International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Evaluating Pedestrian Behavior on Unsignalized Streets and Mid-Blocks in Vadodara Using a Statistical Approach

Khushahal Malakar, Rohan Raj

B.Sc. in Transportation Technology

ABSTRACT

Pedestrian safety at unsignalized midblock crossings is a critical concern, especially in urban areas with inadequate infrastructure and aggressive driver behavior. This research examines pedestrian crossing behavior and interactions with vehicular traffic at such locations in Vadodara, India. Extensive data was collected and analyzed across six strategically selected urban sites to investigate the influence of pedestrian characteristics (age, gender, physical ability), behavioral factors (crossing speed, waiting time, distraction), vehicle dynamics (speed, type), and road infrastructure elements (median presence, number of lanes) on pedestrian crossing decisions and movements.

Key findings reveal correlations between age and walking speed, with older pedestrians tending to cross slower. The study also highlights how vehicle speeds and road infrastructure impact pedestrian behavior, underscoring the need for traffic calming measures and inclusive design. Data analysis uncovered patterns related to crossing attempt frequency and presence of individuals with physical disabilities across locations. While providing valuable insights, the scope is limited to specific Vadodara locations, limiting generalizability. However, the study lays the foundation for future implementations, including integration with Intelligent Transportation Systems, Advanced Driver Assistance Systems, pedestrian behavior monitoring systems, and urban planning efforts. Recommendations emphasize continuous data collection, stakeholder collaboration, prioritizing pedestrian safety, adopting advanced technologies, interdisciplinary cooperation, continuous evaluation and refinement, and public education campaigns. Overall, this research enhances understanding of pedestrian behavior at unsignalized crossings and provides a framework for improving pedestrian safety and urban mobility.

KEYWORDS: *Pedestrian Behavior, Urban planning, Vadodara, Accessibility.*

1. Introduction

Despite advancements in infrastructure, technology and public perceptions, road safety remains a critical global concern for both pedestrians and vehicle drivers (Theofilatos et. al, 2021). Particularly, pedestrians are more vulnerable to traffic accidents, which accounts for 13.3% of total road accidents and 16.9% of total road accident deaths according to MoRTH, 2021. Pedestrians are people who walk or use assistive devices. They are vulnerable when crossing roads (Siti Naquiyah Mohamad Nor, et al., 2017). Unfortunately, over 700 pedestrians lose their lives every day around the world with at least four times as many being seriously injured. This group of people is at an increasing risk of danger when using crosswalks, especially when the crossing is in an uncontrolled or unsignalled midblock location (Kayvan Aghabayk et. al., 2021). Additionally, lower middle-income countries face the challenge of pedestrian exposure on high-speed roads due to a lack of appropriate infrastructure (Theofilatos et. al, 2021).

In a country like India, uncontrolled and unsignalized midblock crosswalks can be dangerous due to lack of proper infrastructure and aggressive driver behavior. In addition, pedestrians who do not comply with crossing rules also contribute to the number of accidents that occur at these locations. According to a study conducted by the Indian Institute of Technology (IIT) in Delhi, 58% of pedestrian fatalities in Mumbai and 47% in Delhi occur in urban areas on the road (Arkatkar Shriniwas, et. al.). Therefore, it is important to understand and evaluate pedestrian crossing behavior and interactions with vehicles and the surrounding environment to promote safe crossing-way.

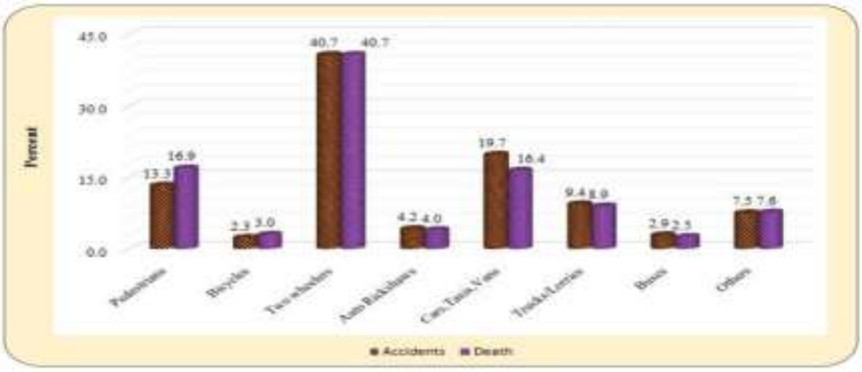

Figure 1: Road user category wise distribution of Accidents and Fatalities during 2021 | Source: MoRTH

[Figure 1]: The data published by MoRTH in 2022 about accidents and fatalities in different modes of transportation presents a clear picture. Especially, pedestrian accidents remain 13.3% from all the modes, but the more worrying part was the higher death rate at 16.9%. This suggests that although pedestrians were involved in a significant number of accidents, the outcomes were more severe, leading to a higher percentage of fatalities. Bicycles saw a slightly upward trend in accidents from 2.3% to 3%, with an equivalent increase in the death rate. Two-wheeler accidents remained same at 40.7%, and the death rate reflected this, indicating a consistent level of risk for riders.

Auto rickshaws experienced a minor decrease in both accidents (4.2% to 4.0%) and fatalities, implying a small improvement in safety. In addition, Cars, taxis, and vans also displayed a positive trend with a decline in both accidents (19.7% to 16.4%) and fatalities, reflecting towards enhanced safety measures for these vehicles. Buses also showed a decrease in accidents (2.9% to 2.5%) and fatalities, showing an encouraging improvement in safety outcomes. Accidents classified as 'others' witnessed slight increment from 7.5% to 7.6%, accompanied by a corresponding increase in the death rate; pointing towards the necessity for targeted safety efforts, particularly for pedestrians, to mitigate the severity of outcomes. While progress has been observed in some transportation modes, similar focus on safety measures across all modes and categories remains imperative for comprehensive road safety.

Midblock and unsignalized pedestrian crossings holds a critical part of pedestrian road safety (Kadali, B.R. et. al., 2015). So, in this study, we will focus on midblock and unsignalized pedestrian crossings, which are essential for safety of road users. A midblock crossing is a crossing point between intersections that does not have a designated crosswalk or is not at an intersection. These crossings may or may not have specific signals or signs to regulate pedestrian traffic. An unsignalized pedestrian crossing, on the other hand, is a crossing point dedicated to pedestrians that does not have traffic lights or signals.

These crossings depend on other means such as pedestrian markings, signs, or zebra crossings to indicate the presence of a crossing area for pedestrians. However, vehicles are not directed to stop for pedestrians at these crossings since there are no traffic signals to regulate the flow of vehicles (Khaled Shaaban, et. al., 2019).

1.1. Factors Affecting the Passenger Crossing at mid-block and Unsignalized Streets

These factors are taken from the study of (Khaled Shaaban, et. al., 2019) and it is as follows:

1.1.1. Pedestrian Characteristics

Pedestrian characteristics play a pivotal role in understanding and mitigating road accidents, contributing significantly to the dynamics of road safety. These traits encompass a wide array of factors, including behavioral, demographic, physical, and cognitive aspects that influence pedestrian interactions with vehicular traffic and infrastructure.

Firstly, age is a significant determinant of pedestrian characteristics. Children and the elderly often exhibit distinct patterns in road behavior. Young children may lack a full understanding of traffic rules and dangers, making them more prone to impulsive actions. On the other hand, elderly pedestrians might face challenges related to mobility and reaction times, impacting their ability to navigate roads safely.

Figure 2: The gender-wise age profile of total Passenger killed during 2022 | Source: MoRTH

[Figure 2] Let's break down the figures for rambler losses in 2022. The data, shown in Chart 1.3, reveals that out of the total 32,862 climbers who lost their lives in road accidents, a maturity were men 26,290 to be precise, making up about 80 of the aggregate. On the other hand, 6,572 were women, constituting around 20 of the rambler losses. Taking a near look at age groups, the map points out a concerning trend among youthful grown-ups progressed 18- 45. In this age type, 13,632 men (about 41.5%) and 2,810 women (8.6%) lost their lives walking on their roads.

Gender influences pedestrian behavior, such as risk-taking tendencies, compliance with traffic rules, and decision-making while crossing roads.

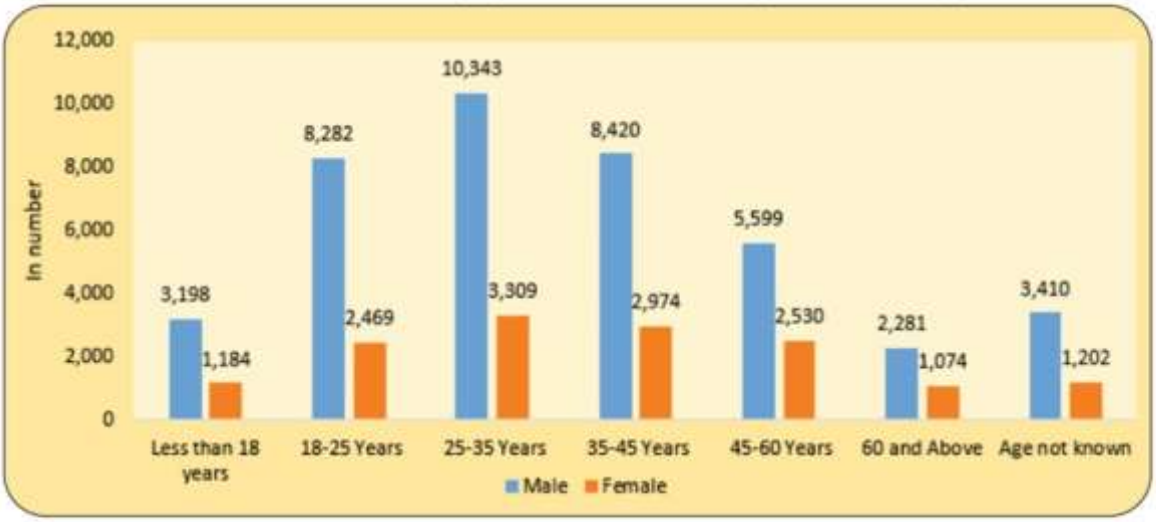

Figure 3: The gender-wise age profile of total Passenger killed during 2022 | Source: MoRTH

[Figure 3] In 2022, further men than women lost their lives in road accidents. Out of the total 56,275 passengers who failed, 41,533 were men (about 74%), and 14,742 were women (around 26%). The situation is indeed more worrying for youthful grown-ups progressed 18-45, where 48.1% of the 27,045 deaths were men, and 15.6% of the 8,752 deaths were women.

Looking at different countries, it's important to see how numerous men and women were affected in each place. This detailed breakdown helps us understand the specific challenges faced by different communities, guiding sweats to make roads safer. The figures punctuate the critical need for targeted safety measures, especially for youthful grown-ups, and emphasize the significance of considering gender differences in road safety enterprises.

By understanding these patterns, we can work towards reducing the impact of road accidents on both men and women across different age groups and regions. Physical capabilities and limitations, such as mobility impairments or visual and auditory impairments, significantly influence pedestrian safety. Designing pedestrian-friendly infrastructure that accommodates these physical variations is crucial in ensuring inclusivity and safety for all individuals.

Another crucial factor is distraction. In an era dominated by smartphones and electronic devices, pedestrian distraction has become a growing concern. Walkers engrossed in their phones may be less attentive to their surroundings, increasing the risk of accidents. Understanding the prevalence and impact of distraction among pedestrians is essential for devising effective safety campaigns and interventions. Also, Group Size affects pedestrian behavior and safety. Larger groups might feel more secure and confident while crossing, potentially affecting their interaction with traffic.

1.1.2. Pedestrian Behavioral Characteristics

Pedestrian behavior at midblock and unsignalized street crossings is influenced by various factors, including waiting time, crossing patterns, speeds, and safety considerations. Understanding these behaviors is crucial for designing safer road systems and implementing effective safety measures.

1.1.3. Vehicle Characteristics

When it comes to vehicle characteristics concerning pedestrian crossings at midblock and unsignalized streets, several crucial aspects profoundly impact pedestrian safety. Vehicles present distinct characteristics and behaviors that intersect with the dynamics of these crossing scenarios, influencing the level of risk and potential for accidents.

2. Aim of the Project

To provide a comprehensive review of the Movement of Pedestrians and the behavior associated while making such decisions and what all factors are crucial that affect the Pedestrian Movement. Along with that also develop a hybrid model which can be implemented further in-vehicle systems or traffic systems in order to increase pedestrian safety and build a threshold for the critical gap and safe gap. Along with that, to model the behavior of pedestrian either through Kerb or Median. Towards the end of the thesis, provide a conclusion comprising the results, highlights, recommendations, challenges, and scope associated while developing the model.

3. Literature Review

This section describes about the previous work on pedestrian gaps, movement of pedestrian at unsignalized streets, accept or reject the gap, also papers associated with autonomous vehicle behavior and pedestrian vehicular unsignalized intersections that have been studied and published before.

3.1. Literature Review of Previous Work

More than 50 research works have been studied associated with pedestrian behavior and vehicular interaction. Out of which 10 major papers aligning to my area of interest related to Evaluation of Pedestrian Movement and Behavior have been studied and analyzed. In place of a particular highlight or summary of the papers, they've been studied and reviewed in 3 steps:

1. Overview and Methodology Used
2. Input and Output Variables
3. Results and Conclusion

Further, the associated theories and relevant concepts have been elaborated and explained in a contextual manner.

Table 1: Literature Review

S. No.	Name of the Paper	Overview and Methodology	Variables	Result
1.	Evaluation of Crossing Decision and Pedestrian Gap Acceptance in Kuala Lumpur (Siti Naquiyah Mohamad Nor, et. al., 2017)	The primary subjects of this study on pedestrian road crossing behavior are the acceptability of gaps and the decision to cross. Real-world data is collected from six zebra crossings and statistically analyzed to identify significant crossing indicators and build models.	Gap acceptance, gender, vehicle type, waiting time, vehicle speed, traffic volume, pedestrian speed, and pedestrian volume are among the factors that influence a gap's size.	The gap's amount varies on several variables, including walking speed, waiting time, gender, jaywalking, vehicle speed, vehicle type, and road width, according to a study conducted in Kuala Lumpur. Vehicle speed and gap size had an impact on pedestrians' decisions to cross. Men's perceived differences in hostility led them to accept smaller discrepancies. Smaller gap sizes decreased the likelihood of crossing, but lower vehicle speeds raised it. This shows how important the road environment and traffic conditions are to pedestrian behaviour.

2.	Simulating the acceptance of pedestrian gaps on a six-lane urban road (Khaled Shaaban, et al., 2019)	This study examines unmarked mid-block areas of a six-lane urban road where illegal pedestrian crossings occur. Regression analysis identifies variables including waiting time, vehicle speed, crossing point, and more that influence gap tolerance. The applications of these findings include simulation, enforcement, and instruction.	Pedestrian characteristics, Behavioral characteristics and vehicle related characteristics.	An average gap size of 6.52 seconds was found in this study, which looked at pedestrian gap acceptance behavior at unmarked crosswalks in the Arabian Gulf region. The waiting period, the crossing location, the speed of the vehicle, and the existence of a rolling gap were all factors that affected gap acceptance. There is a need for pedestrian footbridges, crosswalks with signage, and speed limit decreases due to the high-risk pedestrian behavior that was observed. However, the study included flaws that required additional validation at several sites, including the exclusion of some factors and restrictions on data collecting.
3.	Evaluation of pedestrian safety margin at mid-block crosswalks in India (Arkatkar Shriniwas, et. al.)	According to a study on pedestrian-car interactions in Indian urban midblock, variables including vehicle speed, pedestrian behavior, and vehicle distance affect pedestrian safety. The study created a model to evaluate pedestrian safety at unprotected mid-block crossings using Multiple Linear Regression and suggested improvements.	Pedestrian Safety Margin, Pedestrian Speed, Vehicular Gap size, Vehicle Speed, Pedestrian waiting time, Gender, Age, Rolling behavior , and Type of vehicle	The study employed multiple regression analysis to examine pedestrian safety factors with a focus on pedestrian behavior in urban areas of Western and Northern India. The significance of factors such pedestrian speed, vehicle spacing, and driver behavior was brought to light by the results. The model can assist in enhancing mid-block crossing safety and pedestrian amenities. Regarding age assessment and the necessity of assessing driving behaviour at unprotected pedestrian crossings on multi-lane, two-way roads, the study is limited.
4.	To cross or not to cross? Review and meta-analysis of pedestrian gap acceptance decisions at midblock street crossings (Theofilatos et. al, 2021)	Several research studies have examined contextual and individual factors influencing midblock crossing choices. To combine their findings, this research used both qualitative and quantitative methodologies. Binary logistic models were used in meta-analyses to combine the impact of predictor factors on pedestrian gap acceptance probability in midblock sites.	Beta coefficients of four factors: vehicle speed (VS), gap size (GS), waiting time (WT) and frequency' of attempts (FA)	The results of the study show that the chance of pedestrians crossing the road decreases by 10% with an increase in the speed of incoming vehicles. On the other hand, for every unit increase in temporal gap size and every crossing attempt, the likelihood of pedestrians crossing the road increases dramatically by 7.22 times and 16.6 times, respectively. It was determined that waiting time had no discernible effect on the likelihood of a pedestrian crossing. The practical and policymaking community will need to consider these findings when creating strategies to avoid pedestrian-vehicle collisions at unregulated urban midblock areas. To obtain a better knowledge of the elements impacting gap choice decision making, more research is advised.

5.	Analysis and Prediction of Pedestrian Crosswalk Behavior during Automated Vehicle Interactions (Jayaram, S.K., et. al, 2020)	It presents a six-part hybrid model—crossing decisions, trajectory prediction, pedestrian-AV interaction, hybrid behavior modelling, decision-making, and real-time prediction—that combines pedestrian behavior with AV dynamics to forecast long-term pedestrian trajectories. This model provides a comprehensive method for forecasting pedestrian behavior around driverless cars.	Parameters - AV distance [m], AV speed [m/s], Wait time [s], Gaze ratio, Curb distance [m], CW distance [m], Ped. speed [m/s]	The outcomes show how well the model predicts long-term pedestrian trajectories (more than five seconds) at crosswalks. The research has also discovered similarities between the real-world and immersive virtual environments' observations of pedestrian crossing behaviors. These parallels imply that real-world situations involving both autonomous vehicles (AVs) and human-driven cars can make use of the hybrid model for AV interactions, which was created inside an immersive virtual environment.
6.	Models for pedestrian gap acceptance behavior analysis at unprotected mid-block crosswalks under mixed Traffic conditions (Kadali, B.R, et. al, 2015).	Linear and non-linear pedestrian gap acceptance models have been established in this work. The artificial neural network (ANN) model performs better in mixed traffic situations than the multiple linear regression (MLR) model in terms of prediction accuracy. Moreover, the ANN model offers the benefit of supporting a broader range of variables, enabling a more thorough examination of pedestrian gap acceptance behavior.	Frequency of attempt, Rolling behavior, Speed change condition, Age, Gender, Pedestrian crossing direction, Type of Vehicle, Pedestrian platoon size, Usage of cell phone, Type of gap	Data from real-world observations has been used to validate the multiple linear regression (MLR) model. However, when it comes to estimating the distance that pedestrians are ready to endure, artificial neural network (ANN) models perform better than the MLR model. The study also shows that at unprotected mid-block crosswalks in mixed traffic, pedestrian rolling behavior influences the gap size that pedestrians tolerate. The results of the models, which comprise both MLR and ANN models, demonstrate how much vehicle speed affects pedestrian behavior.
7.	Evaluation of Pedestrian Mid-block Road Crossing Behavior Using Artificial Neural Network (ANN) (Kadali, B.R., et. al, 2014)	Using an Artificial Neural Network (ANN) model, this study investigates pedestrian gap acceptance behavior and clarifies essential elements affecting walkers' choices regarding accepting traffic gaps.	Gap size in seconds, Frequency of attempt, Rolling gap, Speed changes condition, Age, Vehicle speed in kmph, Gender, Movement of pedestrian, crossing path change condition, Type of vehicle, Group size	The acceptance of pedestrian gaps is influenced by important variables such pedestrian rolling gaps, attempt frequency, vehicular gaps, pedestrian speed fluctuations, and vehicle speed. These observations can guide the improvement of pedestrian crossing infrastructure when mid-block crosswalks do not have enough space between vehicles.
8.	Pedestrian Behavior Interacting with Autonomous Vehicles during Unmarked Midblock Multilane Crossings: Role of Infrastructure Design, AV Operations and Signaling (Fengjiao Zou et. al., 2022)	Using virtual reality simulations, this study investigates pedestrian behavior at unmarked midblock zones with different road configurations and autonomous vehicle (AV) signals. It evaluates crossing times based on AV signals and road characteristics. Using virtual reality (VR) simulations of a four-lane road, the methodology examines how pedestrians react	Dependent Variables (Waiting time at the curb and middle, Total crossing time, waiting time) and Independent Variables (Scene, Signal, Demographics, Walking Exposure, Pedestrian Past Behavior)	This study uses virtual reality simulations to examine how pedestrians respond to autonomous vehicles (AVs) at unmarked midblock locations on four-lane roads. It assesses pedestrian wait times, reactions to AV signaling, and the impact of demography by analyzing three traffic scenes and three AV signal scenarios. The findings emphasize the influence of AV signaling and road design on pedestrian behavior, highlighting the

		to various circumstances while considering a range of demographics.		importance of taking infrastructure into account when developing AV systems and the subtle effects of signals on pedestrian choices.
9.	Observational-based study to explore pedestrian crossing behaviors at signalized and unsignalized crosswalks (Kayvan Aghabayk et. al., 2021)	552 pedestrian behaviors at Tehran's signalized and unsignalized crosswalks were examined in the study. We looked at things including age, gender, group-hopping, usage of electronics, and things carried. Crossing speed was measured using linear mixed models, and GLMMs were used to analyze binary results. The principal areas of observation were speed, situational awareness, conflict, and traffic checks.	Gender, Age group, Group Crossing, Technological Distractions, Carrying items, View Obstruction.	552 pedestrian behaviors at Tehran's signalized and unsignalized crosswalks were examined in the study. We looked at things including age, gender, group-hopping, usage of electronics, and things carried. Crossing speed was measured using linear mixed models, and GLMMs were used to analyze binary results. The principal areas of observation were speed, situational awareness, conflict, and traffic checks.
10.	Pedestrian crossing decision-making: A situational and behavioral approach (Brigitte Cambon de Lavalette et. al., 2009)	Different crossing behaviors are displayed by pedestrians, who have less restricted trajectories. This study employs an experimental methodology to classify pedestrian behavior and settings using observations to model decision-making during road crossings. It emphasizes the variety in the manner, location, and time that pedestrians choose to cross, which is influenced by surrounding circumstances and laws.	With or without pedestrian signals (defined as a road crossing facility), Number of traffic lanes (increased vigilance) and One-way or two-way traffic (raised task complexity)	The present study investigates the impact of environmental elements on pedestrian rule infractions. It evaluates the use of footbridges in comparison to street crossings using Ajzen's Theory of Planned Behavior. Factors influencing the severity of violations, such as central traffic islands and pedestrian signals, are highlighted by hierarchical categorization. Pedestrians adjust their behavior in response to environmental limitations. Environmental descriptors construct a hierarchy of rules for compliance that emphasizes the importance of terrain, infrastructure, and core task context for safe behaviors.

3.2. Associated Theories

3.2.1. Unsignalized Streets and Mid-blocks

Unsignalized streets don't use signals or traffic lights. They are roads without tech like ITS applications controlling traffic flow. On the other hand, signalized roads have traffic lights. These help both walkers and cars move safely through intersections.

A mid-block crossing lets people cross a street between intersections. These are needed when crossroad points are too spread out for easy walking. Urban planners often expect people to only cross at corners. But in many places, folks need to cross elsewhere too (Avondale Estates Organization).

3.2.2. Median

Roadways can have divided areas in the middle. These areas separate traffic going in opposite directions. This is called a median strip or central reservation. It exists on divided roads, dual carriageways, and freeways. Streets in cities also have medians. The median may be paved, but it can also have other things like landscaping, trees, barriers, or rails. Urban medians are often raised islands in the center of the road. They may be simple concrete curbs. But they can also have grass, trees, bricks, or stones added to them. Urban medians are different from highway medians but serve the same purpose of dividing traffic.

3.2.3. Kerb

The kerb line separates the road shoulder from the grass. It's the line between the road edge and the verge without shoulders. Kerbs mark the road's end, where walkways or islands begin. They're about 10 cm above the pavement, with a gentle slope for easy vehicle mounting.

3.2.4. Pedestrian

A pedestrian walks instead of driving or riding. They travel on sidewalks, crosswalks, and walking paths. Pedestrians are vulnerable road users relying solely on walking. Their safety and urban mobility matter greatly, deserving care from drivers and policymakers.

3.2.5. Road User

Road users include people walking, cycling, driving vehicles, or riding other modes like scooters. They're diverse individuals utilizing public roads for getting around. Each user must follow traffic laws, yield right-of-way properly, and help maintain safety. It involves rules, infrastructure updates, and education programs to reduce accidents effectively. Manage road users to optimize traffic movement.

3.2.6. Lane

A road has marked sections called lanes. Lanes help traffic move smoothly. They give space for cars going the same way. Lanes keep order and safety. Cars go at different speeds without crashing. Some lanes turn left or right. Other lanes are for buses or carpools. Lanes can be wide or narrow. Following the right lane rules is very important.

4. Analysis of the Survey

We surveyed pedestrian behavior while crossing the road on unsignalized streets and mid-blocks among our classmates. This study looks at data from a survey on how pedestrians cross streets without signals. We got 33 responses in which there were 30 Male and 3 Female and aged 19 to 22. Most (84.8%) walk in urban areas sometimes, and many (75.8%) reported crossing unmarked streets weekly or more

Vehicle speed and personal safety judgment were key factors for crossing decisions. Checking for gaps in traffic was the top way to assess safety when crossing. Listening for approaching vehicles was also common. The vast majority viewed unmarked crossings as much riskier than signalized intersections. Only a few people saw the safety as equal, and none deemed unmarked crossings safer.

Most respondents witnessed or experienced a near-miss or accident crossing unmarked streets. The study results point to pedestrians commonly facing unsignalized crossings in this neighborhood.

We must acknowledge certain limitations. Our sample size is relatively small, so it may not accurately reflect the broader population's perspective. Additionally, having only male participants introduces a gender imbalance, restricting the study's scope. Future analyzes could explore potential correlations between factors like age, crossing frequency, and perceived safety levels.

Investigating the gender-based decision-making rationale mentioned by one respondent could also yield valuable insights. This data underscores the pressing need for enhanced pedestrian safety measures in unsignalized areas. Potential solutions include installing traffic calming infrastructure to reduce vehicle speeds, constructing designated crosswalk zones, or implementing educational campaigns promoting safe crossing practices.

5. Site Selection for Thesis Project

Vadodara is one of Gujarat's most populated areas, with over 21 lakh residents. We carefully selected six places for data collection. We chose them based on their urban setting, accessibility, and how well they suited our study goals. This helped ensure our results were accurate and meaningful. The locations were Front of Meldi Maa Temple, Jail Road, Manjalpur Naka, Palace Road, SSG Hospital, and Vadodara Railway Station. Each spot was strategically chosen after considering several factors. Their relevance to our research goals was crucial. We also considered how convenient they were for data collection. Additionally, we wanted locations that reflected different urban environments. This would allow for comprehensive analysis of the data.

Figure 4: Six-locations selected from City of Vadodara, India

Exploring what made each location valuable for our pedestrian count study is important. Their urban context, accessibility, representation of diverse environments, and potential for in-depth analysis were key considerations. Let's examine the unique nuances of each location that made them suitable choices.

5.1. Front of Meldi Maa Temple

The entrance to Meldi Maa Temple stands as an important religious and cultural hub in Vadodara. This site was chosen to examine the dynamics of pedestrian movement in areas of religious significance. Temples tend to attract diverse visitors, including devotees, tourists, and vendors, offering valuable insights into pedestrian behavior, crowd management, and spatial utilization.

5.2. Jail Road

Jail Road functions as a vital arterial route in Vadodara, facilitating vehicular and pedestrian movement. This location was chosen to investigate pedestrian interactions within bustling commercial districts. The presence of shops, markets, and commercial establishments along Jail Road provides a rich environment for observing pedestrian flows, activity patterns, and the impact of urban design on pedestrian comfort and safety.

5.3. Manjalpur Naka

Manjalpur Naka is a busy intersection in West Vadodara. We chose it to examine pedestrian experiences in high-traffic, complex road areas with diverse land uses. By observing pedestrians here, we aim to find bottlenecks, safety issues, and ways to improve pedestrian connectivity and comfort.

5.4. Palace Road

Vadodara has a rich past. Beautiful Palace Road contains old buildings like Laxmi Vilas Palace. We studied this place to see how people walk in historic areas. And how tourists affect movement. Tourist sites, heritage, and leisure spots on Palace Road make it ideal for this.

5.5. SSG Hospital

SSG Hospital is a big medical centre that helps people nearby. We looked at it to understand how people walk around hospitals. Like entrances and paths. Knowing how patients, visitors, and workers move is key. It helps keep pedestrians safe and lets them get around hospitals well.

5.6. Vadodara Railway Station

Vadodara Railway Station links the city seamlessly to many spots in India. It got picked to understand how people move around places like train stations, bus stations, and hubs where different travel choices meet. Looking at people flow, what's there, and how the different ways to travel are blended at Vadodara Railway Station helps us discover ways to improve connections between travel choices and support greener urban movement.

In brief, selecting six spots in Vadodara lets us thoroughly view how people act, move around in cities, and experience spaces across different urban settings. Gathering data, carefully studying it, and understanding it well at each place aims to give important insights and suggestions from our project work. These findings will help make pedestrian infrastructure better, improve urban planning approaches, and lift people's quality of life overall.

6. Data Collection

When studying how people walk, getting accurate information is vital. To examine walkers in Vadodara, we used two methods: Observational and Random Number Generation. First, we watched walkers at chosen spots for twenty minutes each between 5:00 PM to 5:30 PM. They carefully noted details like gender, movements, carrying bags, and other behaviors. Next, Random data were generate based on the observational data. This approach ensured comprehensive, reliable data about pedestrian activity in Vadodara. Observing walkers directly provided insights into natural behaviors and patterns. Random data then supplemented that data, capturing demographics and perspectives. Combined, these methods generated a thorough, accurate understanding of how Vadodara residents navigate their city on foot.

To make sure the information was right, we were watchful while taking data. The data we got was compared to real events to check its quality. This step found any issues or mistakes, so the results could be trusted to show how people really walk in Vadodara. Moral concerns were also very important when collecting data. We asked for permission from people and kept their personal details private. They followed all the rules for studies with humans, to keep the people they watched safe and their secrets hidden. By doing things the right way, we proved they cared about good and polite research.

7. Data Overview

This data overview provides a comprehensive understanding of the variables and their respective categories, which are crucial for analyzing pedestrian behavior in various road conditions. The table below provides an overview of the variables related to pedestrian characteristics, pedestrian behavioral characteristics, traffic characteristics, and road factors, along with their respective definitions and descriptions.

Table 2: Categorization of Variables

Category	Variables	Definition	Description
Pedestrian Characteristics	Age	Age of the pedestrian by visual appearance.	Child Adolescent Adult Middle Age Old Person
	Gender	Gender of the Pedestrian.	0 = ’Male’ 1 = ‘Female’
	Physical Disability/Ability	Whether pedestrian has some physical disability.	0 = ‘No’ 1 = ‘Yes’
	Group Size	Number of Pedestrian in a group.	1 = ‘Alone’ 2 = ‘Group of Two’ 3 = ‘Group of Three or more’
Pedestrian behavioral Characteristics	Walking Speed	Pedestrian walking speed while crossing the road.	
	Walking Time	Pedestrian waiting time before crossing the road.	
	Frequency of Attempts	The number of attempts made by pedestrians to cross the road.	1 = ‘Crossed the road in first attempt’ 2 = ‘…in second attempt’ 3 = ‘…in third attempt’ 4 = ‘…in fourth attempt’ 5 = ‘…in five attempt or more’
	Number of Stops	Whether pedestrian stops in between while crosses the road.	0 = ‘Didn’t Stopped’ 1 = ‘Stopped once’

			2 = 'Stopped twice' 3 = 'Stopped thrice or more'
	Cell phone Usage	Whether the pedestrian was engaged on his/her cell phone while crossing the road.	0 = 'No' 1 = 'Yes'
Traffic characteristics	Vehicle Speed	The speed of the vehicle while pedestrians are trying to cross the road.	
	Vehicle Type	Type of the vehicle according to its dimension.	2 = '2-wheeler' 3 = '3-wheeler' 4 = '4-wheeler' 5 = '5 or more wheeler'
Road Factors	Presence of Median	Presence of median.	0 = 'No' 1 = 'Yes'
	Number of Lanes	Number of lanes present in the road.	1 = '2-Lane' 2 = '4-Lane'

The above variables are taken in the present study representing the factors that influence pedestrian crossing behavior.

Table 3: Analysis of Vehicle speed, Walking time and Walking speed data

	Minimum	Average	Maximum	St. Deviation
Vehicle Speed	9.27	27.91	46.72	6.14
Walking Speed	1	6.41	14	2.30
Walking Time	4.57	24.39	58	10.75

The table breaks down walking speeds and car speeds. It shows the lowest, regular, highest, and varied walker paces. It also has the slowest, average, fastest, and differing auto velocities. This data gives us the full picture on how people move and cars drive in cities. Learning about walker habits and auto patterns helps plan better for two key groups. We grasp how people on foot act. We know the speeds cars go too. Building from these specifics, we can aid pedestrians the right way. Analysing all the numbers in depth gives deeper insight. More understanding leads to solutions. We can increase safety with this knowledge. New ideas come from the details within. Our goal should be smarter designs for pedestrian zones all across the urban landscape.

8. Data Analysis

It's essential to carefully analyse pedestrian actions, traffic patterns, and road elements. Through detailed inspection, connections between pedestrians and vehicles can be better understood. Statistical tools, machine learning, and data visuals help us find meaningful information. We aim to clarify how people choose to cross roads. Trends may identify risks and inform city planners. Key goals include comprehending behaviours, seeing dangers, and improving safety.

Rigorous investigation of this dataset can provide great knowledge. It can uncover hidden links, reveal unexpected aspects, and find crucial insights. Important findings could enhance pedestrian security. They may guide traffic planning and create safer neighbourhoods. By systematically examining the data, useful interpretations and solutions emerge. Analysing factors behind road crossing decisions unlocks potential improvements. Our work aims to directly contribute to community safety discussions. It assists in developing pedestrian-friendly urban environments.

Through meticulous exploration, we aim to significantly advance understanding. With thoughtful consideration of the information, valuable recommendations surface. This analysis ultimately strives to promote secure, accessible routes for pedestrians. Outcomes have potential to positively impact residents' quality of life. By thoroughly uncovering patterns within the dataset, meaningful progress becomes achievable.

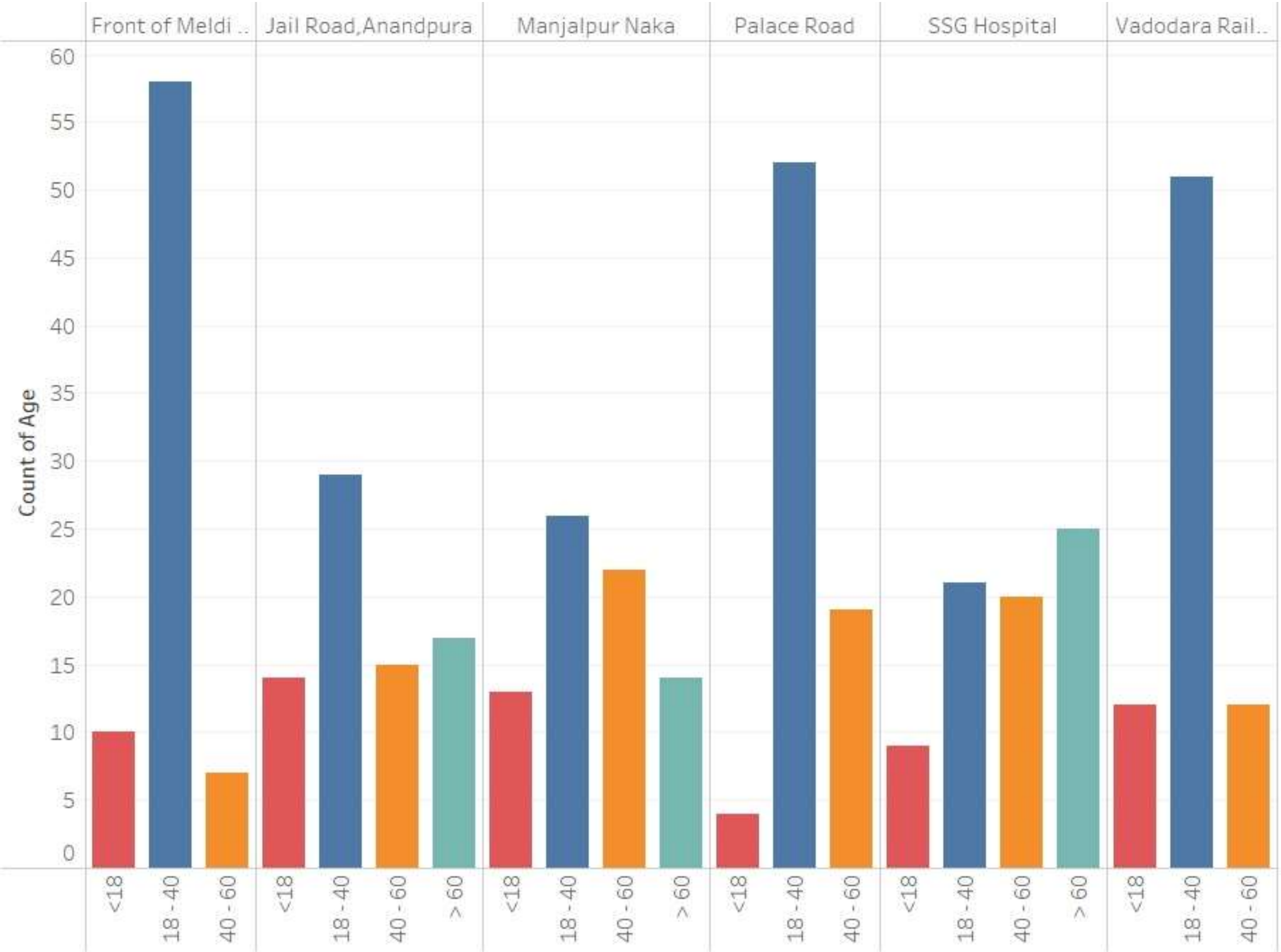

Figure 5: Clustered Bar Graph of Age vs Pedestrian Count

This visual shows how many people of different ages are at six places. The places are on the x line. The y line counts people. Each place shows the age groups with colored bars. So you can easily see how the ages are spread out for each location.

We see people aged 18-40 visiting most of these places often. "Front of Meldi Maa Temple," "Palace Road," and "Vadodara Railway Station" are very popular among this group. People below 18 hardly visit any location. However, people over 60 sometimes go to "Jail Road, Anandpura" or "SSG Hospital," though not too frequently.

This graph is useful for understanding age groups that frequent different areas. It shows demographic trends and patterns across locations. Including this in a thesis about demographics or city planning makes sense.

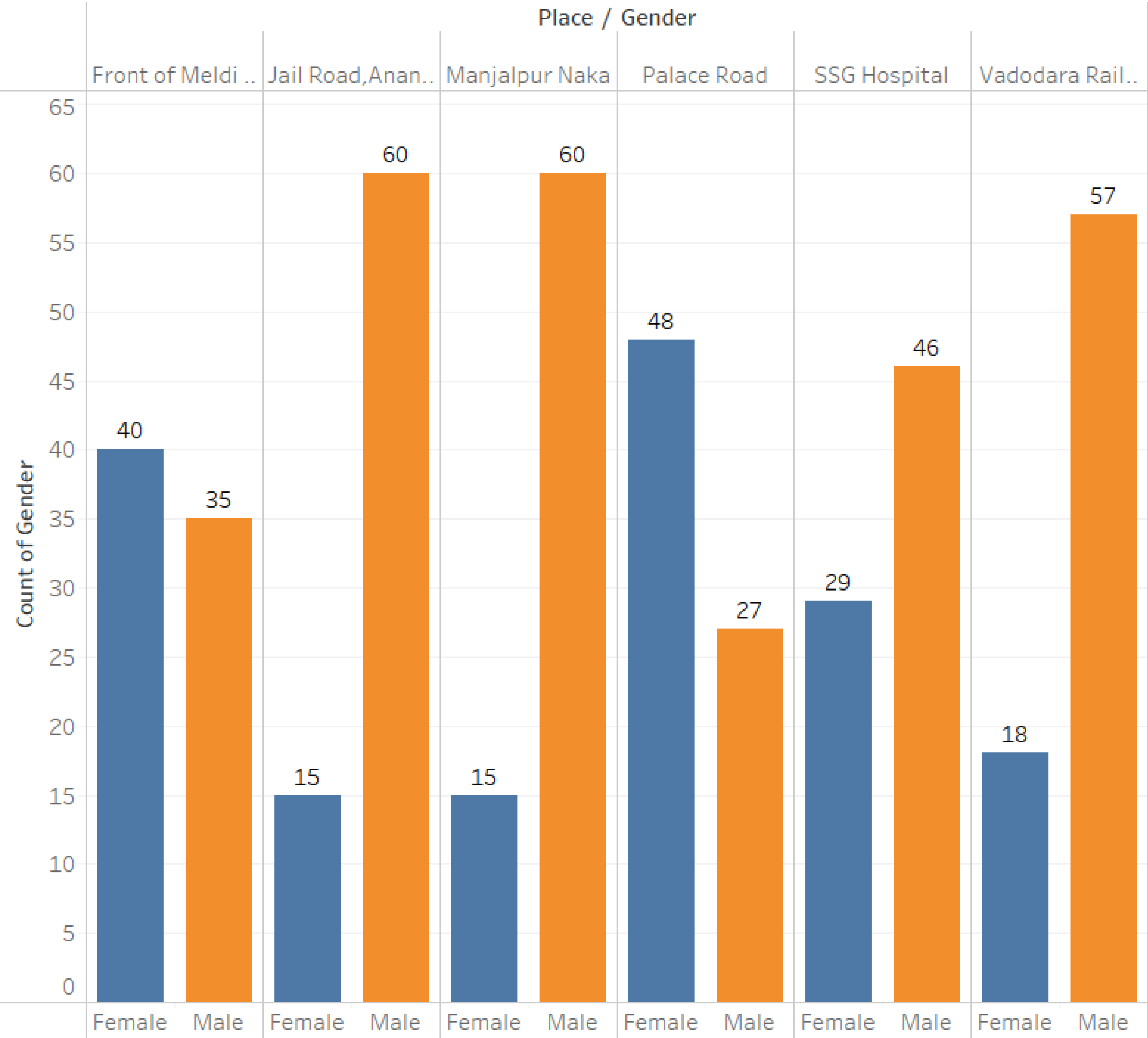

Figure 6: Clustered Bar Graph of Gender vs Pedestrian Count

The chart shows gender numbers in Six spots. Each place has two bars: blue for males, orange for girls. The x-axis lists locations. The observation indicates a notable prevalence of females on Palace Road and in front of Meldi Maa Temple, suggesting that these locations may serve as religious or tourist destinations. The pronounced gender disparity in these areas suggests a significant preference or inclination among females to frequent such places. This disparity could be indicative of cultural or religious practices that attract a higher proportion of female visitors. Further analysis of these locations may provide insights into the specific reasons behind the gender disparity observed.

Gender balance varies in cities worldwide. The chart reveals how males and females are divided in urban areas. It gives important data for studies on gender issues, population trends, and city planning.

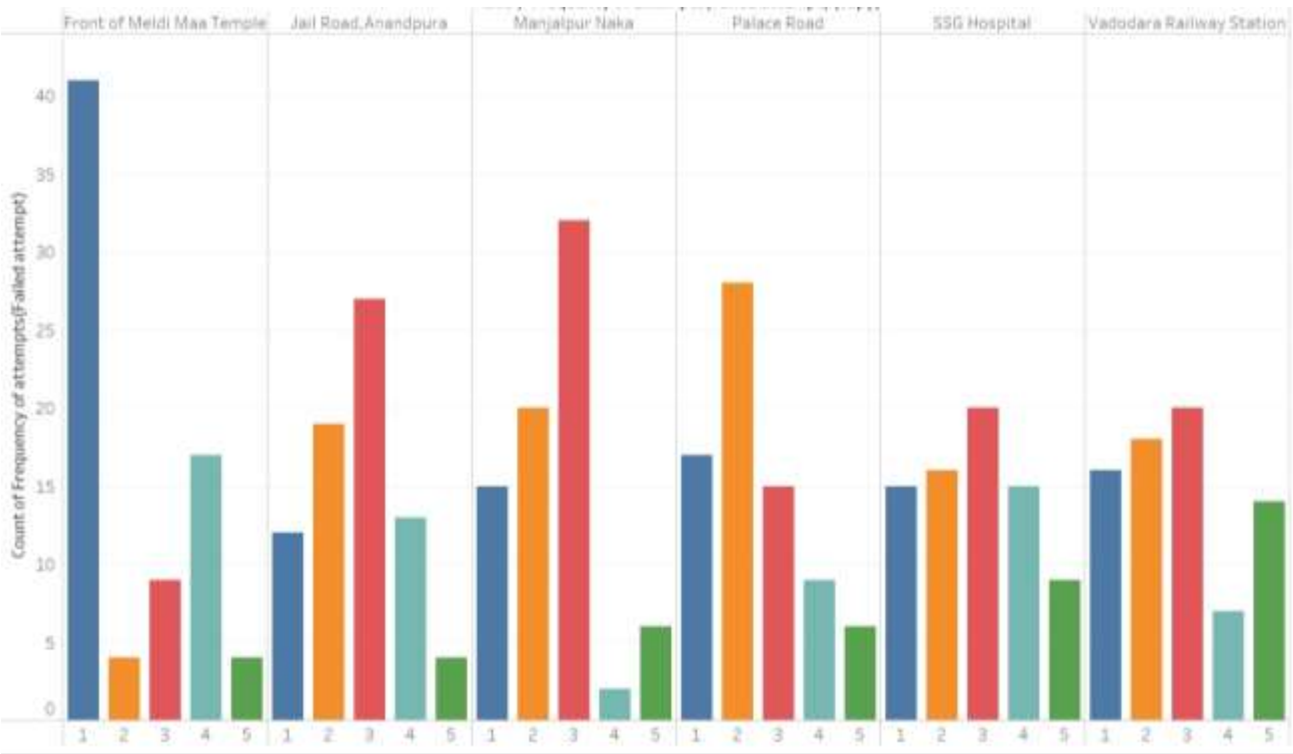

Figure 7: Clustered Bar Graph of Frequency of Attempts vs Attempt Count

The chart shows how often people tried at Six spots. The locations are listed on the bottom. The numbers on the left tell how many tries. There are four colored bars for each place. The bar tops show the counts. At "Front of Meldi Maa Temple," the highest bar reaches 41. "Lalbaug Bridge" has the tallest at 42. "Manjalpur Naka" and "SSG Hospital" also have high bars, with 32 and 37.

The graph illustrates the crossing patterns of individuals at various roads. It employs colour coding to represent different scenarios: blue for those who cross on their first attempt without hesitation, orange for those who attempt to cross twice, red for individuals who require three attempts, and green for locations where there is a high volume of attempts, particularly observed at Vadodara railway station.

Analyzing the graph, it becomes evident that Palace Road experiences significant traffic, leading people to opt for two attempts to safely cross. Similarly, Manjhalpur Road appears excessively congested, with individuals needing three attempts to traverse it. Conversely, the green bar indicates that Vadodara railway station witnesses a substantial number of crossing attempts, likely due to its high foot traffic or complex layout.

The chart compares how often attempts occurred at different places. It shows patterns and areas with more or less activity. It discusses how activities, resources, or behaviors are spread out in cities. The chart's clear design and color codes make the data easy to understand. It's a good way to explain complex info simply.

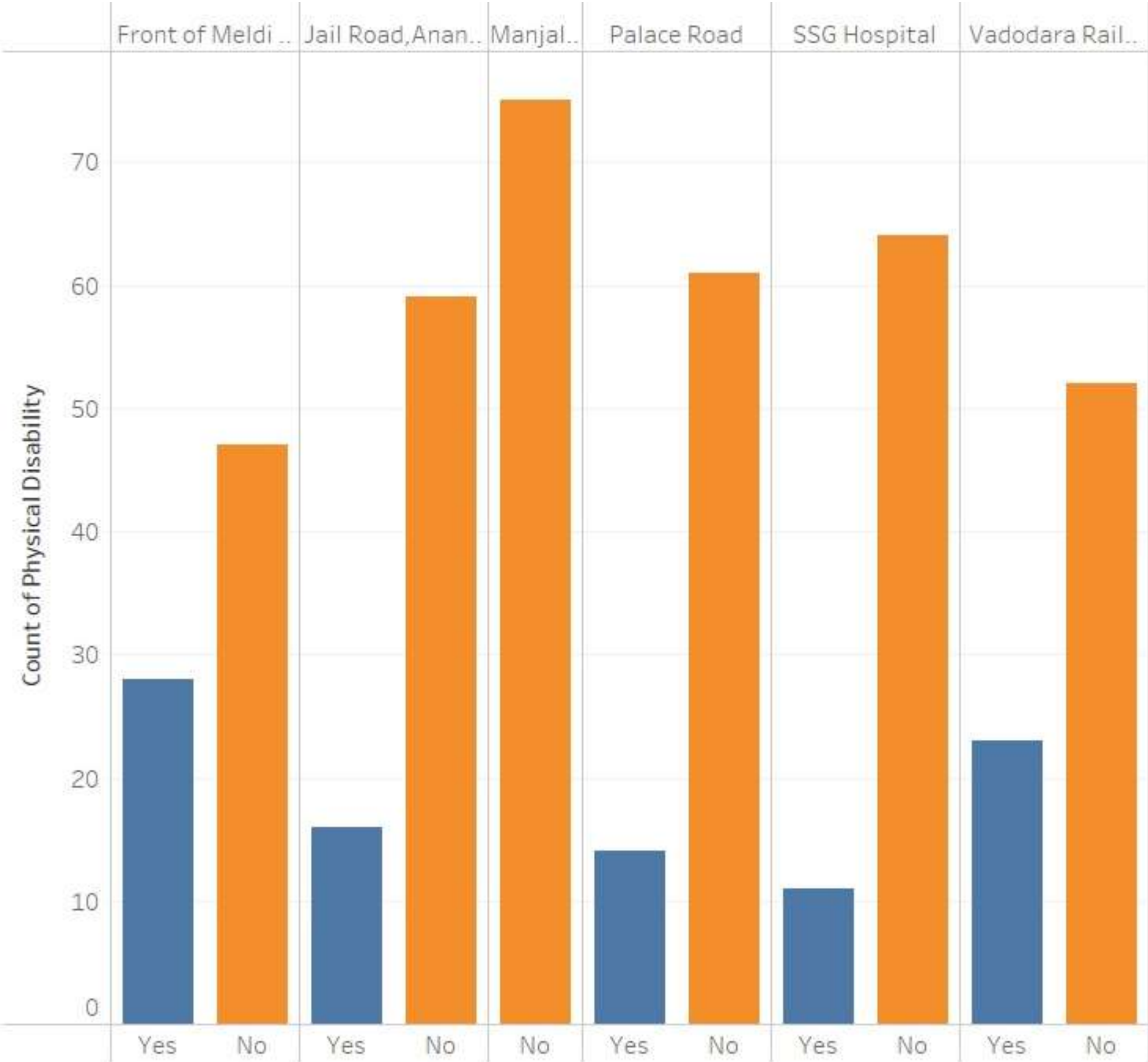

Figure 8: Clustered Bar Graph of Physical Disability/Ability vs Pedestrian Count

The image displays a bar chart presenting data about individuals with physical disabilities across Six locations. The horizontal axis lists these places. For each location, two bars indicate presence ("yes") or absence ("no") of physical disability. The vertical axis shows the count or number of people with disabilities.

The chart reveals significant differences in disability counts between sites. For example, Front of Meidi Maa Temple and Vadodara Railway Station have higher numbers of physically disabled individuals (represented by taller "yes" bars). In contrast, locations like Manjhalpur and Palace Road exhibit lower counts or no physically disabled persons (shorter or non-existent "no" bars).

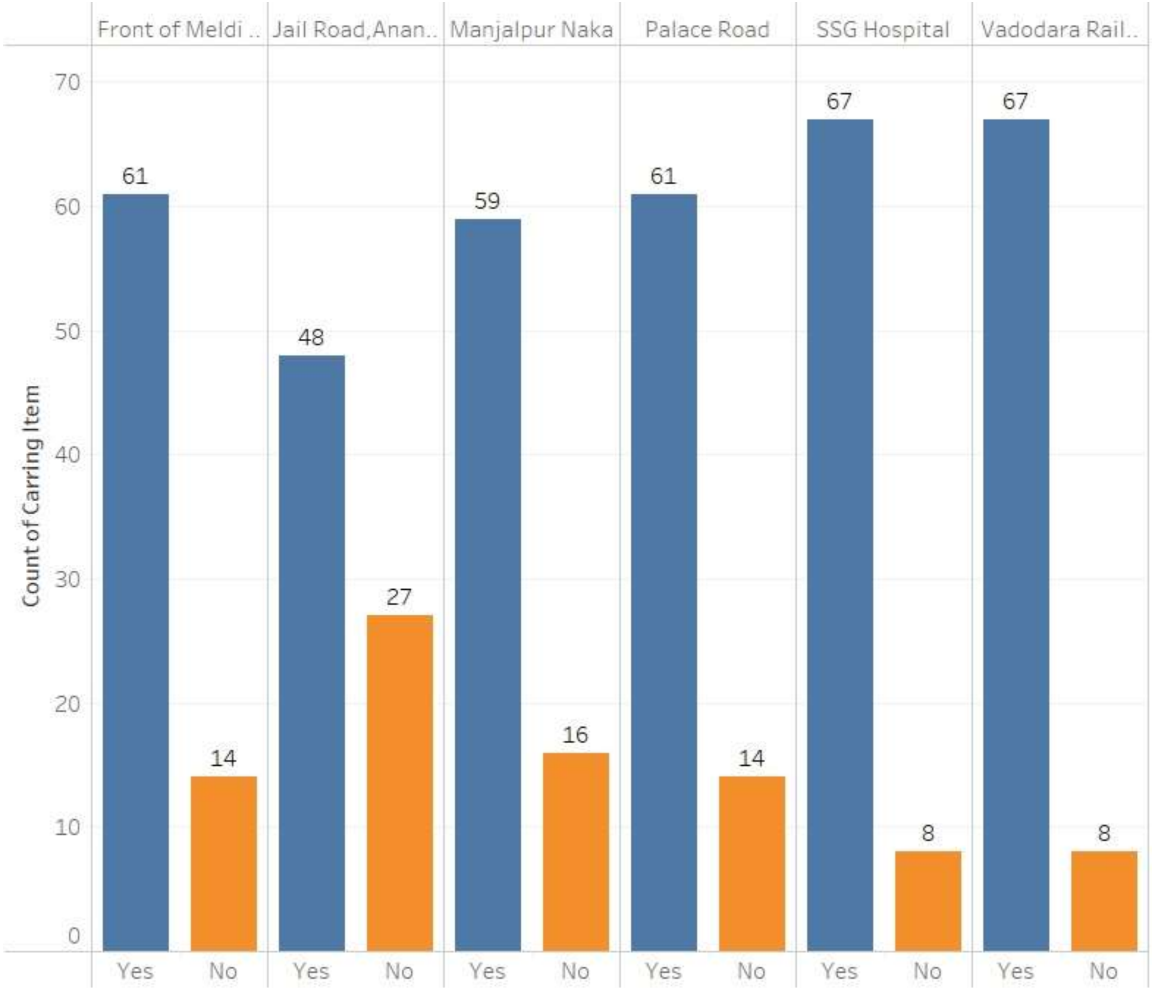

Figure 9: Clustered Bar Graph of Pedestrian with Carrying Items vs Pedestrian Count

On the horizontal axis are six locations. Each location has two categories: "Yes" and "No." These categories may signify whether an item was carried or not at that place. The vertical axis measures the "Count of Carrying" from zero to seventy. The bars use different Blue and Orange shades. Darker Blue may correspond to higher counts of the item being carried, lighter greens to lower counts. This chart could be the first in a series examining various aspects related to carrying items at those Six locations.

The "Yes" category shows a high amount of 67 people at "SSG Hospital" and "Vadodara Railway Station." This suggests that these spots have the most people carrying items means lots of people who use mobile in this reason.

The bar chart clearly displays how often people carry things at different places. Understanding where and how frequently this occurs can provide important information related to your thesis topic.

8.1. Correlation Analysis

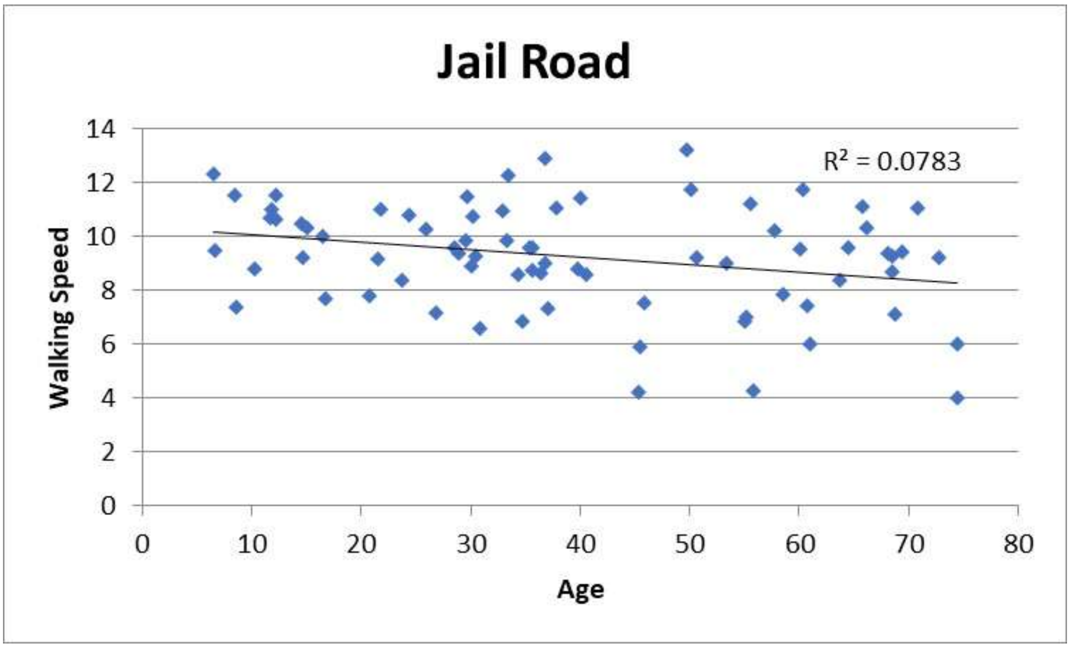

Figure 10: Correlation Chart of Age and Walking Speed at Jail Road

The chart depicts a weak negative correlation between age and walking speed while crossing Jail Road. This suggests that older pedestrians tend to walk slower than younger ones. The R^2 value of 0.0783 indicates that age explains only a small portion of the variation in walking speed.

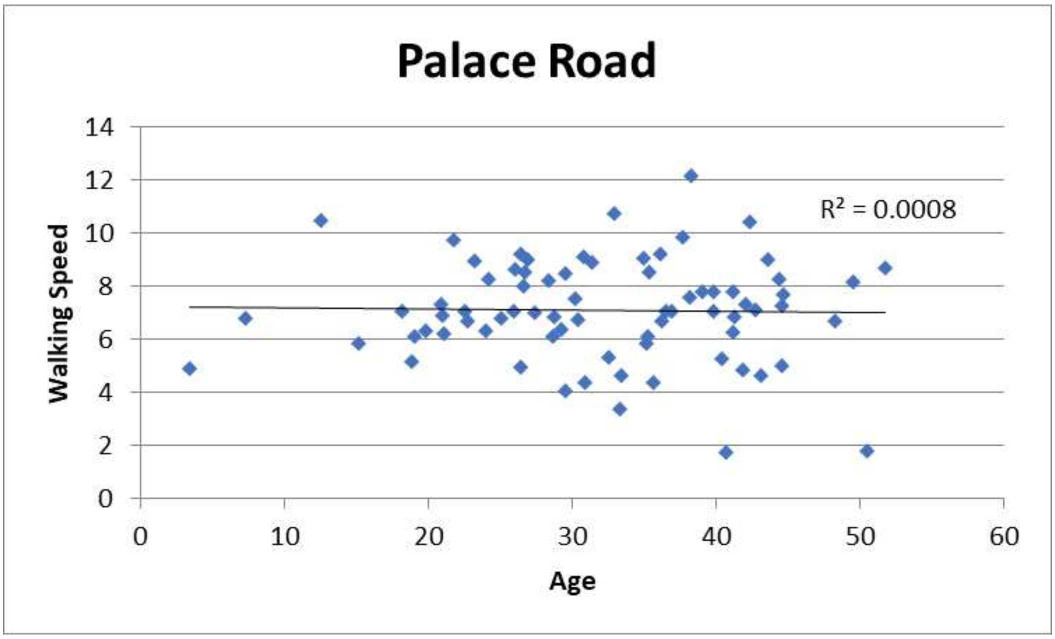

Figure 11: Correlation Chart of Age and Walking Speed at Palace Road

The scatter plot you included depicts a weak negative correlation between age and walking speed while crossing Palace Road. This suggests there might be a slight tendency for older pedestrians to walk slower than younger ones while crossing this road. However, the R^2 value of 0.0008 is very low, indicating that age explains almost none of the variation in walking speed in this case.

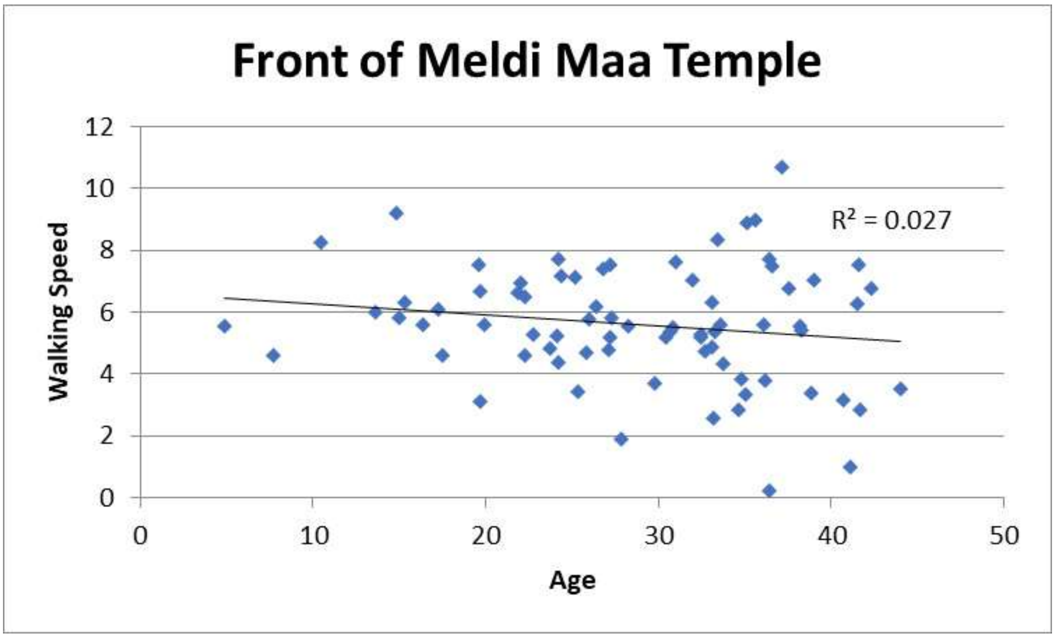

Figure 12: Correlation Chart of Age and Walking Speed at Front of Meldi Maa Temple

The chart depicts a weak negative correlation between age and walking speed while crossing the road in front of Meldi Maa Temple. This suggests that older pedestrians tend to walk slower than younger ones at this location. However, the R^2 value of 0.027 is very low, indicating that age explains only a small portion of the variation in walking speed.

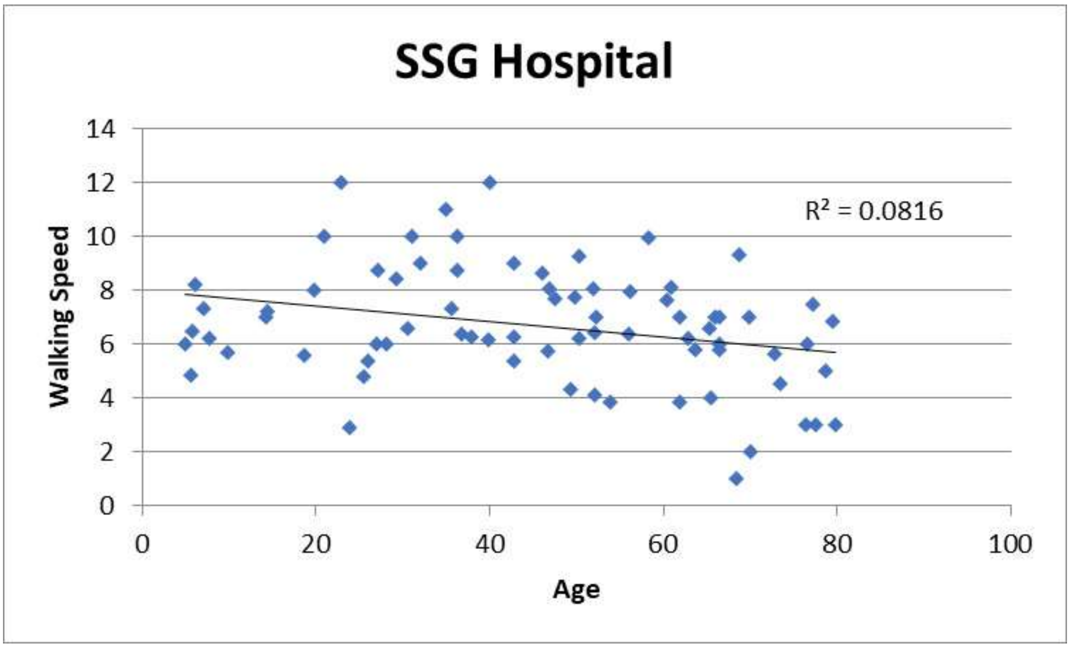

Figure 13: Correlation Chart of Age and Walking Speed at SSG Hospital

The chart depicts a weak negative correlation between age and walking speed while crossing SSG Hospital Road. This suggests that older pedestrians tend to walk slower than younger ones at this location. However, the R^2 value of 0.0816 is very low, indicating that age explains only a small portion of the variation in walking speed.

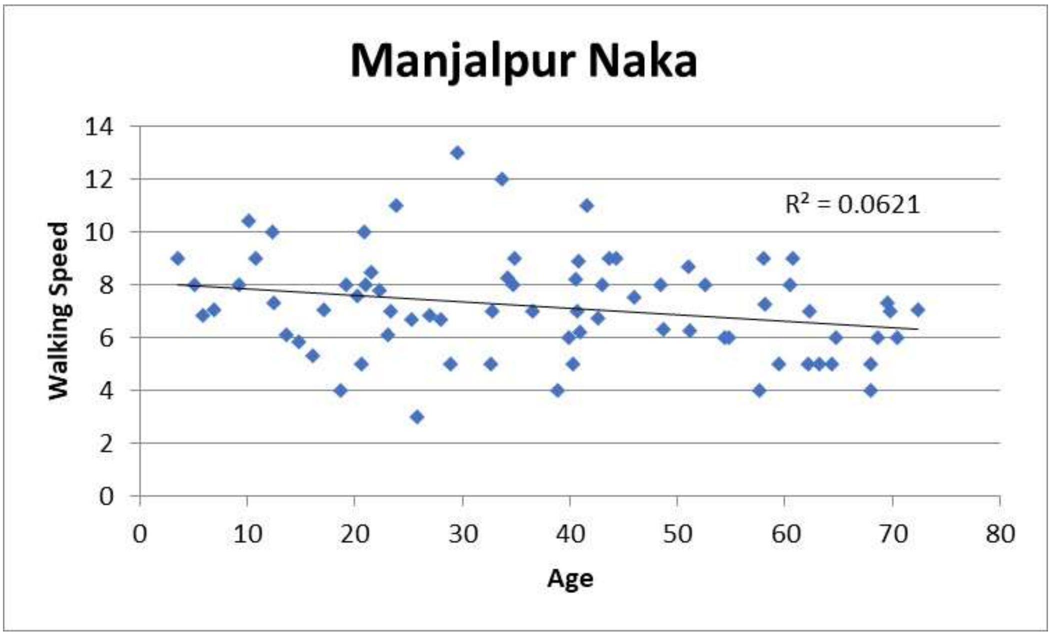

Figure 14: Correlation Chart of Age and Walking Speed at Manjalpur Naka

The chart depicts a weak negative correlation between age and walking speed while crossing at Manjalpur Naka. This suggests that older pedestrians tend to walk slower than younger ones at this intersection. However, the R^2 value of 0.0621 is very low, indicating that age explains only a small portion of the variation in walking speed.

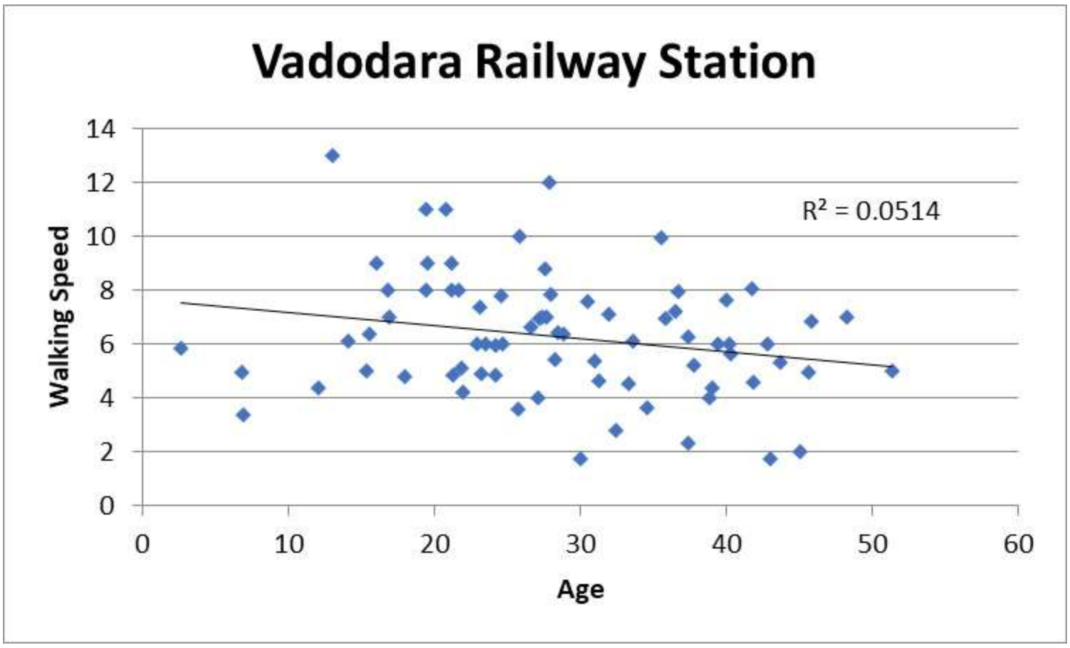

Figure 15: Correlation Chart of Age and Walking Speed at Vadodara Railway Station

The chart depicts a weak negative correlation between age and walking speed while crossing Vadodara Railway Station. This suggests that older pedestrians tend to walk slower than younger ones at this location. However, the R^2 value of 0.0514 is very low, indicating that age explains only a small portion of the variation in walking speed.

8.2. Additional Points to Consider

Here are some reasons why the correlation between age and walking speed might be weak:

- **Small sample size:** The study that produced this data might not have included enough participants to detect a statistically significant correlation between age and walking speed.

- **Health not considered:** The data might not have taken into account health conditions of the participants, which can significantly impact walking speed at any age.
- **Familiarity with the road:** Pedestrians who are familiar with Palace Road might walk at a different pace than those who are unfamiliar, regardless of age.
- **Urgency:** People in a hurry might walk faster than those who are not, regardless of age.

Future studies that collect data on these additional factors, along with a larger sample size, could provide a more comprehensive understanding of pedestrian walking speed at unsignalized intersections. It is also important to note that correlation does not imply causation. While this chart shows a relationship between age and walking speed, it doesn't necessarily mean that getting older causes people to walk slower.

9. Conclusion

This study has provided valuable insights into the complex dynamics of pedestrian behavior at unsignalized midblock crossings and streets. By conducting extensive data collection and analysis across various urban locations in Vadodara, we have gained a nuanced understanding of the factors influencing pedestrian crossing decisions and movement patterns.

One of the key findings of our research is the significant impact of pedestrian characteristics, such as age, on their walking speed and behavior. While the correlation between age and walking speed appeared weak, it is evident that older pedestrians generally tend to walk slower than their younger counterparts. This finding highlights the importance of designing pedestrian infrastructure that accommodates diverse user groups, ensuring accessibility and safety for all ages and abilities.

Additionally, our data analysis revealed intriguing patterns related to the frequency of crossing attempts and the presence of physical disabilities. Certain locations, such as the Front of Meldi Maa Temple and Vadodara Railway Station, exhibited higher counts of individuals with physical disabilities, underscoring the need for inclusive design considerations in these areas.

Furthermore, the study shed light on the influence of external factors, such as vehicle characteristics and road infrastructure, on pedestrian behavior. The varying vehicle speeds observed at different locations emphasize the necessity for traffic calming measures and speed management strategies to enhance pedestrian safety. Additionally, the presence or absence of road elements like medians and designated crossing facilities significantly impacted pedestrian crossing patterns and decision-making processes.

While this study has provided valuable insights, it is crucial to acknowledge its limitations. The sample size, although representative, could be expanded to capture a broader range of pedestrian experiences and demographics. Moreover, the scope of the study was limited to specific urban locations within Vadodara, and the findings may not be directly generalizable to other cities or regions with different infrastructural and socio-cultural contexts.

10. Future Implementations

Integration with Intelligent Transportation Systems (ITS): The outcomes and knowledge from this study can blend with existing Intelligent Transportation Systems (ITS). This helps improve pedestrian safety and traffic control. The models let us forecast pedestrian actions and behaviors at unsignalized crossings. With this data, we can adjust traffic signals, pedestrian crossing signals, and other ITS parts in real-time.

Incorporation into Advanced Driver Assistance Systems (ADAS): The predictive models from this research can be part of Advanced Driver Assistance Systems (ADAS) in vehicles too. By understanding how pedestrians move and act at unsignalized crossings, ADAS systems can warn drivers on time. They can change vehicle speed or even start automatic braking. This prevents potential conflicts between pedestrians and vehicles.

Development of Pedestrian Behavior Monitoring Systems: The findings from this research can be used to develop dedicated pedestrian behavior monitoring systems. These systems can employ computer vision techniques, sensors, and the developed models to continuously monitor pedestrian movements and behaviors at unsignalized crossings. Such systems can provide real-time alerts to traffic authorities, pedestrians, and drivers to enhance safety and facilitate proactive interventions.

Integration with Urban Planning and Infrastructure Design: The insights from this research can help urban planners and designers create cities with pedestrian-friendly features. This includes having special crossings just for people walking, traffic calming like speed bumps, and better lighting. Understanding what makes people decide to cross unsafely is key to fixing the issue. With that knowledge, planners can design safer urban areas for everyone.

Development of Educational and Awareness Campaigns: The results also let experts create educational campaigns teaching smart crossing habits. These can target specific problems, like teaching people the risks of crossing unsafely. With custom info for pedestrians and drivers, the campaigns promote safe practices. Learning why someone might jaywalk means teaching them better options. Awareness is crucial for keeping cities walkable.

By implementing the recommendations outlined above and continuing to prioritize pedestrian safety through research, policy, and design interventions, we can work towards creating more walkable, inclusive, and sustainable urban environments that promote the well-being and mobility of all road users.

11. Recommendations

Continuous Data Collection and Model Refinement: We must gather new data constantly. As foot traffic changes, models require updating. Doing so improves predictions for evolving cities.

Collaboration with Stakeholders and Policymakers: Work together with many groups closely. Talk to transport officials, urban planners, lawmakers, community members. Share results through the process. Use their input to make good decisions on safety ideas that work.

Prioritization of Pedestrian Safety in Urban Planning: Walking safely is very important in cities. This study shows how vital it is to think about people walking when building roads and transport systems. By putting walkers first, cities can make things safer and more walk-friendly. This helps the environment and improves life.

Deployment of Advanced Technologies: We need high-tech tools too. Cities should use sensors, cameras, and smart cars. Combining these with the study's models means real-time tracking, prediction, and action. This boosts walker safety and traffic flow.

Promotion of Interdisciplinary Collaboration: These are complex topics involving many areas. We need people from different fields working together. Researchers, city planners, traffic engineers, lawmakers, and community leaders all bring something important. By collaborating, they can find more complete solutions. Each group looks at things differently - infrastructure, human actions, new technology, and policies. Together, they address pedestrian safety from multiple angles.

Continuous Evaluation and Refinement: It is vital to keep checking if strategies work as planned. See how pedestrians act, note traffic patterns, and look at safety data. Then adjust programs to stay relevant over time. Consistent evaluation and tweaks move towards better pedestrian safety and smoother city mobility. This ongoing process keeps making improvements where needed.

Emphasis on Public Education and Awareness: Fixing issues with pedestrian safety demands more- than just tech upgrades and bette-r infrastructure. We must also educate people, spreading awareness through public campaigns. Teaching pedestrians, drivers, and others about safe ways to walk, traffic rules, and why pedestrian safety matters helps build a culture of shared duty and mutual respect. These campaigns can send info and promote positive changes via different media, schools, and community outreach initiative-s.

By using a complete approach – including research data, advanced tech, working together with invested groups, and public knowledge – cities can hugely boost pedestrian safety, creating environments friendlier for walking. This won't just reduce pedestrian-vehicle conflicts and improve traffic flow but also promote green transportation, environmental sustainability, and a better quality of urban living overall.

12. Reference

1. Avondale Estates Downtown Development Authority. (n.d.). Mid-block Crossings.

2. Brigitte Cambon de Lavalette, Yehoshua Benjamins, Christian Declerck, & Jean-Claude Bergeron. (2009). Pedestrian crossing decision-making: A situational and behavioral approach. Safety Science, 47(9), 1248-1253.

3. Fengjiao Zou, Gulsah Akar, Yaqin Zhou, & Jay Jeffers. (2022). Pedestrian Behavior Interacting with Autonomous Vehicles during Unmarked Midblock Multilane Crossings: Role of Infrastructure Design, AV Operations and Signaling. Transportation Research Record, 2676(5), 358-370.

4. Jayaram, S. K., Kostikov, A., Zhou, X., Spraggon, M., Moacdidit, N., Soongswang, O., & Pitchalatcharin, K. (2020). Analysis and prediction of pedestrian crosswalk behavior during automated vehicle interactions. IEEE Access, 8, 113092-113108.

5. Kadali, B. R., & Vedagiri, P. (2014). Evaluation of pedestrian mid-block road crossing behavior using artificial neural network. Journal of Transportation Safety & Security, 6(4), 338-354.

6. Kadali, B. R., Vedagiri, P., & Rathi, N. (2015). Models for pedestrian gap acceptance behavior analysis at unprotected mid-block crossings under mixed traffic conditions. Transportation Research Part F: Traffic Psychology and Behavior, 32, 168-179.

7. Kayvan Aghabayk, Ramin Mohammadiziazi, Amin Mirshahi, Keyvan Aghayari, Hamid Moayedi, & Mahshid Forooghi. (2021). Observational-based study to explore pedestrian crossing behaviors at signalized and unsignalized crosswalks. Transportation Research Part F: Traffic Psychology and Behaviour, 81, 28-41.

8. Khaled Shaaban, Anusha Vuppuluri, & Abid S. Alhaidan. (2019). Simulating the acceptance of pedestrian gaps on a six-lane urban road. Arabian Journal for Science and Engineering, 44(5), 4683-4696.

9. Ministry of Road Transport and Highways (MoRTH). (2021). Road Accidents in India - 2021.

10. Siti Naquiyah Mohamad Nor, Riza Atiq Ok Rahmat, & Amiruddin Ismail. (2017). Evaluation of crossing decision and pedestrian gap acceptance in Kuala Lumpur. Transportation Research Procedia, 25, 5098-5111.

11. Theofilatos, A., Hauge, E., Ziakopoulos, A., & Yannis, G. (2021). To cross or not to cross? Review and meta-analysis of pedestrian gap acceptance decisions at midblock street crossings. Accident Analysis & Prevention, 156, 106125. https://doi.org/10.1016/j.aap.2021.106125

12. Transportation Research Board. (2010). Highway Capacity Manual. Washington, D.C.: National Research Council.

13. World Health Organization. (2018). Global Status Report on Road Safety 2018.

14. Zegeer, C. V., Stewart, J. R., Huang, H. H., & Lagerwey, P. A. (2002). Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines. Federal Highway Administration, Report No. FHWA-RD-01-075.

15. Zhao, X., Wang, X., & Li, J. (2020). Pedestrian gap acceptance behavior at midblock crosswalks: A case study in China. Journal of Advanced Transportation, 2020, Article ID 8872181.

16. Arkatkar, S., Arvikar, A., Sarkar, A. K., Joshi, G., & Tiwari, G. (n.d.). Evaluation of pedestrian safety at midblock crossings in India. Transportation Research Part F: Traffic Psychology and Behavior, 48, 35-48.

17. Papadimitriou, E., Lassarre, S., & Yannis, G. (2016). Pedestrian risk taking while road crossing: A comparison study between two urban environments. Advances in Transportation Studies, 40, 49-64.

18. Rastogi, R., & Joseph, S. D. (2017). Pedestrian crossing behavior in India: A cross-cultural study. Safety Science, 99, 236-243.

19. Guo, H., Gao, Z., Yang, X., & Krishnan, R. (2018). Modeling pedestrian violation behavior at signalized crosswalks: An integrated approach. Transportation Research Part F: Traffic Psychology and Behaviour, 57, 76-92.

20. Rosenbloom, T., Nemrodov, D., & Eliyahu, A. (2008). Yielding behavior of Israeli drivers: Interaction of age and sex. Perceptual and Motor Skills, 106(2), 485-490.

21. Yannis, G., Dragomanovits, A., Laiou, A., Richter, T., Ruhl, S., La Cour Lund, B., & Chevreuil, G. (2019). Pedestrian safety in urban areas: The effects of traffic calming measures and pedestrian bridges. In Proceedings of the Road Safety and Simulation International Conference (RSS 2019), Iowa City, IA, USA, 17-19 October 2019.

22. Jiang, H., Xu, C., Zhang, W., & Zeng, J. (2021). Evaluating pedestrian safety at unsignalized midblock crossings in China: A case study in Changsha City. Journal of Advanced Transportation, 2021, Article ID 8899822.

23. Transport for London. (2005). Pedestrian Comfort Guidance for London.

24. Zhuang, X., & Wu, C. (2014). Pedestrians' crossing behaviors and safety at unmarked roadway in China. Accident Analysis & Prevention, 71, 83-89.

25. Zhao, J., Malenje, J., & Tang, K. (2021). Pedestrian crossing behaviour at unsignalized midblock locations in Beijing, China. Transportation Research Part F: Traffic Psychology and Behaviour, 77, 141-154.

26. Patten, C. J., Kircher, A., Östlund, J., & Nilsson, L. (2004). Using mobile telephones: Cognitive workload and attention resource allocation. Accident Analysis & Prevention, 36(3), 341-350.

27. Nasar, J., Hecht, P., & Wener, R. (2008). Mobile telephones, distracted attention, and pedestrian safety. Accident Analysis & Prevention, 40(1), 69-75.

28. Mwakalonge, J., Siuhi, S., & White, J. (2015). Distracted walking: Examining the impact of pedestrians on their awareness of roadway dangers. Journal of Traffic and Transportation Engineering, 3(2), 133-142.

29. Hatfield, J., & Murphy, S. (2007). The effects of mobile phone use on pedestrian crossing behavior at signalized and unsignalized intersections. Accident Analysis & Prevention, 39(1), 197-205.

30. Bungum, T. J., Day, C., & Henry, L. J. (2005). The association of distraction and caution displayed by pedestrians at a lighted crosswalk. Journal of Community Health, 30(4), 269-279.

31. Chaudhari Avinasha, Shah Jitenb, Arkatkar Shriniwasa, Joshi Gauranga, Parida Manoranjan (2018), Evaluation of pedestrian safety margin at mid-block crosswalks in India, Safety Science.

32. Nagalla, R., Pothuganti, P., & Pawar, D. S. (2017), Analyzing gap acceptance behavior at unsignalized intersections using support vector machines, decision tree and random forests, Procedia Computer Science, 109, 474-481.

33. Sheykhfard, A., & Haghighi, F. (2020). Assessment pedestrian crossing safety using vehicle-pedestrian interaction data through two different approaches: Fixed videography (FV) vs In-Motion Videography (IMV). Accident Analysis & Prevention, 144, 105661.

34. Asaithambi, G., Kuttan, M.O., and Chandra, S. 2016. Pedestrian Road Crossing Behavior Under Mixed Traffic Conditions: A Comparative Study of an Intersection Before and After Implementing Control Measures:

35. Transportation in Developing Economies, Vol. 2, No. 2, p. 14, DOI: 10.1007/s40890-016-0018-5. Ben-Edigbe, J.E., and Ferguson, N.S. 2005. Extent of capacity loss resulting from pavement distress: Transport, Vol.158, No. 1, pp. 27–32, DOI: 10.1680/tran.2005.158.1.27.

36. Bhuyan, P.K., and Rao, K.V.K. 2011. Defining level of service criteria of urban streets in Indian context: European Transport - Trasporti Europei, Bhuyan, P.K., and Rao, K.V.K. 2010. Fcm Clustering Using Gps Data for Defining Level of Service Criteria of Urban Streets in Indian Context: Transport

Problems, Bonneson, J.A. 1998. Delay to major-street through vehicles due to right-turn activity: Transportation Research Part A: Policy and Practice, Vol. 32, No. 2, pp. 139–148, DOI: 10.1016/S0965-8564(97)00028-1.

37. Brewer, M.A., Fitzpatrick, K., Whitacre, J.A., Street, C., and Lord, D. 2006. Exploration of Pedestrian Gap Acceptance Behavior at Selected Locations: Transportation Research Record, Vol. 250, No. July 2005.

38. Cao, N.Y., and Sano, K. 2012). Estimating Capacity and Motorcycle Equivalent Units on Urban Roads in Hanoi, Vietnam: Journal of Transportation Engineering, Vol. 138, No. 6, pp. 776–785, DOI: 10.1061/(ASCE)TE.1943-5436.0000382.

39. Chandra, S., and Kumar, U. 2003. Effect of Lane Width on Capacity under Mixed Traffic Conditions in India: Journal of Transportation Engineering, Vol. 129, No. 2, pp. 155–160, DOI: 10.1061/(ASCE)0733-947X(2003)129:2(155).

40. Chandra, S., and Prasad, N. V. 2004. Capacity of Multilane Urban Roads Under Mixed Traffic Conditions: Research Bulletin, Traffic Engineering, Indian Road Congress, New Delhi, India,

41. Connelly, M.L., Conaglen, H.M., Parsonson, B.S., and Isler, R.B. 1998. Child pedestrians' crossing gap thresholds: Accident Analysis and Prevention, Vol. 30, No. 4, pp. 443–453, DOI: 10.1016/S0001-4575(97)00109-7.

42. Das, S., Manski, C.F., and Manuszak, M.D. 2005. Walk or wait? An empirical analysis of street crossing decisions: Journal of Applied Econometrics, Vol. 20, No. 4, pp. 529–548, DOI: 10.1002/jae.791.

43. Forde, A., Daniel, J., and Maina, E.V. 2018. Modeling Automobile Interference due to Midblock Pedestrian Activity on Urban Street Segments: Journal of Transportation Engineering, Part A: Systems. 04017067, DOI: 10.1061/JTEPBS.0000115.

44.Forde, A., and Maina, E.V. 2017. Validation and sensitivity analysis of a developed midblock vehicular delay model: Journal of Transportation Engineering, Vol. 143, No. 7, pp. 1–12, DOI: 10.1061/JTEPBS.0000052.

45 Guangxin, L.I.U., and Keping, L.I. 2009. Pedestrian's Psychology on Gap Selecting when Crossing Street: International Conference on Transportation Engineering, Vol. 2009, No. Icte, pp. 2138–2144. HCM (2010). Highway Capcity Manual 2010.

46 Indo-HCM (2017). Indian Highway Capacity Manual (Indo-HCM): CSRI-Central Road Research Institute, New Delhi,.Kadali, R., Rathi, N., and Vedagiri, P. 2014).

47.Evaluation of Pedestrian Mid-block Road Crossing Behavior Using Artificial Neural Network (ANN): Safe, Smart, and Sustainable Multimodal Transportation Systems Kadali, R., and Vedagiri, P. 2013. Modelling pedestrian road crossing behavior under mixed traffic condition: European Transport - Trasporti Europei,

48. Hareshkumar Dahyabhai Golakiya et al. / Transportation Research Procedia 48 (2020) 777–792 16 Golakiya and Dhamaniya / Transportation Research Procedia 00 (2018) 000–000

Kadali, B.R., Vedagiri, P., and Rathi, N. 2015. Models for pedestrian gap acceptance behavior analysis at unprotectedmid-block crosswalks under mixed traffic conditions: Transportation Research Part F: Traffic Psychology and Behavior, Vol. 32, pp. 56–67, DOI: 10.1016/j.trf.2015.04.008.

49 Koh, P.P., and Wong, Y.D. 2013. Gap acceptance of violators at signalized pedestrian crossings: Accident Analysis and Prevention, Vol. 62, pp. 178–185, DOI: 10.1016/j.aap.2013.09.020.

50.Kruszyna, M., Mackiewicz, P., and Szydlo, A. 2006. Influence of Pedestrians' Entry Process on Pedestrian Delays at Signal-Controlled Crosswalks: Journal of Transportation Engineering, Vol. 132, No. 11, pp. 855–861, DOI:10.1061/(ASCE)0733-947X(2006)132:11(855).