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# Pedestrians' Behavioral Analysis Through Critical Gap At Un-Signalized Unmarked Midblock Crossing In Delhi

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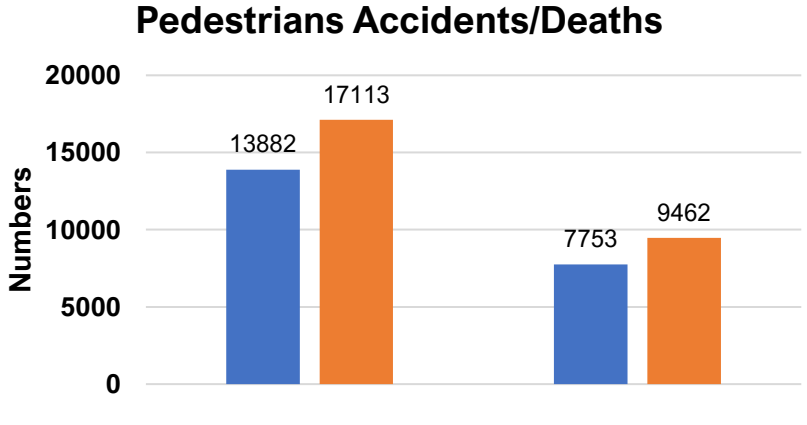
# Introduction



- Walking is still regarded as a universal mode of transportation, especially for start and the end of a trip

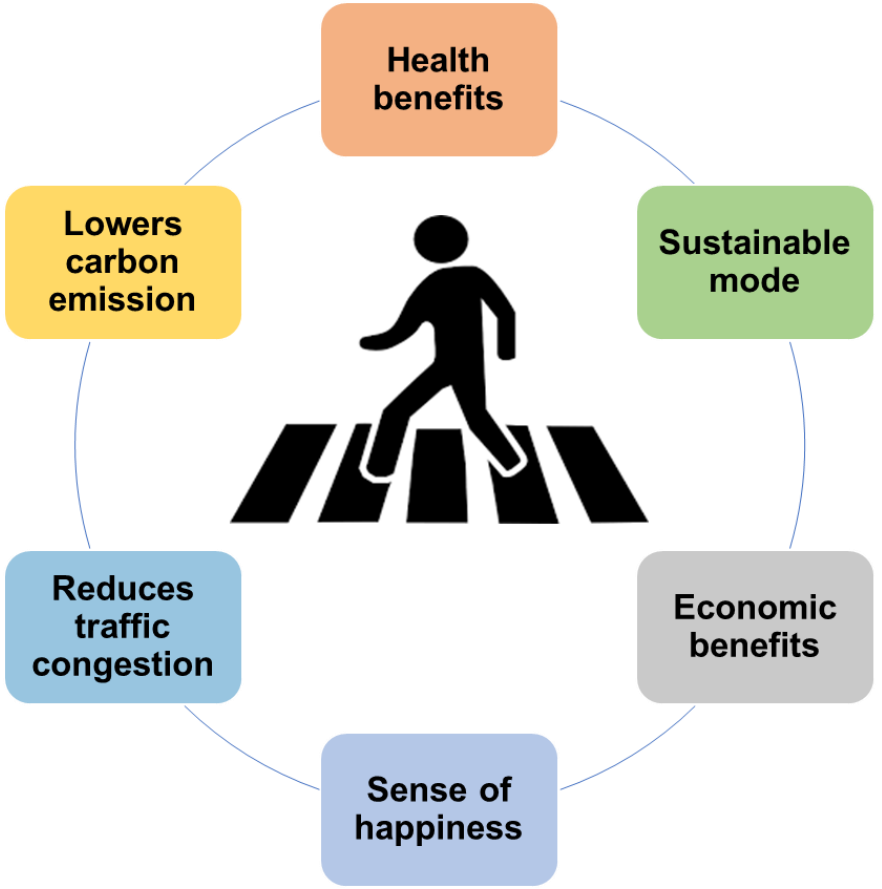
- Inadequate urban transportation facilities, especially for most vulnerable road users such as pedestrians & bicyclists




**Source:** MoRTH (2021)

**62** deaths daily
**15%** of total

**Source:** India Tv News (2021)




- Provision of adequate pedestrian infrastructure, such as sidewalks and crossing facilities, is required to **promote walkability** in an urban area

# Mid-block Crossing



- Higher waiting times at intersections, sometimes, lead to pedestrians crossing through un-signalized crosswalks, such as mid-block locations (between two intersections)
- The fatalities in urban areas have reached up to 60%, of which 85% occur at un-signalized midblock crosswalks (Kadali and Vedagiri, 2016)
- Pedestrian gap acceptance behavior becomes more critical at un-signalized, unmarked midblock crossings due to complex interactions of pedestrians with moving vehicles
- The gap acceptance theory evaluates the safety performance at uncontrolled intersections and un-signalized pedestrian crossings (Pawar and Patil, 2016)
- The critical gap is an essential parameter in exploring the gap acceptance behavior, which is the minimum time gap below which pedestrians do not attempt to cross the road (US-HCM, 2010)
- These behavioral differences may depend on pedestrians' characteristics such as gender, age, and platoon size (group size) while crossing (Kadali and Vedagiri, 2016) (Pawar and Patil, 2016)

# Need of the study



- Existing literature has very limited studies to estimate critical gaps, especially at un-signalized unmarked midblock crossings for pedestrians in the Indian scenario

- Micro-level behavior (through the pedestrians' gap acceptance) need to be studied to improve pedestrians' safety at un-signalized and unmarked mid-block crossings

- the most suitable critical gap estimation method must be identified in the Indian scenario dealing with multiple-sized vehicles and space-sharing-based vehicular movement

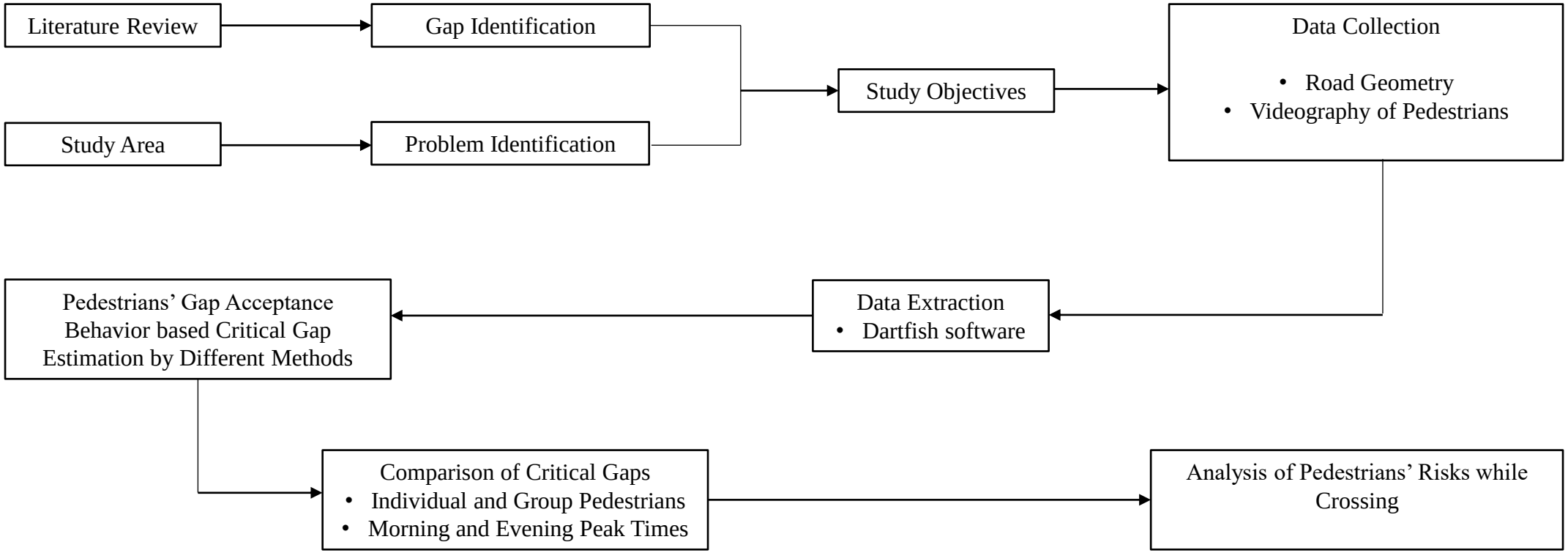
# Study objectives

- To estimate and compare the critical gaps for pedestrians crossing individually and in a group at the un-signalized midblock section based on Clearing time, Greenshield's, Raff's, and Harder's methods

- To explore the perceived risk of crossing pedestrians at the un-signalized mid-block section under study

# Study methodology





# Study area

- An un-signalized (non-functional traffic signal) unmarked pedestrian midblock crossing was selected on Mathura Road, New Delhi, in India

- Though this is on a six-lane divided National Highway, the functionality of this road is more of an urban arterial road in nature

Midblock section on Mathura Road, New Delhi (Source: Author)

# Data collection and extraction



- A two-hour video recording survey was conducted for morning and evening peak times (4:00 pm to 6:00 pm and 8:00 am to 10:00 am) on working days in average weather conditions in September
- A single camera was fixed and positioned on a tripod and extended up to 10 m in height in such a way that it could be able to record vehicular and pedestrian characteristics
- The collected video was run using Dartfish software at a slower speed and horizontal reference line is drawn using the command "Line" provided in the software to determine the vehicular gaps

Midblock section (Source: Author)

***time ($t_1$)***: the rear bumper of the leading vehicle touching the reference line

***time ($t_2$)***: the front bumper of the following vehicle touching the reference line

$t_2 - t_1$ = vehicular gap

**3126** vehicular gaps (accepted and rejected) involving 635 pedestrians

# Collected data/information



| Variable type | Variable name | Description |
|---|---|---|
| Gender | Gender: Male, Female | Based on their appearance |
| Crossing Patterns | Perpendicular: Yes or No | Whether pedestrians crossed perpendicularly to the road or not |
| | Angular: Yes or No | Whether pedestrians crossed angularly to the road or not |
| Pedestrian Behavioural Characteristics | Rolling gap: Yes or No | Whether pedestrians roll over the road to accept the gaps or not |
| | Running: Yes or No | Whether pedestrians run over the road to cross or not |
| | Pedestrian group size: 1, 2, 2-4, 4-7, >7 | Number of pedestrians in a group |
| Vehicle Characteristics | Vehicles type: 2, 3,4-wheelers | Vehicles type during accepted and rejected gap/lag |
| Traffic Characteristics | Waiting time | Waiting time of pedestrians in seconds to accept gap/lag |
| | Crossing time | Pedestrian crossing time in seconds |
| | Vehicular gap size | Time difference of vehicles reaching reference line (in seconds) |
| | Accepted/rejected gap size in seconds | Whether pedestrians accept/reject gap/lag |

# Critical gap estimation methods



| Methods | Critical gap |
|---|---|
| Raff | Intersection point in the frequency distribution of accepted and rejected gap sizes of pedestrians |
| Greenshield | Gap size corresponding to equal value of cumulative percentage of accepted and rejected gap sizes in the frequency distribution of accepted and rejected gap sizes of pedestrians |
| Harder | Gap size corresponding to 50% cumulative gap number in the frequency distribution of accepted and rejected gap sizes of pedestrians |
| Clearing Time | Gap corresponding to the intersection point of cumulative percentage of accepted gap size and (100-cumulative percentage) of Clearing time of pedestrians |

# Analysis and results



- Critical gaps using Greenshield's, Raff's, and Harder's methods were low
- Most critical gaps calculated using these three methods are close to the reaction time of drivers (2 seconds) as per Indian Road Congress
- Critical gaps using the Clearing time method were observed to be high

Estimated critical gaps (second) for morning peak

| Group size | Clearing time | Greenshield | Raff | Harder |
|---|---|---|---|---|
| 1 | 5.5 | 2.8 | 3.0 | 4.0 |
| 2 | 5.3 | 3.0 | 3.0 | 4.1 |
| 2-4 | 6.1 | 2.5 | 2.8 | 3.4 |
| 4-7 | 7.2 | 2.5 | 3.0 | 5.8 |
| >7 | 8.1 | 2.9 | 2.8 | 6.2 |

Estimated critical gaps (second) for evening peak

| Group size | Clearing time | Greenshield | Raff | Harder |
|---|---|---|---|---|
| 1 | 5.6 | 2.0 | 2.4 | 2.4 |
| 2 | 6.4 | 2.7 | 3.0 | 5.1 |
| 2-4 | 7.0 | 2.5 | 3.2 | 4.1 |
| 4-7 | 6.8 | 2.5 | 2.8 | 3.8 |
| >7 | 6.4 | 2.2 | 2.7 | 4.2 |

# Analysis and results

- Clearing time method considers pedestrians' clearing behavior and zig-zag pattern while crossing
- Therefore, based on the study findings and the existing literature, the Clearing Time method is appropriate for calculating critical gaps for a heterogeneous traffic flow with no proper lane discipline, especially for cities of developing nations

## Risk taking behavior while crossing

- The least critical gap, 5.3 seconds was considered to explore the risk-taking gap acceptance behavior of pedestrians while crossing
- Approximately 70% of total gap acceptance events were made with a vehicular gap size of less than the required critical gap of 5.3 seconds, involving about 67% of pedestrians. It indicates that these pedestrians (67%) crossed the road at risk

# Analysis and results

- 92 pedestrians (around 15%) crossed the road by running, indicating their risky crossing behavior due to the absence of adequate vehicular gaps
- 147 pedestrians (around 23%) crossed the road by rolling over it by accepting various smaller gaps in between

## Crossing Patterns

- 127 pedestrians (20%) followed an angular pattern (oblique crossing) to cross the road,
- while 506 pedestrians (approximately 80%) crossed the road perpendicularly

# Conclusions



- The Clearing time method was found appropriate to find critical gaps for heterogeneous traffic flow in cities of developing nations
- The study found approximately 67% of pedestrians were at risk while crossing the selected mid-block location
- 15% of pedestrians were found crossing the road by running, indicating the unavailability of adequate vehicular gaps to accept
- The development authorities should provide well-maintained and working signals for pedestrians so that they can cross safely
- The methodology used in this study could be applied to other cities of developing countries to analyze the pedestrians' gap acceptance behavior at mid-block locations

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*Thank You*

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