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COMPARATIVE STUDY OF PEDESTRIAN CROSSING BEHAVIOUR AT UNCONTROLLED INTERSECTION AND MIDBLOCK LOCATIONS

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Abstract - *Understanding pedestrian-vehicle interactions and individual responding behavior in mixed traffic situations is a difficult issue. Pedestrian factors (age, gender, luggage, and trip intent), environmental features, vehicular flow factors, and land use type all influence how people perceive and take risks when crossing the road. To evaluate the key determinants impacting pedestrian road crossing behavior, the current study compared average pedestrian crossing speeds at several pedestrian crossing locations in medium-sized cities (kothamangalam and perumbavoor in India) under mixed traffic conditions. The videography method was used to acquire four hours of traffic data in each location. The statistical data revealed a considerable difference in crossing speed between the midblock and intersection based on characteristics. Male and middle-aged pedestrians cross at faster speeds than female and younger and older pedestrians. The conclusion is that pedestrian crossing behavior and risk perception vary depending on location and pedestrian characteristics. The findings can be utilized to better assess pedestrian risk in the context of motor movement.*

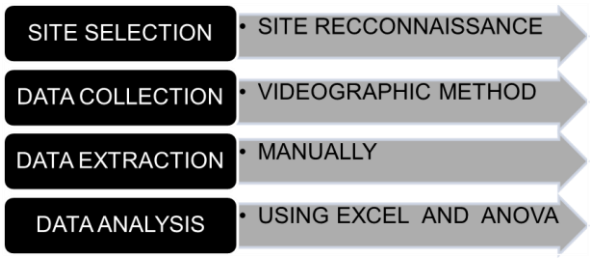
Key Words: Pedestrian Crossing Behaviour, Unsignalised Intersection, Midblock Section, Speed Distribution, Percentile Speed.

1. INTRODUCTION

Age, gender, baggage, intent of travel, ambient variables, vehicle characteristics and vehicle flow factors, and land use type all influence pedestrian perception and risk when crossing the road. Pedestrians with higher crossing speeds can cross the road much faster than pedestrians with lower crossing speeds. Because of the mixed traffic situations and violent behavior of either cars or pedestrians in nations like India, this issue is particularly significant. Pedestrians attempt to cross the road with a great deal of risk due to the lower priority and long wait times, and there is a risk of collisions with various types of vehicles. Pedestrian crossing speeds vary greatly depending on the kind and composition of pedestrian crossings and vehicles. The presence of a local population, local land use practices, safety and protection are all elements that influence the demand for pedestrian infrastructure.

Because of increasing population densities, fast urbanization, and a lack of attention to traffic norms by both drivers and walkers, pedestrian traffic accidents have become a major safety hazard all over the world, particularly in developing countries. Furthermore, pedestrians who are involved in a collision with a motor vehicle usually sustain serious injuries. Some of the elements that influence fatal pedestrian injuries will be investigated as a result of this research. The examination of pedestrian crossing behavior is an important aspect in determining pedestrian safety on roads, and the waiting time of pedestrians can be used to determine the necessity for pedestrian facilities in the area. As a result, the study's findings should aid in reducing fatalities and property damage caused by disputes between crossing pedestrians. It also aids in the maintenance of order in the streets and the protection of both drivers and pedestrians. The findings of this study are likely to aid traffic engineers, planners, and policymakers in better understanding pedestrian behavior at signalized intersection crosswalks. The findings can be used to build pedestrian infrastructure and provide pedestrian guidelines. It can also be used to understand pedestrian risk in the context of motor movement. This study took into account the number of pedestrians in a group and their luggage.

2. METHODOLOGY



3. SITE SELECTION

Observations of 8 sites were done prior to the data collection to check the peak pedestrian flow. Two sites each are chosen for uncontrolled intersection and midblock section. Observation of sites were done prior to the data collection.

The study locations are chosen based on the following criteria:

- The pedestrian traffic is high.
- The flow of traffic is continuous.
- The farthest and the view point should be easily accessible using a camera.

The four locations chosen are as follows

- Government Taluk Hospital, Aluva-Munnar Road, Perumbavoor- This is a two lane road having 7.5m width and shoulder width of 1m. This road is an uncontrolled intersection.
- SH-16, Aluva-Munnar Road, Kothamangalam, Hospital Junction- This is a two lane road having 7.5m width and shoulder width of 1.5m. This road is a midblock section.
- 151 Armana Junction, SH-1, Muvattupuzha- This is a four lane road having 13.7m width and shoulder width of 1.0m. This road is an uncontrolled intersection.
- P.O Junction, Muvattupuzha, near Latha bridge- This is a four lane road having 12m width .This road is a midblock section.

4. METHOD OF DATA COLLECTION

Video is captured using an iphone which is hidden from pedestrians to maintain their behavior. Video is captured for 1hour peak period in morning and 1hour peak period in evening for two days. Thus a total of 4hour data is captured from each location. Morning data is collected around (8:30-9.30) and evening data around (4:00 -5:00). The camera is focused across the width of the road so that the end to end movement of pedestrian can be observed.

4.1 Observation Protocol

The following observation protocol was followed during extracting pedestrian behaviour.

- Only a single pedestrian is observed while a group of pedestrians is encountered and the first pedestrian crossing the road is taken.
- Observations were made across the width of the road from a pedestrian preparing to cross the road to the point where he crosses the road.
- The pedestrians were not aware of the study.
- The pedestrians carrying baggage were included to generalize the study, but pedestrians with strollers and bicycle accompanying are not considered.
- Data was not collected during rain or unusual weather which may affect the pedestrian behaviours.
- Pedestrians using mobile phones while crossing the road were neglected.
- The delay in two step crossing was deducted from the total crossing time.
- Children crossing the road with the aid of parents were not taken into consideration.
- Classification of pedestrians based on age group was purely based on observation.

4.2 Data Extraction

From the video captured, the pedestrian waiting time and crossing time were analysed manually with the help of a video player. The values of pedestrian waiting time and crossing time were written down manually and the following details were noted down from each pedestrian in an MS Excel sheet.

1. Gender
2. Age group
3. Carrying baggage
4. Crossing Pattern

Table -1: Pedestrian data

GENDER	AGE GROUP	BAGGAGE	CROSSING PATTERN
Male-M	Children-C	Without-W	Straight-S
Female-F	Adult-A	With-Y	Oblique-O
-	Elderly-O	-	-

4.3 Primary Analysis

Speed of the pedestrian is calculated using distance time formula using MS Excel.

Speed = Distance ÷ Time

Distance is the width of the road measured using a distance meter and time is the crossing time.

Different graphs were drawn between the crossing speed versus cumulative percentage speed for each location based on age group and gender. From each graph minimum, maximum,15th percentile,50th percentile,85th percentile and Crossing Speed Deviation Factor (CSDF) were measured for all the locations. Crossing speed variation was calculated for each location. It is the difference between 85th percentile speed and 15th percentile speed. CSDF is the ratio of crossing speed variation to average crossing speed at each location.

5. DATA ANALYSIS

This observed data consists of numerical values such as waiting time, crossing time and crossing speed. The data also include categorical value. The speeds are calculated and a parameter CSDF is calculated.

Percentile Speed is the speed below which a specified percentage of vehicles are travelling. For example 85th percentile speed is known as the speed below which 85% of pedestrians are observed to possess. This speed shall be used to design pedestrian crossings. 15th percentile speeds should be considered as the minimum speed while designing pedestrian facilities. The percentile speeds are calculated by plotting graphs between crossing speed and cumulative percentage speed. Different graphs were drawn between the crossing speed versus cumulative percentage speed for each location based on age group and gender. From each graph minimum, maximum,15th percentile,50th percentile,85th percentile and Crossing Speed Deviation Factor (CSDF) were measured for all the locations. Crossing speed variation was calculated for each location. It is the difference between 85th percentile speed and 15th percentile speed. CSDF is the ratio of crossing speed variation to average crossing speed at each location.

5.1 One-Way Anova

A one-way ANOVA is used to compare two means from two independent (unrelated) groups using the F-distribution. ANOVA uses the F-test to determine whether the variability between group means is larger than the variability of the observations within the groups. If that ratio is sufficiently large, you can conclude that not all the means are equal. If the test gives a value pf p < .05, then there is a relation between the variables used. The one-way ANOVA compares the means between the groups you are interested in and determines whether any of those means are statistically significantly different from each other.

5.2 Odds Ratio

Odds ratio (OR) is the ratio of odds that an event will occur in one group to the odds that event will occur in another group. Odds ratio of pedestrians based on gender and behavior such as waiting time, crossing pattern were calculated. The OR statistics shows the percentage of pedestrians more likely to have various behaviors such as crossing pattern, waiting time.

If the OR is greater than 1, the group is more likely to have that behavior and vice versa. If OR is equal to 1, then no different two groups are being compared. If OR is 2, the behavior being measured has two times more likely to occur to a group being studied, compared with the control group.

6. OBSERVED AND ANALYSED DATA

6.1 Observed Number of Pedestrians

Table -2: Observed Pedestrians

CATOGORICAL ATTRIBUTE		UI 1	UI 2	MB 1	MB 2
GENDER	FEMALE	146	77	104	45
	MALE	172	70	151	49
AGE GROUP	ELDERLY	49	40	49	21
	ADULT	256	107	202	74
	CHILDREN	13	0	3	0
PATTERN	STRAIGHT	277	141	239	75
	OBLIQUE	41	6	15	19
BAGGAGE	WITH	83	7	215	9
	WITHOUT	237	140	39	85
Total Number of Pedestrians		465		349	

UI -UNCONTROLLED INTERSECTION
MB-MIDBLOCK SECTION

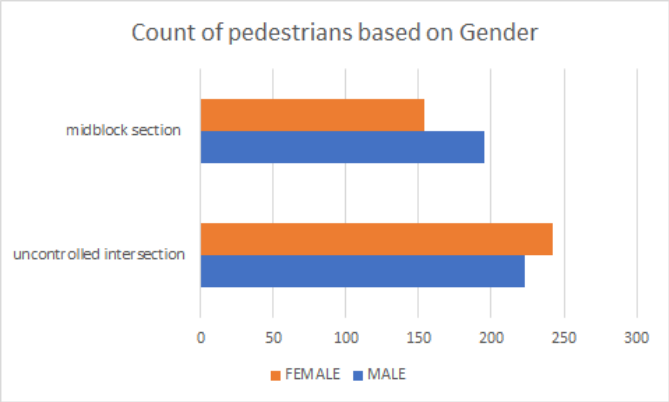


Fig -1: Count of pedestrians based on gender in uncontrolled intersections and midblock section

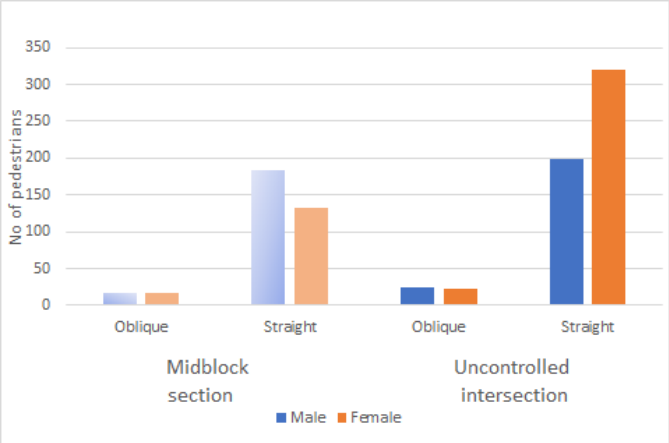


Fig -2: Count of number of pedestrian based on gender and crossing pattern

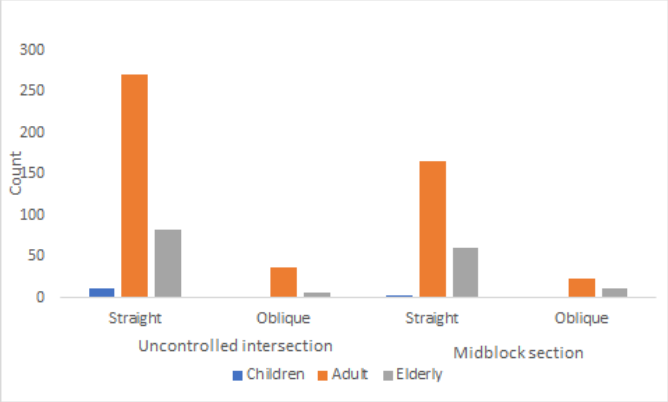


Fig-3: Count of number of pedestrian based on age group and crossing pattern

6.2 Speed Distribution Curves

The crossing speed versus cumulative percentage speed below the gives percentile speeds. It is drawn on the basis of age and gender attributes. From each graph different speeds (minimum, maximum, 15th percentile, 50th percentile, and 85th percentile speeds) and crossing speed deviation factor (CSDF) were measured for all the study locations.

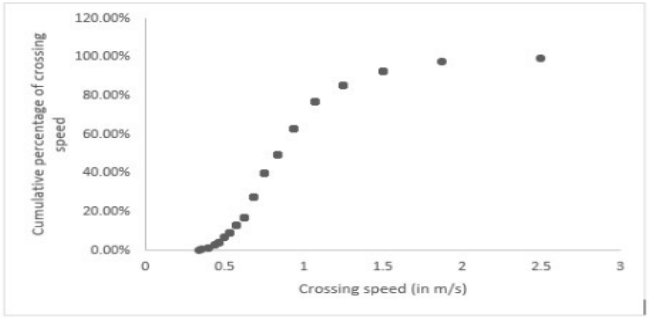


Fig-4: Crossing speed versus cumulative percentage speed below the given speed for Uncontrolled Intersection 1 based on Gender category Male.

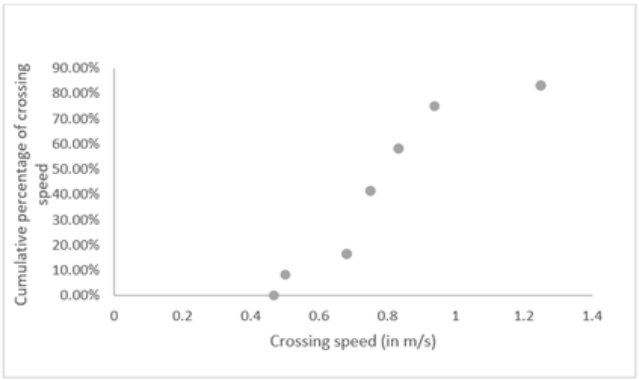


Fig-5: Crossing speed versus cumulative percentage speed below the given speed for Uncontrolled Intersection 1 based on Age category Child.

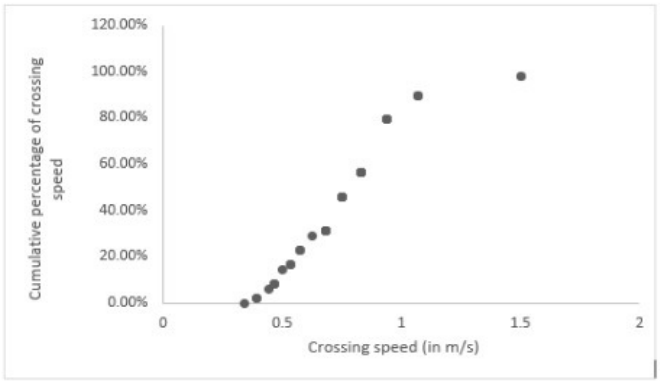


Fig-6: Crossing speed versus cumulative percentage speed below the given speed for Uncontrolled Intersection 1 based on age category elderly.

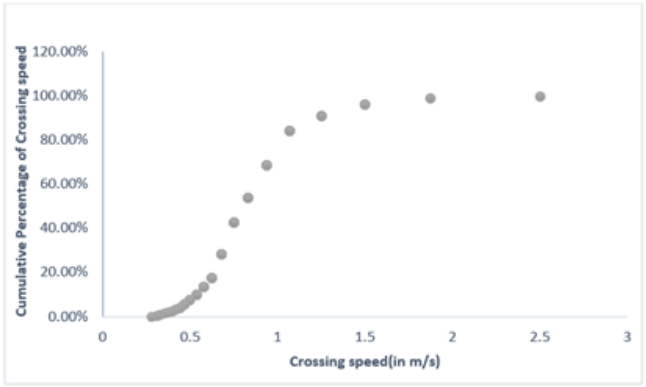


Fig-7: Crossing speed versus cumulative percentage speed below the given speed for Uncontrolled Intersection 1 based on age category Adult.

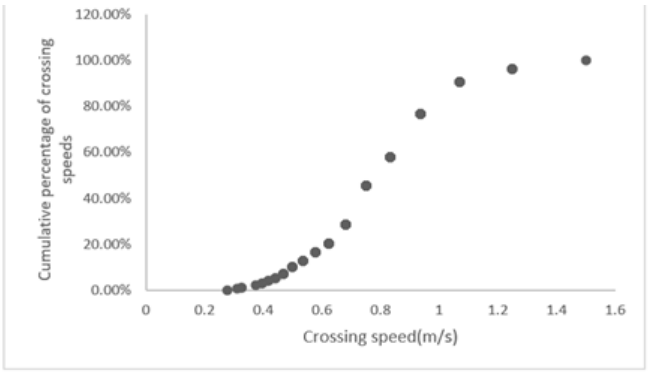


Fig-8: Crossing speed versus cumulative percentage speed below the given speed for Uncontrolled Intersection 1 based on Gender category Female.

6.3 Percentile Speeds of Pedestrians

The US Institute of Transportation Engineers (ITE) suggests a speed of 0.75 m/s at a location with a higher proportion of seniors. This value accommodates 87% of the pedestrian population. The results observed show that male have the greatest 85th percentile speed in both uncontrolled

intersection 1& 2 (1.116m/s and 1.36m/s) also in both midblock locations (1.071m/s and 1.2m/s). It is also observed that females have lower crossing speed compared to male in both uncontrolled intersections, the elderly age group has the lowest 15th percentile speed in all sections taken- 0.341m/s & 0.444m/s for midblock sections and 0. 375m/s and .591m/s for uncontrolled intersections. Bowman and Vecellio (1994) described a Swedish study in which 15 percent of the older pedestrians crossed at speeds below 0.7 m/s. This result is also satisfied in the case of both uncontrolled intersection and midblock location. The average crossing speed of adults is found to be higher against the other age groups- 0.841m/s and 1.051m/s in case of midblock locations. While at an uncontrolled intersection, it was found to be for child-0.836m/s. This result is also considered due to the fact of the sample space of children being small in all cases.

Table -3: Crossing speed and CSDF for the different type of pedestrians (Midblock Section)

Location	Pedestrian Attribute		Minimum	15th percentile	50th percentile	85th percentile	Maximum	Average speed	CSDF
MIDBLOCK SECTION 1	GENDER	Female	.3125	0.625	0.833	0.9375	1.5	0.800	.3906
		Male	.325	0.625	0.833	1.071	2.25	0.855	.873
	AGE	Elderly	.375	0.586	0.75	1.071	1.5	0.805	.639
		Adult	.3125	0.625	0.833	1.071	2.25	0.841	.531
		Child	.5	0.575	0.75	0.808	.833	0.694	.336
MIDBLOCK SECTION 2	GENDER	Female	0.444	.8114	1.091	1.333	1.5	1.069	.4875
		Male	0.631	.70	.92	1.2	1.714	0.949	.5204
	AGE	Elderly	0.444	.6315	.8	1.091	1.5	0.872	.5265
		Adult	0.631	.8	1.091	1.333	1.714	1.051	.5067

Table -4: Crossing speed and CSDF for the different type of pedestrians (Uncontrolled Intersection)

Location	Pedestrian Attribute		Minimum	15th percentile	50th percentile	85th percentile	Maximum	Average speed	CSDF
UNCONTROLLED INTERSECTION 1	GENDER	Female	0.277	0.535	0.75	0.9375	1.5	0.754	.532
		Male	0.341	0.577	0.833	1.116	2.5	0.864	.624
	AGE	Elderly	0.341	0.502	0.75	0.9375	1.5	0.757	.5754
		Adult	0.277	0.577	0.75	1.071	2.5	0.812	.6085
		Child	0.468	0.645	0.75	1.25	1.25	0.836	.723
UNCONTROLLED INTERSECTION 2	GENDER	Female	0.277	.929	1.04	1.133	1.36	1.054	.193
		Male	0.8	1.046	1.23	1.36	1.511	1.186	.265
	AGE	Elderly	0.591	.9617	1.008	1.113	1.236	**1.007**	.150
		Adult	0.8	1.046	1.133	1.36	1.511	**1.167**	.2691

7 STATISTICAL ANALYSIS

7.1 One Way Anova Results

Table -5: ANOVA Results (Uncontrolled Intersection)

Type of Site	Categorical value used	F crit	F	p-value
Uncontrolled Intersection 1	Gender	3.87	11.8637	.00065
	Age group	3.0244	.84613	.43
	Crossing Pattern	3.871054	0.137754	0.710773
Uncontrolled Intersection 2	Gender	3.90639	33.22065	.000
	Age group	3.906392	40.32662	.000
	Crossing Pattern	0.000257	3.907312	0.987223

Table -6: ANOVA Results (Midblock Section)

Type of Site	Categorical value used	F crit	F	p-value
Midblock Section 1	Gender	3.878	3.83291	.049
	Age group	3.03177	1.0977	.33
	Crossing Pattern	3.878774	1.346405	0.24701
Midblock Section 2	Gender	3.944539	5.021362	.027443
	Age group	3.943409	8.068117	.005534
	Crossing Pattern	3.943409	2.122883	0.148481

7.2 Age Group

It if found that there is no significant statistical difference in crossing speed based on age groups in site of Uncontrolled intersection 1 and midblock location 1 as p>.05 while in the case of uncontrolled intersection 2 and midblock section shows a significant difference (p<.05). This may be due to the fact that the children's age group pedestrian numbers were nil in both cases. Hence, we cannot conclude the relation between the crossing speed of pedestrians and age based on the observed data.

7.3 Gender

After the analysis, it is found that gender is the main categorical attribute on which crossing speed of the pedestrians varies. The ANOVA results show a statistical significance difference as p<.05 in all cases. P-value is .00065 & .000 in case of Uncontrolled Intersection 1 & 2 respectively and p value is .049 & 0.0274 of midblock section 1 &2 respectively.

7.4 Pattern

The initial hypothesis of crossing speed of pedestrians has same means based on pattern and cannot be disproved as in all sites gives p value>.05. The crossing pattern of the pedestrians does not have a statistical difference with crossing speed in all cases according to the observed data.

7.5 Waiting Time

It is seen from the number of pedestrians and their waiting times that 65.11 percent of pedestrians in uncontrolled intersections do not wait to cross the road while it is 32.22 percent in case of pedestrians in midblock that do not wait. In uncontrolled intersection, the average waiting time is 9.05228s and in midblock section, the average waiting time of pedestrians is 6.36s. In uncontrolled intersections, female showed an average time of 13.8125s and males showed a mean of 8.1428s. In midblock sections, females showed an average time of 6.912s and males showed an average time of 5.8934s The male pedestrian will wait for shorter time than female pedestrians (Tiwari et al 2007). Hence this is in regard to and satisfies the observations from previous studies. It is also observed that waiting time in uncontrolled intersections is more than in mid-block sections. Roads from different directions converging creates large traffic and hence waiting time may increase

7.6 Odd Ratio Results

Odd ratio for midblock location and uncontrolled intersections were calculated for crossing pattern, waiting time based on gender

Table-7: Odd ratio statistics for gender at uncontrolled intersections

CRITERION	BEHAVIOUR	GENDER	
		Male	Female
Crossing Pattern	Oblique	24	22
	Straight	199	320
	Odd ratio	1.75	1
Waiting Time	Not Waiting	140	153
	Waiting	83	74
	Odd Ratio	1	1.23

Table-8: Odd ratio statistics for gender at midblock sections

CRITERION	BEHAVIOUR	GENDER	
		Male	Female
Crossing Pattern	Oblique	17	17
	Straight	183	131
	Odd ratio	1	1.38
Waiting Time	Not Waiting	51	5
	Waiting	132	99
	Odd Ratio	1	1.54

7.7 At Uncontrolled Intersections

The Odd ratio statistics shows that 75 percent of male pedestrians were more likely to cross obliquely as compared to female pedestrians. The odd ratio statistics shows that 23 percent of female pedestrians were not waiting to cross the road which increase the chance of accidents.

7.8 At Midblock

The Odd ratio statistics shows that 38 percent of female pedestrians were more likely to cross obliquely as compared to male pedestrians. The odd ratio statistics shows that 54 percent of female pedestrians were not waiting to cross the road compared to male pedestrians.

8. CONCLUSIONS

The pedestrian data at uncontrolled intersection and midblock locations are observed to find the variation of pedestrian characteristics. Videography was done in 2 uncontrolled intersection location and 2 midblock locations on week days during peak hours. Data of 813 pedestrians were collected and they were analysed based on pedestrian characteristics. The collected data were tested with statistical analysis.

Male pedestrians have significantly faster walking speeds than their female counterparts in both uncontrolled intersections and midblock section. Pedestrians show greater variation in crossing speed based on gender in uncontrolled intersection than in mid block section. The results observed show that male have the greatest 85th percentile speed in both uncontrolled intersection 1& 2 (1.116m/s and 1.36m/s) also in both midblock locations (1.071m/s and 1.2m/s).

Statistical analysis shows that males are more prone to risk in both uncontrolled intersections and midblock locations as they have greater crossing speeds and lower waiting times. But 23 percent of female pedestrians were not waiting to cross the road which increase the chance of accidents in case of midblock locations and 54 percent of female pedestrians were not waiting to cross the road compared to male pedestrians in uncontrolled intersections. This does not agree with past literature that found males were less willing to wait at crossings and more likely to disregard rules. There is also an increase in the number of pedestrians who do not have waiting time and this is due to decreased traffic volume observed in the pandemic situation.

The results of analysis also do not have statistical significance with respect to age group in both uncontrolled

intersections and midblock sections. This is in disregard for the previous studies conducted in other locations in the past. This effect is mainly due to the fact that there is a very minimal amount of children in the data collected as Covid wave has shut down educational institutions. The elderly age group has the lowest 15th percentile speed in all sections taken and this must be considered while designing pedestrian facilities.

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