedestrians have become a serious safety problem in all over the world, mostly in developing countries like India, because of high growth of population, lack of enforcing laws on pedestrians, lack of safety training and tips and rapidly growth in urban areas. Due to lack of enforcing laws and regulations on pedestrian, they create unhealthy crossing and drivers get frustrated due to heavy pedestrian flow at a crossing on a particular time. Pedestrian always assume that driver may seen them and applying the brake at crossing for safely passing of them. But the heavy pedestrian flow and less gap acceptance by pedestrian causes an unhealthy environment for driver to safely cross the road. So driver aggressive nature overpasses the crossing without applying brake on speed. Pedestrian crossing behaviour is a major component to study the urban traffic characteristics. Heavy and uncontrolled flow of pedestrian at a crossing makes unacceptable vehicular gap. It is found that in India approximately 55% of pedestrians account for deaths in each year and out of them 35% pedestrians is child and younger age (MoRTH, 2010). Hence, for the safety of the pedestrian there is a need to analyzing the crossing behaviour of pedestrians at different intersections and crossings.

2. Literature Review

2.1 Crossing Behaviour

(Jain et al., 2014) found that pedestrians crossing time mostly varies in between 4 - 10 sec and children are crossing the road with higher speed than the young and older pedestrian. It is a greater risk found that 10% of pedestrians have the safety margin as zero second, so they take high risk to cross the road and that result on more accidents. (Atuah et al., 2017) found that approximately 82% of the collision

locations did not have any traffic control device or pedestrian crossing facilities. (Guo et al., 2014) found that most of pedestrians (86.0%) have chosen the overpass to cross the road and only 1.2% of pedestrians choose the crosswalk to cross the street. The study also found that almost half of the pedestrians (43.6%) will cross illegally. (Khatoun et al., 2013) found that Probability of road crossing reduces when faced with a heavy vehicle (bus), whereas it increases in the case of two - wheelers.

(Zhou et al., 2013) found that only 54.53% of the participants are legal crossing pedestrians. (Yan et al., 2013) found that pedestrian more willing to cross the road on red time where there is short distance to cross. (Demiroz et al., 2015) found that 46% of the pedestrians did not use the overpass to cross the road and preferred making illegal crossings instead of using safe routes or they preferred crossing outside the overpasses in order to minimize their walking distance/time. (Zhuang et al., 2011) found that 65.7% of the pedestrians did not look at vehicles after arriving at the curb.

2.2 Waiting Time & Gap Acceptance

(Jain et al., 2014) found that for majority of pedestrians, waiting time varies from 1 sec to 6 sec. It is further examined that crossing time and waiting time is more for the older pedestrian as compared to younger one. Those pedestrians are crossing the road with two step crossing and use oblique path of crossing they takes more time to cross the street. Children are not much aware about the traffic rules so they willing to cross the road with shorter time and makes unsafe crossing pattern. They also wait less at crossing point, but sometimes it observed that some of child pedestrian wait more at crossing because of fear to cross. It is observed that female and older pedestrians have more waiting time and crossing time at intersections and crossing

and they accept the vehicular gap more than young and male pedestrian. So the safety margin of older and female pedestrians are more and they are taking less risk than other pedestrians. (Keegan and O'Mahony, 2003) found that by installing of countdown timer at the intersections and crossings can reduce the accidents of pedestrian and guide the pedestrian for crossing during the red - man (do not walk) signal. (Kadali et al., 2013) found that when pedestrian accept the rolling gap, it significantly help to alert for both the pedestrians and drivers. (Atuah et al., 2017) that pedestrians are often compelled to run in crossing the roads before the allocated green time elapsed. It was also determined that the red times ranged from a minimum of 73 s to a maximum of 110 s.

(Khatoun et al., 2013) found that after the construction of the grade separator, the critical gap size increases from 6 s to 11 s. Since all at grade crossings are unsafe after the grade separator tends to pedestrians accept a larger gap size. (Keegan and O'Mahony, 2003) found that number of pedestrians crossing during the red light period for the longer cycle time sub - sample is 28% compared with 20% for the shorter cycle time sub - sample. The results indicate that reducing the cycle length results in a statistically significant improvement in pedestrian behaviour. (Koh and Wong, 2014) found that about 20% of the violators were observed to utilise "rolling gaps", that is, they did not wait for all vehicles to clear the conflict area before they started to cross

2.3 Road User Variables

(Moyano, 2002) found that young pedestrians between 17 and 25 yr of age consistently score higher on the model components than adults. Consistent with the above, in comparison with the adults, young pedestrians state that they commit a larger number of violations, errors, and lapses as pedestrians. (Atuah et al., 2017) found that pedestrians within 26 and 30 years of age are most predisposed to pedestrian collisions. (Khatoun et al., 2013) found that male and young adults have higher probability of road crossing as compared to female and older persons. (Demiroz et al., 2015) found that as the age of the pedestrians increased, the safety margins and crossing times increased.

3. Drawback of Past Researches

(Kadali et al., 2013) study has found that does not effective because of less preconisation of the pedestrian age during capturing the crossing pattern. They assumed that the pedestrian change direction is same as in all condition and consider as binary condition. But in real field pedestrian may change the crossing pattern in different ways. (Moyano, 2002) Among the limitations of this study, the fact that the variable 'accident involvement' does not distinguish between the degrees of culpability, damages or consequences suffered could account for the fact that no differences were found. (Khatoun et al., 2013) study does not correlate the observed risk to the actual crashes, because the actual crashes data were not collected from police station. To conduct such an analysis we need to rely on police data over a much longer period of time. There are some missing data in (Zhuang et al., 2011) methodology of

data collection because of heavy traffic, some of pedestrians are not properly observed.

4. Proposed Study

From the research of (Kadali et al., 2013), there is future scope to examine the different speed of crossing of pedestrian at different lane and pedestrian crossing pattern at different condition. It is also important to study and formulate the pedestrian pattern of crossing with the path change conditions. (Moyano, 2002) study can be further extended towards different road characteristics to assess the pedestrian gap acceptance behaviour. Future works could verify some hypotheses concerning the comparison of subgroups of specific users defined by age, sex and accident involvement. (Guo et al., 2014) studied the pedestrian behaviour on crossing location, so there should be further consideration of Origin - Destination studies and the reason for violation of rules. (Khatoun et al., 2013) study only done on the video recording at the locations, but no actual data was collected from police station. So there is future scope to correlate the observed data with actual crashes data by collecting from police station for a long period. (Keegan and O'Mahony, 2003) study can be extend fully at the impact of traffic levels on pedestrian behaviour. (Yan et al., 2013) studied on the pedestrian crossing behaviour during red time. So the difference of pedestrian crossing behaviour during red time and green time should also be further analyzed. (Zhuang et al., 2011) study can be extending for the collection of data by using wide angel cameras. Study also can be done based on pedestrian parties' survey.

5. Methodology

5.1 Pedestrian attitude survey

The aim of this survey is to examine the reasons for variation in behaviour of the pedestrians at different signalised pedestrian crossings. Another objective is to establish the attitudes of pedestrians and their awareness of crossing behaviour. Data (s) of pedestrian were collected for a day about the age, sex, education, monthly income and different situations of the pedestrian. Individual pedestrian (s) situation during crossing are observed by the way of watching their attitudes towards crossing the road. During observation it was found that, those pedestrians who are not in hurried they do not have any objection to take part for the interview and also willing for to give their interview without hesitation. Whereas, in - hurried situation, pedestrian hesitate to give their interview, comment and also avoid to taking part in the questioner, they are considered mostly hurried pedestrian. It is noted that the weather condition was sunny during that day of survey as per the climatic condition seen and found for the particular day. The data (s) of a single day is shown in Table - 1. Survey was conducted on the peak hour of the day (9.30am - 10.30 am & 4.30pm - 5.30pm) to cover different traffic conditions.

Following data was collected at the location by questioners and field survey -

- Attitude of different age group of pedestrian.
- Behaviour of pedestrian on different kind of days.

- Attitude and driving pattern of the drivers in different roads (rural or urban) and different road condition (wet/slippery or dry/road top).

5.2 Video survey

In this video survey method, the statistical required data has been collected by using appropriate methodology. Study was done based on pedestrian attitude survey. From this experimental data collecting observation, at each located intersections and crossings data (s) were recorded for one hour of each, from 9.30 am to 10.30am and 4.30pm to 5.30 pm for a single day. Observed characteristics data (s) of pedestrian crossing behaviours are shown in Table 2 and Table 3. After collecting the videos at different location, data collectors extracting the recordings to record information about the following data: -

- Position of crossing
- Pedestrian Image
- Speed of vehicle
- Minimum Distance from which the driver started to de - accelerate his vehicle

6. Results & Discussions

a) Statistics of Questionnaires Survey

Table 1: Statics data collected at crossings

Variable	Item	Frequency	Percentage
Age	< 18	57	20.50
	18 - 30	121	43.53
	31 - 55	49	17.62
	>55	51	18.35

Table 2: Variation of Time with Respect to Age of Pedestrian

Location	Children		Adults		Older People	
	Average Waiting Time (Sec)	Average Crossing Time (Sec)	Average Waiting Time (Sec)	Average Crossing Time (Sec)	Average Waiting Time (Sec)	Average Crossing Time (Sec)
Jharsuguda Gandhi Chowk	2.44	5.15	2.07	6.28	3.12	8.68
BTM Bypass	2.69	6.31	2.48	7.54	3.65	9.56

After extracting data from the video survey (see Table - 2) and analysing, it is found that children are taking more waiting time than of adults pedestrian because of fear to cross. But children are taking less time to cross the road at both the location in hurry. Result showed that adult pedestrians are more liable to taking risky crossing by decreasing both waiting time and crossing time those older pedestrians.

Table 3: Variation of Time with Respect to Pedestrian Gender

Location	Male		Female	
	Average Waiting Time (Sec)	Average Crossing Time (Sec)	Average Waiting Time (Sec)	Average Crossing Time (Sec)
Jharsuguda Gandhi Chowk	2.38	6.13	2.86	7.65
BTM Bypass	2.57	7.12	2.93	8.37

From the analysis of video survey data (see Table - 3), it is found that female pedestrian waiting time is more than that

Education	Primary and Above	97	34.89
	High School	102	36.69
	Bachelors	56	20.15
	Masters and Above	23	8.27
Monthly Income	< 5 thousand	114	41.01
	5 - 10 thousand	86	30.94
	11 - 20 thousand	53	19.06
	>20 thousand	25	8.99
Situation of Pedestrian	Not hurried	42	15.11
	Moderate Hurried	196	70.50
	Most Hurried	40	14.39

From the questionnaires survey (Table - 1) it is found that pedestrian aged 18 - 30 account user of the road for a high proportion (43.53 %), while other age group pedestrians are approximately 20% each. Education has greater impact on pedestrian crossing behaviour, due to lack of knowledge regarding traffic safety, pedestrian in India are more liable to accidents. It is also observed that from the questionnaire survey there are approximately 35% of pedestrian belongs to middle school and below. It is observed that, approximately 41% of pedestrians have income level below 5 thousand rupees, so their living style is so simple and they are not much aware about the traffic rules and regulations. Being in a hurry is an important factor which influence the pedestrian crossing behaviour mostly. And it is observed that approximately 15% of pedestrian are not in hurried, which is very less in percentage. Most of pedestrian are being in moderate & most hurried due to low income group to survive their lives, which leads to more accidents in India like developing countries.

b) Statistics Data extracted from Video Survey

of male pedestrian and also takes more time to crossing than male pedestrian. Result showed that male pedestrians are more willing to violate the rules and taking more risky crossing behaviour.

Table 4: Pedestrian Crashes during 2019

Age	Male	Female
Less than 5 years	13	8
6 - 9 years	24	9
10 - 14 years	72	21
15 - 17 years	166	19
18 - 20 years	258	61
21 - 24 years	405	61
25 - 34 years	495	81
35 - 44 years	454	64
45 - 54 years	333	55
55 - 64 years	123	29
65 years & above	36	11

(Source: - C. I. D., Crime Branch, Odisha)

From the statistics data (see Table - 4) of C. I. D., Crime Branch, Odisha, it is found that pedestrian aged 15 - 54

years are more percentage of crash during 2019. Male pedestrians are more willing to cross the road with a greater risky and in hurry situations. Female pedestrian crashes rate is less due to they take the very consciousness decisions during crossing the road. The sex wise distribution revealed

that males are predominantly affected with male: female ratio 5.67: 1. In this study the increased number of Road Traffic Accidents cases among male in the age group of 15 - 54 years.

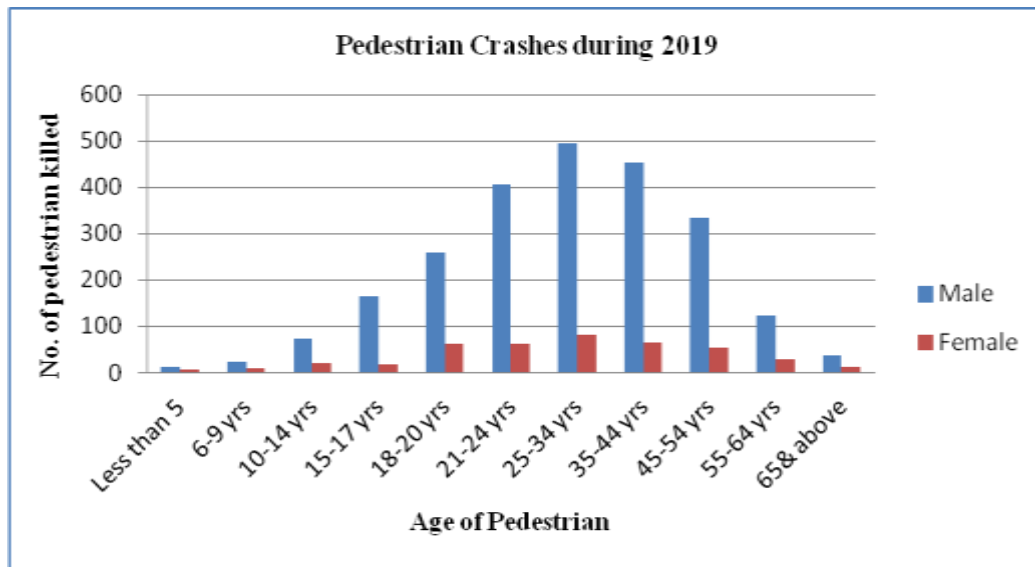


Figure 1: Age VS No. Of Pedestrian crashed

From the Fig - 1, it is concluded that young male pedestrians are the vulnerable group of a system. There is high rate of accidents occurs in the aged of 18 - 54, for their carelessness and aggressive behaviour during crossing.

7. Conclusion

This paper examined the crossings behaviour of pedestrian at crossings based on data from video observations and field questionnaire survey. The study formulates factors which influence the crossing behaviour of pedestrians. It is found that male pedestrians have significantly faster walking speeds than female pedestrians. This paper finds that average crossing speeds of pedestrian varies at different study locations with respect to various characteristics of pedestrian like gender, age, education and being in hurry. So it is concluded that pedestrian crossing behaviour analysis is an important factor for ensuring safety of pedestrian on crossings. And also the waiting time of pedestrians can be used to control the need of pedestrian safety facilities in the urban area.

8. Conflicts of Interest

The authors declare that there have no conflicts of interest.

References

- [1] Atuah D., Boansi M., Cobbinah P. B. (2017). "Pedestrian crossing in urban Ghana: Safety implications." *Journal of Transport & Health*, Volume 5, Pages 55 - 69.
- [2] Demiroz Y. I., Onelcin P., and Alver Y. (2015). "Illegal road crossing behaviour of pedestrians at overpass locations: factors affecting gap acceptance, crossing times and overpass use." *Accident Analysis & Prevention*, vol.80, pp.220-228.
- [3] Guo H. W., Zhao F., Wang W., Zhou Y., Zhang Y., and Wets G. (2014). "Modelling the perceptions and preferences of pedestrians on crossing facilities." *Discrete Dynamics in Nature and Society*, vol.2014, Article ID 949475, 8 pages.
- [4] Jain A., Ankit J., and Rastogi R. (2014). "Pedestrian crossing behaviour analysis at intersections." *International Journal for Traffic and Transport Engineering*, vol.4, no.1, pp.103-116.
- [5] Kadali B. R. and Vedagiri P. (2013). "Effect of vehicular lanes on pedestrian gap acceptance behaviour." *Procedia - Social and Behavioural Sciences*, vol.104, pp.678-687.
- [6] Keegan O. and O'Mahony M. (2003). "Modifying pedestrian behaviour." *Transportation Research Part A: Policy and Practice*, vol.37, no.10, pp.889-901.
- [7] Khatoun M., Tiwari G., and Chatterjee N. (2013). "Impact of grade separator on pedestrian risk taking behaviour." *Accident Analysis & Prevention*, vol.50, pp.861-870.
- [8] Koh P. P. and Wong Y. D. (2014). "Gap acceptance of violators at signalised pedestrian crossings." *Accident Analysis & Prevention*, vol.62, pp.178-185.
- [9] Moyano E. D. (2002). "Theory of planned behaviour and pedestrians" intentions to violate traffic regulations." *Transportation Research Part F: Traffic Psychology and Behaviour*, vol.5, no.3, pp.169-175.
- [10] Yan Y. and Jian S. (2013). "Study on pedestrian red - time crossing behaviour." *Transportation Research Record: Journal of the Transportation Research Board*, vol.2393, no.1, pp.117-124.
- [11] Zhou Z. P., Liu Y. S., Wang W., and Zhang Y. (2013). "Multinomial logit model of pedestrian crossing behaviours at signalized intersections." *Discrete*

Dynamics in Nature and Society, Article ID 172726, 8 pages.

- [12] Zhuang X. and Wu C. X. (2011). "Pedestrians" crossing behaviours and safety at unmarked roadway in China. " *Accident Analysis and Prevention*, vol.43, no6, pp.1927–1936.