COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

CIEN 4011
Big Data in Transportation
Professor Xuan Sharon Di

Field Experiment Report
Urban Planning Challenges and Opportunities Revealed by Traffic Flow Data

Group Members

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1. Introduction

Problem Statement

Motor vehicle and pedestrian safety are consistently prominent subjects in the field of transportation. As the number of cars increases, the higher traffic volume at intersections presents additional difficulties and possible hazards to both pedestrian and driver safety. The convergence of pedestrians and motor vehicles at intersections creates an intricate and ever-changing traffic setting in which numerous latent hazards of possible accidents exist. For this field experiment, we selected the intersection of 110th St. & Broadway as the location to observe and analyze the behavioral traits of all individuals and vehicles, including cars, pedestrians, and cyclists. We specifically focused on the possible dangers that older pedestrians may encounter when crossing the street. A questionnaire was designed and distributed to older pedestrians to obtain related information. Using all the information we obtained, we analyzed the data to derive specific conclusions. Our goal was to provide recommendations to relevant agencies to enhance traffic conditions and minimize potential risks at intersections, particularly for elderly pedestrians.

Questionnaire Design

Before the field experiment, we developed our questionnaire. The big question of our questionnaire was whether elderly pedestrians feel sufficient safety and convenience when crossing intersections. Ten sub-questions were devised to achieve this large goal, and the questionnaire was distributed at 110th St. & Broadway to collect the questionnaire answers and investigate them later in the report. The questions in the questionnaire were as follows:

1. Do you usually feel safe when crossing the street? (Yes or No)
2. Do you feel that the wait time at stoplights is long enough for you to cross the street safely? (Yes or No)
3. Have you experienced any difficulties when crossing the street? (Yes or No)
4. Do you feel there is a need to improve the design of traffic light intersections? (Yes or No)
5. Do you use any assistive devices (e.g., crutches, walkers, etc.) to cross the street? (Yes or No)
6. In terms of visual or auditory signals, do you feel that the existing traffic signals are effective enough? (Enough, Need improvement but enough, Not enough)
7. What do you think are the particular challenges older people face when crossing the street compared to younger people? (open question)
8. Do you deliberately choose to avoid crossing the street during rush hour? (Yes or No)

9. Do you intentionally avoid certain intersections that are particularly complicated or feel unsafe? (Yes or No)
10. What suggestions do you have for local government to improve safety at intersections? (open question)

2. Data Description

The study's data were sourced from two key methods. The first part comes from traffic flow Data which was gathered via recorded videos that captured a comprehensive view of traffic dynamics, including vehicles, pedestrians, and other transportation modes. Analyzing these recordings allowed researchers to examine traffic flow in various directions and during different times, alongside changes in pedestrian patterns. The second part will be a questionnaire survey. Focused on elderly individuals aged 65 and above, this survey aimed to delve deeper into the specific travel behaviors and needs of older adults. It collected information on their peak activity times, preferred walking routes, and general transportation experiences. Integrating these two data sets has provided a robust foundation for understanding both the operational aspects of the urban transport system and the unique behaviors of elderly users within this space. The insights gleaned from this comprehensive analysis are instrumental in shaping future urban planning and transportation strategies, ensuring they cater effectively to the needs of older residents. Detailed findings from this study will be further elaborated in the upcoming data visualization section, enhancing our strategic approach to traffic management and infrastructure improvements.

Pedestrian and Vehicle Orientation Schematic

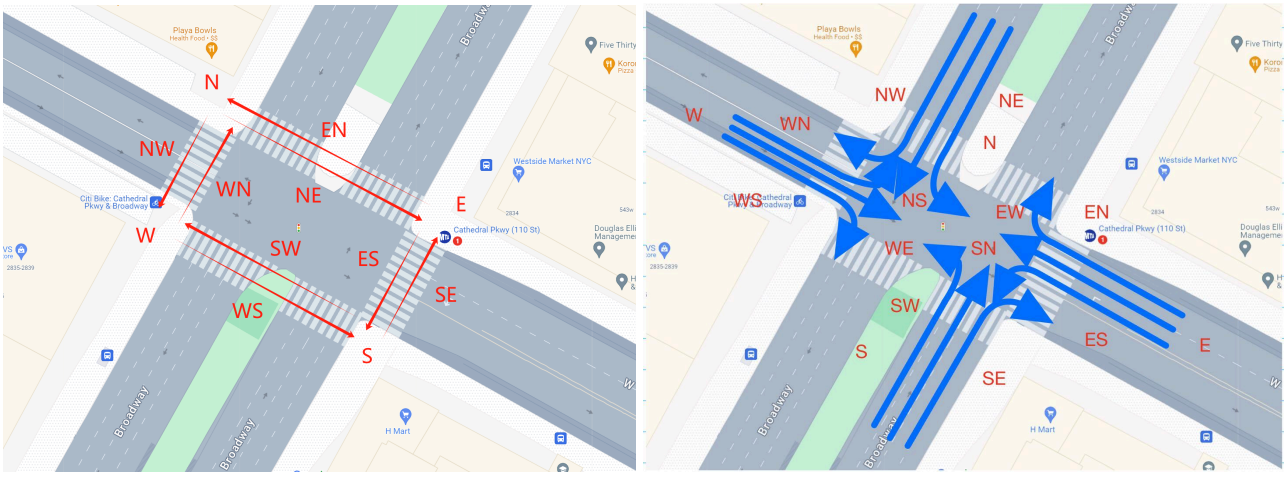

Figure 1. Pedestrian and Vehicle Orientation Schematic

3. Data Visualization & Interpretation

Car volume analysis

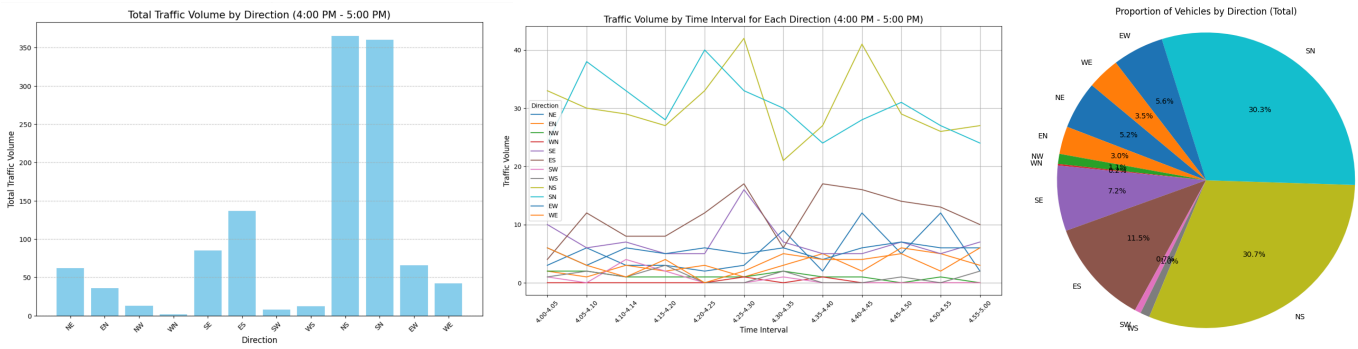

Figure 2. Car volume visualization

The **bar chart** shows in detail the traffic counts in different directions between 4pm and 5pm. The **pie chart** visualizes the share of total vehicle traffic per direction. Significantly, the South to North (NS) and North to South (SN) directions have much higher volumes than the other directions, indicating that these directions are the main arterials connecting the main areas of the city also known as Broadway Street, which carries a lot of commuter and commercial traffic. The southeast (SE), southeast-to-west (ES), and west-to-east (WE) directions, on the other hand, have relatively low volumes, indicating that these directions are secondary routes or connect to less populated areas. This **time series graph** shows the change in traffic flow in different directions during each five-minute time period between 4:00 and 5:00 PM. As can be seen from the graph, the traffic volume fluctuates significantly, with significant differences between the different directions. In particular, the South-to-North (SN) and North-to-South (NS) directions maintain high levels of traffic for most of the time period, indicating that these directions are the main arterials, i.e., Broadway Street, which is also consistent with the results of the bar charts. The east-to-west (EW) and west-to-east (WE) directions have relatively low traffic volumes, but also have peaks during certain specific time periods, such as 4:25-4:30. This suggests that even in the secondary directions, there are short periods of increased flow, possibly due to traffic signal changes or the influence of surrounding activities. In the case of the video, it was due to the presence of a large commercial vehicle that caused the brief traffic congestion during that time period. If drivers can be made aware of this information in advance, drivers may avoid passing through the area reducing the likelihood of congestion. This would

improve understanding of the dynamics of urban traffic and help optimize signal control and congestion relief.

Cyclists data analysis

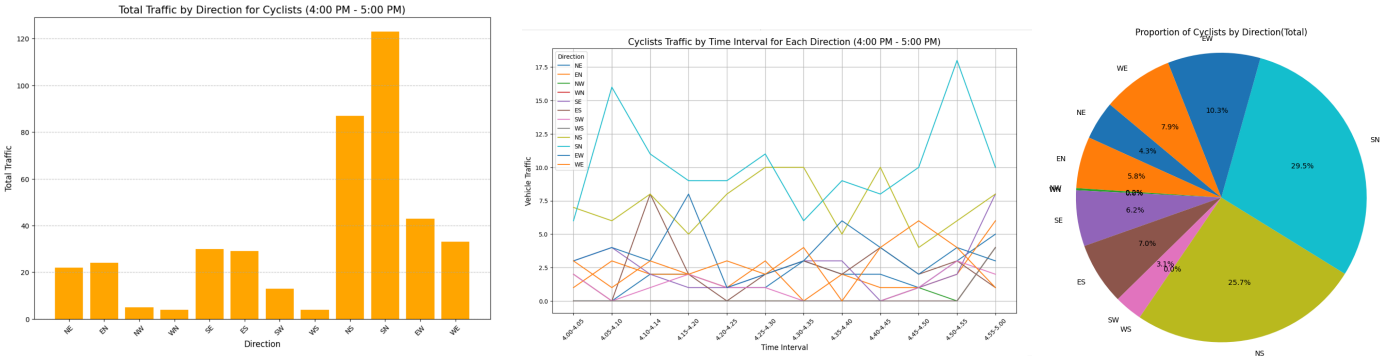

Figure 3. Cyclists data visualization

This **bar graph** shows the statistics of bicycle traffic in different directions between 4:00 pm and 5:00 pm. The **pie chart** illustrates the distribution of cyclists across directions. It is clear from the graphs that the highest bicycle traffic is in the south-to-north (SN) direction, followed by the north-to-south (NS) direction. These two directions have significantly higher volumes than the other directions, and the field survey found that this is due to the fact that these two directions have better bicycle path facilities along the routes, connecting major commercial and residential areas. In contrast, the southeast (SE), southwest (SW), and west-east (WE) directions have relatively low bicycle volumes. These routes are not major bicycle travel routes. In addition, the east-to-west (EW) direction does not have as much traffic as the north-south direction, but it does have some bicycle traffic, which connects some important points, and some residential buildings are set up in these directions. This **time-series graph** shows the variation in bicycle traffic in different directions during each five-minute time period between 4:00 p.m. and 5:00 p.m. The graph also shows the variation in bicycle traffic in different directions during each five-minute time period. As can be seen from the graph, bicycle traffic is relatively flat in most directions, but several directions show significant peaks in traffic. In particular, during the 4:10-4:15 time period, the southeast bound (SE) direction shows a sharp increase in traffic, reaching the highest peak of the day, possibly due to certain time-specific events or traffic route dominance. Meanwhile, the south-to-north (SN) direction also experienced a significant increase in traffic from 4:50-4:55, suggesting that this time period may be dominant for bicyclists.

Pedestrians data analysis

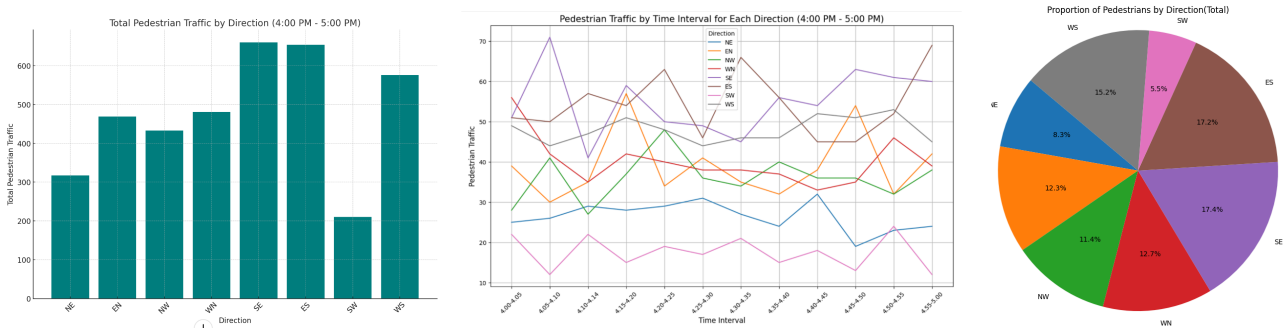

Figure 4. Pedestrians data visualization

This **bar chart** shows in detail the pedestrian flow statistics for different directions between 4:00 PM and 5:00 PM. The **pie chart** shows the percentage of pedestrians per direction. From the graphs, it can be seen that the southeast (SE) and northwest (NW) directions have the highest pedestrian flow, showing a greater density of pedestrian traffic. Comparatively, the northeast (NE) and southwest (SW) directions have less pedestrian flow, probably because there are fewer access routes in these directions or they are not major travel paths. This data can be used to analyze the distribution of urban traffic flow, which is important for urban planning and traffic management. Meanwhile, the **time series graphs** show the variation of pedestrian flow in different directions at five-minute intervals between 4:00 p.m. and 5:00 p.m.. It can be seen that pedestrian flows fluctuate significantly in most directions, especially in the east-west directions (EN and WN) where the difference between the peaks and troughs of the flows is large, suggesting that there may be timed peaks of access and egress in these directions. In contrast, the flows in the southeast (SE) and southwest (SW) directions are relatively smooth, indicating a more even pedestrian flow in these directions. These data are useful for understanding the patterns of urban pedestrian flows during specific time periods.

Combining these two charts, we can find that for overall traffic distribution, the first bar chart shows that during the one-hour period (4:00 PM - 5:00 PM), pedestrian traffic is highest in the Southeast (SE) and Northwest (NW) directions, which may indicate that there are important access nodes or popular commercial areas in these directions. According to Google Maps there are two stores, CVS and westside market, in each of these directions, which may contribute to the high pedestrian volumes. The northeast (NE) and southwest (SW) directions have lower pedestrian flows, which may be less traveled areas. In aspect of time interval fluctuation: The second time series plot reveals the fluctuation of pedestrian flow

over different time intervals. Although the Southeast (SE) and Northwest (NW) directions have higher flows during the overall hour, other directions such as East and West (EN and WN) show more significant peaks and troughs of flows during specific five-minute time intervals. We also need to consider spikes during specific time periods because as seen in the time series graphs, some directions such as Northwest (NW) show spikes in flow during specific five-minute time periods, such as 4:10 PM - 4:15 PM, which may be related to the off-duty rush hour or crowds of people letting out of school from the university at that time.

Older pedestrian traffic analysis

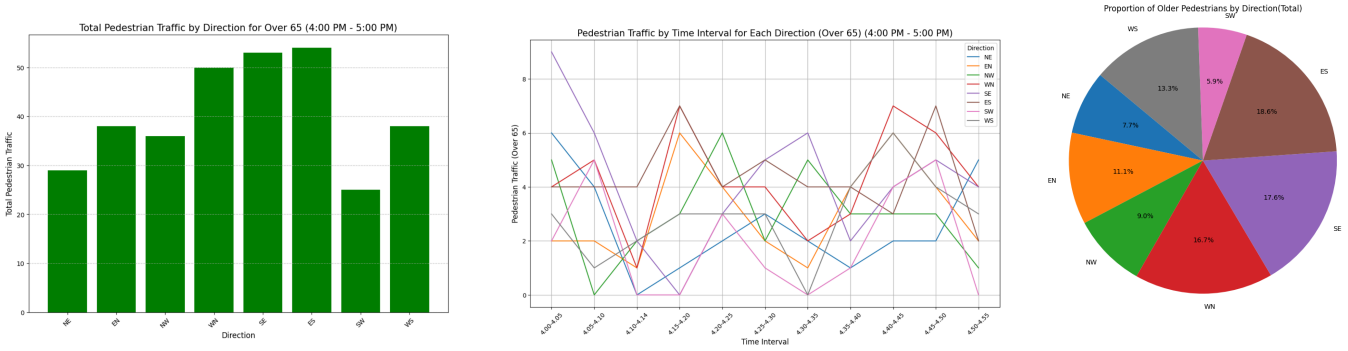

Figure 5. Older pedestrian traffic visualization

This **bar chart** shows the traffic counts of pedestrians over the age of 65 in different directions between 4:00 pm and 5:00 pm. The **pie chart** represents the proportion of older pedestrians in each direction. As can be observed from the charts, the relatively high flow of older pedestrians in the Southeast (SE) and Southwest (SW) directions may indicate that there are senior-friendly facilities in these directions, and that riverside park happens to be located in this direction. In contrast, the northeast (NE) and west-to-east (WE) directions have relatively low flows. Although pedestrians over the age of 65 do not make up a significant portion of the total number of pedestrians, their safety while traveling is especially important given that seniors may move slower and are more likely to be involved in accidents. This data suggests that city planners need to pay special attention to pedestrian safety in areas with high senior traffic, such as adding crosswalks, improving street lighting, setting longer crossing times, and providing more rest areas. These measures will not only improve the safety of older adults, but also enhance their ease of travel, which in turn will enhance their quality of life. Such population-specific data analysis is essential for the formulation of inclusive urban development policies. This **time-series graph** shows the

variation in the flow of pedestrians over the age of 65 in different directions during the period from 4:00 pm to 5:00 pm. As can be observed from the graph, the flow of seniors fluctuates significantly in all directions, suggesting that the activity patterns of seniors have a large variation during different time periods. Particularly, in the southwest (SW) direction, the flow of elderly people reaches a peak at 4:35-4:40, which may be due to certain community activities or timed public services. Meanwhile, the Northeast (NE) direction also shows a sudden increase in flow at 4:10-4:15, which may be related to the operating hours of nearby facilities such as stores.

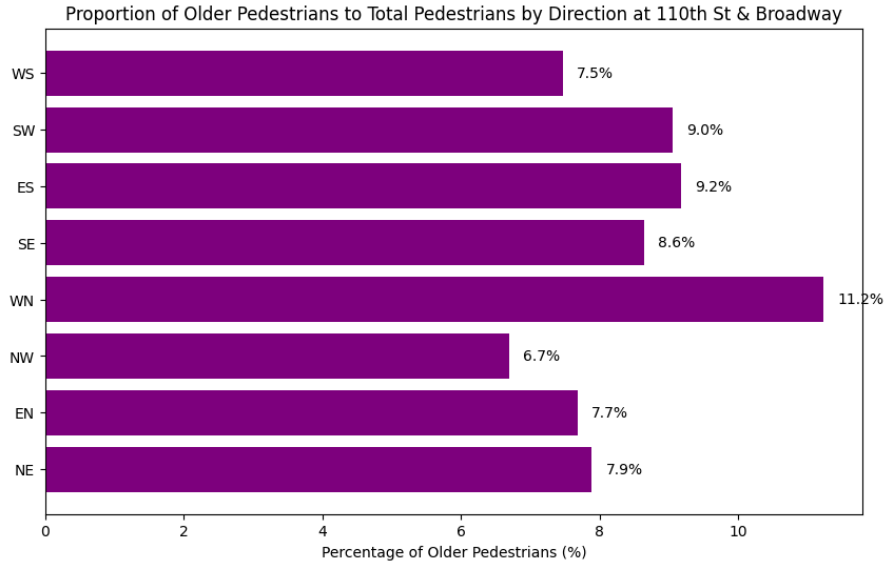

Figure 6. Proportion of Older Pedestrians to Total by Direction

The **horizontal bar chart** details the percentage of older pedestrians compared to the total pedestrian count by direction at the intersection of 110th St & Broadway. It shows significant variation in these percentages, with the southeast (SE) direction recording the highest at 11.2%, and the northwest (NW) direction the lowest at 6.7%. These differences may indicate the varying levels of accessibility and safety in different parts of the intersection or could be linked to the proximity of amenities that attract older people.

Traffic composition analysis

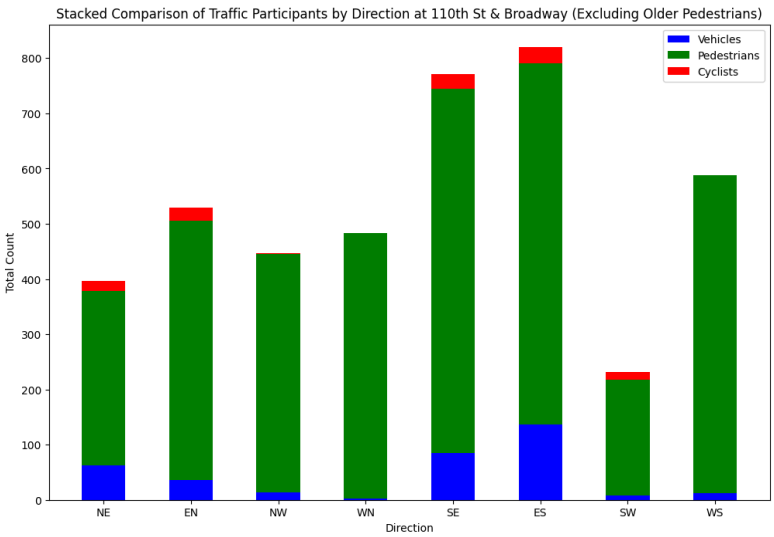

Figure 7. Stacked Comparison of Traffic Participants by Direction

This **stacked bar chart** displays the distribution of traffic participants—vehicles, pedestrians, and cyclists—at the intersection of 110th St & Broadway, with each bar representing a specific direction segmented by color: blue for vehicles, green for pedestrians, and red for cyclists. The chart shows a clear predominance of pedestrians in nearly all directions, indicating high pedestrian activity at this intersection, which could suggest pedestrian-friendly infrastructure or proximity to pedestrian-heavy areas such as shopping districts or educational institutions. While the vehicle counts are significantly lower than those of pedestrians, they remain substantial across most directions, reflecting consistent vehicular traffic. Cyclists are the least represented group, pointing to either less favorability or inadequate infrastructure for cycling compared to other modes of transport.

4. Policy Making & Validation

Based on a detailed analysis of pedestrian and vehicular flows for various age groups during different time periods, several policy recommendations are made to enhance community traffic safety and in turn create a more friendly and inclusive urban transport environment: **additional or optimized crosswalks should be installed in response to the frequent activities of older persons on specific high-traffic roadways, such as the Southwest (SW) direction in the afternoon peak period**. This includes ensuring that crosswalk markings are clearly visible and that the floor is made of non-slip

materials, while installing adequate warning signals and ground lighting to improve the safety and convenience of crossing the street. **In addition, consideration should be given to extending the green light duration of traffic lights at specific times along road sections with a high flow of elderly people, such as in the north-east (NE) direction, to ensure that elderly people can cross the road safely and comfortably**. Consideration should be given to enhancing roadway lighting for nighttime pedestrian visibility, especially at locations with high pedestrian and vehicular volumes. Nighttime visibility and safety for all pedestrians, especially at intersections and turns with complex traffic, should be improved by installing more efficient streetlights and directional light sources. **In addition, in order to reduce private vehicle usage, traffic congestion and environmental pollution, accessibility to public transportation should be promoted.** Especially on high-traffic sections such as South-to-North (SN) and North-to-South (NS), the frequency of bus and subway services should be increased to ensure the punctuality and comfort of the transportation means, so that public transportation can become the preferred mode of travel for the public. **At the same time, traffic safety education courses should be held regularly at community centers, targeting the elderly to teach them how to cross streets safely and to recognize and understand traffic signals.** Moreover, drivers should be educated to improve their understanding and patience with the behavioral patterns of the elderly, especially in areas with a large number of elderly people, and to enhance drivers' sense of responsibility and protection.

To validate the effectiveness of the transportation policies aimed at enhancing safety for elderly pedestrians, we will focus on implementing the simpler and more cost-effective measures first, such as extending traffic light timings in the northeast (NE) direction and conducting community traffic safety education programs. These initiatives have been selected for early testing due to their lower implementation barriers and reduced costs, which make them ideal for pilot trials. **By initiating pilot tests at strategic intersections, such as 110th Street, we will collect comprehensive pedestrian and vehicular flow data over a two-month period, using the same methodologies as the initial study.** This direct comparison will help determine the policies' impact. If the pilot results indicate enhanced safety and improved traffic conditions, these measures will be considered successful and expanded to additional locations. Conversely, if the results reveal minimal impact, further adjustments and community input will be sought to optimize the policies, ensuring that they effectively address the specific needs of elderly pedestrians in the community.

5. Conclusions & Potential Future Work

Approximately 35% of older adults expressed concerns about their safety when crossing streets, according to recent survey results. This significant feedback underscores the urgent need to consider their safety more carefully in the design of intersections. Moreover, over half of the elderly respondents reported that the duration of existing traffic signals is insufficient for them to cross safely. These findings point to a deficiency in our urban infrastructure's ability to accommodate the pedestrian safety needs of older adults. To address these issues, it is crucial for authorities to implement changes such as extending the timing of traffic signals and enhancing the layout of sidewalks and crosswalks. Such improvements would not only bolster the confidence of older individuals in navigating streets but would also elevate overall pedestrian safety standards within the community.

In terms of future work, ongoing efforts will be dedicated to enhancing the accessibility and safety of crossings for elderly pedestrians. The monitoring of policy implementation and the continuous gathering of feedback from elderly community members will remain a priority. This systematic approach ensures that policies can be dynamically adjusted and optimized based on real-world experiences and outcomes. The ultimate goal is to create an environment where elderly individuals can cross streets without fear of danger or feelings of guilt and unease caused by their physical limitations, particularly when faced with waiting vehicles. By doing so, it is hoped that the policies will not only improve safety but also foster a sense of independence and confidence among elderly pedestrians, thereby enriching their quality of life and integration into the community.

Appendix

Results of questionnaire

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q 9	Q 10
Yes	No	Yes	Yes	No	Need improvement but enough		Yes	Yes	Implement longer pedestrian crossing timeser
No	Yes	Yes	Yes	Yes	Enough	We're moving too slow	Yes	Yes	
Yes	No	Yes	No	Yes	Need improvement but enough		Yes	Yes	Clearer markings on crosswalks
Yes	Yes	No	Yes	No	Enough		Yes	Yes	
No	Yes	Yes	Yes	Yes	Need improvement but enough	Afraid with the car	Yes	Yes	
Yes	No	Yes	Yes	No	Enough		Yes	Yes	Installing more pedestrian-activated crosswalk lights.
Yes	No	No	Yes	No	Need improvement but enough	Struggle with judging the speed and distance of approaching vehicles.	Yes	Yes	Creating designated senior crossing zones with slower traffic speeds
No	Yes	Yes	Yes	Yes	Need improvement but enough		Yes	Yes	
Yes	No	Yes	No	Yes	Need improvement but enough		Yes	Yes	Increasing the duration of pedestrian crossing signals and adding more visible crosswalk markings.
Yes	Yes	Yes	Yes	No	Enough	Poor concentration	Yes	Yes	
No	Yes	Yes	Yes	Yes	Need improvement but enough		Yes	Yes	Installing audible pedestrian signals and improving the visibility of crosswalks.

Yes	No	Yes	Yes	No	Enough		Yes	Yes	Enhancing pedestrian crosswalk visibility
Yes	No	Yes	Yes	Yes	Need improvement but enough	More afraid	Yes	Yes	
Yes	Yes	No	Yes	No	Enough		Yes	Yes	Adding audible pedestrian signals
No	Yes	Yes	Yes	Yes	Need improvement but enough		Yes	Yes	Installing pedestrian refuge islands
Yes	No	Yes	Yes	No	Enough		Yes	Yes	Adding more audible pedestrian signals and improving sidewalk conditions.
Yes	No	Yes	Yes	Yes	Need improvement but enough	I can't hear the car very well.	Yes	Yes	
No	Yes	Yes	Yes	Yes	Need improvement but enough		Yes	Yes	
Yes	Yes	Yes	Yes	No	Enough		Yes	Yes	Better signals

Team member's roles & contributions

Task	Xuyan	Kailai	Yuchi	Kaiwen
Problem statement	✔			
Data description	✔	✔	✔	✔
Data visualization & interpretation		✔	✔	
Policy making & validation				✔

Conclusion & potential future work	✔	✔	✔	✔
Appendix		✔		
Report Formatting	✔	✔	✔	✔