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Select High Risk Pedestrian Midblock Crossings and Perform Safety Evaluations for Developing Pedestrian Crossings

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Pedestrian fatalities on high-speed, multi-lane roads in Texas, particularly in San Antonio, Houston, and Dallas, highlight an urgent need for focused interventions at midblock crossings. These sites often serve vulnerable populations and connect neighborhoods to transit, retail, and essential services, yet their safety challenges are magnified by speed, poor visibility, and insufficient infrastructure. To address this, researchers conducted a deep-dive review of safety literature, compiled extensive crash data, and leveraged geospatial tools to identify the riskiest locations across urban corridors. They developed localized Crash Modification Functions (CMFs), advanced exposure-based models, and predictive analytics tailored to Texas's unique roadway environments. A key outcome was the creation of the Midblock Crossing Pedestrian Safety Action Plan, a comprehensive guide for TxDOT districts that integrates field observations, stakeholder input, and cost-benefit analysis. This plan provides detailed site rankings, treatment prioritization strategies, and implementation pathways, including engineering upgrades, education initiatives, and enforcement considerations, grounded in local crash dynamics and pedestrian demand. Recommended treatments, such as PHBs, RRFBs, raised medians, and high-visibility markings, were evaluated for effectiveness and feasibility. The plan empowers decision-makers with a data-driven roadmap to improve safety, promote equitable access, and reduce fatalities through strategic midblock crossing improvements statewide.		
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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The researcher in charge of this project was Hatim Sharif.

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AADT	annual average daily traffic.
AIC	Akaike information criterion.
API	Google Maps API context.
CMF	Crash Modification Factor.
CRIS	Crash Records Information System.
FDOT	Department of Transportation (cited guidance).
FHWA	Federal Highway Administration.
GLM	Generalized Linear Model.
IA-21	FHWA Interim Approval 21 for RRFBs.
LEHD	Longitudinal Employer-Household Dynamics.
MPS	Midblock Pedestrian Signal.
MPA	Metropolitan Planning Area.
MMLOS	Multimodal Level of Service.
MUTCD	Manual on Uniform Traffic Control Devices.
NCHRP	National Cooperative Highway Research Program.
NCTCOG	North Central Texas Council of Governments.
NHTSA	National Highway Traffic Safety Administration.
PHB	Pedestrian Hybrid Beacon.
RRFB	Rectangular Rapid Flashing Beacon.
RS	Rigby and Stasinopoulos fitting algorithm.
SPF	Safety Performance Function.
TxDOT	Texas Department of Transportation.
V2P	Vehicle-to-pedestrian communication.
VMT / WMT	Vehicle Miles Traveled / Walk-Miles Traveled.

CHAPTER 1 : INTRODUCTION

Midblock pedestrian crossings on high-speed, multi-lane roadways have emerged as critical safety concerns across urban Texas corridors. Despite relatively low pedestrian travel volumes, fatalities at these crossing types are disproportionately high, particularly in San Antonio, Houston, and Dallas. These cities consistently record the greatest number of pedestrian crashes statewide, exposing vulnerabilities in existing roadway infrastructure and signaling an urgent need for targeted interventions.

Midblock crossings serve vital connectivity needs for transit users, pedestrians, and surrounding land uses. However, their safety management challenges are compounded by the absence of localized Crash Modification Factors (CMFs) to evaluate countermeasure effectiveness under Texas-specific conditions. This project addressed that gap by establishing a research-backed framework to identify high-risk crossing sites, develop actionable CMFs, and prioritize countermeasures tailored to the unique characteristics of Texas roadways.

RESEARCH APPROACH

To guide treatment selection and improve midblock crossing safety, researchers employed a multi-phase methodology that combined data integration, field observation, stakeholder engagement, and statistical modeling:

- Literature Review and Synthesis: The team examined national guidance documents (e.g., FHWA, NCHRP), state safety plans (HSIP, SHSP, HSP), Vision Zero strategies, and peer-reviewed studies to catalog risk factors, effective treatments, and advanced prioritization methods. Findings were compiled into a summary of best practices, countermeasure options, and lessons from high-performing jurisdictions.
- Data Compilation and Geodatabase Development: Researchers integrated crash data (CRIS), pedestrian activity proxies (e.g., land use, transit infrastructure), and traffic attributes into a spatially referenced geodatabase for Dallas, Houston, and San Antonio. Novel tools such as Replica and INRIX helped estimate pedestrian exposure. Quality control protocols supported machine learning methods for site risk prediction.
- Site Identification and Field Assessments: Using five years of crash data and spatial analytics, the team identified candidate midblock segments for on-site evaluation. Field visits documented geometric features, visibility conditions, and observed behaviors. A ranking framework was developed to prioritize crossing segments based on predicted crash frequency, pedestrian activity, and physical context.
- Treatment Evaluation and CMF Development: A national scan of treatments combined with surveys of engineers and safety officials produced a prioritized countermeasure list. Treatments such as pedestrian hybrid beacons (PHBs), rectangular rapid-flashing beacons (RRFBs), raised medians, and enhanced signage were evaluated via before-after and cross-

sectional analyses. Tailored CMFs were developed for high-speed, multi-lane environments to inform local investment decisions.

- Safety Action Planning: Researchers synthesized findings into a Midblock Crossing Pedestrian Safety Action Plan. It outlines recommended treatments, implementation strategies, and supporting guidance for TxDOT districts, including design considerations, cost-effectiveness assessments, outreach, and evaluation techniques.

RESEARCH RESULTS

The study revealed key contributors to pedestrian crash severity at midblock crossings:

- Multiple travel lanes and high-speed traffic
- Absence of pedestrian refuge or adequate lighting
- Proximity to transit stops, commercial land use, and low-income areas

Newly derived CMFs for treatments such as PHBs and RRFBs demonstrated meaningful crash reductions, especially at high-volume locations. BCR analyses confirmed strong safety returns, guiding agencies toward cost-effective, evidence-based interventions.

This project equips TxDOT districts with:

- Jurisdiction-specific CMFs for midblock crossing treatments
- A geospatial site-ranking methodology integrating crash risk and pedestrian demand
- A technical framework for evaluating and implementing safety enhancements

By linking data, field evidence, and stakeholder insight, this research supports long-term pedestrian safety improvements across urban Texas corridors. Resources such as the Safety Action Plan and technical reports provide enduring value for infrastructure planning, community engagement, and future safety audits.

CHAPTER 2 : STATE-OF-THE-PRACTICE REVIEW

INTRODUCTION

Walking has been often overlooked by city, state, and federal governments in favor of motorized transportation. However, there is a growing segment of the population who are seeking a shift in the common approach to transportation and mobility and are advocating for more livable communities where they can commute, socialize, and engage in activities that are accessible by foot. Recent socioeconomic trends show a desire for more walkable and bikeable communities. According to the “15-Year Report on Walking and Biking," 12 percent of all trips in 2009 were made on foot or by bicycle. This ratio is remarkable considering the lack of adequate facilities for safe walking or bicycling. Pedestrians and cyclists make up 14% of traffic fatalities, and the budget for biking and walking projects is approximately 2 percent of the federal transportation budget (Bushell et al., 2013).

The competition between motorists and pedestrians has been a challenge for most of this century. Safety campaigns have been mobilized towards pedestrians, which advised them to use intersections to cross the roadway. This advice might be viable in downtown locations where road signals are more frequent and road intersections are shorter and more manageable for pedestrians. But with the advent of suburbs and a more car-centric society, the roads have evolved to become wider, and some blocks longer, causing the distance between signalized intersections to become longer. Due to the effect of wider roads, vehicle speeds tend to also increase, which adds another layer to the safety hazard. (FHWA, 2013).

The Federal Highway Administration (FHWA, 2023) states that “observation of pedestrian behavior clearly indicates that people routinely cross at mid-block locations. Pedestrians will rarely go out of their way to cross at an intersection unless they are rewarded with a much-improved crossing; most will take the most direct route possible to get to their destination, even if this means crossing several lanes of high-speed traffic.” In other words, rarely will a pedestrian choose to walk to the next pedestrian-protected intersection if it involves extending their walking distance significantly many times. The probability of “jaywalking” is thus significantly increased by factors such as the length of the blocks between intersections and other factors such as traffic gaps and even weather conditions.

Pedestrian crossings are crucial for accessing adjacent facilities nearby. And are a part of everyday life, and poorly designed crossings are not only an inconvenience to pedestrians but also can cause safety risks and disrupt the flow of traffic (Kadali and Vedagiri, 2016). The National Association of City Transportation Officials states in its Urban Street Design Guide (NACTO< 2023) that “Midblock crosswalks facilitate crossings to places that people want to go but that are not well served by the existing traffic network. These pedestrian crossings, which commonly occur at schools, parks, museums, waterfronts, and other destinations, have historically been overlooked or difficult to access, creating unsafe or unpredictable situations for both pedestrians and vehicles”. The current design challenge is to locate workable crossing points to aid pedestrians in crossing high-speed roadways. A lack of manageable crossing points could cause pedestrians to cross at unpredictable locations (jaywalking), which could add risk to themselves and the drivers.

To counter pedestrian fatalities and reduce traffic disruptions, refuge islands or medians are introduced at midblock. In urban planning, an island refers to a section in the street that pedestrians can use as a refuge when crossing multi-lane roads. A midblock island allows pedestrians or cyclists to cross the street in two stages and only requires a gap in traffic from one direction at a time. Midblock islands are a Federal Highway Administration (FHWA)-proven safety countermeasure (Cox and Prudhomme, 2014). When a pedestrian is faced with multiple lanes of traffic in each direction, they must determine a safe gap in two, four, or even six lanes at a time. The task is complex, as it requires them to make accurate decisions. The gap tolerance could also vary between younger and older pedestrians, as older pedestrians have reduced gap acceptance skills compared to other age groups. This gap assessment might be affected by the time of day, as pedestrians typically have poor gap assessment skills at night.

Chu et al. (2003) discussed the selection of potential determinants that can affect pedestrian quality of service at midblock locations. The study aimed to identify the factors that influence pedestrian behavior and preferences when crossing streets at midblock locations. It proposed a framework for measuring pedestrian quality of service, considering factors such as traffic volume, pedestrian volume, crossing distance, crossing time, and pedestrian perception. The study suggested that further research is needed to validate and refine the proposed framework and determine the relative importance of different determinants in influencing pedestrian quality of service at midblock street crossings. Figures 2-1 and 2-2 show the difference in gap assessment when crossing a midblock with and without a median.

Figure 2-1. Mid-block crossing without median (Illustration: NACTO 2023)

- Requires one 16-second gap.
- Pedestrians must look in both directions and find a gap in both directions. The wait will be considerable because, statistically, two 8-second gaps are more likely than one 16-second gap.
- Requires two 8-second gaps.
- Pedestrians only have to look in one direction.

Figure 2-2. Mid-block crossing with a median (Illustration: NACTO 2023)

Crossing at midblock poses greater challenges compared to intersection crossings due to three key factors. Firstly, there are numerous potential crossing locations midblock, surpassing the relatively limited options at intersections. Secondly, motorists are less likely to anticipate pedestrians crossing midblock, adding an element of unpredictability. Lastly, pedestrians with vision disabilities face a lack of audible cues when determining the appropriate time to cross the midblock. These distinctions necessitate specific design considerations in AASHTO's Guide for Planning (AASHTO, 2021) for midblock crossings:

1. Pedestrian Convenience

Midblock crossings should be strategically placed where intersection crossings are either unavailable or inconvenient for pedestrians. By providing convenient midblock crossings, pedestrians are more likely to use them instead of opting for other, more accessible, unmarked midblock locations.

2. Driver Awareness

To enhance safety, drivers should be alerted to the presence of a midblock crossing well in advance. The crossing itself should be highly visible to approaching drivers, with considerations such as adequate lighting to improve visibility, especially during the night. Clear lines of sight to the crossing should be ensured, and the approach should encourage drivers to reduce their speed before reaching the crossing. Providing drivers with ample time to recognize pedestrians and stop in advance of the crossing is crucial for overall safety.

3. Pedestrian Awareness

Ensure that pedestrians, especially those with vision disabilities, are well-informed about the presence of a midblock crossing and the crossing opportunities. Implement auditory and tactile aids to compensate for the absence of certain cues typically found at intersection crossings, such as the distinct sounds of traffic stopping and starting. This inclusive approach helps create a safer environment for pedestrians with varying needs.

4. Educating and Guiding Responsibilities

Communicate the responsibilities and obligations of both drivers and pedestrians at the midblock crossing. Follow guidelines from the Manual on Uniform Traffic Control Devices (MUTCD) to establish legal crossing procedures. Design the approach for vehicles, pedestrians, and traffic control to convey explicit messages regarding when pedestrians should cross and where drivers should yield and stop. Additionally, consider incorporating raised refuge areas to allow pedestrians to complete their crossing in stages when necessary. Employ traffic control devices strategically to create gaps in traffic, facilitating safe opportunities for pedestrians to cross. This comprehensive approach ensures that everyone involved understands and adheres to their roles in promoting safety at midblock crossings.

Being attentive to the surrounding environment is a critical skill for pedestrians to safely navigate road crossings. Pedestrians rely on various sources of traffic information to determine safe crossing opportunities, but they also consider social cues when making crossing decisions. The presence of fellow pedestrians, for instance, creates a situation where individuals may feel that the responsibility to assess traffic is shared. When others serve as lookouts, people within a group crossing scenario may reduce their vigilance and follow the lead of the group without thoroughly checking traffic conditions (Harrell, 1991; Wagner, 1981). Gardner and Steinberg (2005) have suggested that this tendency to conform varies significantly across age groups. Adolescents, influenced by risk-prone peers, are more inclined to follow social cues and others' actions compared to adults (Gardner et al., 2005).

However, it worth noting that relying solely on social cues is not always a safe practice. Crossing mid-block sections, especially when not alone, often involves social influence. Underestimating the impact of this factor can diminish the effectiveness of road safety strategies and interventions aimed at reducing pedestrian crashes. It is imperative to study the relationship between the level of caution exercised by pedestrians across different age groups and their susceptibility to conformity in greater detail (Soathong, 2023).

The National Highway Traffic Safety Administration (NHTSA) fact sheet for 2021 shows the age groups of pedestrians involved in traffic crash fatalities. Table 2-1 compares age groups of total deaths in traffic crashes versus the number of pedestrians killed and their percentages.

Table 2-1. Pedestrians Killed in Traffic Crashes and Fatality and Injury Rates per 100,000 Population, by Age Group and Sex, 2021 (NHTSA 2023)

Age Group	Male			Female			Total[1]		
	Killed	Population	Fatality Rate	Killed	Population	Fatality Rate	Killed	Population	Fatality Rate
<5	37	9,624,352	0.38	22	9,202,986	0.24	61	18,827,338	0.32
5-9	28	10,376,158	0.27	22	9,915,390	0.22	50	20,291,548	0.25
10-14	35	10,988,223	0.32	29	10,459,561	0.28	65	21,447,784	0.30
Children (≤14)	*100*	*30,988,733*	*0.32*	*73*	*29,577,937*	*0.25*	*176*	*60,566,670*	*0.29*
15-20	180	13,242,042	1.36	92	12,669,303	0.73	272	25,911,345	1.05
21-24	258	8,754,172	2.95	112	8,423,146	1.33	372	17,177,318	2.17
25-29	435	11,379,058	3.82	170	11,013,419	1.54	606	22,392,477	2.71
30-34	513	11,674,304	4.39	191	11,428,324	1.67	706	23,102,628	3.06
35-39	478	11,263,833	4.24	215	11,035,485	1.95	694	22,299,318	3.11
40-44	455	10,593,780	4.29	171	10,510,756	1.63	630	21,104,536	2.99
45-49	378	9,875,757	3.83	144	9,905,753	1.45	526	19,781,510	2.66
50-54	417	10,436,202	4.00	158	10,470,724	1.51	579	20,906,926	2.77
55-59	491	10,630,059	4.62	176	10,937,255	1.61	667	21,567,314	3.09
60-64	492	10,333,259	4.76	178	10,902,491	1.63	676	21,235,750	3.18
65-69	382	8,748,213	4.37	146	9,646,107	1.51	529	18,394,320	2.88
70-74	231	7,120,873	3.24	115	8,150,929	1.41	348	15,271,802	2.28
75-79	133	4,472,410	2.97	83	5,432,359	1.53	216	9,904,769	2.18
80+	169	4,872,047	3.47	112	7,405,015	1.51	282	12,277,062	2.30
Ages 65+	*915*	*25,213,543*	*3.63*	*456*	*30,634,410*	*1.49*	*1,375*	*55,847,953*	*2.46*
Total[2]	**5,171**	**164,384,742**	**3.15**	**2,154**	**167,509,003**	**1.29**	**7,388**	**331,893,745**	**2.23**

Contradicting the expectation, Table 2-1 showed that age groups below 65 and older than 25 had higher fatality rates than elderly age groups (70–80+). The table also shows that males are almost 2.5 times more likely to die from a traffic crash than females. However, this data doesn't indicate crashes that occurred at midblock crossings. But it could allude to the likelihood of overconfidence in younger age groups when using road facilities and/or alcohol.

Table 2-2 provides information on traffic fatalities in 2020, broken down by race and ethnicity and whether the victims were motorcyclists, nonoccupants, or occupants of a vehicle. It indicates that 66% of total traffic fatalities were vehicle occupants, 20% were nonoccupants, and 14% were motorcyclists. In pedestrian fatalities from traffic crashes in 2020, white individuals constituted 41%, compared to 21% Hispanic or Latino and 20% Black or African American. Similarly, in pedal cyclist fatalities, white individuals represented 51%, while Hispanic or Latino made up 17%, and Black or African American 13%.

Table 2-2. Occupant and Nonoccupant Fatalities in Traffic Crashes, by Race-Ethnicity, 2020 (NHTSA 2023)

Description	Race-Ethnicity												Total*	
	Hispanic or Latino		AIAN		Asian		Black or African American		NHPI		White			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	**6,817**	**17%**	**557**	**1%**	**404**	**1%**	**6,471**	**17%**	**15**	**0%**	**19,697**	**50%**	**39,007**	**100%**
Occupants														
Passenger Vehicles	4,189	18%	342	1%	209	1%	4,146	17%	8	0%	12,082	51%	23,914	100%
Passenger Cars	2,314	18%	149	1%	123	1%	2,785	22%	7	0%	5,720	45%	12,628	100%
Light Trucks	1,875	17%	193	2%	86	1%	1,361	12%	1	0%	6,362	56%	11,286	100%
–Pickups	740	17%	79	2%	16	0%	333	8%	1	0%	2,618	60%	4,333	100%
–SUVs	975	16%	104	2%	55	1%	907	15%	0	0%	3,246	54%	6,015	100%
–Vans	160	17%	10	1%	15	2%	121	13%	0	0%	498	53%	938	100%
Large Trucks	135	16%	7	1%	8	1%	116	14%	1	0%	434	53%	822	100%
Buses	5	26%	0	0%	1	5%	0	0%	0	0%	9	47%	19	100%
Other/Unknown	128	13%	38	4%	1	0%	98	10%	0	0%	578	59%	976	100%
Total	**4,457**	**17%**	**387**	**2%**	**219**	**1%**	**4,360**	**17%**	**9**	**0%**	**13,103**	**51%**	**25,731**	**100%**
Motorcyclists														
Motorcyclists	778	14%	42	1%	34	1%	605	11%	1	0%	3,319	60%	5,506	100%
Nonoccupants														
Pedestrians	1,367	21%	114	2%	132	2%	1,340	20%	3	0%	2,662	41%	6,565	100%
Pedalcyclists	163	17%	13	1%	17	2%	127	13%	2	0%	484	51%	948	100%
Other/Unknown	52	20%	1	0%	2	1%	39	15%	0	0%	129	50%	257	100%
Total	**1,582**	**20%**	**128**	**2%**	**151**	**2%**	**1,506**	**19%**	**5**	**0%**	**3,275**	**42%**	**7,770**	**100%**

Based on Table 2-3, In 2021, approximately 31 percent of pedestrians who lost their lives had blood alcohol concentrations (BACs) of .08 g/dL or higher, showing a decrease from the 36 percent recorded in 2012. In 2012, individuals in the 45-to-54 age group constituted the highest percentage of pedestrians killed with BACs of .08 g/dL or higher, reaching 49%, surpassing other age groups. However, in 2021, pedestrians in the 21-to-24 age group exhibited the highest percentages, at 38%, in terms of BACs of .08 g/dL or higher.

Table 2-3. Pedestrians Killed in Traffic Crashes, by Age Group and Their BACs, 2012 and 2021 (NHTSA 2023)

Age Group	2012					2021				
	Number of Fatalities	Percentage With No Alcohol (BAC = .00 g/dL)	Percentage With BAC = .01+ g/dL	Percentage With BAC = .01–.07 g/dL	Percentage With BAC = .08+ g/dL	Number of Fatalities	Percentage With No Alcohol (BAC = .00 g/dL)	Percentage With BAC = .01+ g/dL	Percentage With BAC = .01–.07 g/dL	Percentage With BAC = .08+ g/dL
15-20	310	72%	28%	5%	24%	272	74%	26%	3%	23%
21-24	358	47%	53%	5%	48%	372	56%	44%	5%	38%
25-34	684	47%	53%	6%	47%	1,312	62%	38%	4%	34%
35-44	592	49%	51%	5%	46%	1,324	61%	39%	4%	34%
45-54	907	46%	54%	6%	49%	1,105	60%	40%	4%	36%
55-64	741	62%	38%	5%	33%	1,343	61%	39%	6%	33%
65-74	448	80%	20%	4%	15%	877	75%	25%	3%	22%
75-84	360	89%	11%	3%	8%	379	88%	12%	2%	9%
85+	141	96%	4%	1%	3%	119	88%	12%	4%	7%
Total Killed*	**4,541**	**59%**	**41%**	**5%**	**36%**	**7,103**	**65%**	**35%**	**4%**	**31%**

PEDESTRIAN-VEHICLE CRASH CHARACTERISTICS

Crash characteristics refer to the specific circumstances of a traffic crash. These characteristics vary widely and may include the vehicles involved in the crash, environmental conditions, the time of day, land use, etc. Understanding crash characteristics plays a key role in identifying the causes of crashes and improving safety measures for all road users. Chu et al. (2004) analyzed pedestrian crossings at 20 different locations to understand the influences of pedestrian and environmental factors on crossing location choice. The paper discussed the components of the street environment that influence pedestrian street-crossing behavior, including midblock locations, intersections, and the roadside environment. It considered factors such as traffic conditions, roadway characteristics, and signal-control characteristics as very significant.

The pedestrian-motor vehicle crashes in the 2021 report, according to the National Highway Traffic Safety Administration (NHTSA), stated that 7,388 people were killed in the U.S.A. At the rate of every 71 minutes, on average, one pedestrian is killed, which equates to 142 people per week. Pedestrians are 1.5 times more likely to be killed in pedestrian-motor vehicle crashes than the vehicle occupants. The statistics show that 15% of the people killed in those crashes are children aged 14 and below. Pedestrian-related crash rates might be considered minimal compared to vehicle-on-vehicle crashes, as they only represent 2% of all crashes. Despite that, pedestrian-related crashes have higher fatality rates, and those crashes are most likely to cause serious injuries. Pedestrian fatalities, according to NHTSA, occurred more often at non-intersections than at intersections, at a percentage of 75% and 16%, respectively.

Overall pedestrian fatalities have increased by 12.5% since 2020 (Geedipally, 2022; NHTSA, 2023). The report states that most of the pedestrian fatalities occurred more in urban areas (84%) than in rural areas (16%). And demonstrated the effect time of day has on pedestrian fatalities, as most of the fatalities occurred in the dark (77%) rather than in daylight (20%), as shown in

Figure 2-3. This suggests that improved lighting, including innovative intelligent options, could significantly reduce pedestrian crashes at both On-System and Off-System mid-block crossings.

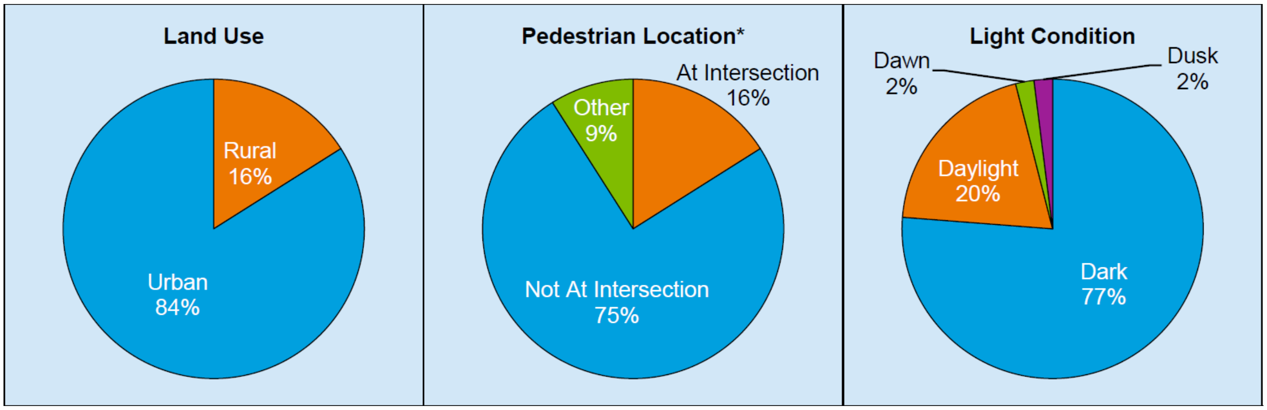


Figure 2-3. Percentages of Pedestrian Fatalities in Traffic Crashes concerning Land Use, Pedestrian Location, and Light Condition (NHTSA 2023)

Additionally Figure 2-4 shows that during the winter months (December to January of the following year), more than one-third of pedestrian fatalities (36%) occurred from 6 to 8:59 p.m. This is compared to the spring months (March to May), where the largest group of pedestrian frailties (30%) occurred from 9 to 11:59 p.m. During the summer months (June to August), more pedestrian fatalities occurred from 9 to 11:59 p.m. (35%) than any other time, followed by 17 percent from midnight to 2:59 a.m. During the fall months (September to November), 28 percent of the pedestrian fatalities occurred from 6 to 8:59 p.m.; the next largest group was 20 percent during the hours of 9 to 11:59 p.m.

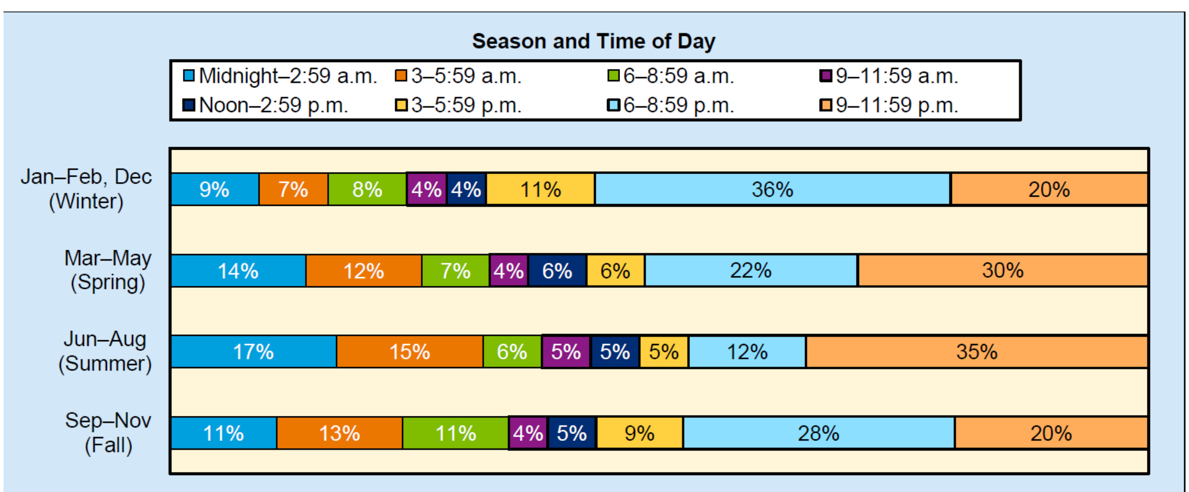


Figure 2-4. Percentages of Pedestrian Fatalities in Traffic Crashes by Season and Time of Day (NHTSA 2023)

This data suggests fatigued and distracted drivers driving from work to residential areas where a lot of driver and pedestrian activities align. A second set of data in Figure 2-5 suggests that darkness could contribute most to the fatalities.

The day of the week affects the percentage of pedestrians, whereas generally weekends tend to have a higher percentage of fatalities when combined with the time of day, especially between the evening and early morning periods. The peak weekday activity, accounting for 24% of the total, was observed between 6:00 PM and 8:59 PM. Following closely, there was a significant 22% of activity recorded from 9:00 p.m. to 11:59 p.m. On the other hand, the lowest weekday activity, at 6%, was registered during the hours of 9:00 AM to 11:59 AM. Turning to the weekends, the highest percentage of activity, making up 30%, was found during the late evening hours of 9:00 PM to 11:59 PM, with 27% also occurring from 6:00 PM to 8:59 PM. The lowest weekend activity, at a mere 2%, was recorded during the morning hours of 9:00 AM to 11:59 AM and the early afternoon from noon to 2:59 PM.

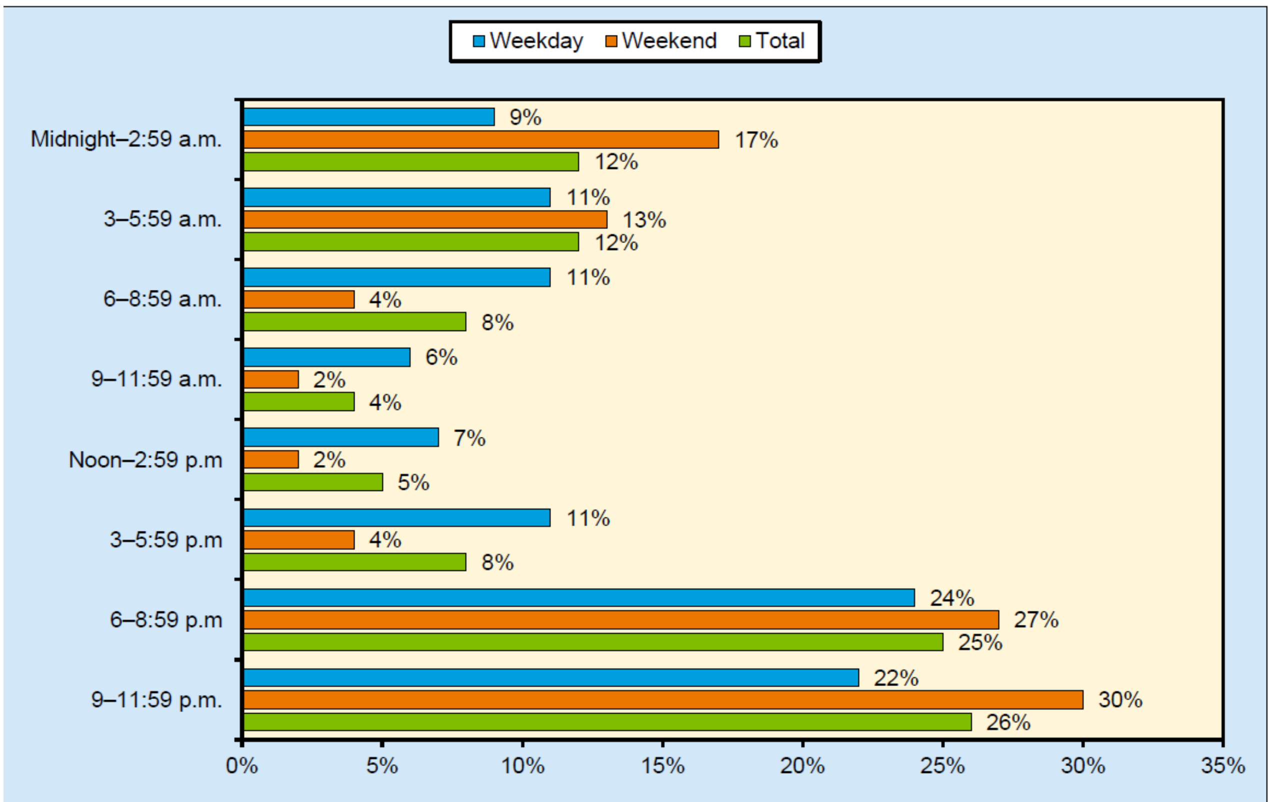


Figure 2-5. Percentages of Pedestrian Fatalities in Traffic Crashes, by Time of Day and Day of Week (NHTSA 2023)

Figure 2-6 shows that California had the most pedestrian fatalities (1,108), followed by Florida and Texas (817 each). The pedestrian fatality rate per 100,000 people in Texas is 2.77. (NHTSA, 2023). New Mexico recorded the highest pedestrian fatality rate per 100,000 population at 4.82, with Louisiana close behind at 3.98 and Florida at 3.75. The national pedestrian fatality rate in 2021 averaged 2.23. Conversely, New Hampshire had the lowest pedestrian fatality rate per 100,000 population, standing at 0.58, followed by Rhode Island with 0.64 and Nebraska at 0.76.

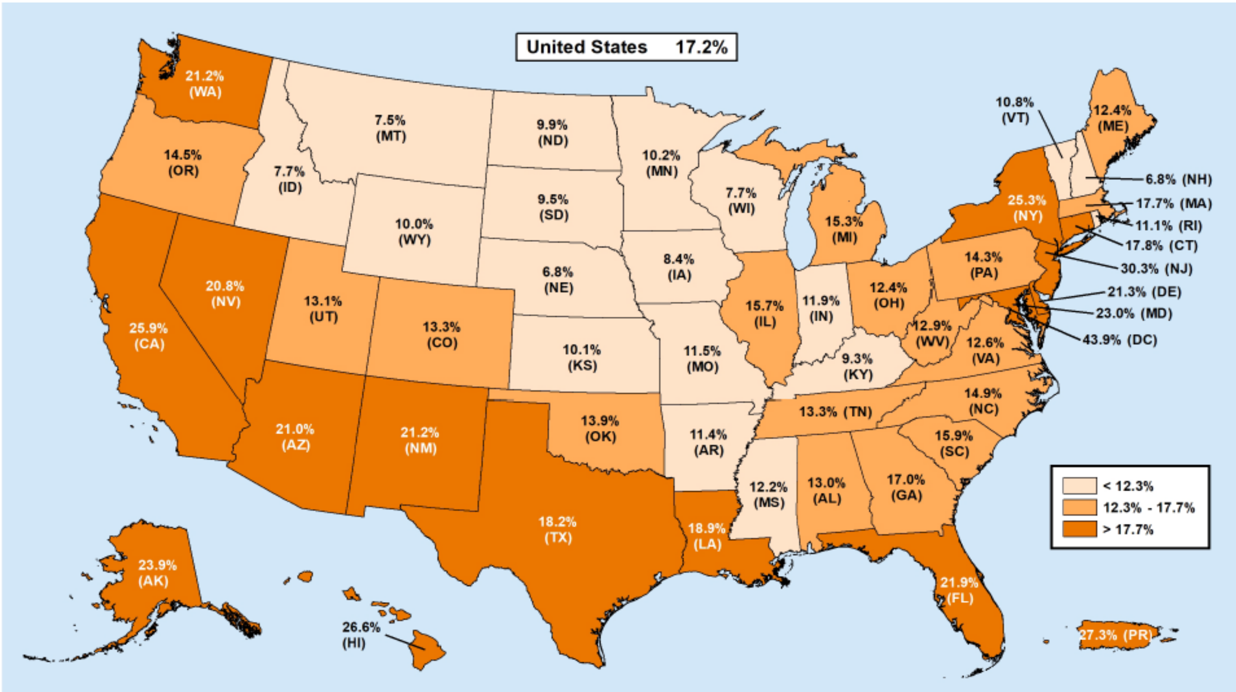


Figure 2-6. Percentages of Total Traffic Fatalities Who Were Pedestrians, by State (NHTSA 2023)

Focusing the spotlight on the state of Texas, Table 2-4 lists the pedestrian and cyclist injuries and crashes reported by TxDOT in 2022. The table indicates that 919 fatalities occurred in total in that year.

Table 2-4. Pedestrian and cyclist injuries and crashes (TxDOT 2022)

Person Type	Fatal Crashes	Fatalities	Suspected Serious Crashes	Suspected Serious Injuries	Suspected Minor Crashes	Suspected Minor Injuries
Cyclist	92	91	321	326	1120	1124
Pedestrian	825	828	1389	1442	2111	2227
Total	917	919	1710	1768	3231	3351

Fitzpatrick (2014) conducted a review of the geometric characteristics, derived from aerial photographs, of about 1,554 reportable pedestrian injuries and fatal crashes in the TxDOT Districts of Austin, Bryan, Corpus Christi, Laredo, and San Antonio in 2011. A higher proportion of injury crashes occurred on arterial roads, whereas equal proportions of fatal crashes took place on arterials and freeways. A significant majority of the crashes (78 percent, or 1,208 out of 1,554) occurred on roadways lacking on-street parking, while 67 percent (1,041 out of 1,554) occurred in areas with roadway lighting and sidewalks. These well-equipped locations generally offer safer conditions for pedestrians. However, according to the authors, the high occurrence of crashes may be correlated with the prevalence of roadways featuring lighting and sidewalks in the system.

The majority of crashes (33 percent, or 513 out of 1,554) occurred on two-lane roads without left-turn lanes. Following this, five-lane roads with a left-turn lane saw a significant number of crashes (335 out of 1,554). The median width of roadways in the study varied from 0 to 389 feet, with a significant portion of crashes taking place on roadways with medians less than 50 feet wide. The width of the crossing to refuge areas spanned from 10 to 186 feet, with the crossing distance increasing in correspondence with the total number of lanes.

In terms of posted speed limits, the largest number of crashes (49 percent, or 761 out of 1,554) occurred on roadways with posted speed limits of either 30 mph or 35 mph. However, the posted speed limit could not be identified for 12 percent of the crash locations (181 out of 1,554). The majority of crashes (60 percent, or 943 out of 1,554) took place at either intersections or driveways, with a significant number of driveway locations lacking traffic control. Furthermore, 18 percent (174 out of 943) of the intersection and driveway locations exhibited skewed geometry, meaning they did not intersect at 90 degrees. (Fitzpatrick et al., 2014a).

Table 2-5. Distribution of 2011 TxDOT-Reportable Fatal and Injury Crashes in Select TxDOT Districts by Posted Speed Limit (mph) and Total Number of Lanes.

Main: Posted Speed Limit (mph)	Main: Total Number of Lanes					Total	Percentage
	1	2	3	4	5+		
10	0	1	0	0	0	1	0%
15	0	12	1	0	0	13	1%
20	0	41	3	17	16	77	5%
25	1	13	1	1	1	17	1%
30	4	282	39	74	50	449	29%
35	1	27	21	103	160	312	20%
40	0	10	4	31	152	197	13%
45	2	15	2	9	110	138	9%
50	0	8	2	2	15	27	2%
55	0	6	1	4	16	27	2%
60	0	12	0	8	36	56	4%
65	0	4	0	10	24	38	2%
70	0	2	0	10	7	19	1%
75	0	0	0	2	0	2	0%
Not Found	6	82	10	33	50	181	12%
Total	14	515	84	304	637	1554	100%
Percentage	1%	33%	5%	20%	41%	100%	

Based on Table 2-5, most crashes occurred on roads with a posted speed limit of 30 mph, resulting in a total of 449 injuries and fatalities. The number of lanes also contributed to the number of injuries; roads with 5 lanes and above had a total of 637 injuries or fatalities, which is 41% of all crashes in the selected districts.

Table 2-6. Number of TxDOT-Reportable Pedestrian Crash Records by Person Type.

Person Type Code	Person Type Description	Injury Severity							
		Unknown	Incapacitating Injury	Non-incapacitating Injury	Possible Injury	Killed	Not Injured	Blank	Total Number of Records
1	Driver	7789	245	808	1146	28	27562	313	37891
2	Passenger/Occupant	423	86	308	496	13	12188	18	13532
3	Pedalcyclist	115	1250	4857	3698	240	357	8	10525
4	Pedestrian	252	4448	8717	7507	1981	579	14	23498
5	Driver Of Motorcycle Type Vehicle	78	192	524	294	16	201	1	1306
6	Passenger/Occupant On Motorcycle Type Vehicle	2	17	35	21		21	1	97
10	Motorized Conveyance	1	13	27	26	2	1		70
95	Not reported	1	1	2	2				6
97	Not applicable	2	1	6	1				10
98	Other (Explain In Narrative)	6	26	37	43	6	17		135
99	Unknown	96	9	27	21	1	9	3	166
99999	Internal (Charge Person Name No Match)	891							891
	Total	9656	6288	15348	13255	2287	40935	358	88127

Table 2-6 illustrates the distribution of crash records categorized by person type. It highlights that in crashes involving pedestrians, a disproportionately high number of pedestrians sustain fatal or serious injuries. In contrast, the majority of drivers or passengers involved in these incidents typically do not suffer injuries, which aligns with expectations.

In addition, acknowledge the crash characteristics of medians based on their type and width. Table 2-7 illustrates the frequency of fatal pedestrian crashes categorized by median type and median width. Notably, the majority of these incidents, accounting for 653 out of 2,232 cases, or 29 percent, occurred in areas lacking a median, followed by medians 25-100 which accounted for 27% of the pedestrian crashes, indicating that median widths <25 might lead to an increase in pedestrian crashes. Blank data indicates that the width of the lane is unknown/unavailable.

Table 2-7. Fatal Pedestrian Crashes by Median Type and Median Width (Fitzpatrick et al., 2014)

Median Type/ Median Width	0	1–6	7–12	13–18	19–24	25–50	51–100	>100	Blank	Total
No Median	653	0	0	0	0	0	0	0	0	**653**
Curbed	0	4	16	26	21	22	2	4	0	**95**
Positive Barrier	0	4	8	42	84	239	89	2	0	**468**
Unprotected	0	0	2	1	4	100	155	16	0	**278**
One-Way Pair	6	0	0	1	0	0	0	0	0	**7**
Blank	0	0	0	0	0	0	0	0	731	**731**
Total	**659**	**8**	**26**	**70**	**109**	**361**	**246**	**22**	**731**	**2232**

ANALYSIS OF PEDESTRIAN CRASHES AT MIDBLOCK LOCATIONS

Safety analysis of midblock locations requires the development of SPFs (Safety Performance Functions) and the estimation of CMFs (Crash Modification Factors). An SPF is a regression equation that predicts crash frequency at a location, typically as a function of AADT (average annual daily traffic) and segment length. In some cases, other roadway factors, such as lane width, shoulder width, horizontal curve presence and degree, or other specific conditions may be incorporated (Srinivasan et al., 2015). The Generalized Linear Model (GLM) approach with a zero-inflated negative binomial (ZINB) distribution is typically used to develop SPFs for pedestrian crashes at midblock locations. A CMF is a multiplicative factor used to estimate the expected number of crashes after implementing a specific countermeasure at a site. A CMF less than 1 indicates a reduction in crash frequency, while a CMF greater than 1 indicates an increase. CMF development methods fall into two broad categories: before-and-after studies and cross-sectional studies. Cross-sectional analysis serves as an alternative when before-and-after studies are impractical due to data limitations, unavailable treatment implementation dates, or other factors. In a cross-sectional analysis, crash frequencies for sites with and without pedestrian countermeasures (treatment and comparison sites, respectively) are compared. The difference in crash frequency is attributed to the installed countermeasures. Often, a lack of data leaves cross-sectional analysis of treatment and comparison sites as the only option to estimate CMFs for midblock pedestrian treatments. SPFs and CMFs for midblock pedestrian crashes can be developed by collecting pedestrian safety data and using statistical modeling techniques.

The CMFs are derived from the regression models (SPFs). One approach is to estimate pedestrian volumes at midblock locations, which can be done by exploring options such as direct demand models that consider variables like posted speed limit, number of bus stops, sidewalk width, and type of area (Vinayaraj et al., 2023). Once pedestrian volumes are estimated, a safety performance function (SPF) can be developed to estimate pedestrian crashes. Variables that influence pedestrian safety in SPFs include traffic volume and pedestrian crossing volume (Srinivas et al., 2022). These models can be used for proactive safety planning activities, including identifying hazardous midblock locations and implementing safety countermeasures (Linda et al., 2022). The results of these studies provide important methodological tools for understanding and improving pedestrian safety at midblock crossings (Anthony et al., 2022).

COMMON MID-BLOCK TREATMENTS

Multiple commonly practiced treatment solutions are discussed below, along with their pros and cons. The main challenge of midblock safety solutions is locating crosswalk locations and determining the demand. Pedestrians will always tend to choose shorter walking trips. Signs and barriers have little impact on changing pedestrian behaviors. 85% of the people will not go out of their way to cross at a signalized crosswalk. Additionally, signalized intersections might not always be the safest option, mainly because intersections tend to generally have more lanes and many turning movements, which could affect the driver's attention (Cox and Prudhomme, 2014). Proposed treatments include:

1. Overpasses

Despite seeming like a clear-cut solution, overpasses are often a poor allocation of limited resources. Ramps add a lot of distance to a trip and are challenging for those with mobility impairments. Additionally, with the cost of one overpass, about 30 crossing islands or medians can be built.

Figure 2-7. Typical overpass and ramp (Image: Cox, N., and Prudhomme, C. 2014)

2. Crossing Islands

Crossing islands facilitates the crossing gap decision by crossing the street in two stages and only requiring a gap in traffic from one direction at a time. The presence of islands in the streets aids in making crossings more prominent and reduces pedestrian crashes by 40%. It is advised to us whenever possible on the road and is much cheaper to implement compared to an overpass.

Figure 2-8. Mid-block island (Illustration: The Greenway Collaborative, Inc.)

3. Zigzag Crossing Islands

A modified version of crossing islands with a larger refuge area provides room for multiple users and longer vehicles such as tandems and bike trailers, which is helpful with trail crossings. Islands are usually used in conjunction with Rectangular Rapid Flash Beacons and Pedestrian Hybrid Beacons based on the crosswalk length and the traffic/pedestrian volumes.

Figure 2-9. Zigzag crossing island (left) Stop for pedestrian sign (right) (Illustration: The Greenway Collaborative, Inc.)

4. Rectangular Rapid Flash Beacon (RRFB)

High-intensity LED flashers are combined with crosswalk signs to capture the attention of motorists when the crosswalk is active. They can be activated either by a push button or passively through automatic detection. Additionally, these flashers can be synchronized with advanced warning signs featuring LED flashers. There is also a solar-powered alternative available. However, one potential concern arises when the flashers stop while pedestrians are still in the crosswalk.

Figure 2-10. Rectangular rapid flashing beacon active (Image: Texas A&M Transportation Institute 2019)

It can be used by itself on two-lane roads or in conjunction with crossing islands. on roads with three or more lanes. RRFBs have better yielding and stopping rates on one-way roadways and higher yield and stop rates when used with crossing islands. RRFBs are particularly effective at multilane crossings with speed limits of less than 40 mph. Consider the Pedestrian Hybrid Beacon (PHB) instead for roadways with higher speeds.

Numerous studies indicate that Rectangular Rapid Flashing Beacons (RRFBs) play a crucial role in enhancing pedestrian safety, particularly at uncontrolled crossings like mid-block crosswalks and roundabouts. (Zegeer et al., 2017). The Federal Highway Administration (FHWA) has granted interim approval (IA-21) for the use of Rectangular Rapid Flashing Beacons (RRFBs). State and local agencies are required to seek and obtain permission through a formal request before implementing RRFBs. Notably, IA-21 lacks specific guidance or criteria based on factors such as the number of lanes, speed, or traffic volumes.

RRFBs are strategically placed on both ends of a crosswalk. In cases where the crosswalk incorporates a pedestrian refuge island or a different type of median, the RRFB should be positioned to the right of the crosswalk and on the median rather than the left side. These beacons typically derive power from standalone solar panels, although they can also be connected to a

conventional power source. IA-21 outlines conditions for incorporating accessible pedestrian features into the RRFB assembly.
To facilitate community understanding and acceptance, outreach efforts are recommended in areas where RRFBs are not commonly used. Educating the public and law enforcement officers about the purpose and usage of RRFBs can enhance their effectiveness.
In terms of costs, RRFB installation expenses range from $4,500 to $52,000 per unit, with an estimated average cost of $22,250. This includes the entire system installation, encompassing labor and materials.

5. Pedestrian Hybrid Beacon (PHB)

Pedestrian hybrid beacons are ideal for multi-lane crossings with constrained gaps and elevated speeds; this solution can be employed both with and without crossing islands. It has demonstrated impressive results, including a 29% reduction in roadway crashes and a remarkable 69% reduction in pedestrian crashes. Furthermore, it imposes minimal delay on motorized vehicles. Recognized as an FHWA-proven safety countermeasure, it is worth noting that this is a relatively recent device, emphasizing the importance of educational efforts upon installation.

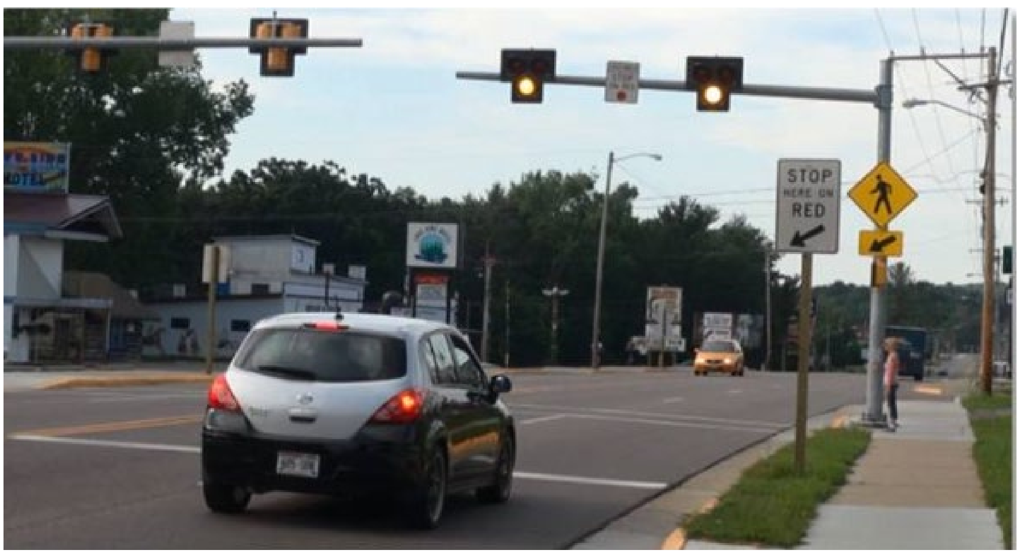


Figure 2-11. Pedestrian Hybrid Beacon (Image: Wisconsin Department of Transportation)

Pedestrian Hybrid Beacons (PHBs) serve as a potential solution for roads boasting three or more lanes and an annual average daily traffic (AADT) exceeding 9,000. These beacons are particularly recommended for midblock and intersection crossings where the speed limits on the roadway equal or surpass 40 miles per hour (mph). Adherence to the application guidelines outlined in the Manual on Uniform Traffic Control Devices, considering both existing and anticipated pedestrian volumes, is essential for proper PHB implementation.

From a cost perspective, PHBs often present a more economical alternative compared to a complete traffic signal installation. Costs vary within the range of $21,000 to $128,000, with an average per unit cost of $57,680, according to FHWA. While PHBs are primarily designed for

midblock locations, their installation at intersections is permissible. However, it is crucial to install them exclusively in conjunction with marked crosswalks and pedestrian countdown signals.
In communities where PHBs are not yet widely utilized, it is advisable to initiate outreach efforts aimed at educating the public and law enforcement officers about the purpose and usage of PHBs. The flashing sequence is explained in Figure 2-12. A common motorist mistake at PHB is not comprehending the flashing red sequence, which indicates that the motorist can cross if the pedestrians are clear (FHWA, 2018).

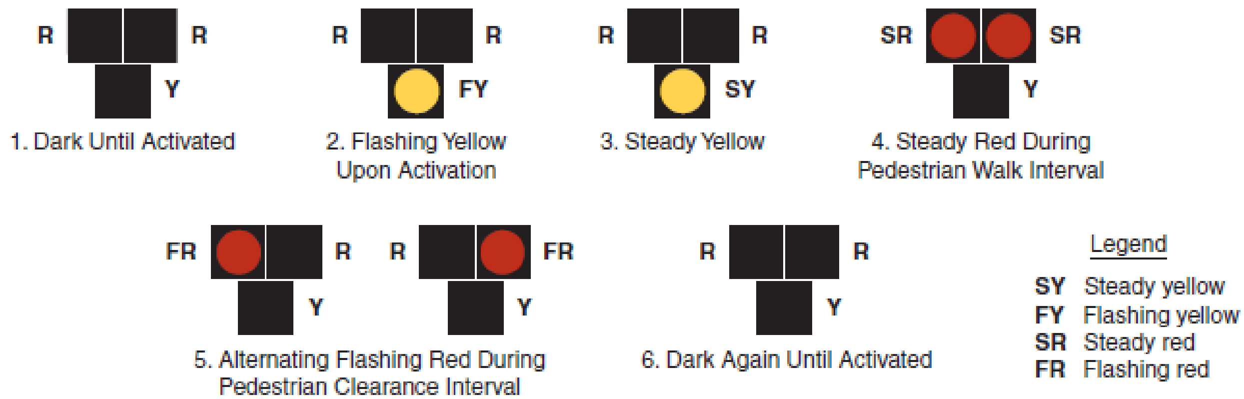


Figure 2-12. Sequence for a Pedestrian Hybrid Beacon from FHWA's Manual on Uniform Traffic Control Devices (FHWA 2009)

According to the Manual on Uniform Traffic Control Devices (MUTCD), the guidelines for the installation of RRFB and PHB can be summarized in Figures 2-13 and 2-14 for both low- and high-speed roadways, respectively.

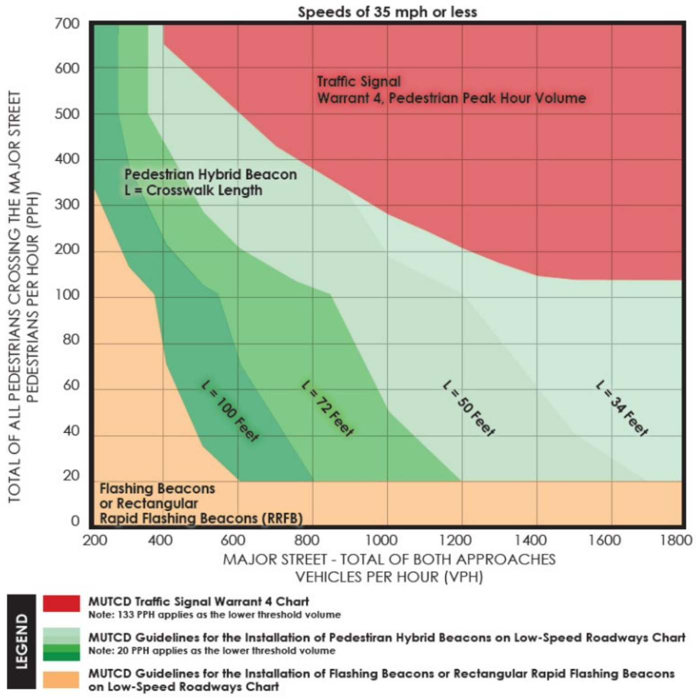


Figure 2-13. Guidelines for the Installation of Pedestrian Treatments on Low-Speed Roadways (FDOT 1999)

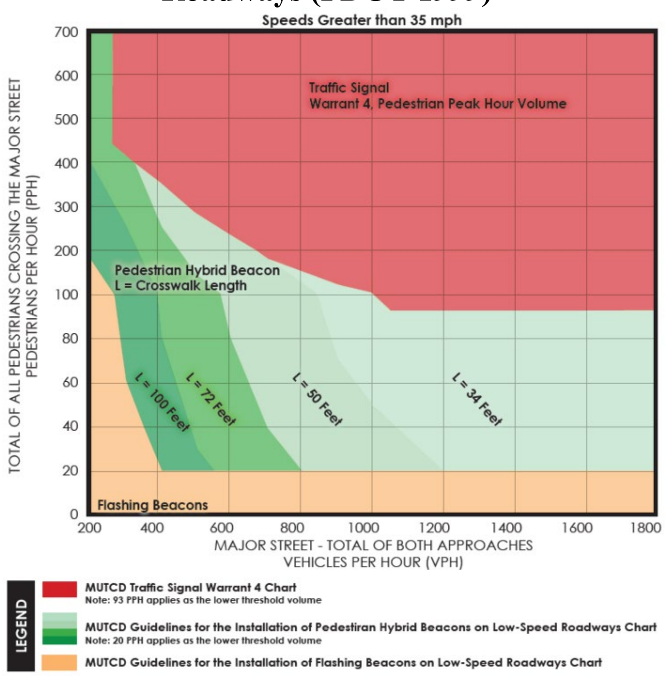


Figure 2-14. Guidelines for the Installation of Pedestrian Treatments on Highspeed Roadways (FDOT 1999)

The guidelines in Figure 2-13 and 2-14 suggest that both treatments are usually recommended on lower-volume roads over traffic signals and that PHBs can accommodate higher vehicle/pedestrian volumes than RRFBs. Research by Fitzpatrick et al. (2014) on the effectiveness of pedestrian hybrid beacons (PHBs) and rectangular rapid-flashing beacons (RRFBs) has yielded several key conclusions. The utilization of both PHBs and RRFBs leads to a notable enhancement in driver compliance with yielding and stopping to pedestrians at marked crosswalks. Therefore, these devices are recommended for consideration at crosswalks where driver compliance is currently low. Despite the observed advantages, the impact of installing a traffic control device is not universally consistent across all locations. Factors such as the specific characteristics of a given crosswalk and the demographics of the pedestrian and driver populations must be considered when deciding on the installation of PHBs or RRFBs.

The study found no significant or practical difference in driver-yielding and stopping effectiveness between RRFBs and PHBs across the range of speed limits investigated (30 to 45 mph). This suggests that these devices are suitable for installation within this speed limit range. However, it's worth noting that the study had limited data for 45-mph installations, and further research could validate the appropriateness of these devices for roads with a 45-mph speed limit. The field study considered RRFB-treated sites with total crossing distances ranging from 38 to 120 ft. The findings indicated lower compliance for RRFBs at longer crossing distances, suggesting that alternative devices may be more suitable for such scenarios.

For on-system roads where road diets aren't feasible, creating safe mid-block crossings requires a multi-pronged approach that prioritizes both traffic calming and pedestrian visibility. One effective strategy is a combination of textured surfaces and high-visibility markings, paired with automated enforcement like speed cameras or red-light cameras. This technique physically hinders speeding vehicles while ensuring clear alerts for drivers approaching the crossing. Additionally, pedestrian-activated flashing beacons paired with improved street lighting can grab drivers' attention and provide better pedestrian visibility, especially at night. Furthermore, employing rumble strips and narrowed lane markings strategically before the crossing can both audibly and visually alert drivers to slow down. Finally, consider installing raised medians or planted medians where feasible, not only to discourage mid-block crossing but also to further physically slow traffic at the designated crossing point. Remember, a successful approach hinges on a comprehensive plan that tackles both driver behavior and pedestrian safety through visible cues, physical deterrents, and automated enforcement.

Jurisdictions opting to install these devices should identify multiple locations for installation to familiarize pedestrians and drivers with their presence and expected operation. Additionally, an educational outreach effort targeting nearby populations and expected users should be implemented to enhance user understanding of these devices before their installation.
For a more accurate comparison of comparable conditions at each site, Fitzpatrick et al. (2014) specifically examined results for staged crossings. Focusing solely on staged crossings facilitated comparison with consistent numbers of crossings and a uniform crossing method. This approach helped eliminate potential variability that could arise when considering non-staged pedestrians at the crosswalk or pedestrians engaged in jaywalking. The yielding and stopping data for staged crossings is presented to provide a more refined and controlled analysis of pedestrian behavior and driver compliance towards RRFB and PHB.

When looking at yielding and stopping rates in Table 2-8, the treated sites demonstrated comparable improvements for staged crossings as observed for all crossings. Notably, GA-19 and SA-01 exhibited the most significant enhancements, with yielding and stopping rates escalating from virtually zero to nearly 90 percent for the Rectangular Rapid-Flashing Beacon (RRFB) at GA-19 and surpassing 90 percent for the Pedestrian Hybrid Beacon (PHB) at SA-01. Staged crossing yielding and stopping rates at GA-18 were akin to those at GA-19, hovering in the mid-80s. These yielding and stopping rates align with findings from other research on RRFBs and PHBs, as well as the far side and total yielding and stopping rates from FR-01. Typically, RRFBs are associated with yielding and stopping rates in the 80 percent range, while PHBs are commonly linked with yielding and stopping rates ranging from 95 to 98 percent. These consistent patterns across multiple sites reinforce the efficacy of RRFBs and PHBs in promoting improved yielding and stopping behavior.

Table 2-8. Driver Yielding and Stopping to Staged Crossings at Before-and-After Study Sites (RRFB vs PHB) (Fitzpatrick et al., 2014)

Site	Period	Staged Crossings	Yielding Vehicles			Non-Yielding Vehicles			Yielding Rates (%)		
			Near	Far	Total	Near	Far	Total	Near	Far	Total
Study treatment installed for after period: RRFB											
FR-01	Before	40	22	4	26	48	42	90	31	9	22
	After	40	58	57	115	28	11	39	67	84	75
GA-18	Before	48	25	23	48	99	24	123	20	49	28
	After	40	43	40	83	7	9	16	86	82	84
GA-19	Before	36	1	1	2	299	212	511	< 1	< 1	< 1
	After	40	80	74	154	11	9	20	88	89	89
W-04	Before	40	0	4	4	143	30	173	0	12	2
	After	60	29	45	74	94	31	125	24	59	37
Study treatment installed for after period: PHB											
SA-01	Before	39	0	0	0	137	94	231	0	0	0
	After	60	65	83	148	7	1	8	90	99	95

6. Other considerations

When placing crosswalks at a bus stop, it is crucial to take into consideration that pedestrians often opt to cross the road at a bus stop, even in the absence of a designated crosswalk. To address this behavior, it is advisable to align bus stop placements with crosswalk locations. One effective approach is to position the crosswalk behind the bus stop. This arrangement helps mitigate visibility issues for pedestrians within the crosswalk. However, it's essential to maintain an appropriate distance between the bus stop and the crosswalk to prevent confusion between those waiting for a bus and those intending to cross the road.

Figure 2-15. Bus obscuring vision of pedestrians in crosswalk (Image: Cox, N., and Prudhomme, C. 2014)

Lighting directly overhead is ineffective at adequately illuminating pedestrians in the crosswalk. To enhance visibility, it is recommended to position lighting to illuminate the side of the person facing traffic and the approach area. Offset lighting, when combined with reflective bollards and signposts, can further increase the visibility of a crossing island. Additionally, combining overhead lighting with overhead crosswalk signs is a viable approach for improved visibility and safety.

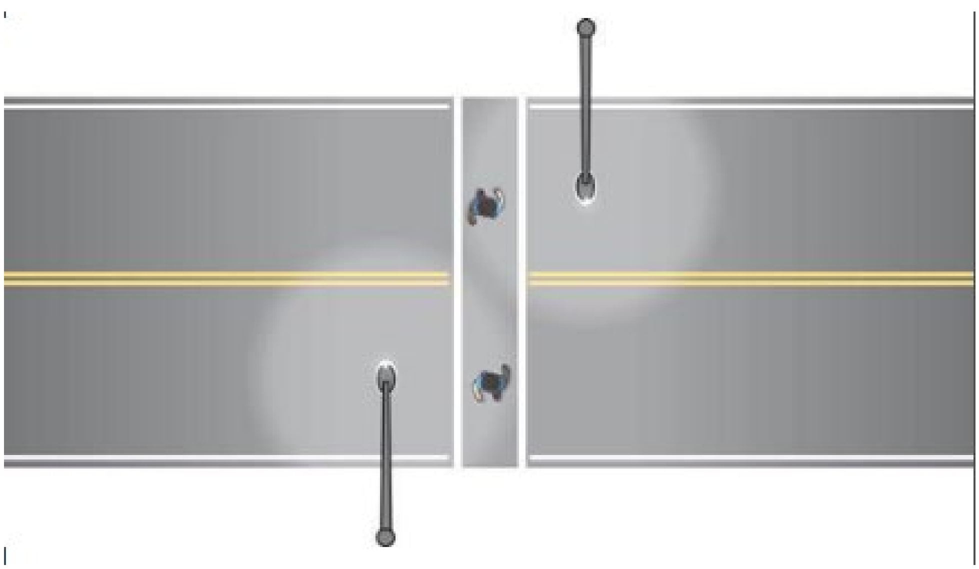


Figure 2-16. Offset Lighting (Illustration: FHWA 2009)

Figure 2-17. Overhead pedestrian sign (Illustration: The Greenway Collaborative, Inc.)

A study conducted by Sandt and Zeeger (2006) comparing crashes at intersections and blocks due to lighting conditions shows that the lighting conditions at the time of crashes exhibited similarities between the intersection and midblock crash groups, with no significant difference in mean values observed between the two. Notably, a substantial proportion of both midblock (64% to 70%) and intersection crashes (66% to 73%) occurred during daylight hours. This trend can be attributed to the inherently higher levels of exposure during the daytime compared to the nighttime. Existing empirical evidence supports the notion that low-lighting conditions contribute to an elevated risk to pedestrian safety.

The outcomes of the difference of means test suggest that the lack of adequate lighting may pose a comparable pedestrian safety concern for both types of crash groups. In essence, addressing insufficient lighting conditions emerges as a common factor influencing pedestrian safety in both intersection and midblock crash scenarios.

EDUCATIONAL AND ENFORCEMENT COUNTERMEASURES

Educational countermeasures for pedestrian crashes include campaigns, surveys, and educational measures targeted at different types of road users. The "Bulls Walk and Bike Week Campaign" in Florida aimed to improve pedestrian safety through educational efforts (Sunday et al., 2023). The Federal Highway Administration (FHWA) developed promotional materials, best practices reports, and webinars to educate transportation professionals about the benefits of using countermeasures such as medians, pedestrian refuge areas, and walkways (Yu et al., 2013). A study conducted by a local hospital network in conjunction with the police evaluated the effectiveness of an educational program aimed at improving pedestrian safety among elementary school students in Los Angeles. The study employed both an in-class educational component and an observational component. Students were observed crossing the street before and after school, one week prior to the program and one week afterward. Results indicated that scores on pedestrian safety knowledge tests, which included questions such as "How do you know a driver has seen you?" or "What should you do if you see a friend going after a ball in the street?" improved significantly following the educational program. Additionally, observational data revealed a notable increase in the proportion of students who looked both ways before crossing the street, rising from 10% before the program to 41% afterward. Schools that participated in the intervention exhibited lower rates of pedestrian injuries one year after the program's implementation (McLaughlin et al., 2019). These findings underscore the effectiveness of school-hospital-police partnerships in promoting pedestrian safety education. Moreover, a similar study comparing three different educational models targeting elementary, middle, and high school students demonstrated significant gains in pedestrian safety test scores following the interventions (Bachman et al., 2015). The FHWA also started pilot projects in Las Vegas, Miami, and San Francisco to test how well safety engineering and smart transportation systems-based solutions work. These included things like leading pedestrian intervals and pedestrian countdown signals (Bartlett et al., 2012). These projects demonstrated that carefully planned and targeted countermeasures can help improve pedestrian safety. Tamara, 2011). Overall, educational countermeasures should consider the specific needs and perceptions of pedestrians, bicyclists, and drivers and should be tailored to different types of road users (Mouyid et al., 2022). Beyond in-class education, other strategies, such as billboards and out-of-home advertising campaigns, have proven effective in raising awareness about pedestrian safety, particularly when crossing the street or at railroad crossings. For instance, Operation Lifesaver, a public awareness campaign implemented in the Minneapolis light rail system, was associated with a notable reduction in pedestrian crashes involving the rail system (OLIM_MN, 2023).

Law enforcement has been used as a preventive intervention to reduce pedestrian crashes and fatalities. In one study, an engineering/technology approach was used, and after engineering reforms, pedestrian injuries in children decreased by 37.5% (Stigson et al., 2023). Another study discussed the implementation of targeted enforcement programs aimed at reducing pedestrian traffic violations, which resulted in a reduction in targeted crashes specific to the countermeasure program focus areas (Rezapur-Shahkolai et al., 2022). The Federal Highway Administration (FHWA) also encouraged states and cities to develop pedestrian safety action plans, which included law enforcement interventions, to reduce pedestrian fatalities. The FHWA provided free technical assistance and training to focus states and cities, and the National Highway Traffic Safety Administration provided grant funding for pedestrian safety education and enforcement programs (Savolainen et al., 2023). Implementing a combined approach utilizing candidate enforcement programs alongside tailored engineering and cutting-edge technology solutions for both on-System and off-System highways can significantly improve pedestrian safety. On-System highways, characterized by higher speeds and traffic volumes, may benefit from dedicated speed enforcement campaigns and intelligent traffic management systems, while off-System roads could prioritize infrastructure improvements and pedestrian-friendly crosswalk designs. Data-driven monitoring systems can be particularly valuable in areas with limited law enforcement resources, providing continuous oversight and real-time alerts for potential safety concerns.

ACTION PLANS

Pedestrian safety action plans (PSAPs) are comprehensive strategies that aim to improve pedestrian safety and walkability in communities (Zeeger and Sandt, 2008). These plans typically outline a range of measures, including infrastructure improvements, policy changes, and public education campaigns, to create a more pedestrian-friendly environment (Tamar et al., 2011). Pedestrian action plans are important for several reasons:

- PSAPs prioritize the safety of pedestrians by addressing factors that contribute to pedestrian crashes, such as speeding, distracted driving, and a lack of pedestrian infrastructure.
- PSAPs encourage walking as a mode of transportation by improving sidewalks, crosswalks, and other pedestrian facilities, making it easier and safer for people to walk to their destinations.
- PSAPs contribute to improved public health outcomes by encouraging physical activity, reducing air pollution, and promoting a sense of community.
- PAPs can revitalize neighborhoods and commercial districts by creating a more pedestrian-friendly and vibrant environment, attracting businesses and residents.

An effective pedestrian action plan typically starts with a thorough assessment of pedestrian crash data, pedestrian behavior patterns, and existing infrastructure to identify areas of concern and prioritize interventions. A PSAP should establish clear and measurable goals for reducing pedestrian crashes and improving walkability. These goals should be translated into actionable strategies that address infrastructure, policy, education, and enforcement aspects of pedestrian safety. To be effective, a PSAP must involve a diverse range of stakeholders, including pedestrians, cyclists, motorists, businesses, community organizations, and government agencies, to ensure that the plan reflects the needs and priorities of the community (Siddiqui et al., 2014). A PSAP should outline a plan for implementation, including resource allocation, timelines, and performance measurement frameworks, to track progress and evaluate the effectiveness of the strategies. Typically, a PSAP is considered a living document that is regularly reviewed and updated based on emerging data, changing needs, and new technologies. Several cities around the world have implemented successful pedestrian action plans that have significantly improved pedestrian safety and walkability. These are published online and are typically updated every few years.

SUMMARY

Pedestrian crashes at midblock crossings, also known as non-intersection pedestrian crashes, are a major concern for road safety. These crashes occur when pedestrians are struck by vehicles while crossing the street between intersections. In the United States, midblock pedestrian crashes account for approximately 75% of all pedestrian fatalities and 65% of all pedestrian injuries. These crashes at midblock crossings demand immediate and comprehensive attention. By implementing a combination of infrastructure improvements, traffic law enforcement, public education, and community-based initiatives, we can effectively reduce the prevalence of these crashes and create safer roads for pedestrians.

Examining pedestrian crash factors, several contributors emerge, including pedestrian age, distracted driving (and the debated notion of "distracted pedestrians"), the presence or absence of pedestrian facilities, and vehicle speed. Age influences crossing speed, impacting the exposure time of pedestrians in marked or unmarked crosswalks. Older adults face an elevated risk of injury and death when struck by a vehicle, with the mortality risk for a 70-year-old equivalent to that of a 30-year-old hit by a vehicle traveling 11.8 mph faster. Distracted driving emerges as a common factor in various crash types, and speed significantly influences crash severity, with each 1 mph increase between 25 and 40 mph associated with a 3% rise in the risk of pedestrian death. At 54 mph, the death risk reaches 90%.

Drawing from existing literature, the installation of marked midblock crosswalks entails a two-step process. Firstly, potential locations undergo evaluation to determine the necessity of a midblock crosswalk. This assessment encompasses factors such as pedestrian and traffic volume, posted speed, crash history, and proximity to established crossing points. Additionally, considerations include pedestrian generators and attractors, age, ability, and roadway geometrics. All countermeasures should undergo assessment based on the balance between benefits and costs, considering both infrastructure-related expenses and any injuries and fatalities incurred. The valuation of benefits should encompass the prevention of fatalities and injuries as well as the relative demand for the proposed countermeasures.

Once a suitable location is identified, the subsequent step involves determining the type and scope of pedestrian treatments. Numerous options exist for both controlled and uncontrolled crosswalks, with state and local transportation agencies commonly referencing national guidelines.

In essence, midblock crosswalks have the potential to enhance pedestrian safety by guiding individuals to specific crossing points, thereby mitigating random crossings that heighten risks for pedestrians and motorists alike. However, the challenge lies in strategically placing marked midblock crosswalks to effectively enhance pedestrian safety. Existing national, state, and local warrants and guidelines provide helpful guidance for implementing pedestrian safety treatments at midblock locations.

Pedestrian safety action plans have been implemented by the FHWA in collaboration with state and local agencies to reduce pedestrian fatalities. The FHWA encourages the development and implementation of these plans in different states and cities with the highest numbers or rates of pedestrian fatalities. The Strategic Plan developed by the FHWA identifies research needs and recommends updates to existing technology transfer tools and resources. A guide was also created to assist state and local agencies in developing and implementing their pedestrian safety action plans, providing a framework for addressing pedestrian safety issues through street redesign and engineering countermeasures. The effectiveness of targeted low-cost countermeasures in improving pedestrian safety was demonstrated in a study conducted in three cities. However, pedestrian safety still faces barriers such as current road usage culture and underestimation of the problem, which can be overcome through advocacy, policies, and actions.

CHAPTER 3 : COMPILATION OF SAFETY AND OPERATIONAL DATA

INTRODUCTION

This chapter details the creation of a comprehensive geodatabase encompassing potential variables influencing pedestrian crashes at midblock crossings in Dallas, Houston, and San Antonio. Integrating data from 2003 to 2022, the database combines TxDOT's CRIS crash records, roadway geometry and facilities, demographic and socioeconomic data, land-use information, and detailed details on transit stops, hospitals, schools, and shopping centers. By analyzing these diverse factors, the aim is to identify key variables impacting pedestrian safety at midblock locations, ultimately informing strategies to improve pedestrian outcomes in these major cities.

Before starting this data compilation, the researchers conducted a comprehensive review of the state's Strategic Highway Safety Improvement Program (HSIP) with a specific focus on pedestrian crash statistics and related information, including emphasis areas and strategies aimed at enhancing pedestrian safety. They examined the existing pedestrian safety projects within the HSIP, examining how these projects are identified for funding and eventual implementation. In addition to the HSIP, they also analyzed pertinent data from the Strategic Highway Safety Plan (SHSP) and the State's Highway Safety Plan (HSP). Through this thorough investigation, the researchers gained insights into the current state of pedestrian safety initiatives, identified potential areas for improvement, and assessed the effectiveness of existing strategies in addressing pedestrian safety concerns on state roadways.

PEDESTRIAN CRASH DATA

The analysis of pedestrian crashes encompasses both on-system and off-system roadways in the three cities from 2010 to 2022, utilizing descriptive statistics. The TxDOT CRIS system plays a crucial role in crash data analysis for various studies. It gathers detailed information from police reports across all Texas counties and municipalities, offering a comprehensive picture of crash events. CRIS data is organized into three main categories: Crash file, Person file, Primary Person File, and Unit file. Other files, such as the Charge file, may be used as needed.

However, it's important to acknowledge some limitations. Missing data is common, and not all crashes are reported, particularly those with minor damage. Additionally, crucial factors like pedestrian homelessness or residence may be absent, especially for unidentified individuals. Furthermore, police records may not always capture every aspect of the incident.

Despite these limitations, CRIS remains a valuable resource for crash analysis. Its large sample size allows for the creation of useful prediction models, even with the existing gaps and inconsistencies. Therefore, while acknowledging its limitations, CRIS provides valuable information for understanding and predicting crash patterns.

ROADWAY CHARACTERISTICS DATA

To analyze the impact of roadway characteristics, researchers extracted detailed data from the TxDOT Roadway Inventory database, including annual average daily traffic (AADT), number of lanes, median type and width, surface width, and presence of signalized intersections. Additional data was obtained from websites maintained by the three cities. Both on-system roads and off-system roads not under TxDOT's purview are included in the database. To provide granular detail, expressway main lanes and frontage roads are each represented as separate road segments. This means that a road segment with both left and right frontage roads would typically be reflected as four distinct road segments in the data, one for each direction of travel. Importantly, the database distinguishes between centerline miles, which measure the mileage of a segment regardless of lane count, and lane miles, which encompass the mileage of all lanes within a segment. While the road inventory has detailed data on design, traffic (VMT, AADT, truck%), lanes, speed limits, and shoulder/median details, it lacks geometric information. To bridge this gap, horizontal curve data (GEO-HINI) will be spatially linked with the inventory.

CENSUS DATA

Population and job data, crucial for understanding pedestrian activity, were acquired from the US Census and Census and Longitudinal Employer-Household Dynamics (LEHD) datasets, respectively. The census data were primarily extracted from the 2020 United States Census Bureau, with selected fields extracted from the 2015-2019 American Community Survey (ACS). The Census Block Group is the smallest geographical unit for which the Bureau publishes sample data. Utilizing ArcGIS's spatial join function, each road segment was paired with the closest census tract centroid, normalizing the data according to the block group's area. The most relevant variables are total population, education, housing, and economic characteristics. Utilizing ArcGIS's spatial join function, each road segment will be paired with the closest census tract centroid, normalizing data by the block group's area.

PEDESTRIAN VOLUMES

To estimate pedestrian exposure, walk-miles traveled (WMT) was employed as a crucial metric. Leveraging the 2017 National Household Travel Survey (NHTS) Texas add-on data and subsequent reports provides a robust foundation for pedestrian VMTs. This household travel survey captured comprehensive trip information for each participant, including origins, destinations, and distances derived from Google Maps API route geometry. Individual WMT for each travel day is estimated, subsequently informing the development of an ordinary least-squares regression model. This model accounted for variables impacting WMT, such as respondent demographics, socioeconomic factors, and built environment characteristics (e.g., population density, job density). By meticulously weaving together these diverse datasets and analytical tools, a richly layered understanding of the factors influencing pedestrian crashes along Texas roads will be established.

With the advent of smartphone technology, researchers have begun to use innovative means to extract pedestrian exposure data. The most detailed source of pedestrian volumes and trips is Replica, a data provider that keeps track of walking trips and provides information on pedestrian activities. Replica goes beyond traditional pedestrian counts by blending anonymized phone location data, weather, and other factors into machine learning models. This generates real-time, granular estimates of pedestrian traffic, not just overall volumes but for specific times, days, and even individual sidewalks. Replica prioritizes privacy through data aggregation and anonymization while constantly refining its models against reliable sources to ensure accuracy.

OTHER DATA RELATED TO PEDESTRIAN INFRASTRUCTURE

Data on pedestrian infrastructure, including the presence of a shared path, sidewalk barrier, sidewalk width, etc., were obtained from multiple sources. To better understand the spatial context of pedestrian crashes in Texas, the CRIS data underwent a comprehensive enrichment process. This involved merging it with diverse datasets representing land use, demographics, economic activity, environmental factors, and infrastructure features. ArcGIS spatial analysis tools efficiently calculated the number of transit stops within each road segment's vicinity and measured the Euclidean distances to the nearest schools and hospitals. Examples of additional datasets are shown in Table 3-1 below:

Table 3-1. A partial list of complementary data sources and the variables provided

SHAPE FILE NAME	DESCRIPTION	REFERENCE	LINK
ROAD INVENTORY 2022	Roadway attributes of certain roadbeds that were routed using linear referencing tools to the TxDOT Roadway Linework	TxDOT	CLICK HERE
TxDOT_AADT_Annuals	Point layer of traffic stations for TxDOT-owned and maintained roadways. The traffic stations at these locations collect Average Annual Daily Traffic (AADT). Toll road traffic counts may be shown for context purposes and may not represent on-system traffic	TxDOT	CLICK HERE
TxDOT_Median	Polyline layer of median type on the Texas roadway network	TxDOT	CLICK HERE
TxDOT_Speed_Limits	Max speed limit values in miles per hour.	TxDOT	CLICK HERE
US Hospitals	Hospitals derived from various sources for the Homeland Infrastructure Foundation-Level Data (HIFLD) database	HIFLD	CLICK HERE
Tx HOTELS	Hotels	OpenStreetMap	CLICK HERE
BEXAR-landparcels_48029_lp	Land parcels are boundaries that have associated information such as property owner, land use, value, and location attributes. In Texas, this property information is recorded and maintained at the county level by the local appraisal districts	TNRIS	CLICK HERE
DALLAS-landparcels_48113_lp	Land parcels are boundaries that have associated information such as property owner, land use, value, and location attributes. In Texas, this property information is recorded and maintained at the county level by the local appraisal districts	TNRIS	CLICK HERE

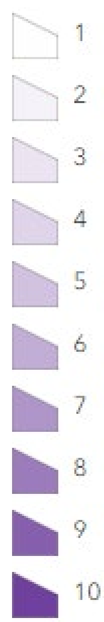
HARRIS-landparcels_48201_lp	Land parcels are boundaries that have associated information such as property owner, land use, value, and location attributes. In Texas, this property information is recorded and maintained at the county level by the local appraisal districts	TNRIS	CLICK HERE
Bexar_Current_Land_Use_(2017)	Vector dataset consists of existing land use and impervious cover data for Bexar County, Texas.	San Antonio River Authority	CLICK HERE
Dallas Land Use Shapefile_2	Parcel and appraisal data from the county appraisal districts for current certified roll year (2016)	City of Dallas	CLICK HERE
Network Link Volumes_Spring_2023_Bexar	Network link volumes and distance traveled by pedestrians per link for Bexar County	Replica	CLICK HERE
Network Link Volumes_Spring_2023_Dallas	Network link volumes and distance traveled by pedestrians per link for Dallas County	Replica	CLICK HERE
Network Link Volumes_Spring_2023_Harris	Network link volumes and distance traveled by pedestrians per link for Harris County	Replica	CLICK HERE
Tx RESTAURANTS	Restaurants in Texas	OpenStreetMap	CLICK HERE
Tx Schools_2022_to_2023	School campus data for the school year 2022 -2023 taken from the AskTED directory	Texas Education Agency	CLICK HERE
Tx RETAIL SHOPS	General store, department store, mall, supermarket, kiosk	OpenStreetMap	CLICK HERE
US CENSUS 2010-2021	Heat maps for all worker locations in Texas from 2010 to 2021	Census.gov	CLICK HERE

DART (DALLAS)	DART bus stops, train stops, and train routes in Dallas	Dallas Enterprise GIS	CLICK HERE
METRO (HOUSTON)	METRO bus stops, train stops and train routes in Houston	COHGIS DATA HUB	CLICK HERE
VIA (SAN ANTIONIO)	VIA bus stops in San Antonio	VIA Transit Open Data	CLICK HERE
COH LAND USE	Land use map shapefile by City of Houston staff based on appraisal district land use codes	COHGIS Open Data	CLICK HERE

DATA OVERVIEW

Houston, San Antonio, and Dallas witnessed a concerning rise in pedestrian fatalities over the past two decades. Despite only accounting for 1.44% of crashes, pedestrians represented a startling 30% of all traffic fatalities (3,451 deaths) between 2003 and 2022. This number climbed at a significantly faster rate (88%) compared to overall fatalities, population growth, and vehicle miles traveled. While Americans are walking slightly more, it's insufficient to explain this surge. The three largest Texas cities, Houston, San Antonio, and Dallas, bore a disproportionate burden, accounting for 28% of pedestrian deaths despite housing only 19.3% of the population.

Pedestrian crashes exhibit significantly higher levels of injury severity compared to other motor vehicle crashes. This vulnerability is amplified at night, with 80% of fatalities occurring in darkness or twilight. The highest risk period falls between 9 PM and 10 PM, with early mornings (5 AM to 7 AM) also posing an elevated threat. Reasons for this elevated risk may include reduced traffic leading to disregard for safety rules, pedestrian activities like jogging coinciding with low visibility, and potential alcohol or drug involvement during nighttime hours.



Crash Density Legend (Qualitative, with higher values indicating greater crash density)

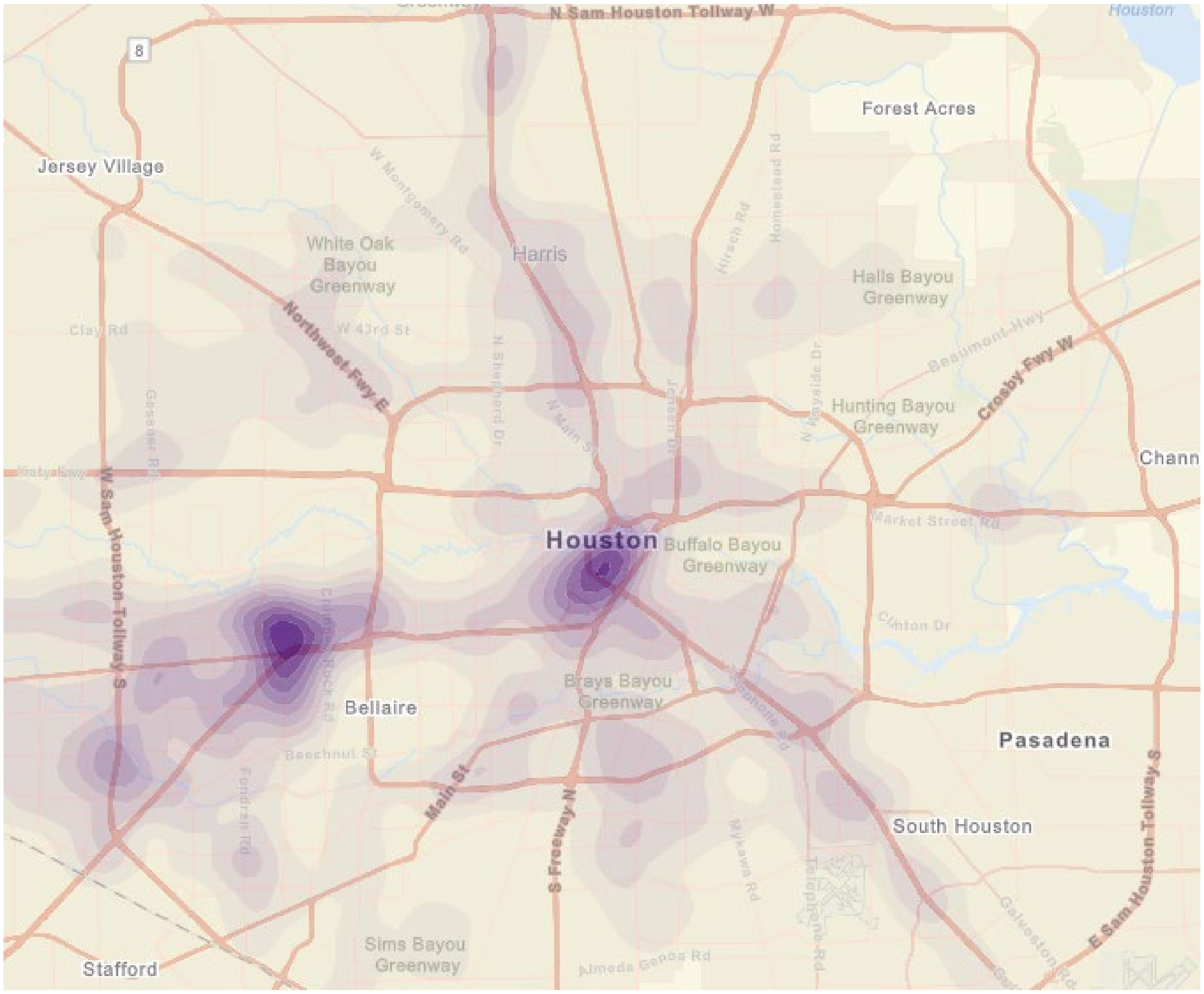


Figure 3-1. Density of Pedestrian-Involved Midblock Crashes, Houston, 2003-2022

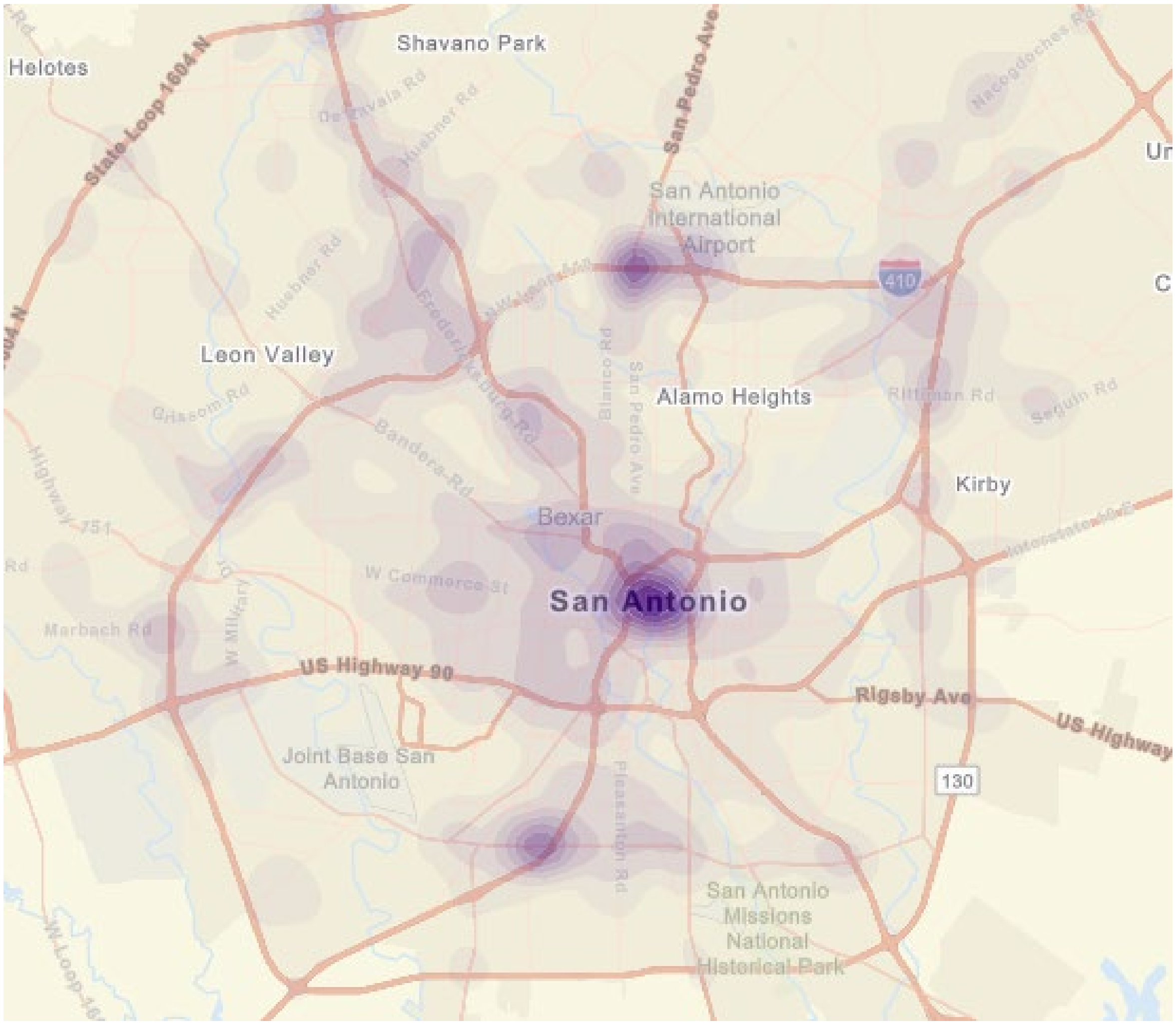


Figure 3-2. Density of Pedestrian-Involved Midblock Crashes, San Antonio, 2003-2022

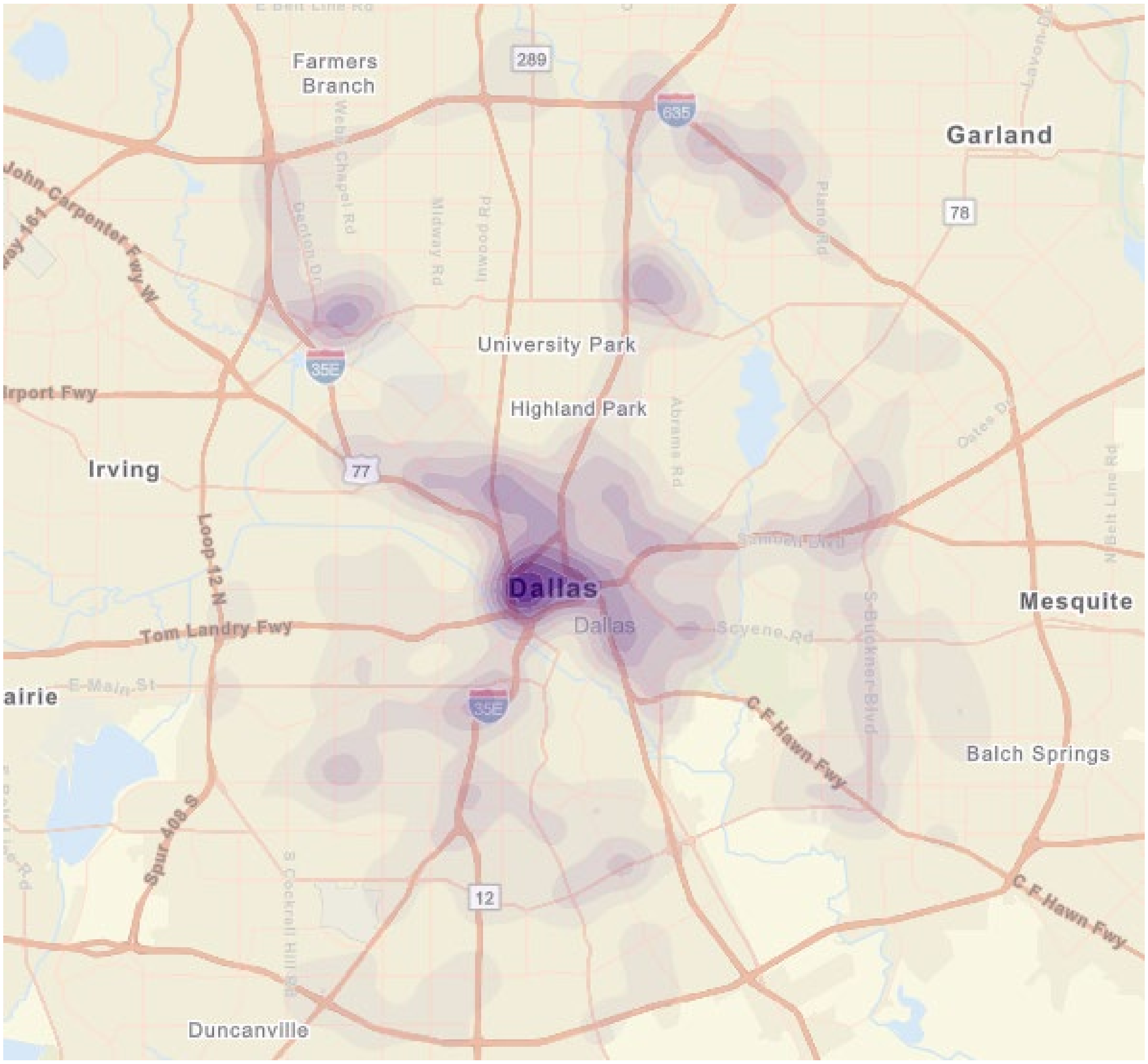
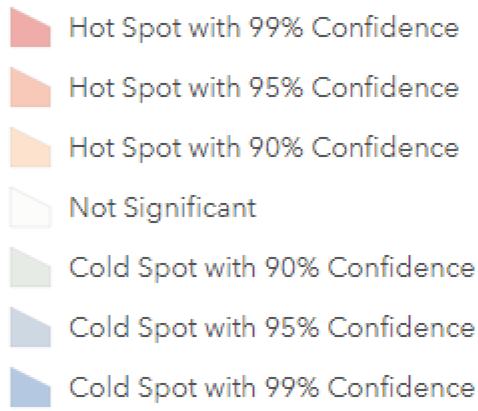


Figure 3-3. Density of Pedestrian-Involved Midblock Crashes, Dallas, 2003-2022



Legend for Hot Spots for Midblock Pedestrian-Involved Crashes

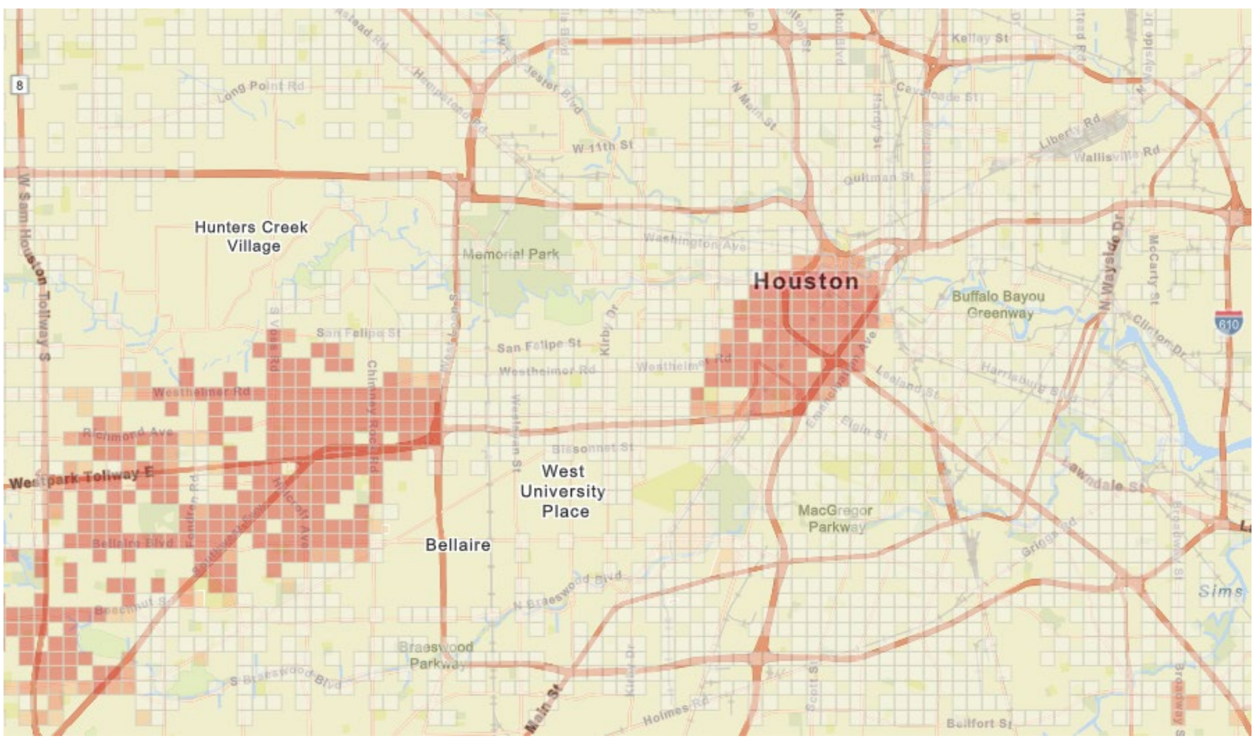


Figure 3-4. Hot Spots for Midblock Pedestrian-Involved Crashes, Houston, 2003-2022

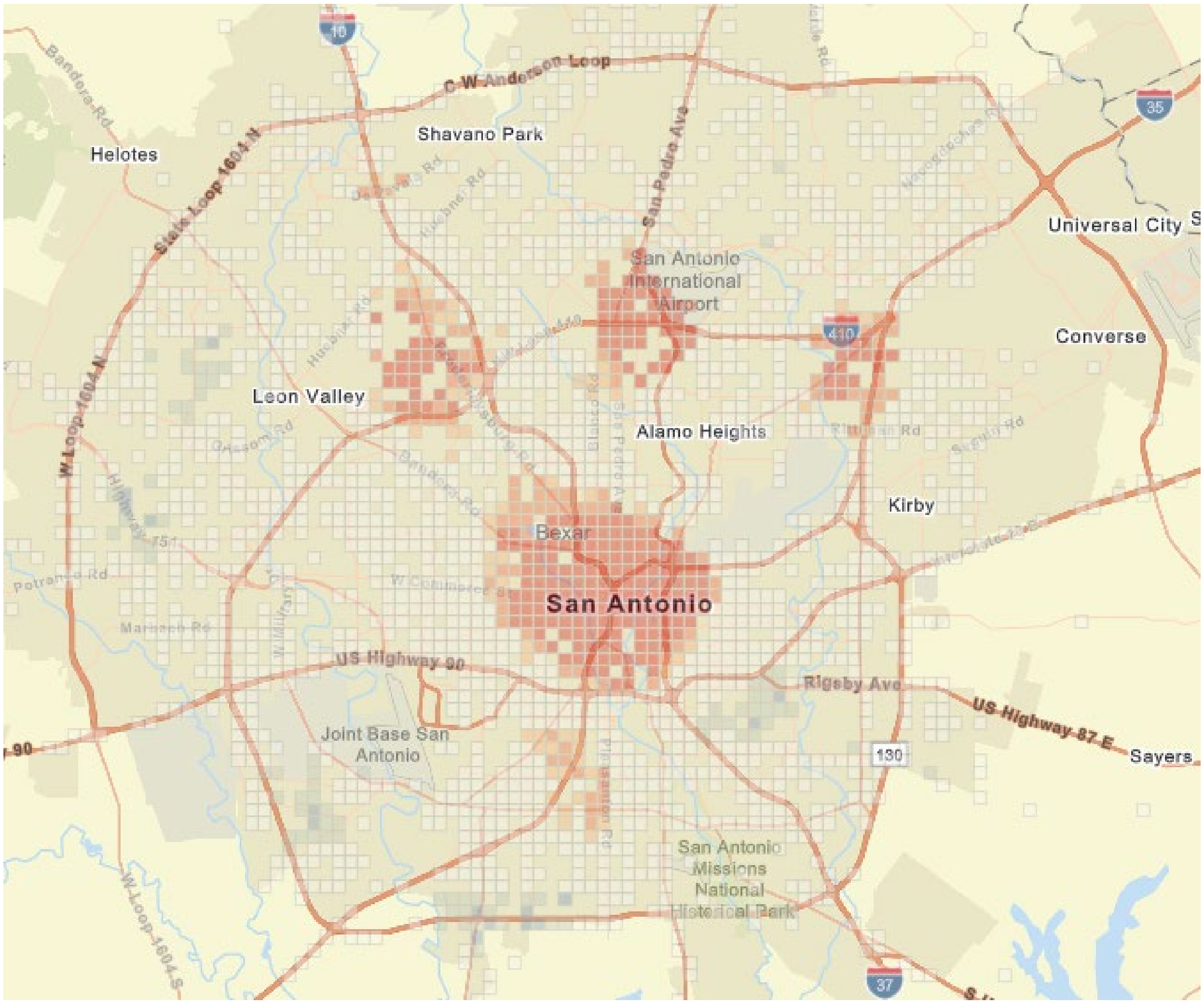


Figure 3-5. Hot Spots for Midblock Pedestrian-Involved Crashes, San Antonio, 2003-2022

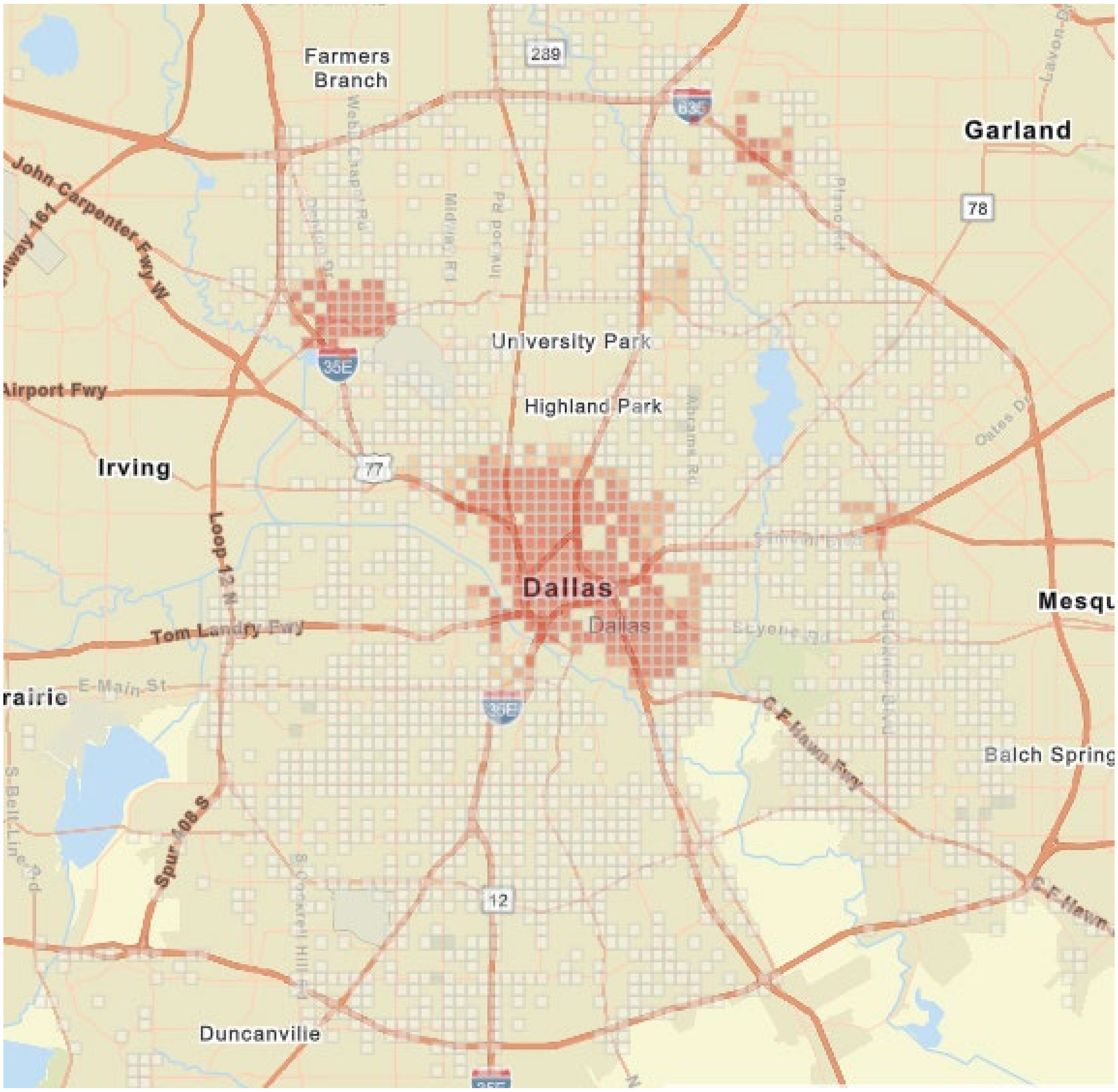


Figure 3-6. Hot Spots for Midblock Pedestrian-Involved Crashes, Dallas, 2003-2022

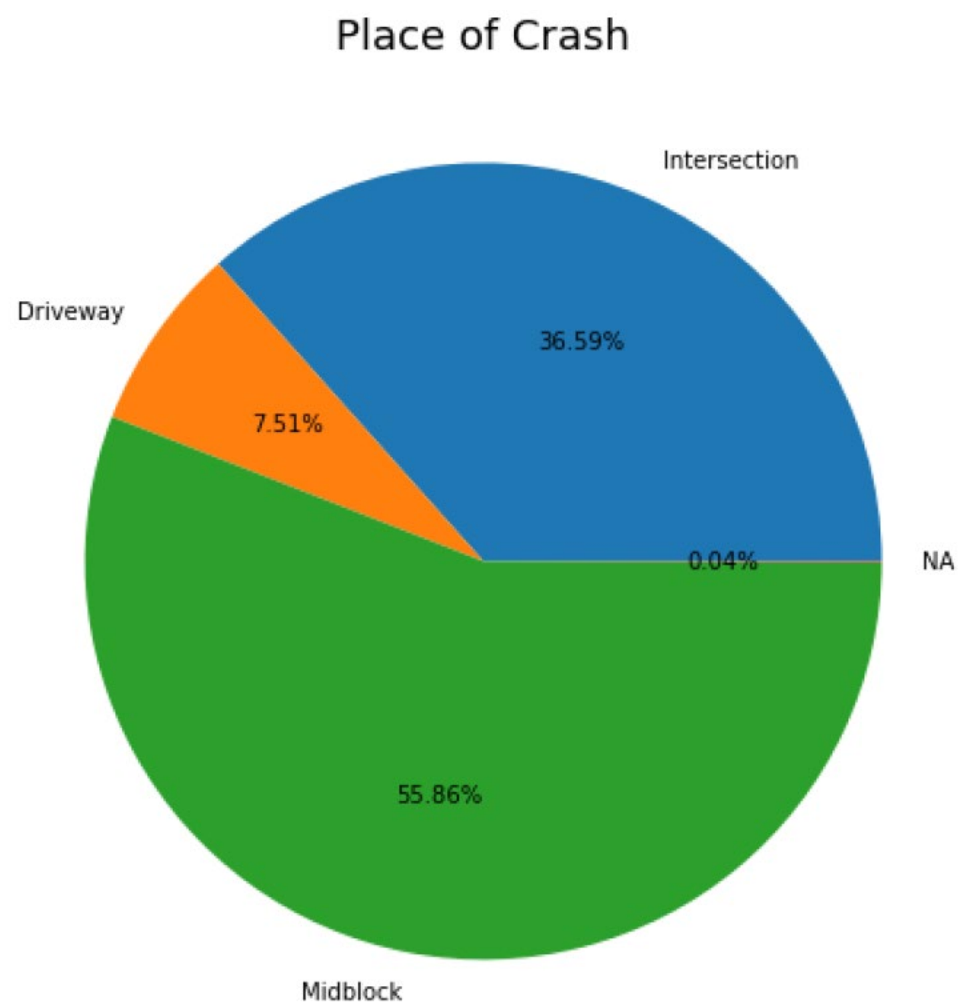


Figure 3-7. Crashes in the three cities by location (all crashes)

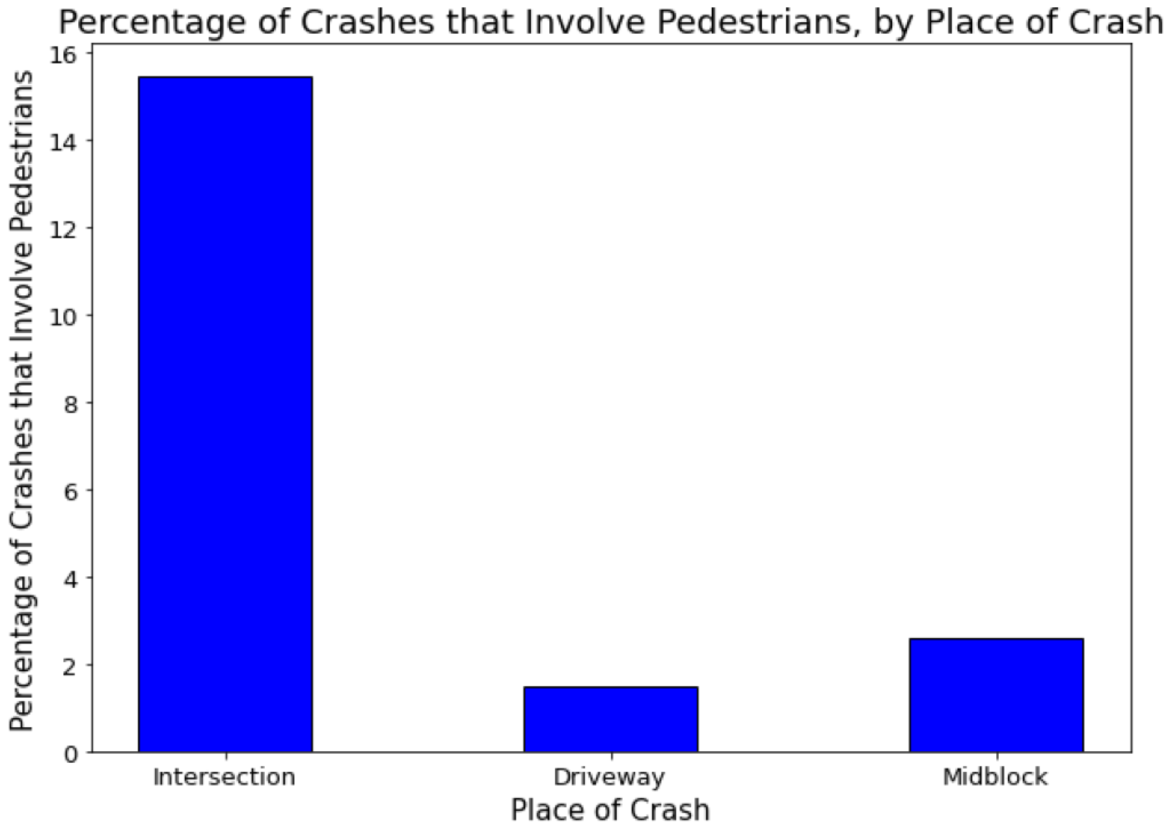


Figure 3-8. Pedestrian crashes in the three cities by location (percentage of all crashes)

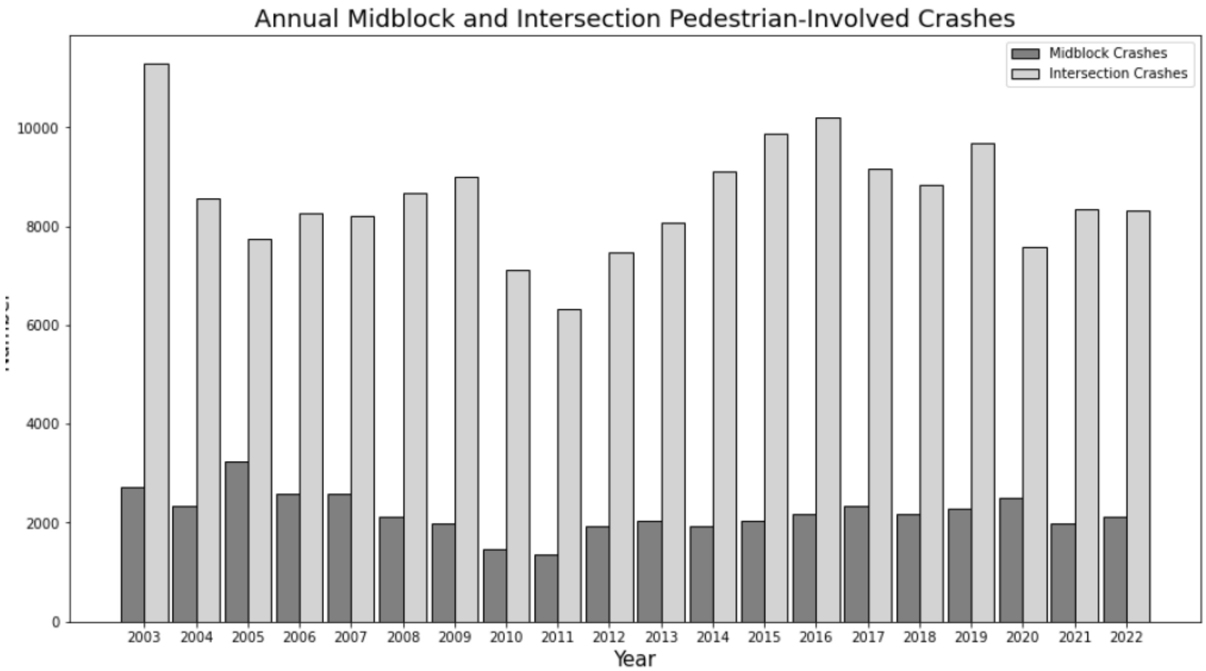


Figure 3-9. Annual pedestrian crashes in the three cities by location

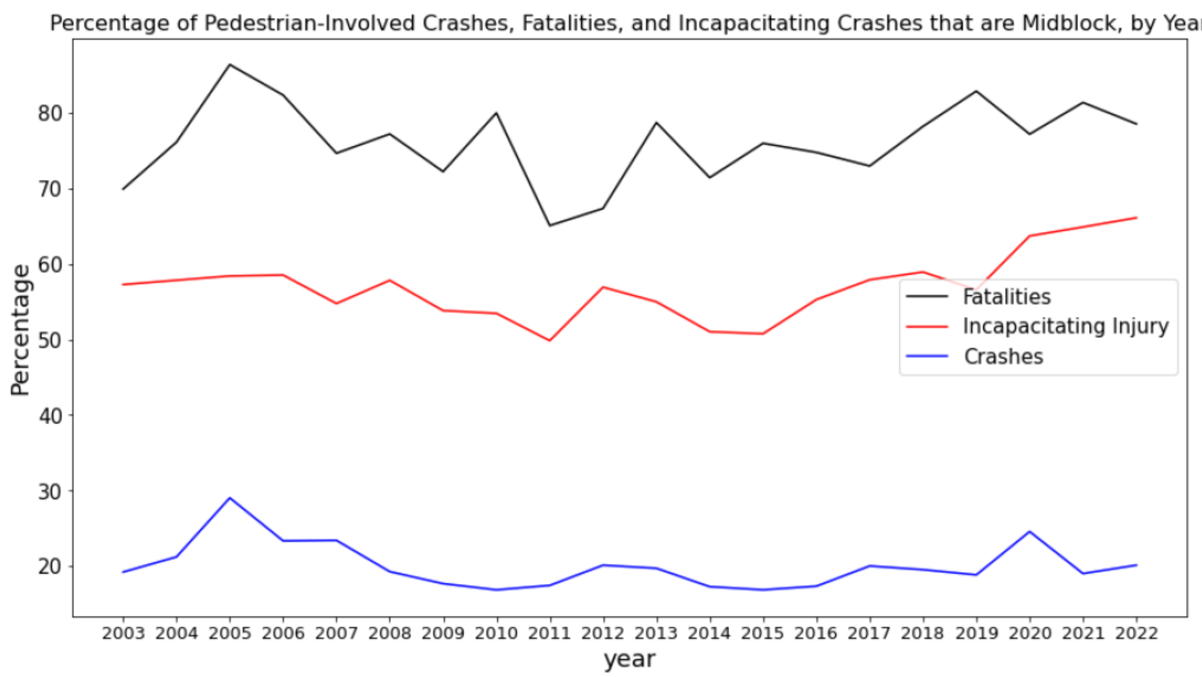


Figure 3-10. Annual percentage of midblock pedestrian crashes by severity

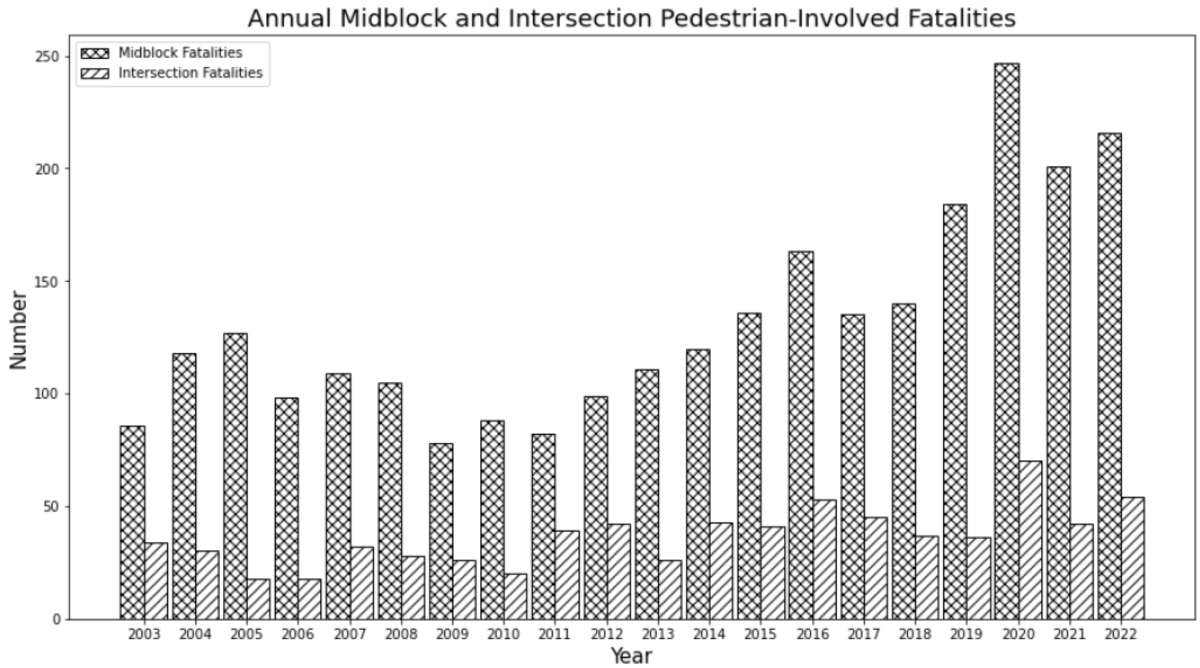


Figure 3-11. Annual pedestrian fatalities in the three cities by location

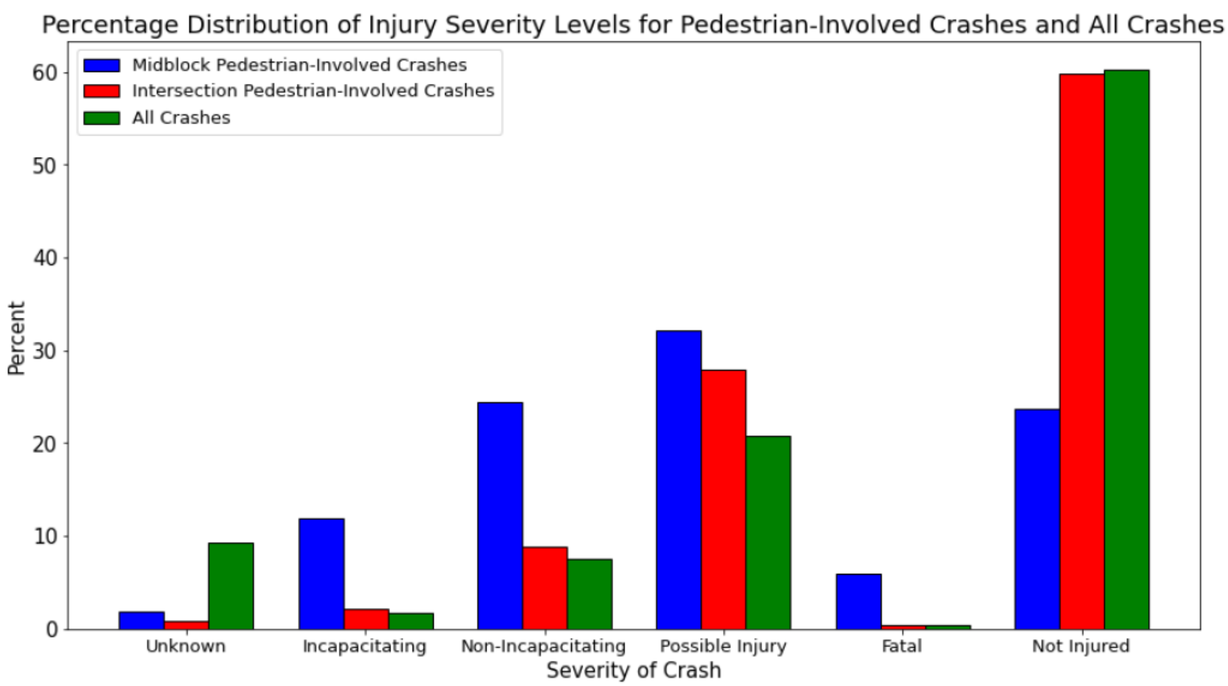


Figure 3-12. Severity distribution of pedestrian and all crashes

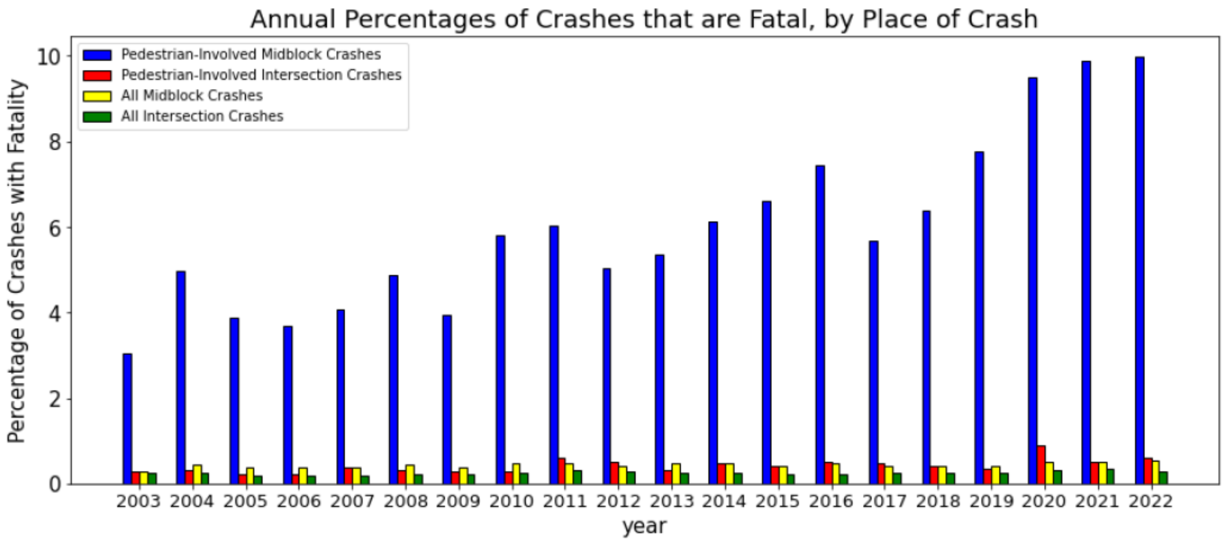


Figure 3-13. Annual percentage of fatal pedestrian and all crashes in the three cities by location

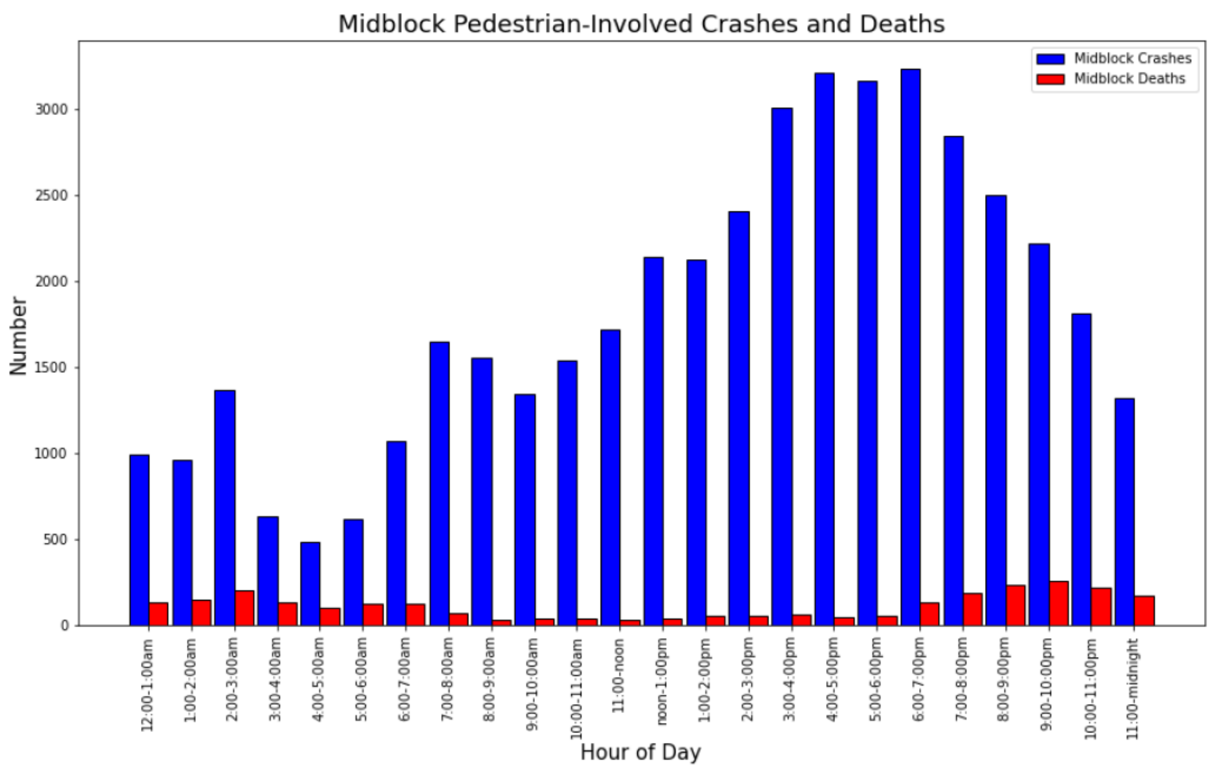


Figure 3-14. Midblock pedestrian crashes and fatalities by time of the day

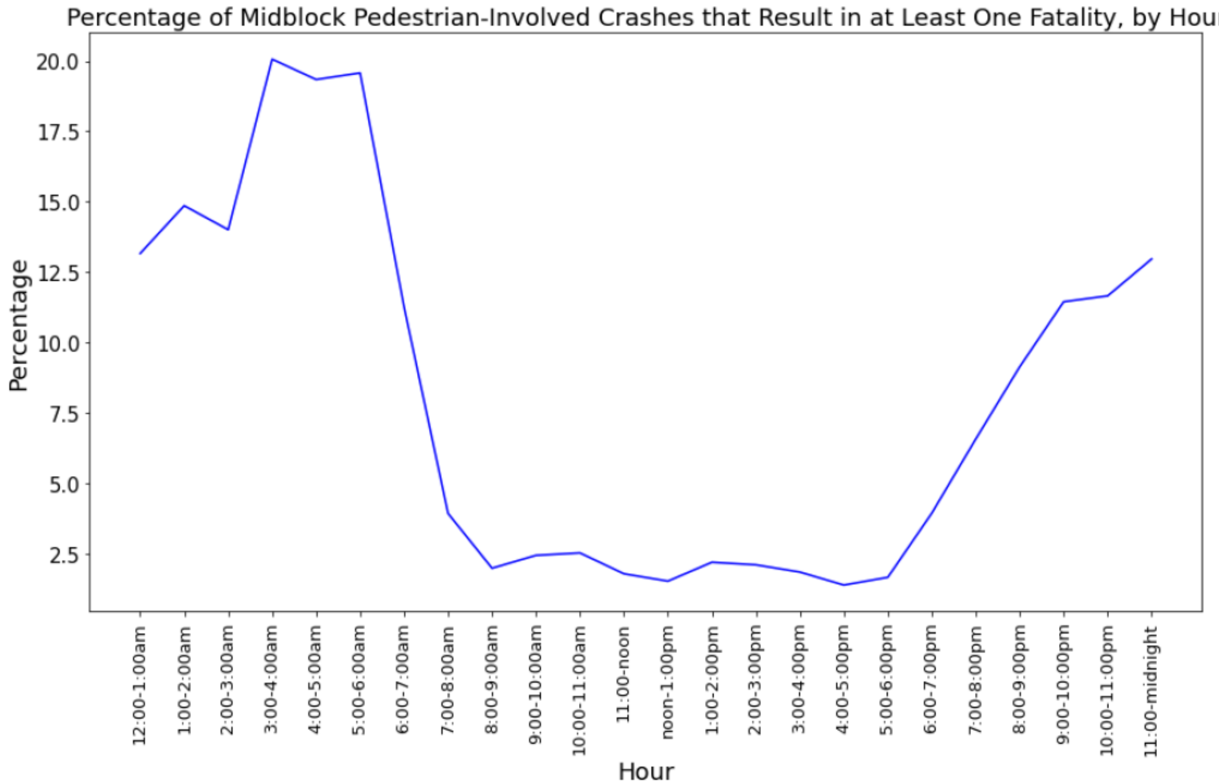


Figure 3-15. Percentage of midblock pedestrian fatalities by time of the day

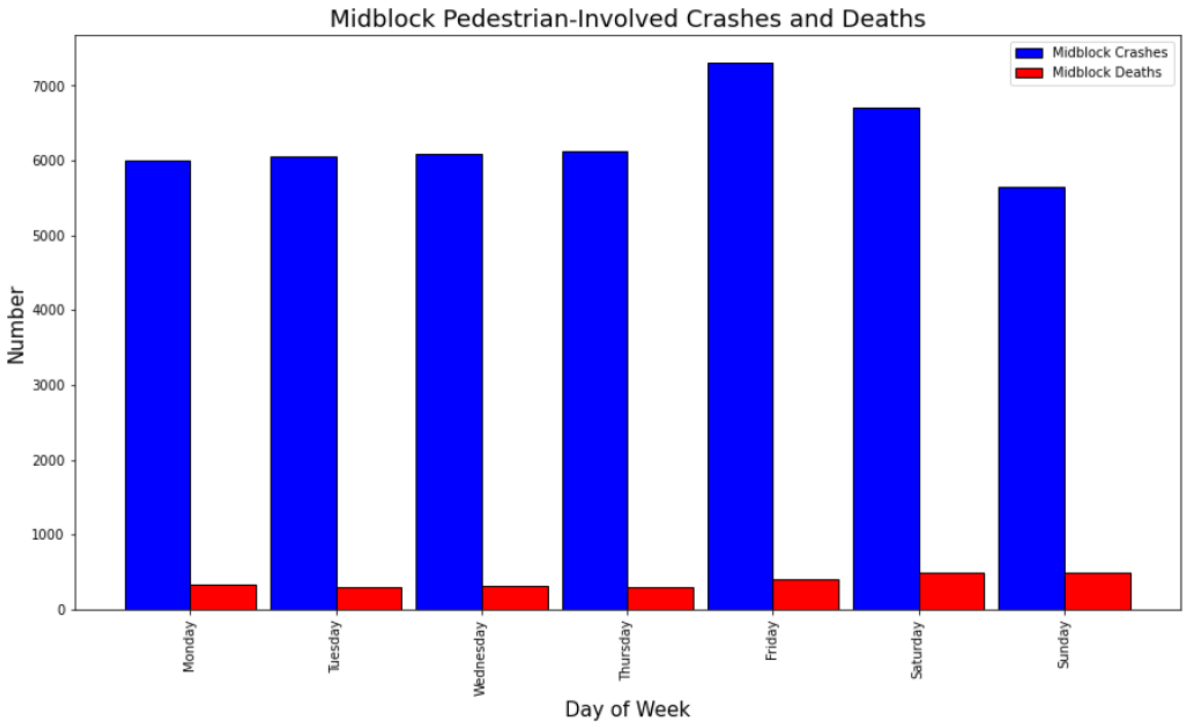


Figure 3-16. Midblock pedestrian crashes and fatalities by day of the week

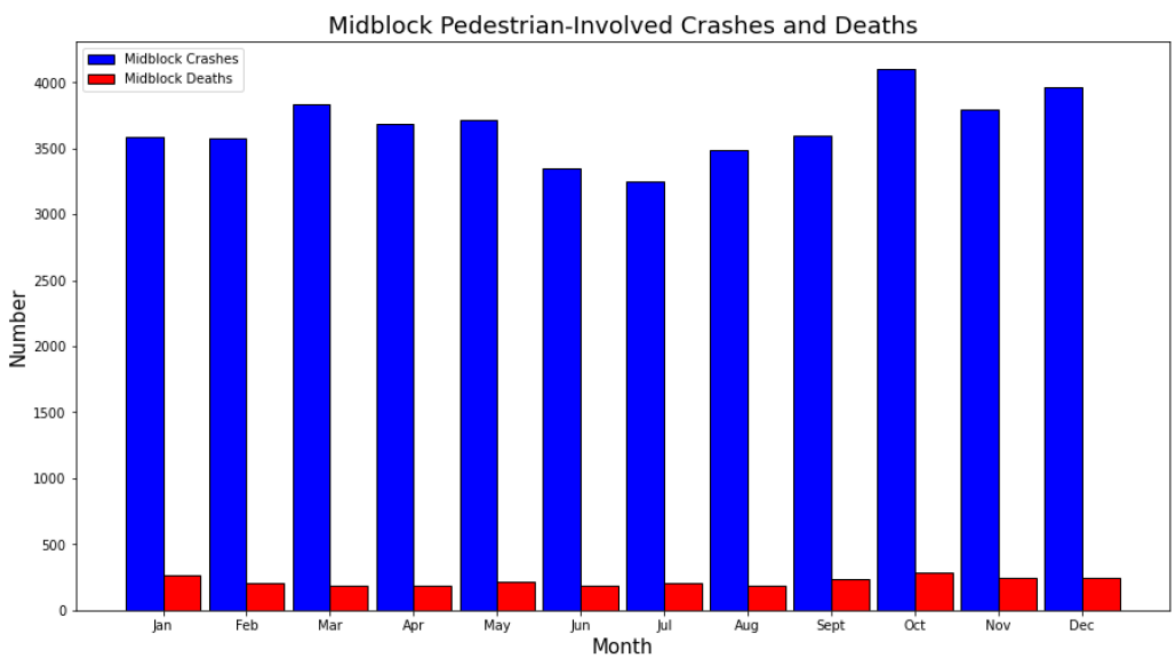


Figure 3-17. Midblock pedestrian crashes and fatalities by month

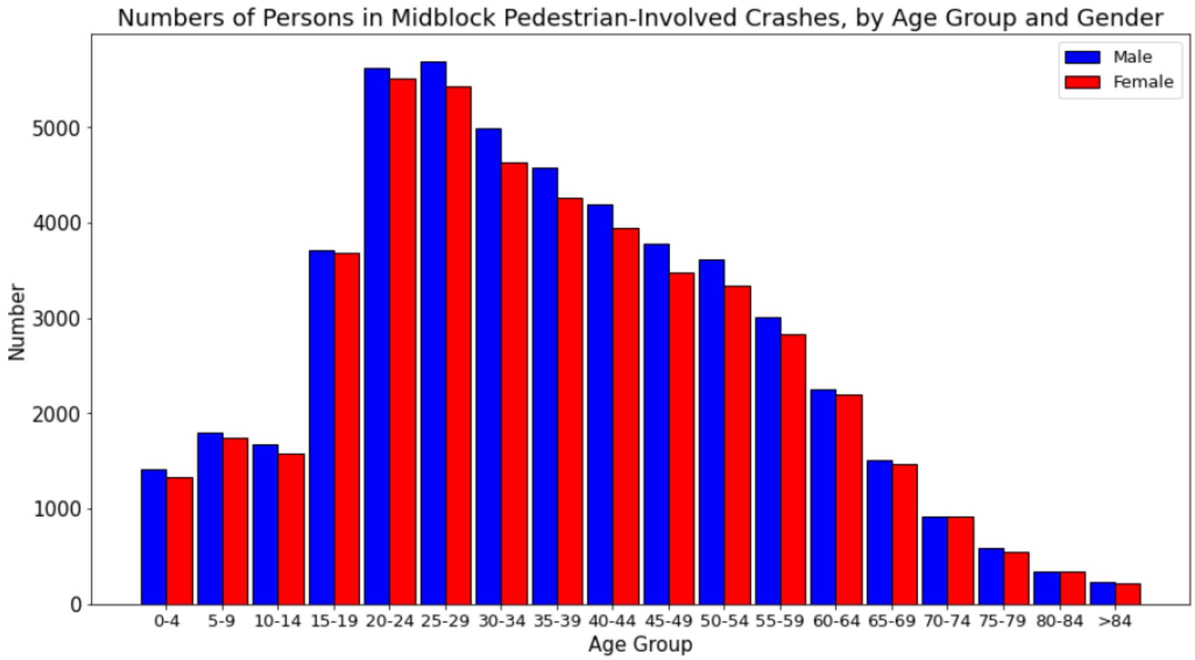


Figure 3-18. Pedestrians involved in midblock crashes by age and gender

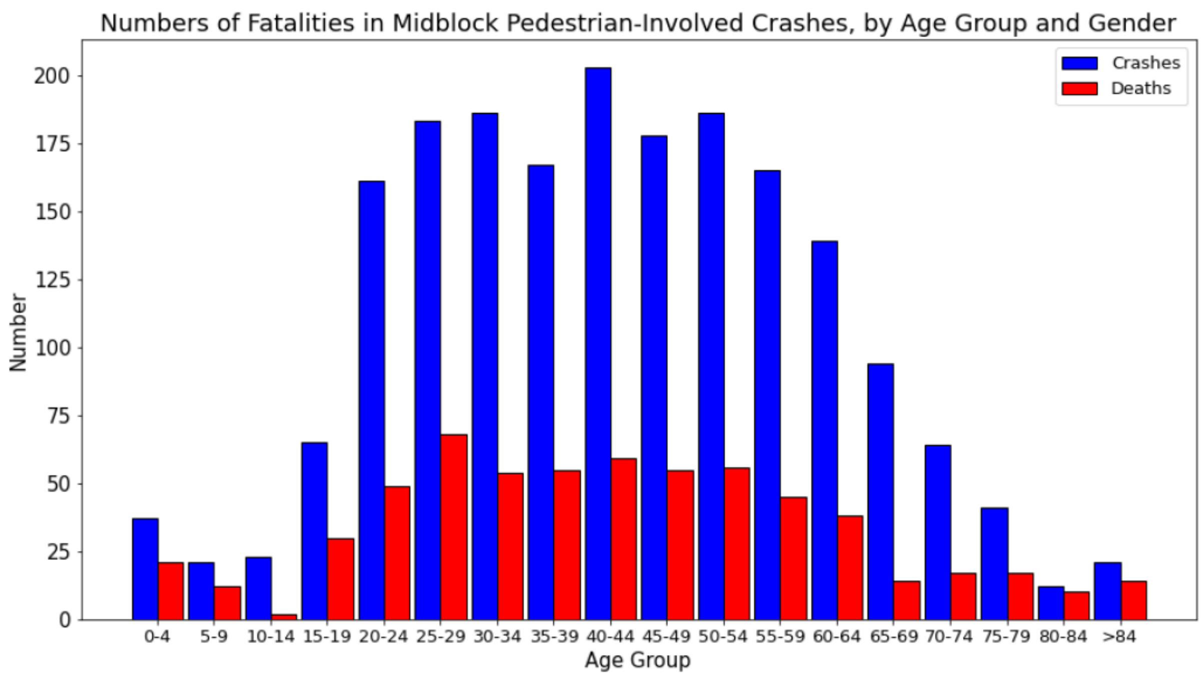


Figure 3-19. Pedestrian fatalities in midblock crashes by age and gender

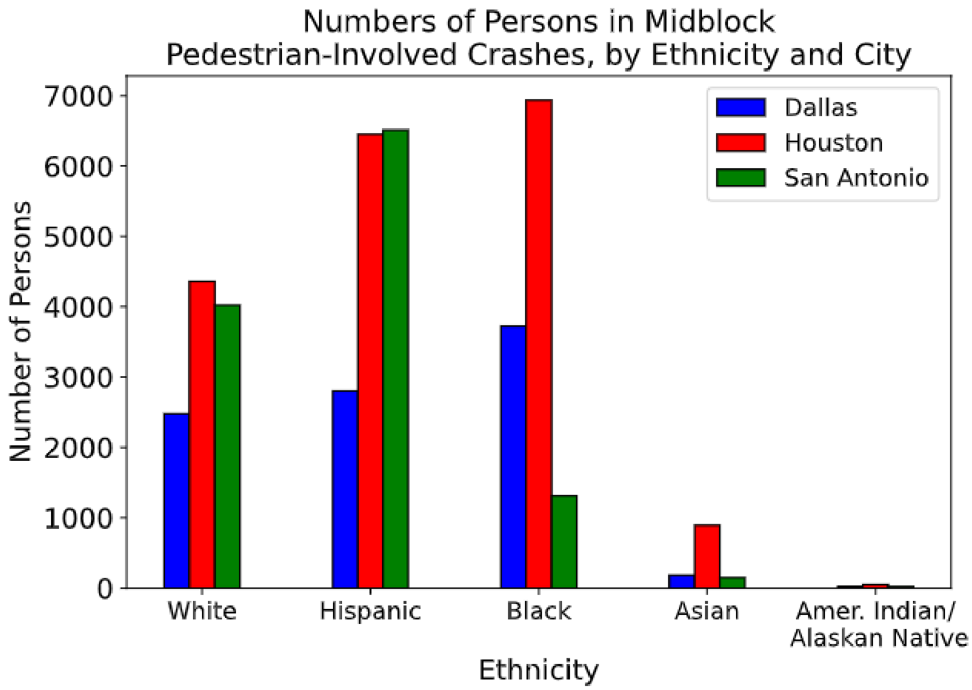


Figure 3-20. Pedestrian involved in midblock crashes by Ethnicity

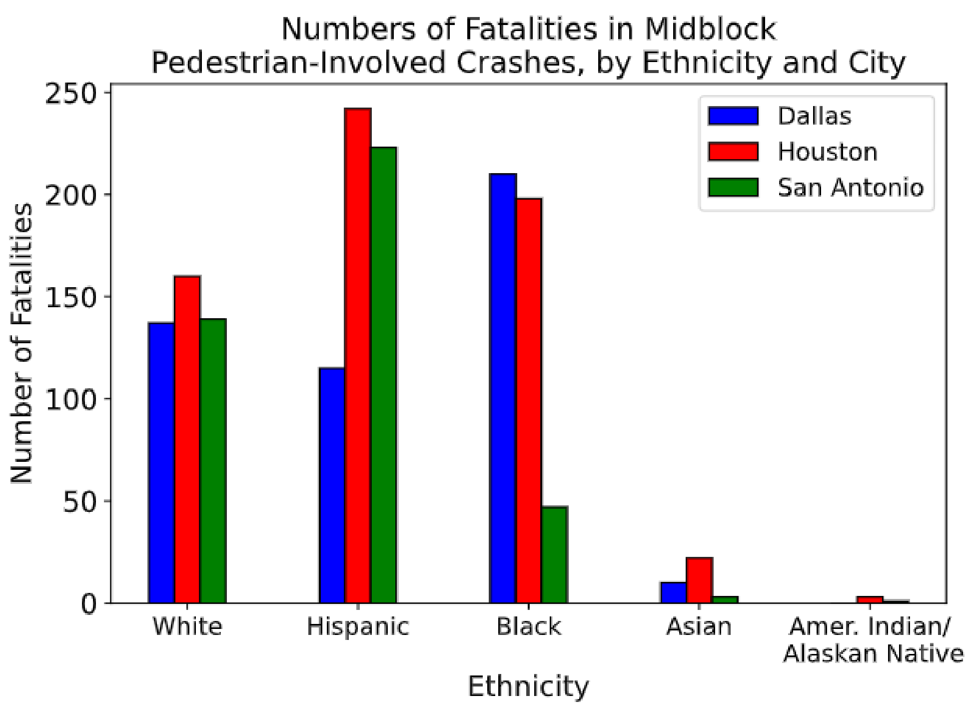


Figure 3-21. Pedestrian involved in midblock fatalities by ethnicity

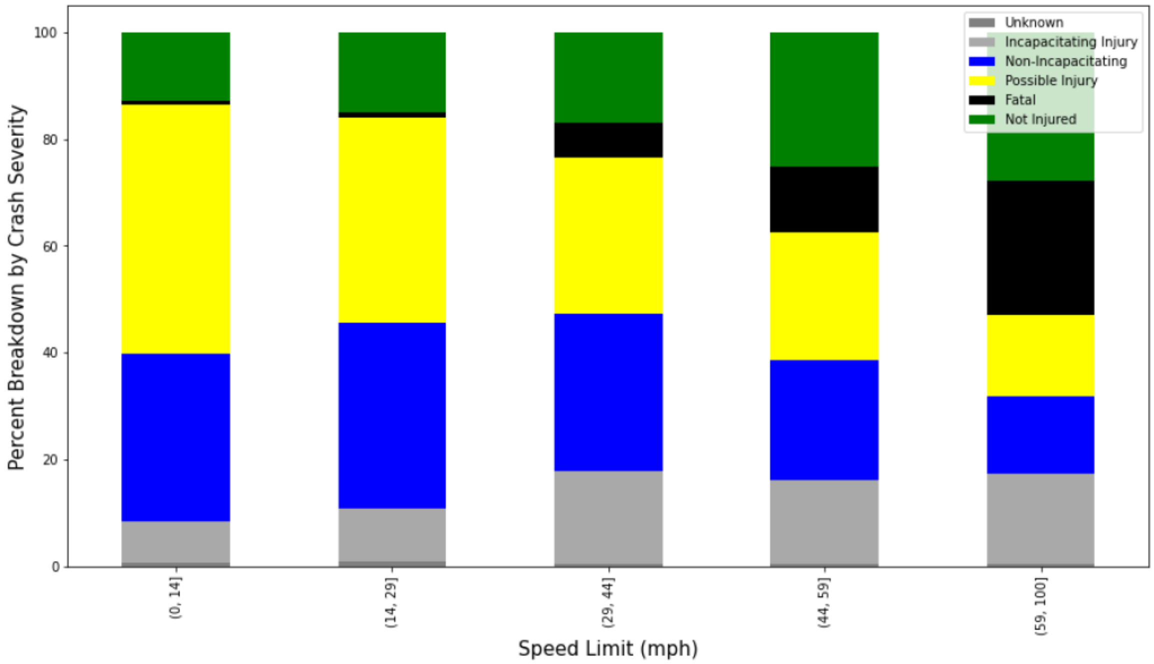


Figure 3-22. Midblock pedestrian crash severity by roadway speed limit

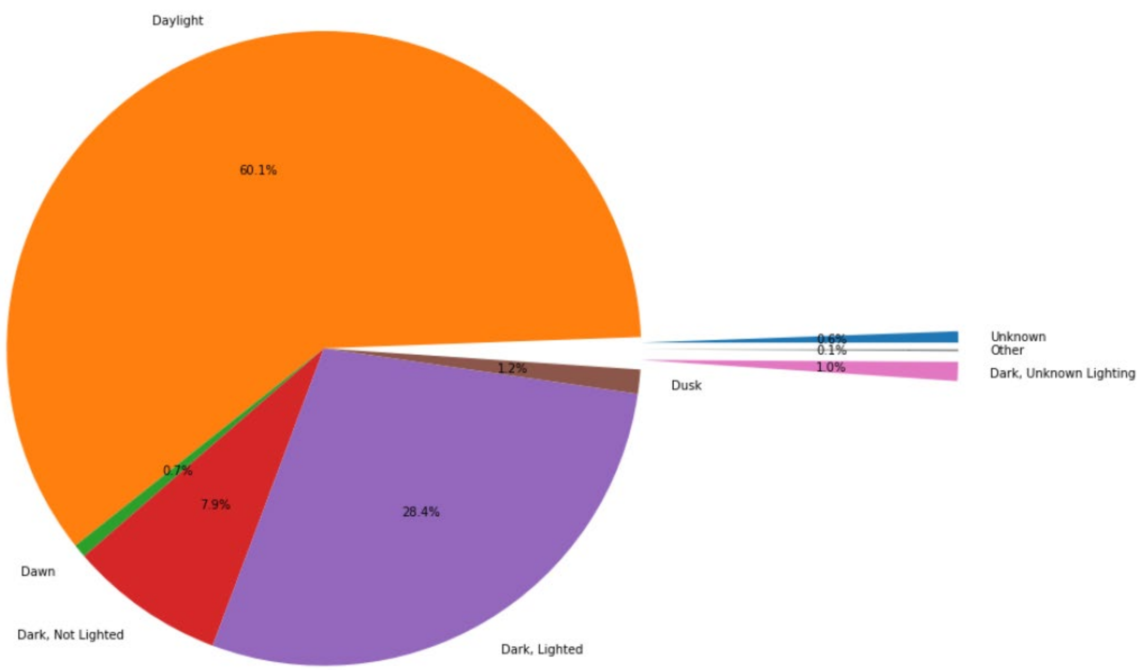


Figure 3-23. Midblock pedestrian crashes by lighting condition

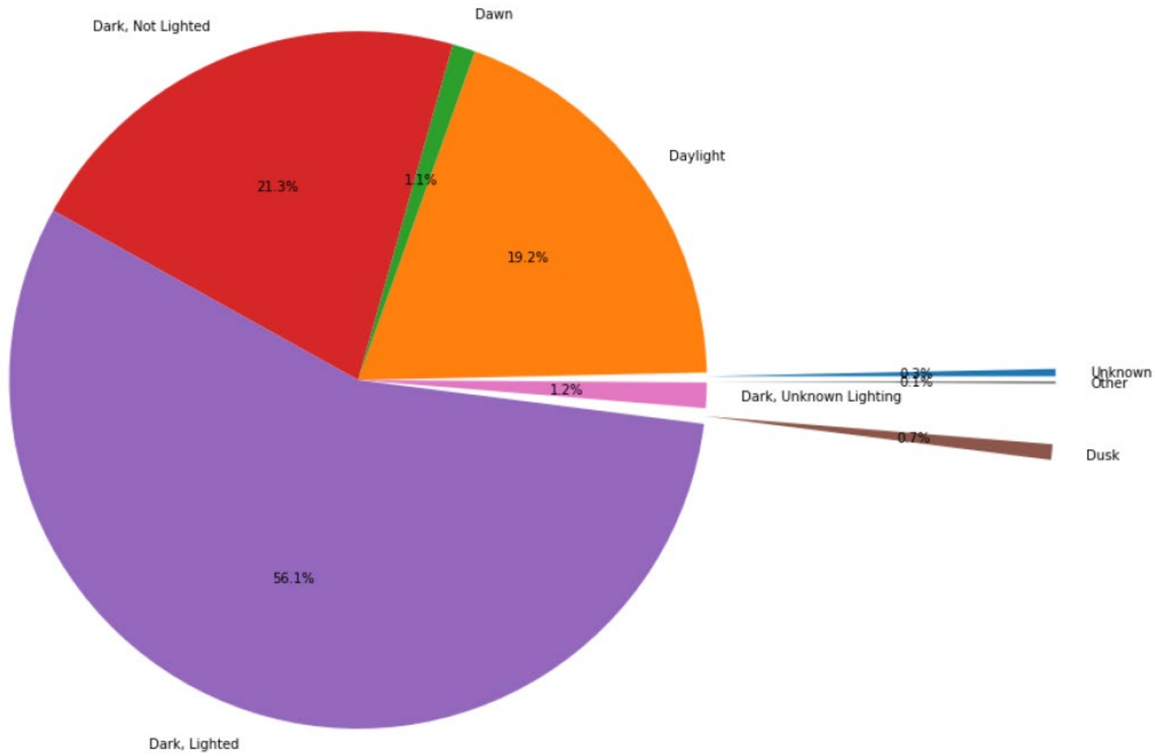


Figure 3-24. Midblock fatal pedestrian crashes by lighting condition

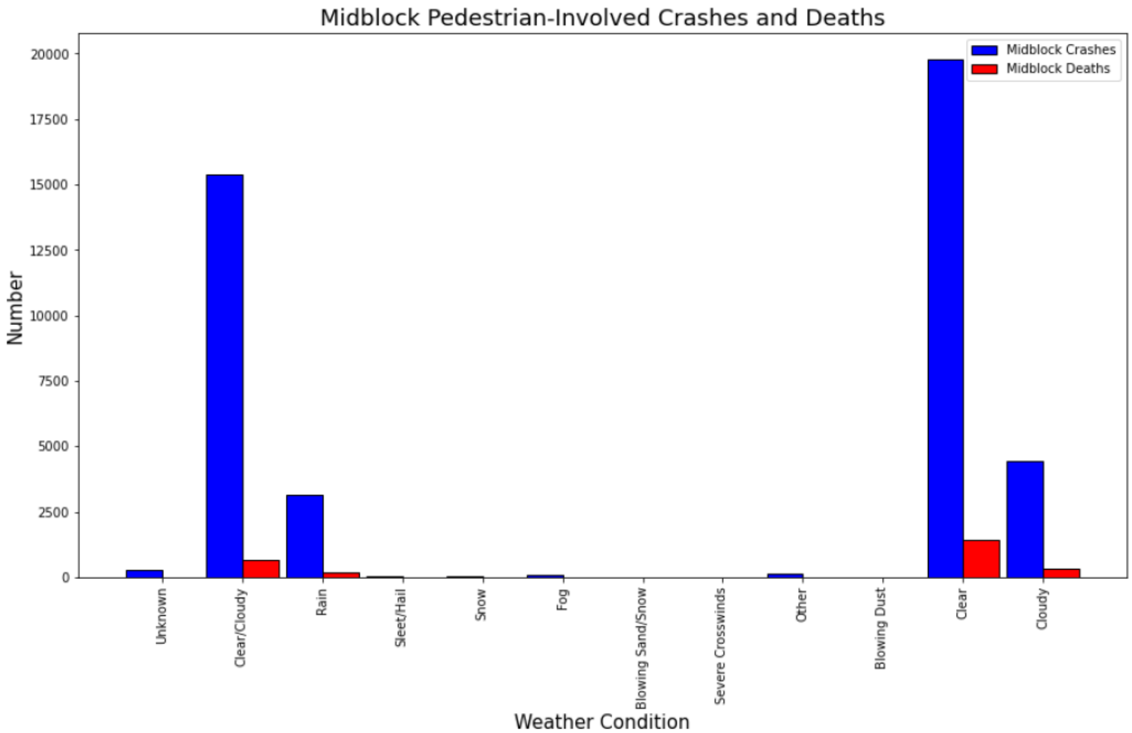


Figure 3-25. Midblock pedestrian crashes and fatalities by weather condition

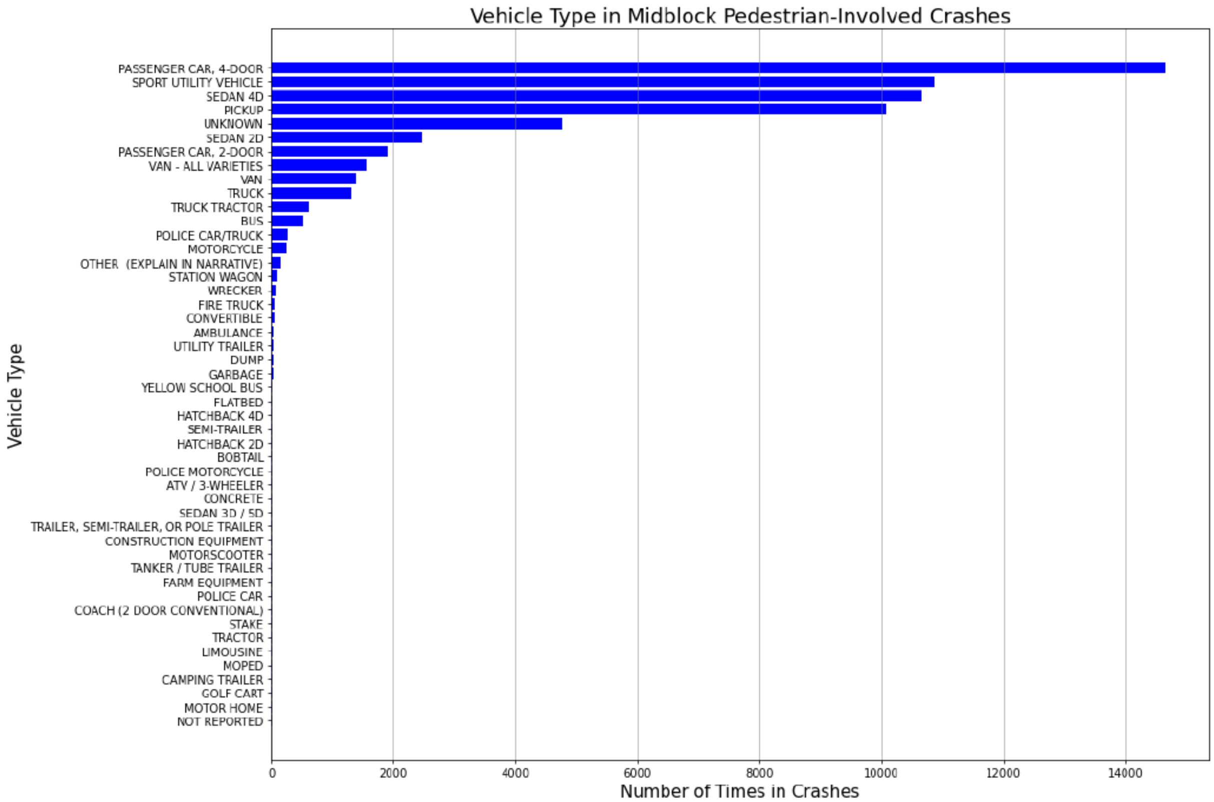


Figure 3-26. Midblock pedestrian crashes by vehicle type

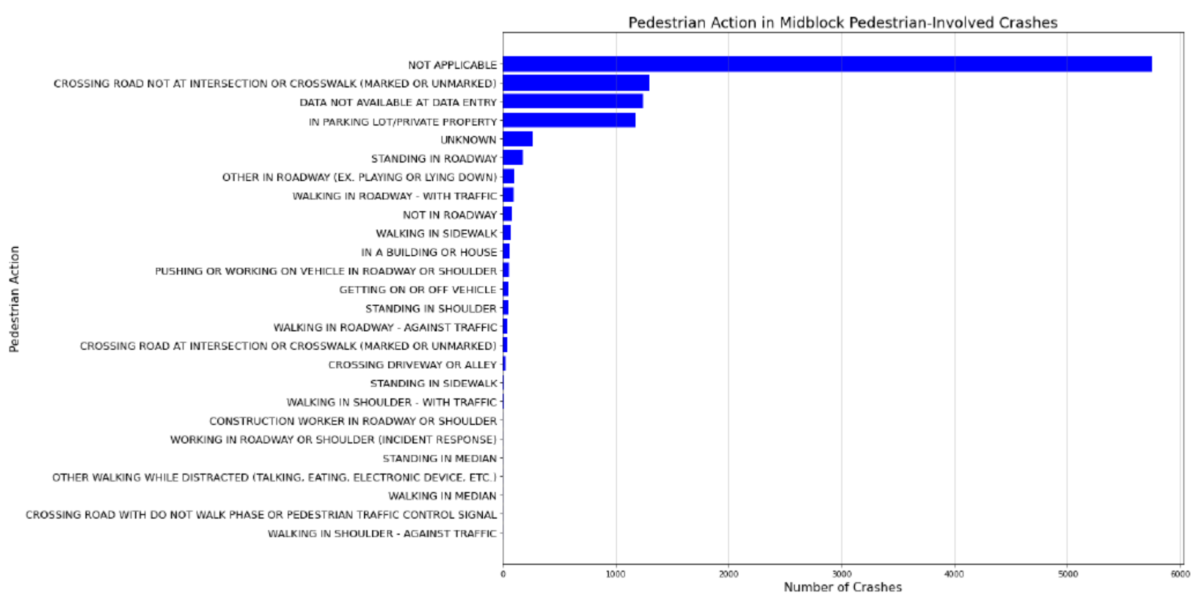


Figure 3-27. Midblock pedestrian fatalities by vehicle type

SUMMARY

The dataset generated through this task offers valuable insights into the trends and risk factors associated with midblock pedestrian crashes in Texas. Additional data will be gathered as the analysis progresses to address any gaps. Despite the limitations highlighted earlier, both the CRIS and TxDOT Roadway Inventory datasets are primed for integration with other datasets detailed in this technical memorandum to facilitate various project activities. These activities encompass ongoing preliminary analyses and visualizations, such as heat maps and regressions. These endeavors will contribute to the formulation of predictive models for crash rates and injury severity, the identification of crash modification factors, and the development of cost-effective countermeasures.

How data was processed for the above charts

The above Figures 3-1 through 3-27 are derived from the Crash Records Information System (CRIS) for the years 2003-2022. All data extraction, processing, and chart generation were developed through Python coding in a Jupyter notebook and are available to TxDOT. The figures showing maps were developed through ArcGIS, based on files developed through the Python Jupyter notebook.

The CRIS data was downloaded as a series of folders, one for each year, each containing a CSV with the focus of its content reflected in its name. For example, the CSV file containing 'crash' in its name provided information regarding the crash, such as its location, the number of people involved, etc., while the CSV file containing the word 'person' focused on information about the persons involved, such as their names, ages, etc. Each crash has a unique ID, stored in the column heading 'Crash_ID', the first column in each file. Identifying whether this Crash_ID value corresponds to a crash of our concern is the key to extracting all the data related to the particular crash.

The CRIS data contains crash records for the entire state, while our interest is limited to Dallas, Houston, and San Antonio, and particularly the midblock pedestrian-involved crashes in those cities. To determine only the Crash_IDs of crashes in the three cities, we used the CRIS "lookup" City_ID values of 107 (Dallas), 208 (Houston), and 379 (San Antonio), and then extracted the corresponding "Crash_ID" values from the 'crash' csv files. Then, to further reduce this Crash_ID subset to only those for crashes occurring away from intersections, we used the "lookup" value of INTRSCT_RELAT_ID = 4 in the crash file set. To further restrict the Crash_ID set to only those involving pedestrians requires considering data not only from the 'crash' files but also from the 'unit', 'person', and 'primary person' files. However, only the 'crash' file reveals that the crash occurred in one of the three cities and was midblock. Therefore, this preliminary set of Crash_IDs acts as a crash superset, as it includes crashes that do not involve pedestrians but is to be used as a precondition when identifying pedestrian-involved crashes to be included in our dataset.

The 'crash' file data was used to identify pedestrian-involved crashes within the crash superset by identifying those Crash_IDs for which HARM_EVNT_ID = 1, with the '1' indicating that a PEDESTRIAN was harmed. To be conservatively careful not to exclude any crashes that might even remotely be thought to include pedestrians, we also included OTHR_FACTR_ID = 27 (Swerved or Veered - For Officer, Flagman, or Traffic Control Device), 28 (Swerved or Veered-Avoiding Pedestrian, Pedalcyclist, etc. in Road), 38 (Slowing/Stopping for Officer, Flagman, or Traffic Control), and 39 (Slowing/Stopping for Pedestrian, Pedalcyclist, etc. in Road). Ultimately, however, we would exclude these OTHER_FACTR_ID values unless there was other evidence that a pedestrian was involved.

In the ‘unit’ file set, UNIT_DESC_ID = 4 indicates pedestrian involvement. Also in the unit file set, CONTRIB_FACTR_ID = 36 means that a driver failed to yield and stop the right of way to a pedestrian, and 59 means that the pedestrian failed to yield and stop the right of way to a vehicle. This exact column heading does not actually appear as a heading in any of the file sets, but we will assume it is appearing in the unit file set in multiple forms under the very similar column names there: "Contrib_Factr_1_ID", "Contrib_Factr_2_ID", "Contrib_Factr_3_ID", "Contrib_Factr_P1_ID", and "Contrib_Factr_P2_ID". And lastly,CMV_EVNT_ID=12 in the lookup file set means COLLISION INVOLVING PEDESTRIAN. This name does not appear as a column heading in any of the file sets, but in the unit file set, we see "Cmv_Evnt1_ID", "Cmv_Evnt2_ID","Cmv_Evnt3_ID", and "Cmv_Evnt4_ID". None of these columns appeared before 2010. Starting in 2010, all four of them appeared every year. All CrashIDs satisfying any of the conditions here described for the unit file set were included, so long as they were also members of the crash superset, which ensures that the crash occurred in one of the three cities and was ‘midblock’.

In the "lookup" file, PRSN_TYPE_ID = 4 indicates the person is a pedestrian. This column name appears in the person file set each year except in 2006 and 2007. Also, it appears in the primaryperson file set (The primaryperson file set began in 2008). Also appearing in the years 2020 through 2022 in the primaryperson file set are the columns PBCAT_Pedestrian_ID and Pedestrian_Action_ID, which, based on the lookup files for these years, show interesting details regarding pedestrian-involved crashes. Most cells in these columns are either 'blank' or have '97', which means 'Not Applicable'. However, some do display values other than '97'. All CrashIDs satisfying any of the conditions here described for the person and primaryperson file sets were included, so long as they were also members of the crash superset.

The dataset developed from applying all the conditions listed above in the ‘crash’, ‘unit’, ‘person’, and ‘primary person’ files is herein referred to as Crash Set 1.

Figures 3-1 through 3-6 are based on Crash Set 1. However, the inconsistent column names for the geographic coordinates posed an obstacle to writing a CSV file that could be read by ArcGIS. For 2003, 2004, and 2005, the heading ‘Lat’ indicates the latitude in decimal degrees, but from 2006 onward, the heading ‘Latitude’ was used. Furthermore, ‘Rpt_Latitude’ appears as yet another column accompanying ‘Latitude’ beginning in 2010, though a value very rarely appears in this column. Python coding was used to generate a CSV that contains a new column ‘lat_coor’ and that obtained corresponding values, when available, from the ‘Lat’, ‘Latitude’, and ‘Rpt_Latitude’. Similarly, a new column ‘long_coor’ was used for the longitude values. However, about a third of the crashes have no coordinates at all, and so they do not contribute to these six figures.

The legend for Figures 3-1 through 3-3 is qualitative, with higher values indicating higher crash densities in terms of crashes per unit area. In the upcoming and more thorough statistical analysis phase, the density will be re-expressed in terms of crashes per unit length of roadway, and the missing data will be formally considered. The legend for Figures 3-4 through 3-6 is more quantitative than that of Figures 3-1 through 3-3, but is nonetheless preliminary, as it too is based on unit area rather than unit length and cannot be considered a formal statistical analysis, which will also formally identify the physical threshold (in terms of crashes per unit length per unit time) for consideration as a 'hot spot'.

Figure 3-7 includes all crashes in the three cities, regardless of whether a pedestrian was involved. The portion of the pie that represents the midblock crashes represents the crash superset. The remaining portions of the pie were determined based on the value of INTRSCT_RELAT_ID ("Intersection" based on '1-intersection' and '2-intersection-related', and "Driveway' based on '3-Driveway Access').

Figures 3-8, 3-9, and 3-11 rely on Crash Set 1 for the 'midblock' values. The 'intersection' values in these three figures and the 'driveway' value in Figure 3-8 are from datasets developed exactly as in Crash Set 1, but with the needed adjustment to the INTRSCT_RELAT_ID value.

Figures 3-10 and 3-12 through 3-25 focus strictly on the midblock pedestrian-involved crashes. At this point, a decision was made to more tightly define which crashes truly involve pedestrians. In particular, the variable 'Other_Factr_ID' in the 'crash' files was no longer used to identify pedestrian involvement. If the value was ambiguous regarding pedestrian involvement, such as '28 (Swerved or Veered- Avoiding Pedestrian, Pedalcyclist, etc. in Road)', but no other indication of pedestrian involvement was indicated in any of the files for that crash, then that crash was no longer included. The resulting new dataset is herein referred to as Crash Set 2. While Crash Set 1 includes 43,926 crashes, Crash Set 2 includes 33,101, about 11,000 fewer than Crash Set 1. Most of these 11,000 – actually, 9,400 - have the 'Other_Factr_ID' value of 38 (Slowing/Stopping for Officer, Flagman, or Traffic Control)'. This very high number for a single contributing factor calls for special attention, but as officers and flagmen are not typically considered pedestrians, the category is outside of the scope of this study.

In general, to reduce clutter in the figures, the number of missing values or the number of values for which the value 'Unknown' is not included. For the upcoming and more rigorous statistical analysis, the number of missing and 'Unknown' values will be consistently reported.

CHAPTER 4 : ANALAYSIS OF SAFETY AND OPERATIONAL DATA

OVERVIEW

This chapter presents an in-depth analysis of the top 30 pedestrian crash hotspots in San Antonio, identified through spatial analysis of crash data obtained from the Texas Department of Transportation's Crash Records Information System (CRIS) between 2003 and 2023. Hotspots were selected based on pedestrian crash frequency, with additional consideration for clustering of crashes and location context, such as proximity to transit stops, commercial activity, and residential areas.

Each hotspot section includes:

- Intersection location and coordinates
- Land use context and notable nearby features (e.g., stores, schools, transit stops)
- Crash pattern summary, including:
    - Days of week and times of day with the highest crash occurrence
    - Common contributing factors (e.g., driver inattention, failure to yield and stop)
- Supporting visuals:
    - Street-level satellite view of the intersection
    - Crash density map for the hotspot area

In addition, each hotspot was assessed **on-site** to document roadway features and observe pedestrian and driver behavior. A standardized field form was used to collect data on crosswalk conditions, signage, traffic control, pedestrian wait times, driver yielding and stopping, and other key factors.

A Pedestrian jaywalking path map was also created to note pedestrian's points of interest. These observations, combined with crash pattern analysis, provide a comprehensive understanding of safety risks at each location.

The findings support the identification of recurring risk patterns and will inform recommendations for pedestrian safety improvements.

SAN ANTONIO TOP 10 HOTSPOTS

1. S Zarzamora St x W Mayfield Blvd and SW Military Dr

Coordinates: 29°21'41.2"N 98°32'02.7"W

The hotspot is a mix of commercial and residential. The most notable points of interest are an HEB Plus, a Wells Fargo bank, multiple restaurants, and 4 VIA bus stops.

Figure 4-1. S. Zarzamora St. x W. Mayfield Blvd. and SW Military Dr.

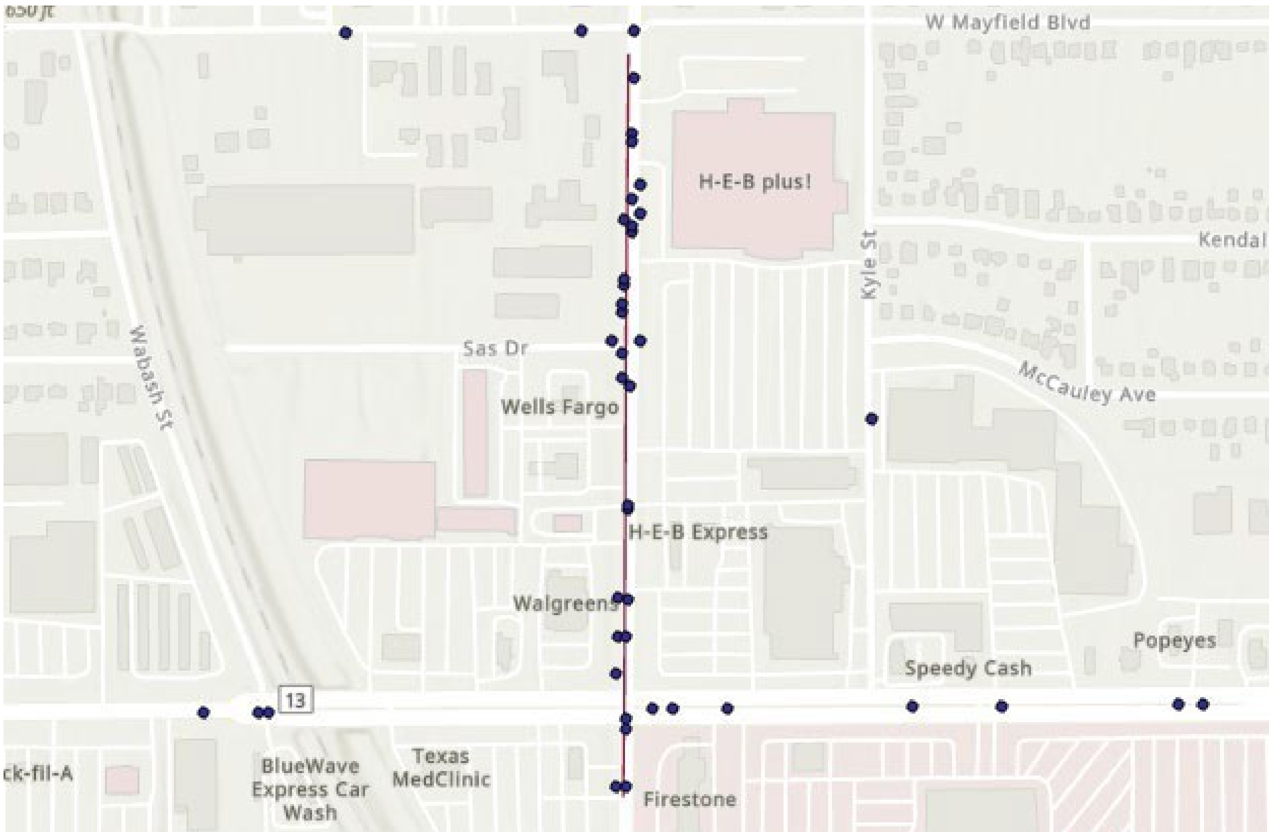


Figure 4-2. Crash map of S. Zarzamora St. x W Mayfield Blvd. and SW Military Dr.

CRIS DATA SUMMARY:

- Thursdays and Fridays are the days with the highest number of crashes.
- The evening between 6:00-8:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 3 cases of DRIVER INATTENTION and 1 case of DRIVER FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN.

2. Fredericksburg Rd x Louis Pasteur Dr

Coordinates: 98°34.0781223'W 29°30.7026605'N

The area has multiple hotels and apartment areas, a UPS store, multiple restaurants, a 7-Eleven convenience store, and a VIA bus stop. A block away from the hotspot, a church and a medical center can be noted.

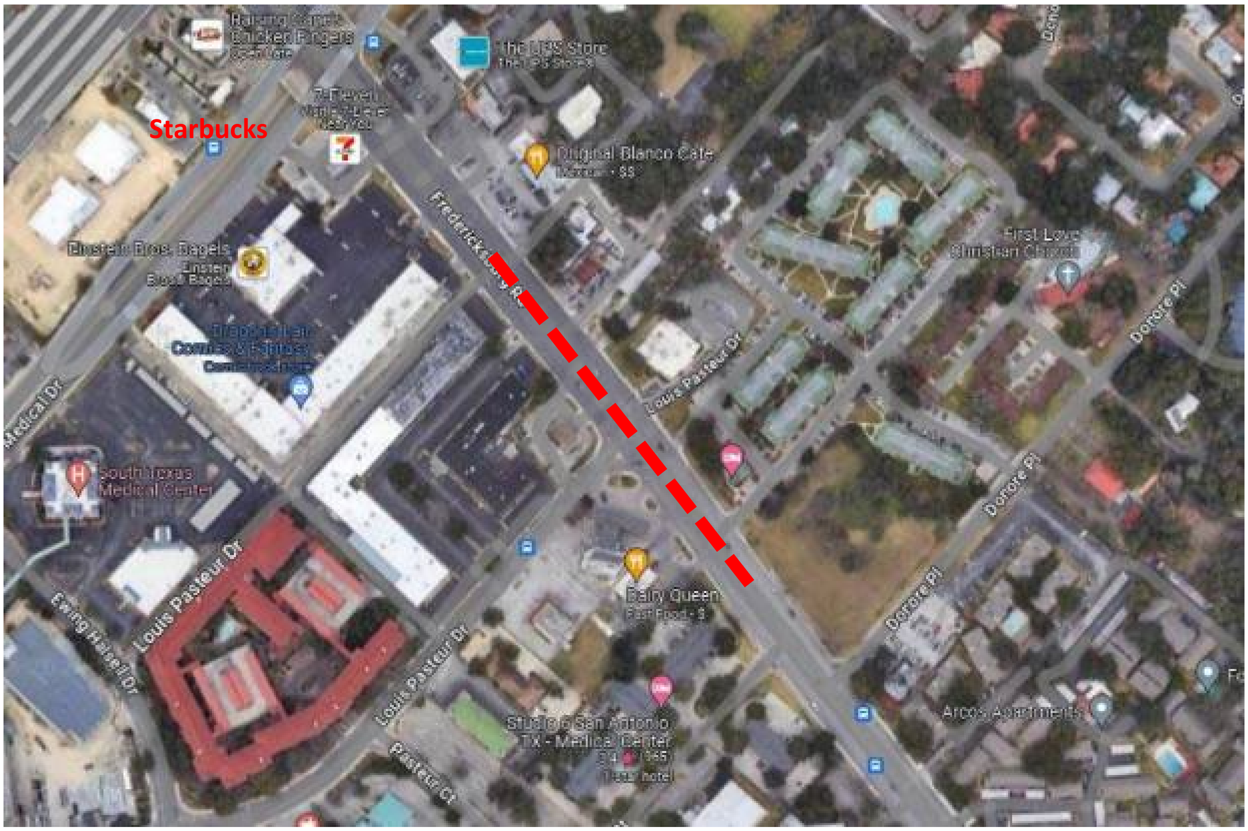


Figure 4-3. Fredericksburg Rd. x Louis Pasteur Dr.

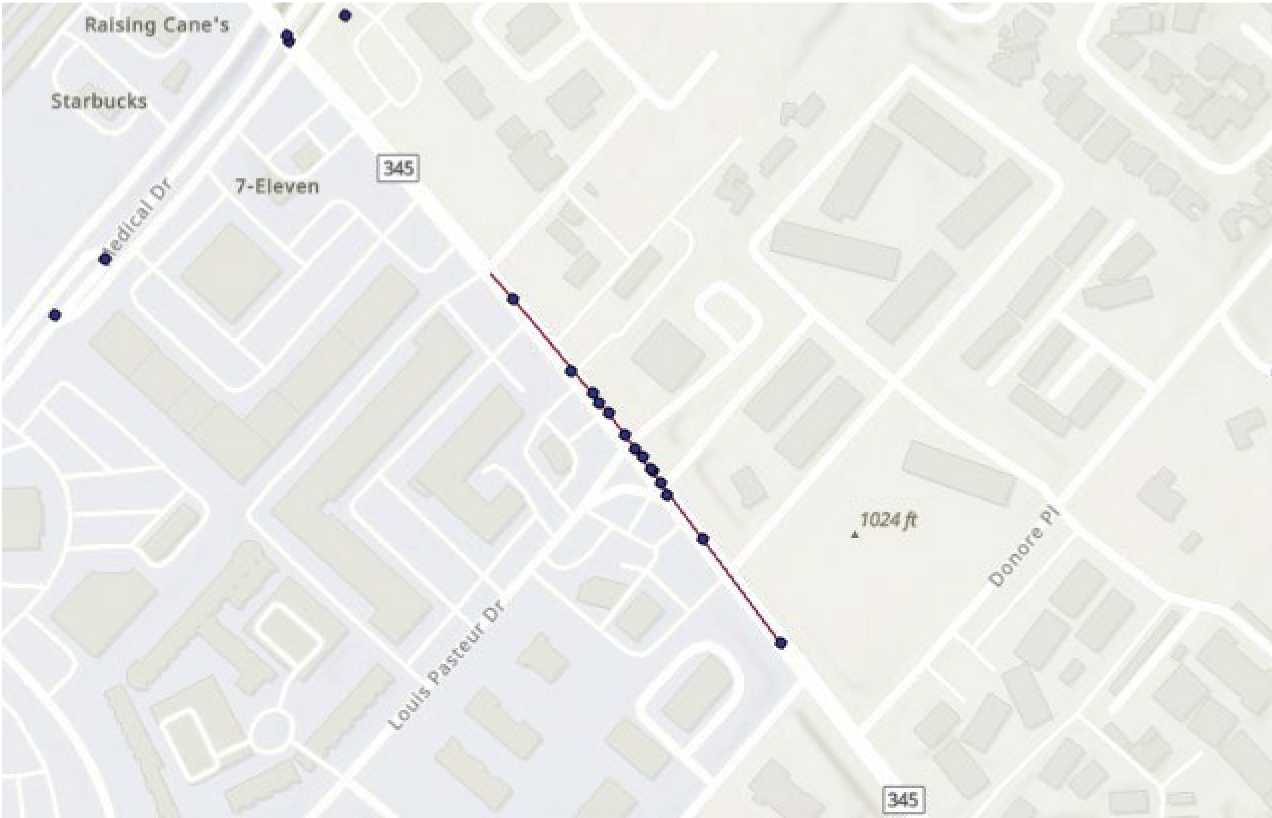


Figure 4-4. Crash map of Fredericksburg Rd. x Louis Pasteur Dr.

CRIS DATA SUMMARY:

- Thursdays and Fridays are the days with the highest number of crashes.
- The afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had no recorded contributing factors.

3. Fredericksburg Rd. x Babcock Rd.

Coordinates: 98°32.1886096'W 29°28.4945176'N

The area is a mix of both commercial and residential, with the commercial area being concentrated around the hotspot. Most notable are Goodwill, Restaurant Depot, Walgreens, Circle K gas station, a donut shop, a glass store, multiple restaurants (Original Donut and Cocina Mexicana breakfast taco restaurant). and 3 VIA bus stops.

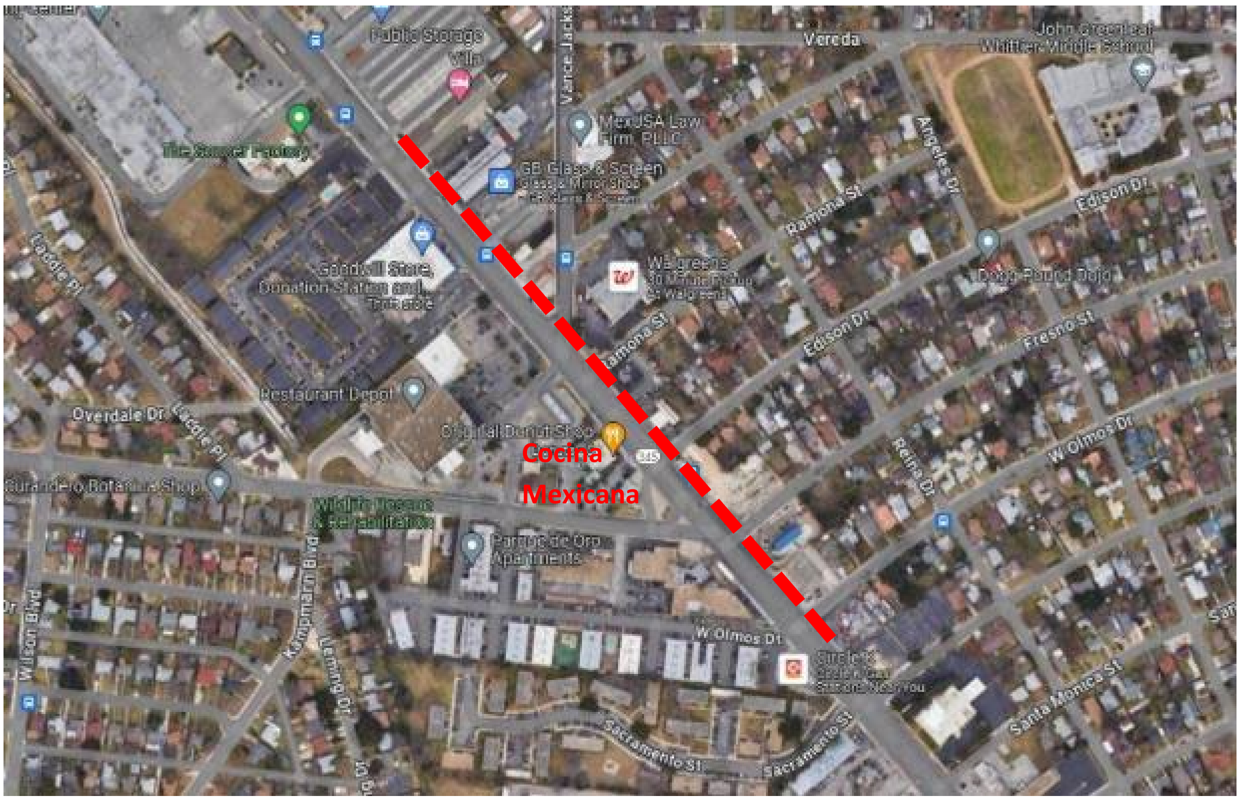


Figure 4-5. Fredericksburg Rd. x Babcock Rd.

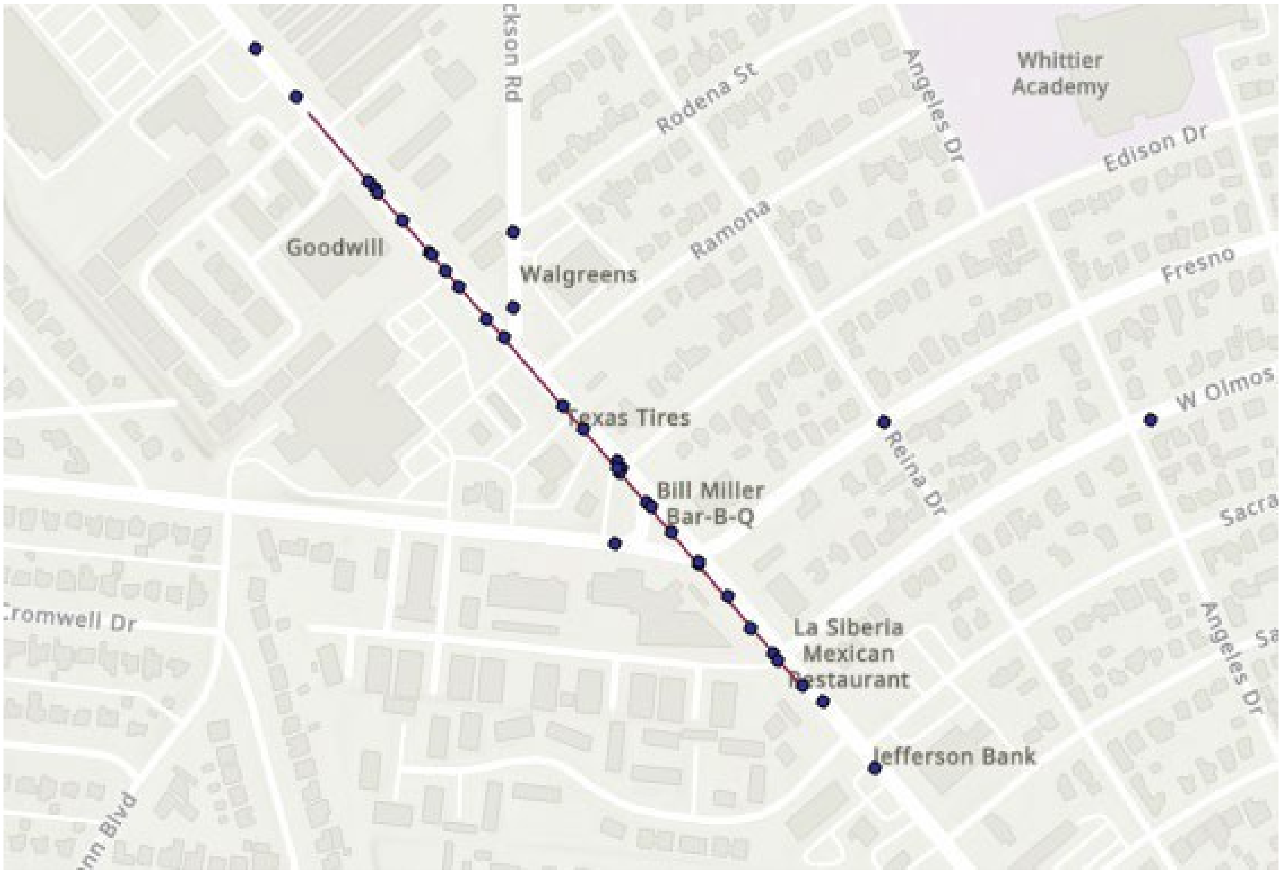


Figure 4-6. Crash map of Fredericksburg Rd. x Babcock Rd.

CRIS DATA SUMMARY:

- Saturdays and Tuesdays are the days with the highest number of crashes.
- The afternoon between 12:00 – 5:00 p.m. And at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 1 case of recorded DRIVER INATTENTION.

4. Wurzbach Rd. x Gardendale Rd.

Coordinates: 98°34.2422243'W 29°31.3632716'N

A residential area with mostly restaurants, a family dentist, a Valero gas station with multiple food trucks parked inside, and 4 VIA bus stops.

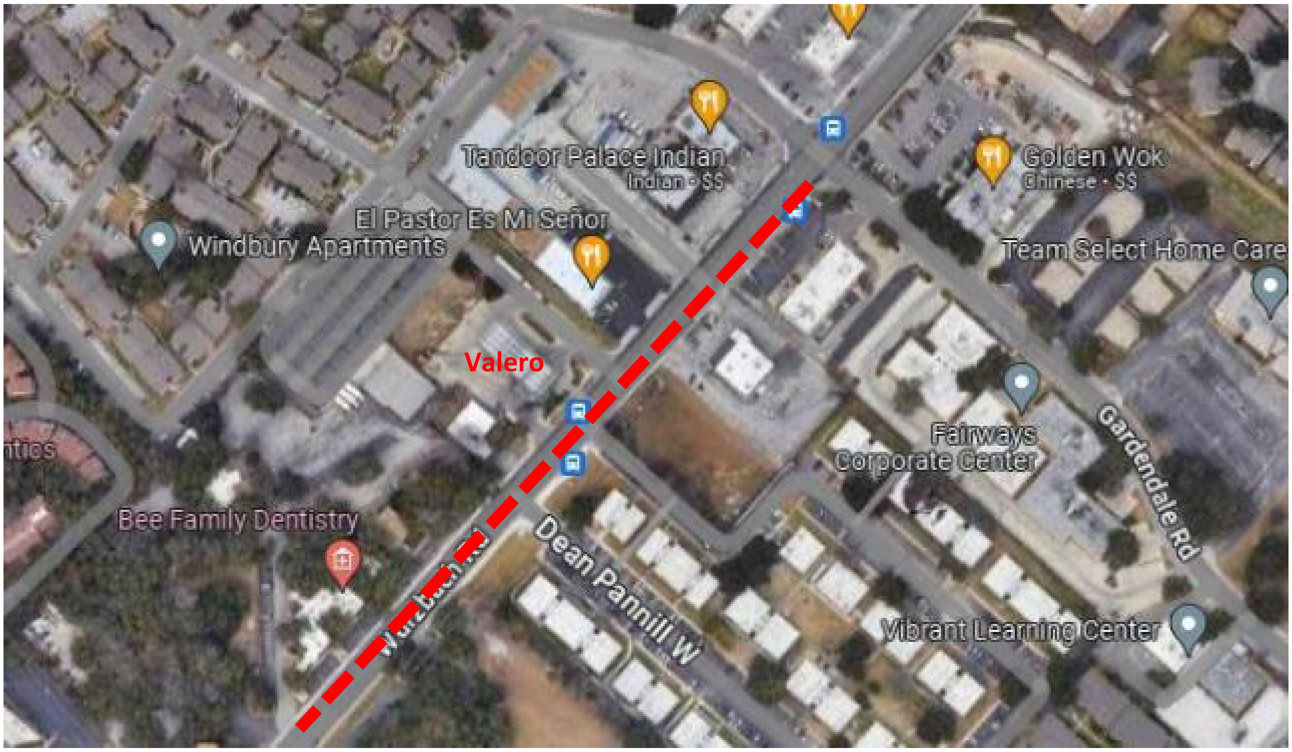


Figure 4-7. Wurzbach Rd. x Gardendale Rd.

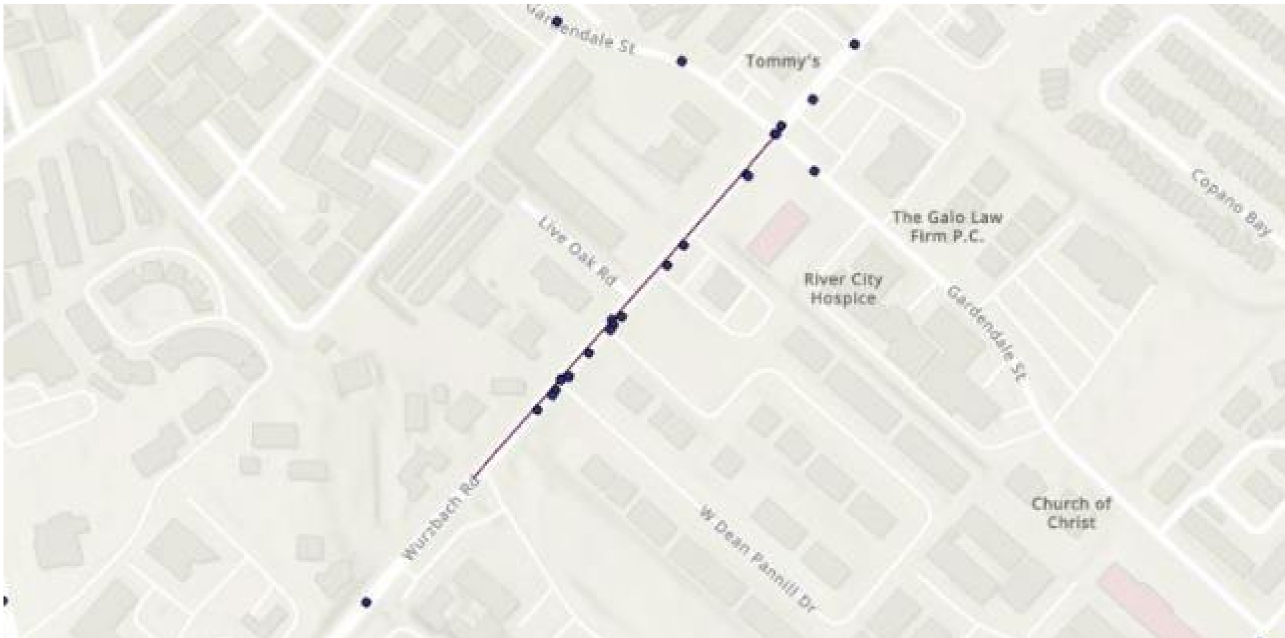


Figure 4-8. Crash map of Wurzbach Rd. x Gardendale Rd.

CRIS DATA SUMMARY:

- Fridays and Wednesdays are the days with the highest number of crashes.
- In the evening between 5:00 – 8:00 p.m. And at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- No recorded contributing factors available.

5. Bandera Rd. x Zachry Dr.

Coordinates: 98°33.7492700'W 29°27.7752221'N

This is mainly a residential area. It has a school (Rise & Shine Academy), an O'Reilly Auto Parts store, multiple restaurants, a Bandera Express gas station, and 2 VIA bus stops.

Figure 4-9. Bandera Rd. x Zachry Dr.

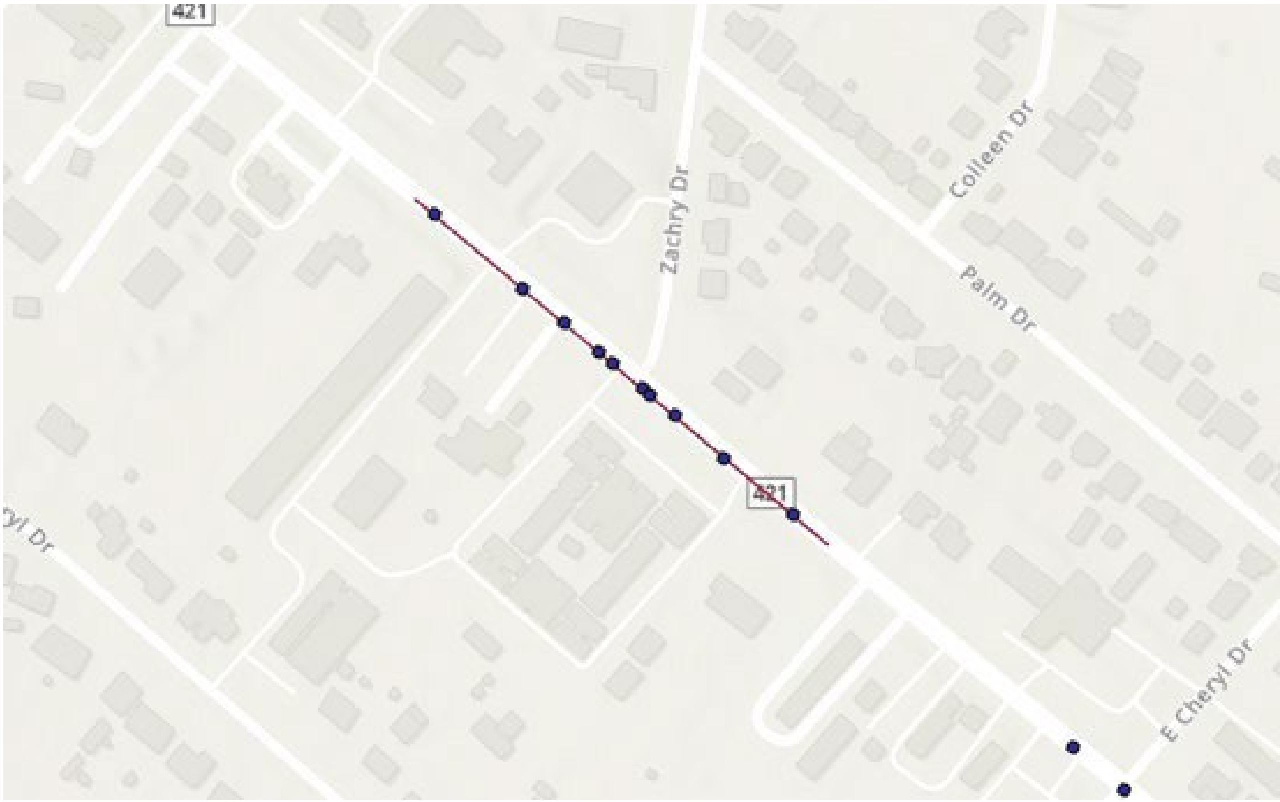


Figure 4-10. Crash map of Bandera Rd. x Zachry Dr.

CRIS DATA SUMMARY:

- Fridays and Wednesdays are the days with the highest number of crashes.
- The evening between 5:00 – 8:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- No recorded contributing factors available.

6. Blanco Rd. x West Ave.

Coordinates: 98°30.5031561'W 29°32.7463528'N

The area is a mix of commercial and residential. The most notable locations of interest are H-E-B, Exxon gas station, multiple restaurants, and four VIA bus stops.

Figure 4-11. Blanco Rd. x West Ave.

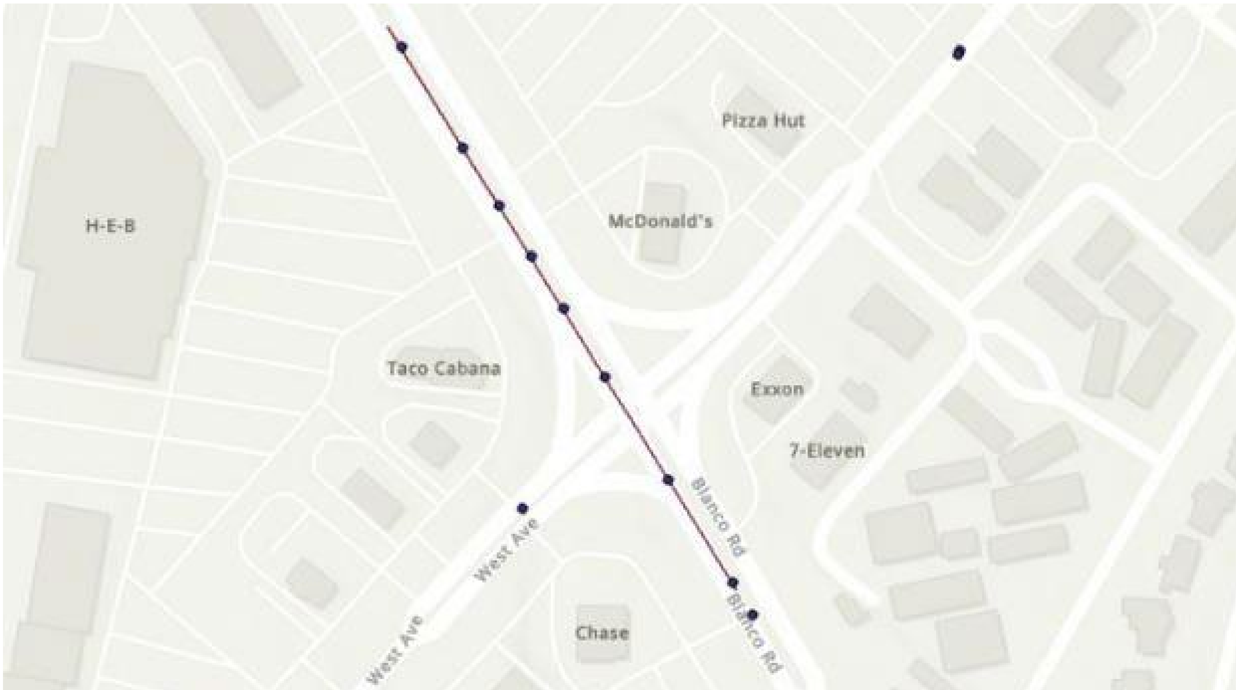


Figure 4-12. Crash map of Blanco Rd. x West Ave.

CRIS DATA SUMMARY:

- Friday is the day with the highest number of crashes.
- The afternoon between 12:00-5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- No recorded contributing factors available.

7. Marbach Rd. x I-410

Coordinates: 98°39.1216017'W 29°25.0717075'N

This is a mostly commercial area with multiple restaurants, H-E-B Plus, an Exxon gas station, a Circle K gas station, and 5 VIA bus stops.

Figure 4-13. Marbach Rd. x I-410.

Figure 4-14. Crash map of Marbach Rd. x I-410.

CRIS DATA SUMMARY:

- Tuesdays and Wednesdays are the days with the highest number of crashes.
- The afternoon between 12:00-5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- Although 6:00 – 8:00 am are not the hours with the highest numbers of crashes, this hot spot had substantially more crashes during these hours than did other hot spots.
- No recorded contributing factors available.

8. Rittiman Rd. x I-35 Frontage

Coordinates: 98°24.1695125'W 29°29.0438582'N

The area is a mix of commercial and residential and includes multiple restaurants, 7-Eleven, Circle K, and 4 VIA bus stops.

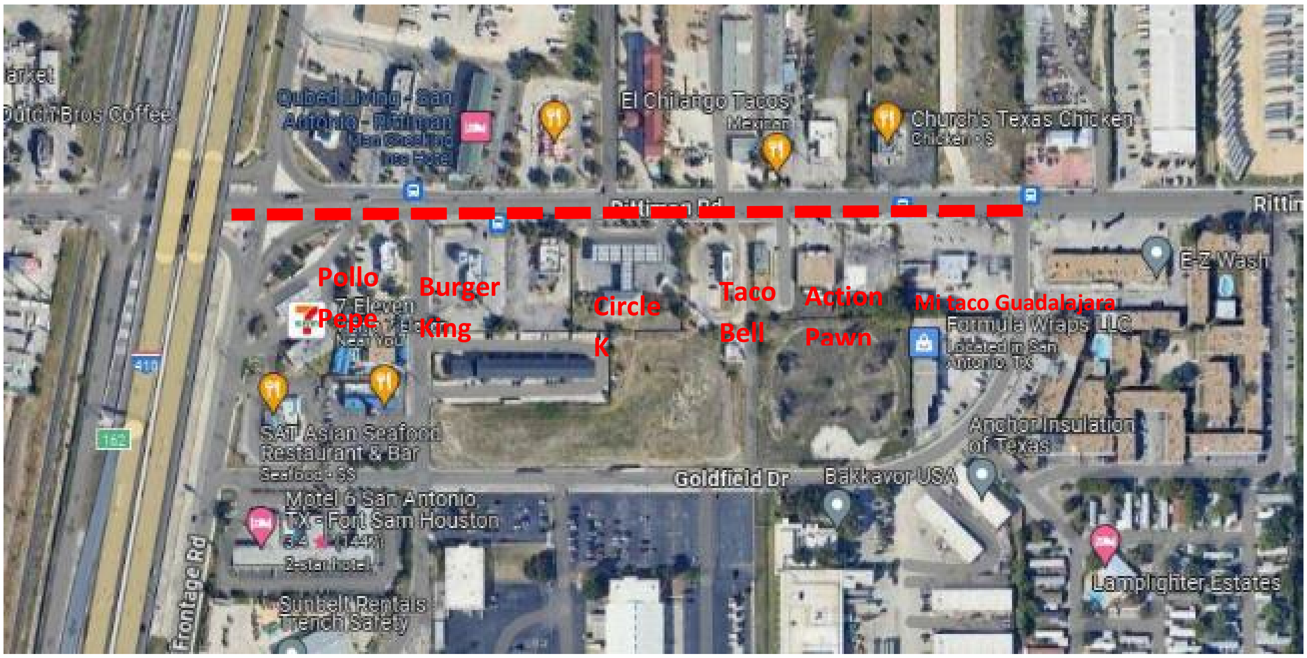


Figure 4-15. Rittiman Rd. x I-410.

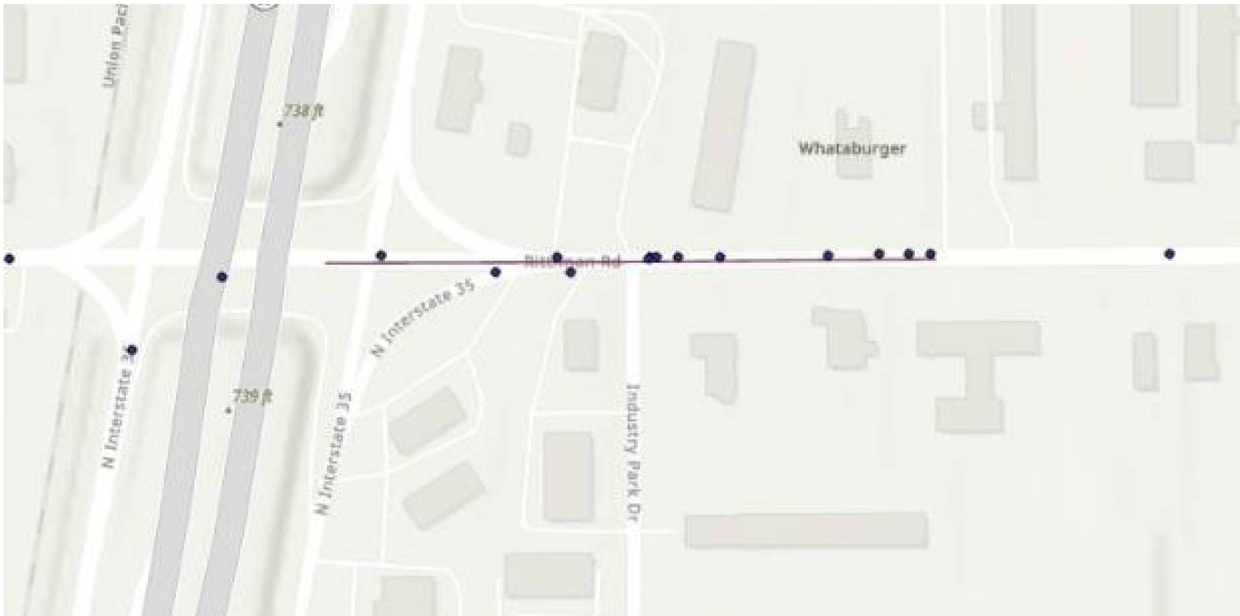


Figure 4-16. Crash map of Rittiman Rd. x I-410.

CRIS DATA SUMMARY:

- Thursdays and Mondays are the days with the highest number of crashes.
- The morning between 6:00 a.m. – 12:00 p.m. and at afternoon between 12:00 – 5:00 p.m. are the hours with the highest number of crashes.
- No recorded contributing factors available.

9. SE. Military Dr. x Spur 536 and Roosevelt Ave.

Coordinates: 98°28.9557938'W 29°21.3607517'N

A mainly commercial area with multiple restaurants, an Exxon, Mission Plaza, a learning center, an urgent care Medclinic, a motel, a Walmart supercenter, and 4 VIA bus stops.

Figure 4-17. SE. Military Dr. x Spur 536 and Roosevelt Ave.

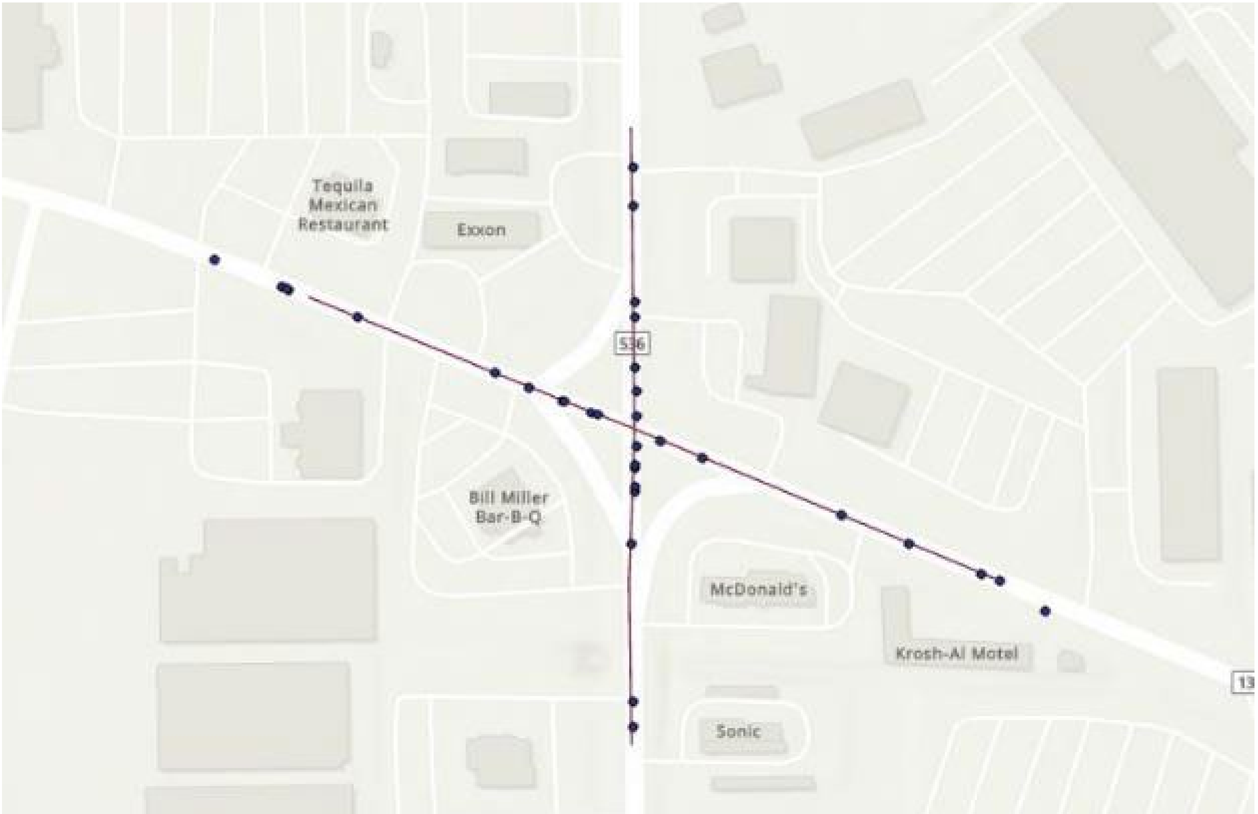


Figure 4-18. Crash map of SE. Military Dr. x Spur 536 and Roosevelt Ave.

CRIS DATA SUMMARY:

- Saturdays and Wednesdays are the days with the highest number of crashes.
- The afternoon between 12:00-5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- No recorded contributing factors available.

10. Airport Blvd. – E. Terminal Dr. (REDACTED)

Coordinates: 29.526074807104113, -98.47217705935009

The hotspot is at terminal A of the San Antonio International Airport. The hotspot has not been considered due to the difficulty of assessing that location.

Figure 4-19. Airport Blvd. – E. Terminal Dr.

Figure 4-20. Crash map of Airport Blvd. – E. Terminal Dr.

CRIS DATA SUMMARY:

- Mondays, Fridays, and Saturdays are the days with the highest number of crashes.
- The afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had no recorded contributing factors.

DALLAS TOP 10 HOSPOTS

1. E Ledbetter Dr. x Sunnyvale St. and Bonnie View Rd.

Coordinates: 32°41'32.4"N 96°46'36.0"W

The strip has multiple apartment buildings and a suburban area. Multiple restaurants, a family Dollar store, and an Exxon gas station. The strip is also used by students to cross to Brack Obama Male Leadership Academy.

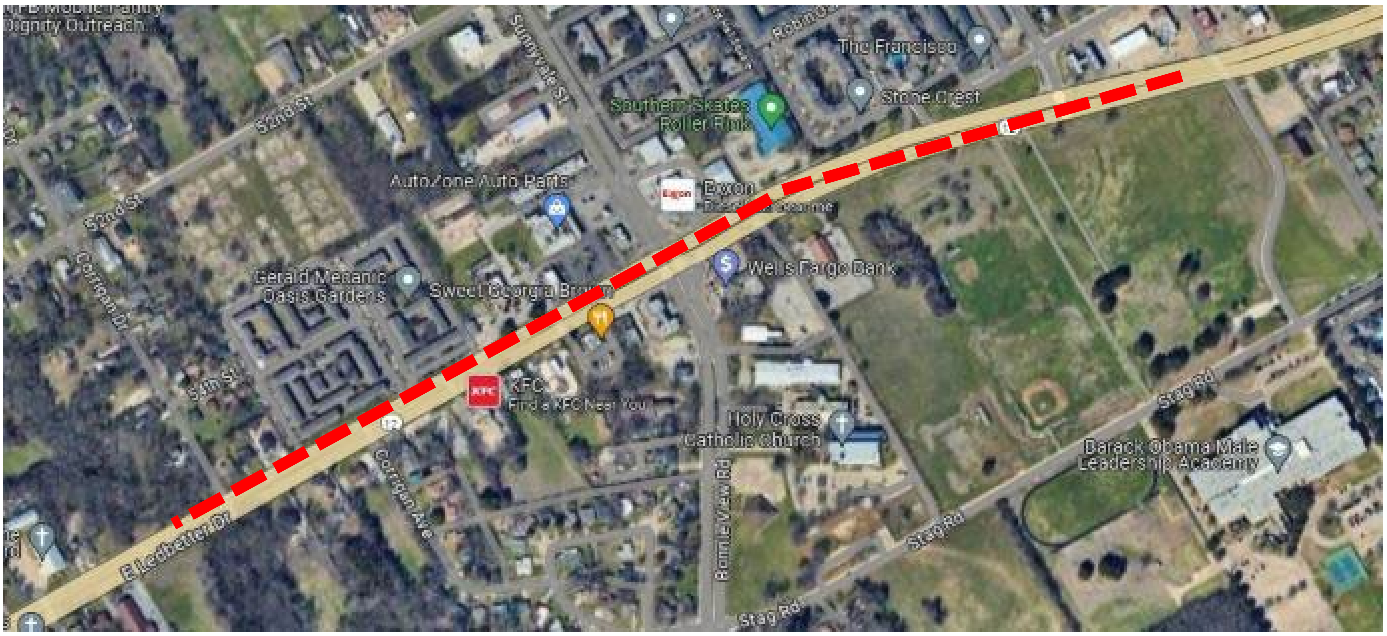


Figure 4-21. E. Ledbetter Dr. x Sunnyvale St. and Bonnie View Rd.

Figure 4-22. Crash map of E. Ledbetter Dr. x Sunnyvale St. and Bonnie View Rd.

CRIS DATA SUMMARY:

- Saturdays and Sundays are the days with the highest number of crashes.
- The evening between 5:00 – 8:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- A small number of crashes occurred in the morning.
- Among the contributing factors are: 2 cases FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID], 1 case FAILED TO DRIVE IN SINGLE LANE [1_ID]
  2 cases PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID], 1 case INTOXICATED - DRUG [P1_ID]. 1 case FAULTY EVASIVE ACTION [1_ID], 1 case SPEEDING - (OVERLIMIT), and 1 case of UNSAFE SPEED [1_ID], and 1 case of DISTRACTION IN VEHICLE [1_ID].

2. S. Great Trinity Forest Way x Ohanian Dr. and Murdock Rd.

Coordinates: 32°42'44.1"N 96°41'11.2"W

The strip has a Family Dollar and a MacDonalds. A Shell gas station, a Texaco gas station surrounded by two food stores and two DART bus stops.

Figure 4-23. S. Great Trinity Forest Way x Ohanian Dr. and Murdock Rd.

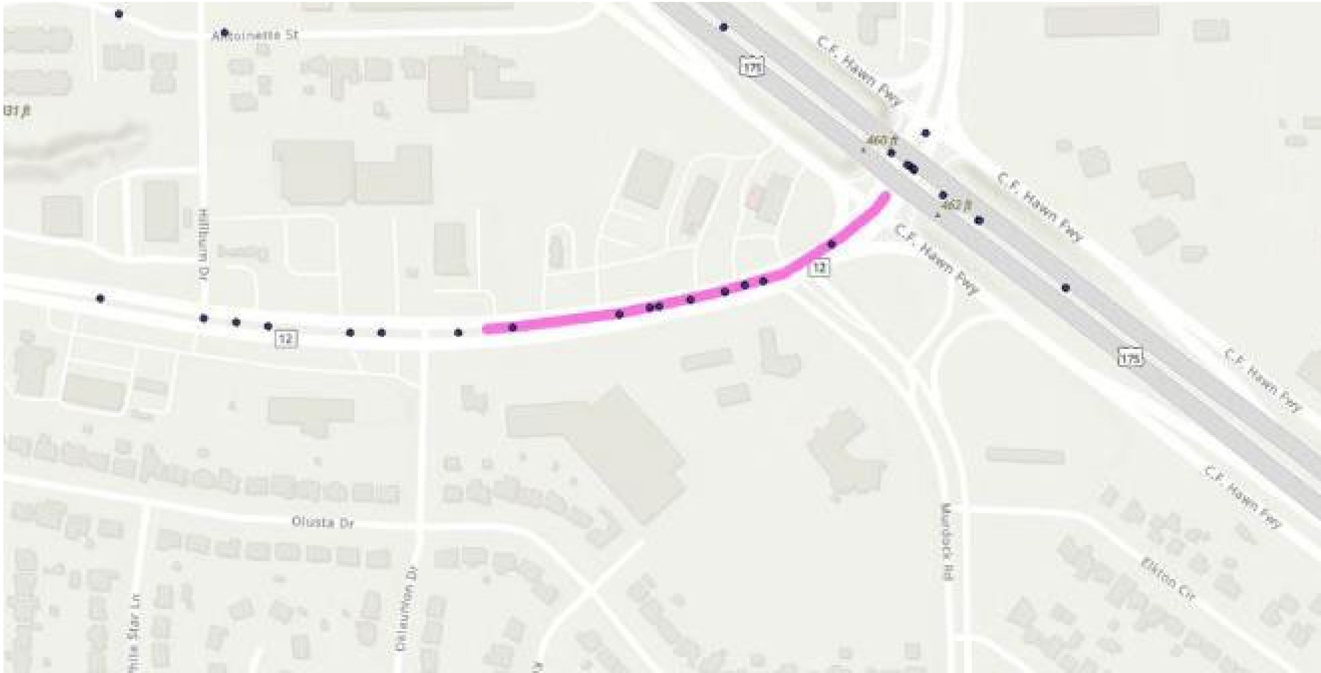


Figure 4-24. Crash map of S. Great Trinity Forest Way x Ohanian Dr. and Murdock Rd.

CRIS DATA SUMMARY:

- Tuesday is the day with the highest number of crashes.
- The afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 1 case FAILED TO YIELD AND STOP RIGHT OF WAY - TURNING LEFT [1_ID], 1 case BACKED WITHOUT SAFETY [1_ID], 1 case PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID], 1 case FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID] and 1 case DISREGARD WARNING SIGN AT CONSTRUCTION [1_ID], SPEEDING - (OVERLIMIT) [2_ID].

3. Martin Luther King Jr. Blvd. x S. Ervay St.

Coordinates: 32°45'34.0"N 96°46'46.5"W

The strip had multiple liquor stores, a night club, a clothing store, a barber shop, and a GYM. The strip also had 4 dart bus stops.

Figure 4-25. Martin Luther King Jr. Blvd. x S. Ervay St.

Figure 4-26. Crash map of Martin Luther King Jr. Blvd. x S. Ervay St.

CRIS DATA SUMMARY:

- Fridays and Saturdays are the days with the highest number of crashes.
- The afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- Nighttime had more crashes than afternoon for this strip, suggesting visibility issues.
- The strip had 1 case of FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID].

4. Maple Ave. x Hawthorne Ave. and Wycliff Ave.

Coordinates: 32°48'34.7"N 96°49'13.5"W

The strip has a Cost + Plus Grocery store, a smoke shop, a barber and nail salon, multiple restaurants, and a food market. The strip also had 4 DART bus stops.

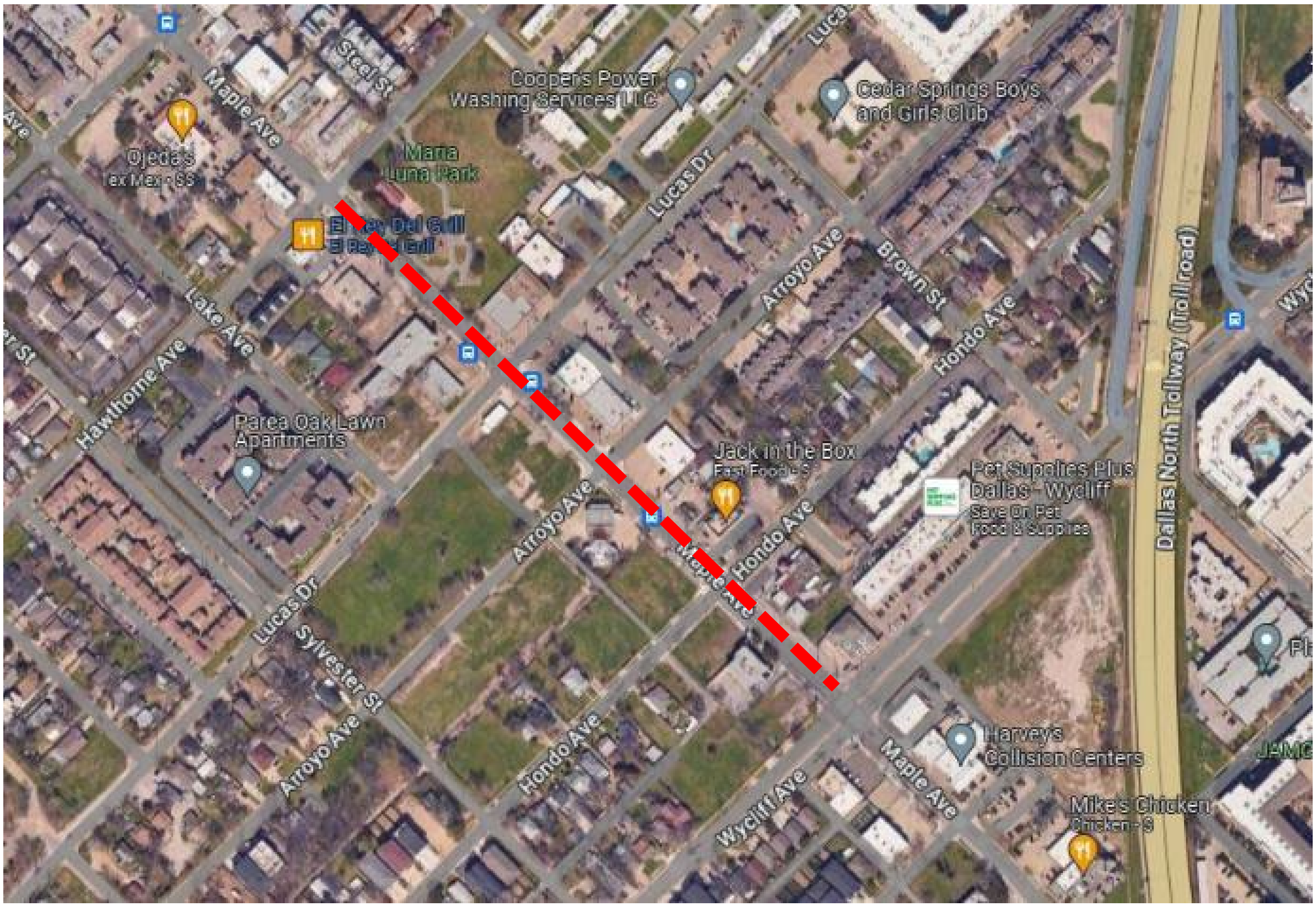


Figure 4-27. Maple Ave. x Hawthorne Ave. and Wycliff Ave.

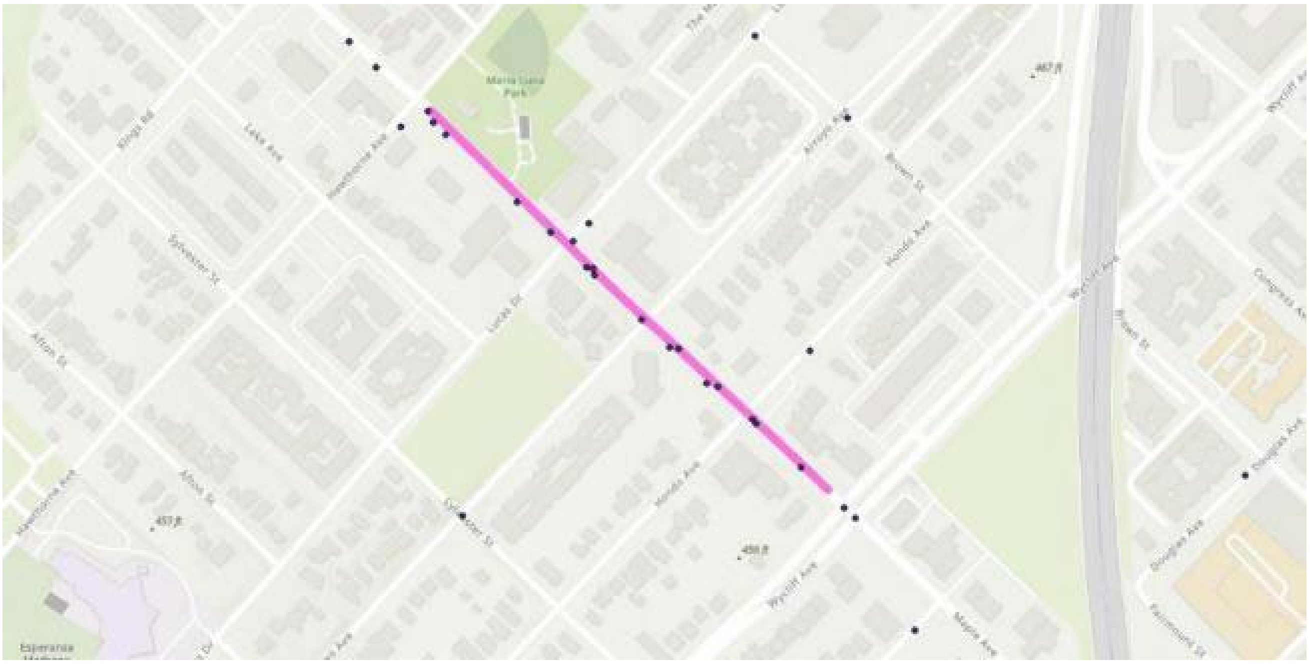


Figure 4-28. Crash map of Maple Ave. x Hawthorne Ave. and Wycliff Ave.

CRIS DATA SUMMARY:

- Fridays, Saturdays, and Tuesdays are the days with the highest number of crashes.
- The afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 1 case of INTOXICATED - ALCOHOL [1_ID] and 1 case of FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID].

5. Stemmons Fwy. x Medical District Dr.

Coordinates: 32°48'20.5"N 96°50'18.6"W

The strip has a Marriot Suits and a children's hospital complex on the opposite side of the road. A chevron with a food mart and a Shell gas station with 7-Eleven stations can also be seen. Two dart bus stations are located along the strip.

Figure 4-29. Stemmons Fwy. x Medical District Dr.

Figure 4-30. Crash map of Stemmons Fwy. x Medical District Dr.

CRIS DATA SUMMARY:

- Thursday is the day with the highest number of crashes.
- The morning between 5:00 a.m. – 12:00 p.m. and afternoon 12:00 p.m. – 5:00 p.m. are the hours with the highest number of crashes.
- The strip had 3 cases of FAULTY EVASIVE ACTION [1_ID], 1 case DRIVER INATTENTION [1_ID], 1 case FAILED TO CONTROL SPEED [1_ID], and 1 case IMPAIRED VISIBILITY (EXPLAIN IN NARRATIVE) [1_ID

6. Lombardy Ln. and Webb Chapel Rd.

Coordinates: 32.86653031224936, -96.86498089552828

The strip is in a mixed-use area and is located along two plazas, most notable are the Fiesta Mart and La Michoacana Meat Market located in Pecan Plaza. There are also multiple restaurants, a bar, and a check cashier. A Dart bus stop can be noted on Webb Chapel Rd.

Figure 4-31. Lombardy Ln. and Webb Chapel Rd.

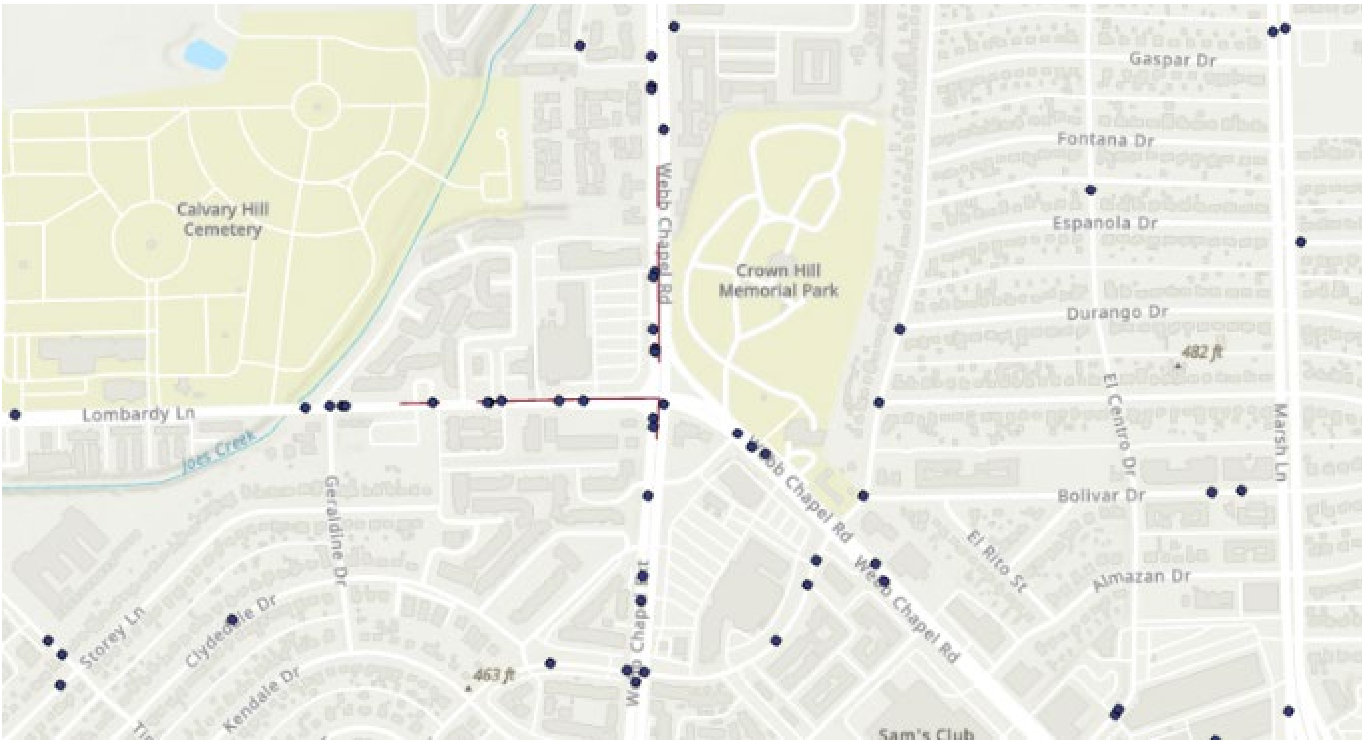


Figure 4-32. Crash map of Lombardy Ln. and Webb Chapel Rd.

CRIS DATA SUMMARY:

- Fridays and Saturdays are the days with the highest number of crashes.
- The afternoon between 12:00 p.m. – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 1 case of INTOXICATED - ALCOHOL [1_ID], INTOXICATED - DRUG [2_ID], 2 cases of FAILED TO YIELD AND STOP RIGHT OF WAY - TURN ON RED [1_ID]

7. N. Buckner Blvd. x John West Rd.

Coordinates: 32°48'24.1"N 96°40'57.4"W

The strip is in a mixed-use area, and among the most notable landmarks is the El Rio Grande Latin Market. The strip also has multiple restaurants and a 7-Eleven gas station. a dart bus stop can be noted.

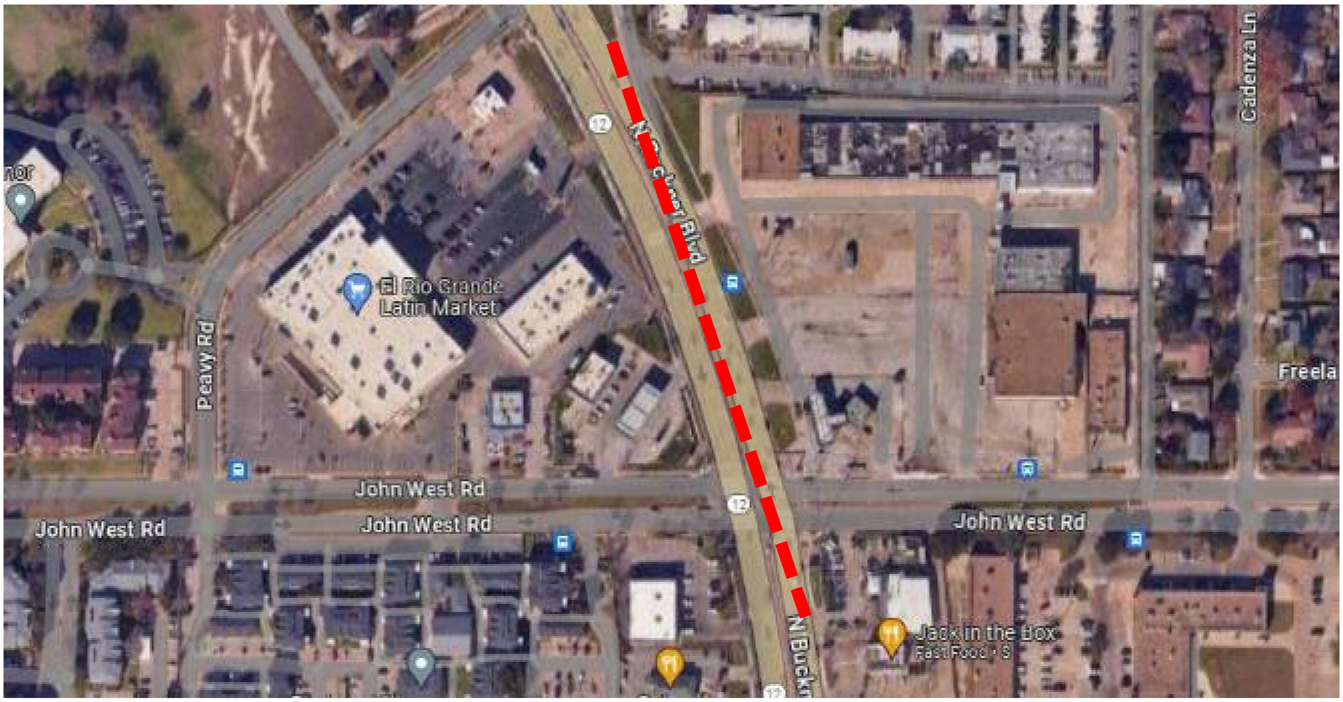


Figure 4-33. N. Buckner Blvd. x John West Rd.

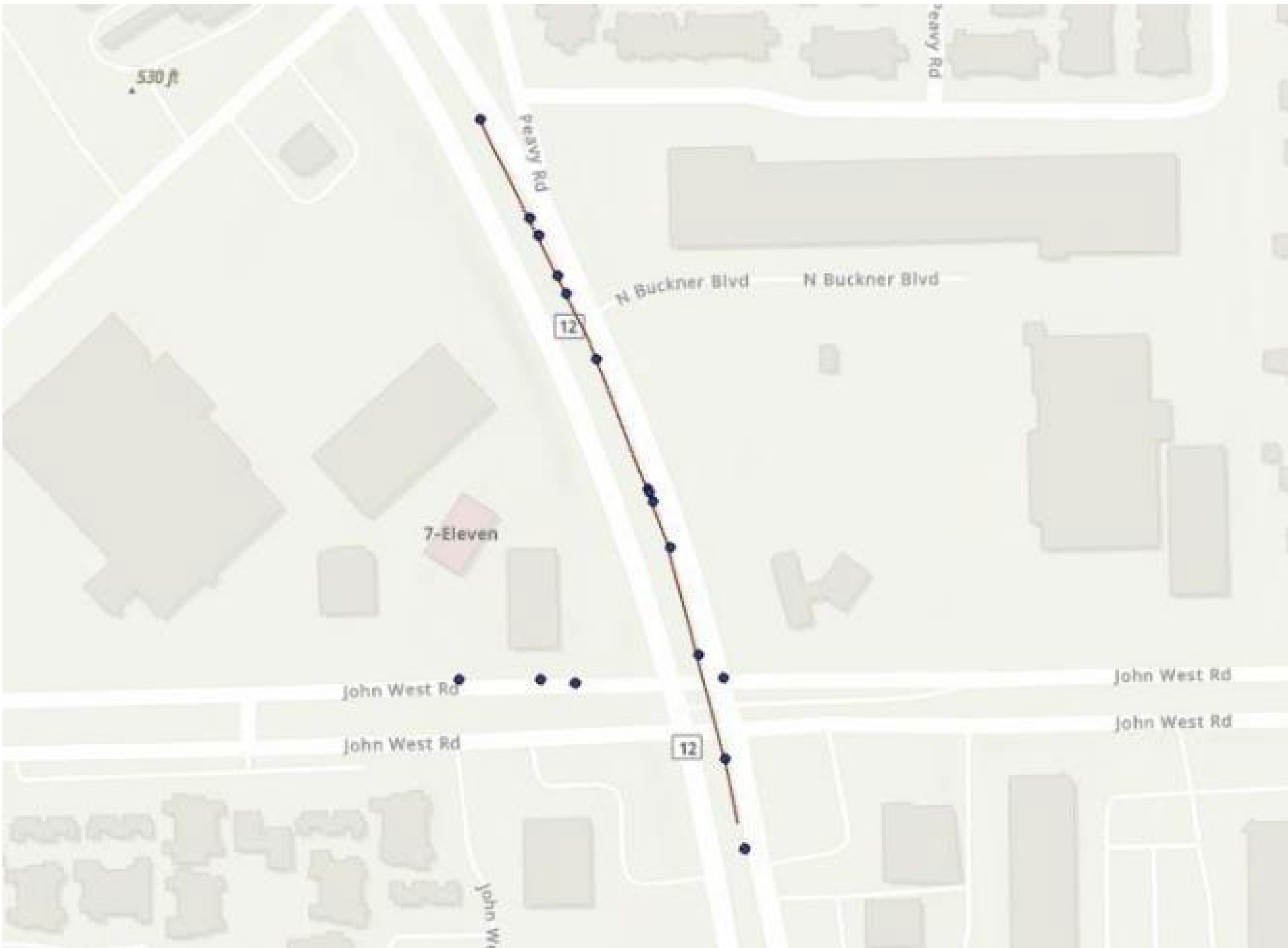


Figure 4-34. Crash map of N. Buckner Blvd. x John West Rd.

CRIS DATA SUMMARY:

- Saturdays and Sundays are the days with the highest number of crashes.
- The morning between 5:00 am – 12:00 p.m. and at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 1 case of INTOXICATED - ALCOHOL [1_ID], INTOXICATED - DRUG [2_ID], 2 cases of FAILED TO YIELD AND STOP RIGHT OF WAY - TURN ON RED [1_ID]

8. Park Ln. x Greenville Ave.

Coordinates: 32°52'18.8"N 96°45'57.6"W

The strip is located along Vickery Park Library, Greenville Plaza, and EL Centro supermarket. Multiple restaurants can be noted, and a 7-Eleven gas station can also be noted. There are two DART bus stops on opposite sides of the road. Additionally, there is a DART train station at the end of the strip.

Figure 4-35. Park Ln. x Greenville Ave.

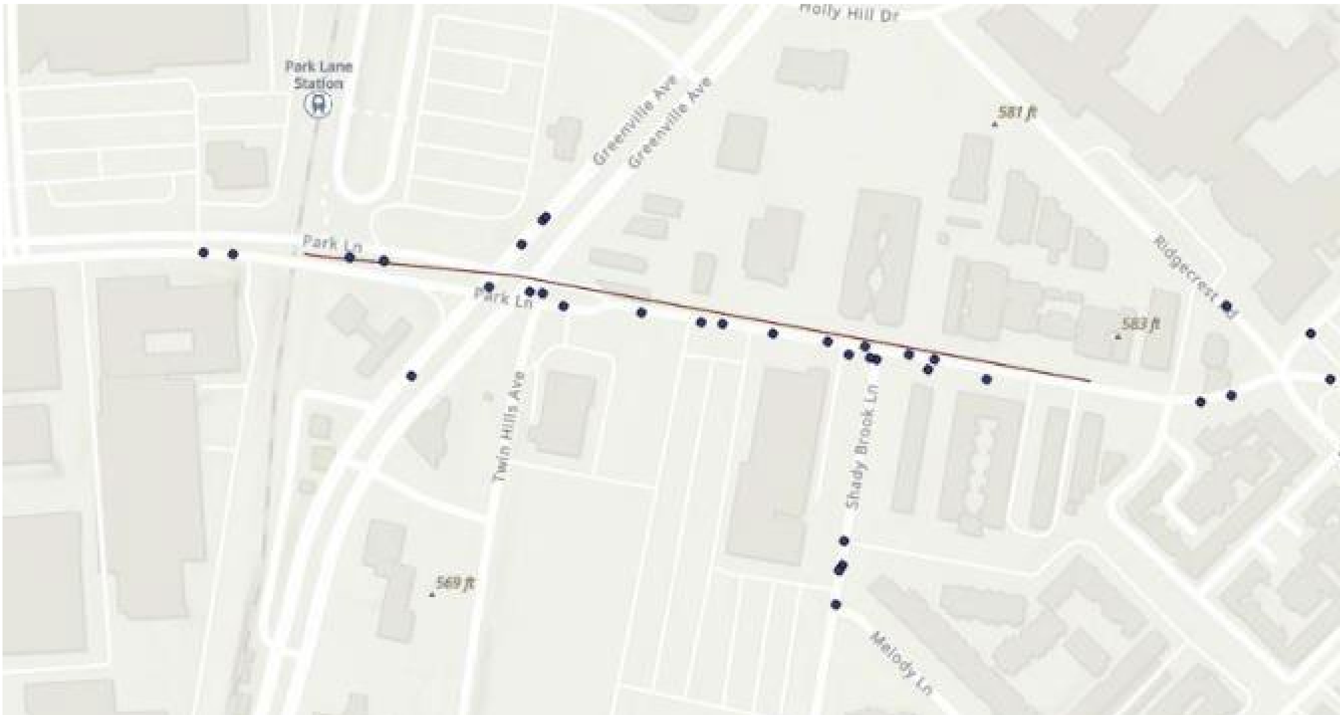


Figure 4-36. Crash map of Park Ln. x Greenville Ave.

CRIS DATA SUMMARY:

- Fridays and Saturdays are the days with the highest number of crashes.
- Crashes occurred at the same rate throughout the day.
- The strip had 1 case FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID], 1 case TURNED WHEN UNSAFE [1_ID], 1 case FAILED TO YIELD AND STOP RIGHT OF WAY - TURNING LEFT [1_ID], 1 case PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID], 1 case FLEEING OR EVADING POLICE [2_ID], and 1 case IMPAIRED VISIBILITY (EXPLAIN IN NARRATIVE) [1_ID].

9. Cedar Springs Rd. x Reagan St. and Knight St.

Coordinates: 32°48'35.7"N 96°48'35.4"W

The strip is in a mixed-use area and has plenty of bars and restaurants. A Walgreens, a UPS store, and a fire station. Two DART bus stops can be noted.

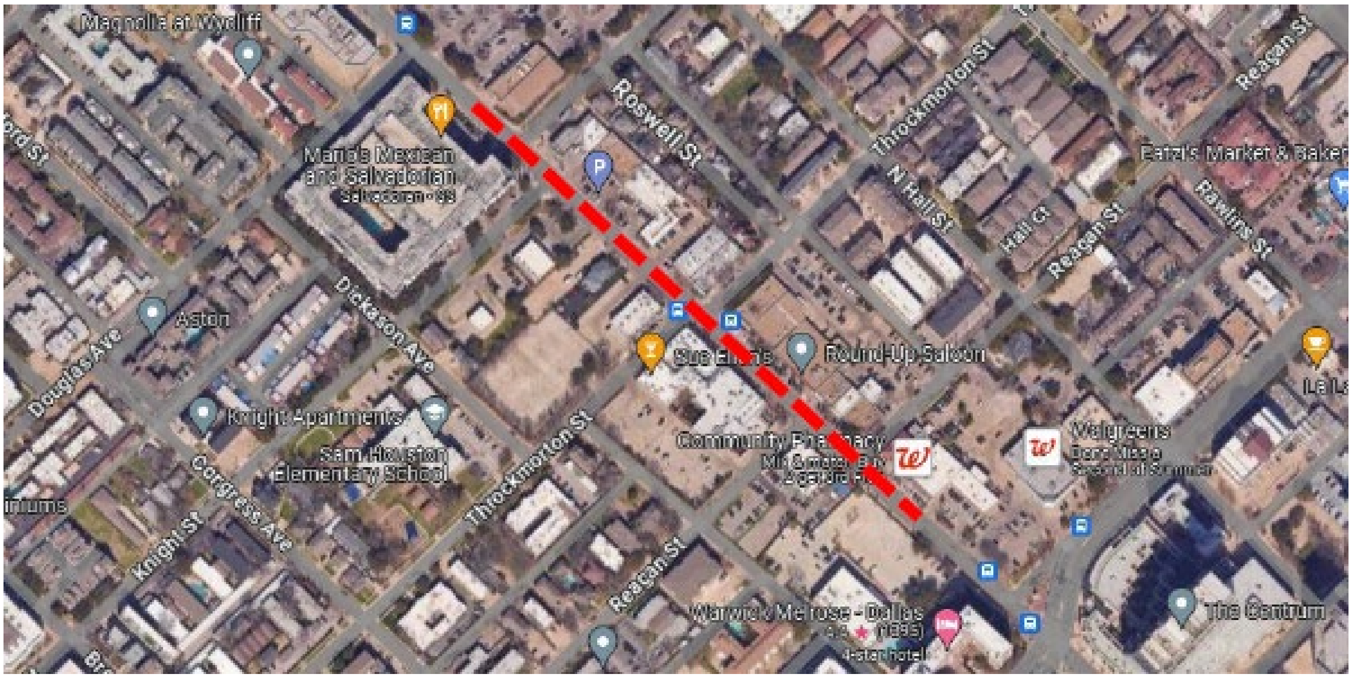


Figure 4-37. Cedar Springs Rd. x Reagan St. and Knight St.

Figure 4-38. Crash map of Cedar Springs Rd. x Reagan St. and Knight St.

CRIS DATA SUMMARY:

- Fridays and Sundays are the days with the highest number of crashes.
- Midnight between 12:00 - 5:00 am. And at night between 8:00 p.m. – 12:00 a.m. are the hours with the highest number of crashes.
- The strip had 6 cases of FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID], 1 case of DRIVER INATTENTION [P1_ID] 1 case TURNED WHEN UNSAFE [1_ID], 1 case FAILED TO CONTROL SPEED [1_ID] 1 case TURNED WHEN UNSAFE [1_ID] 2 cases INTOXICATED - ALCOHOL [1_ID].
- There is a significant number of drivers who failed yielding and stopping for pedestrians, indicating there might be a visibility issue.

10. W Northwest Hwy x Community Dr and Starlight Rd

Coordinates: 32°51'27.2"N 96°52'23.5"W

The strip is in a mixed-use area with multiple restaurants, two clinics, two gas stations, a law office ,and an American Bank. No bus stops along the strip.

Figure 4-39. W. Northwest Hwy. x Community Dr. and Starlight Rd.

Figure 4-40. Crash map of W. Northwest Hwy. x Community Dr. and Starlight Rd.

CRIS DATA SUMMARY:

- Saturdays and Wednesdays are the days with the highest number of crashes.
- The evening between 5:00 – 8:00 p.m. and morning between 12:00 a.m. – 12:00 p.m. are the hours with the highest number of crashes.
- TURNED WHEN UNSAFE [1_ID] FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID] FAILED TO CONTROL SPEED [1_ID], IMPAIRED VISIBILITY (EXPLAIN IN NARRATIVE) [P1_ID] FAULTY EVASIVE ACTION [1_ID]

HOUSTON TOP 10 HOTSPOTS

1. Addicks-Howell Rd x Piping Rock Ln

Coordinates: 29°44'29.0"N 95°38'39.3"W

The strip is surrounded by commercial areas from both sides, with one side being mixed with residential. The strip has one big plaza that has stores like Ross Dress for Less, Best Buy, pOpshelf, and multiple restaurants can be seen on the opposite side of the plaza. There is also 1 hotel that can be noted. No bus stops at this strip.

Figure 4-41. Addicks-Howell Rd. x Piping Rock Ln.

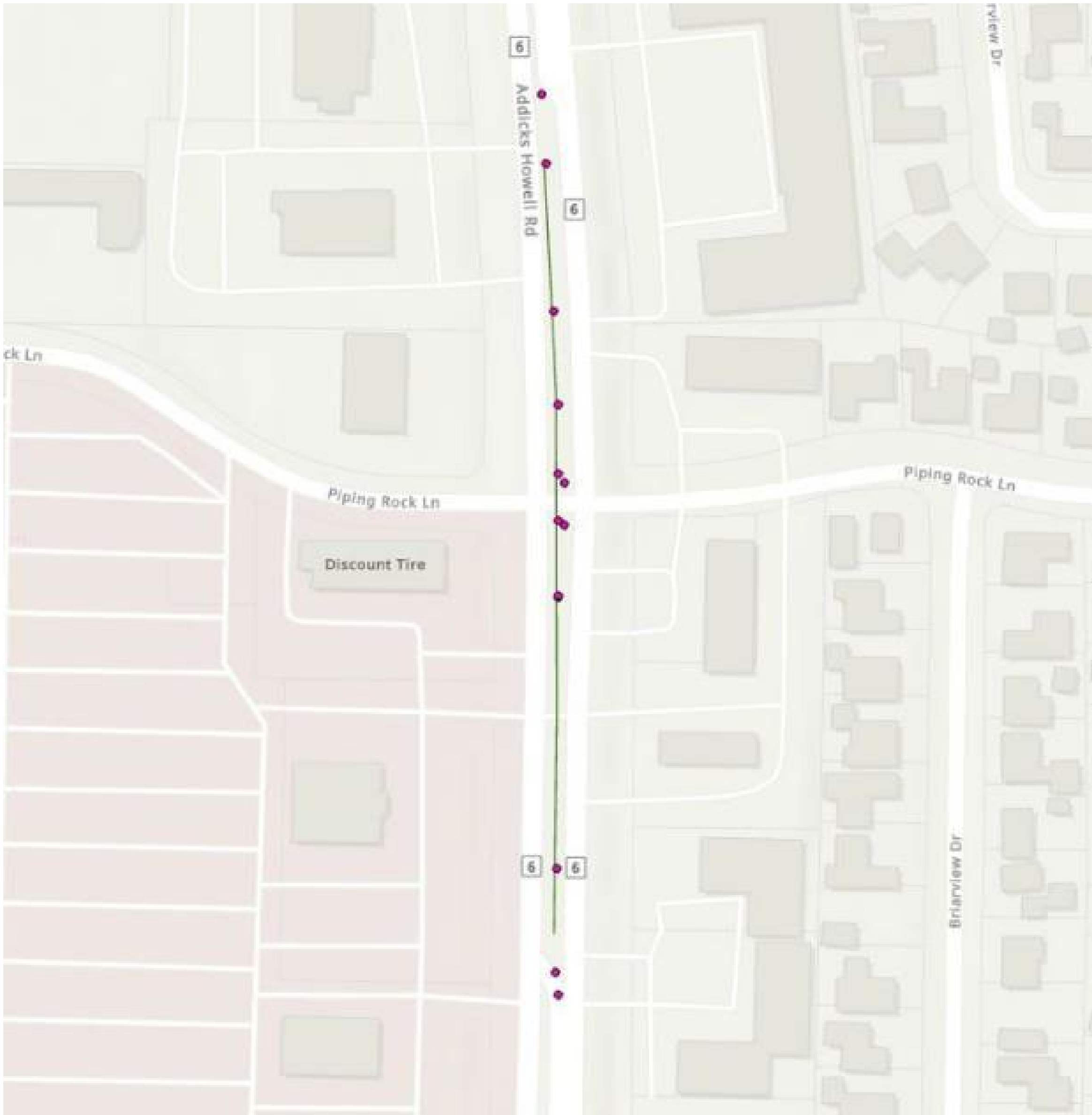


Figure 4-42. Crash map of Addicks-Howell Rd. x Piping Rock Ln.

CRIS DATA SUMMARY:

- 3 crashes each occurred on the following days, Tuesday, Sunday, and Thursday.
- The highest number of crashes occurred at night between 8:00 p.m. – 12:00 a.m.
- Some of the contributing factors include: 10 CASES OF PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID] and 1 case of INTOXICATED - DRUG [P1_ID].

2. Beechnut St. x Wilcrest Dr.

Start Coordinates: 29°41'21.2"N 95°33'49.6"W

The strip is surrounded by multiple plazas and a mall, most notably Wazobia African Market. There are plenty of restaurants, a Valero gas station, a Walgreens, and an immigration firm. The strip has five Metro bus stops.

Figure 4-43. Beechnut St. x Wilcrest Dr.

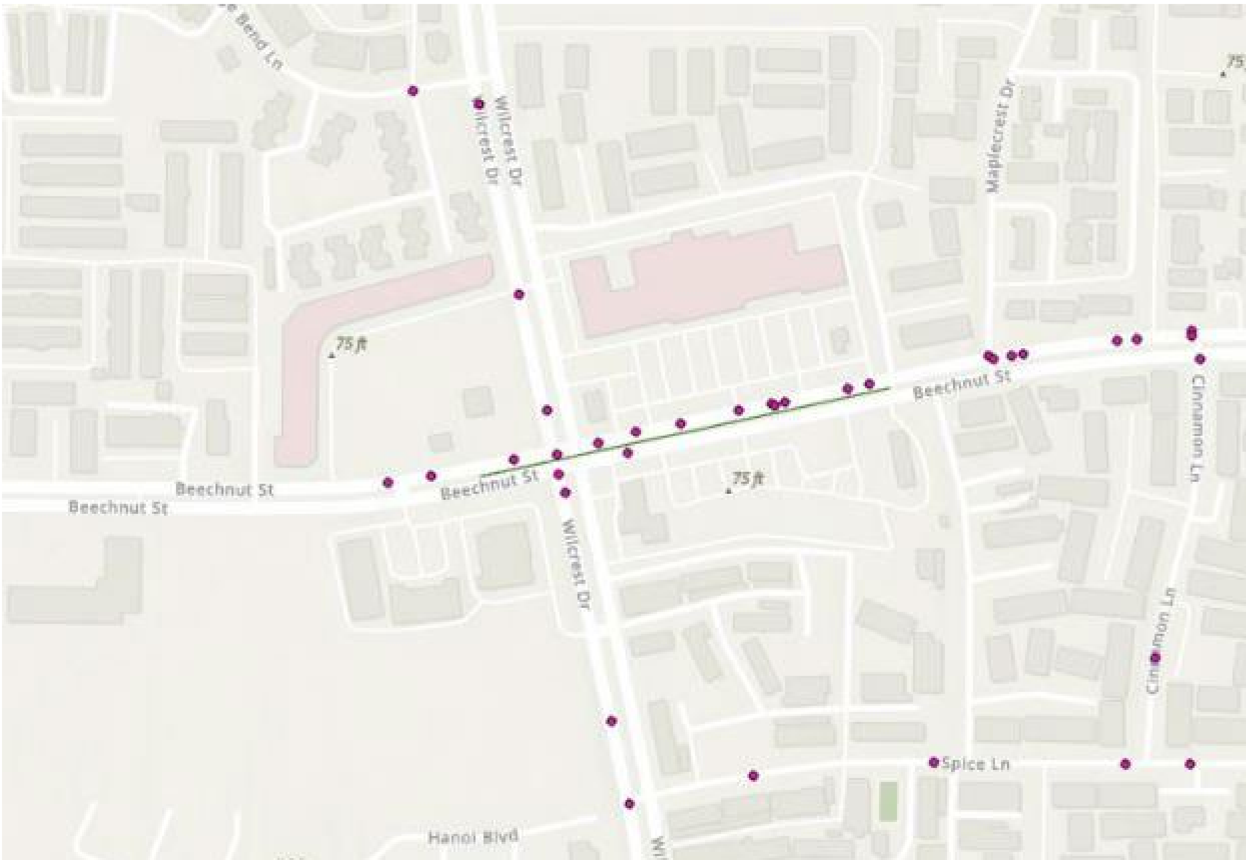


Figure 4-44. Crash map of Beechnut St. x Wilcrest Dr.

CRIS DATA SUMMARY:

- Most crashes occurred on Saturdays.
- Most crashes occurred in the afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m.
- Among the highest contributing factors are 8 cases PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID] followed by 2 cases FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID] And 1 case INTOXICATED - ALCOHOL [1_ID].

3. Belfort Ave. x Broadway St .

Coordinates: 29°40'20.5"N 95°16'37.7"W

The strip is surrounded by commercial areas. Belfort Street KinderCare is located close to the strip. The strop has 1 plaza and is near a Shell gas station, a UPS access point, multiple restaurants, and a Walgreens. There are four metro bus stops on the strip.

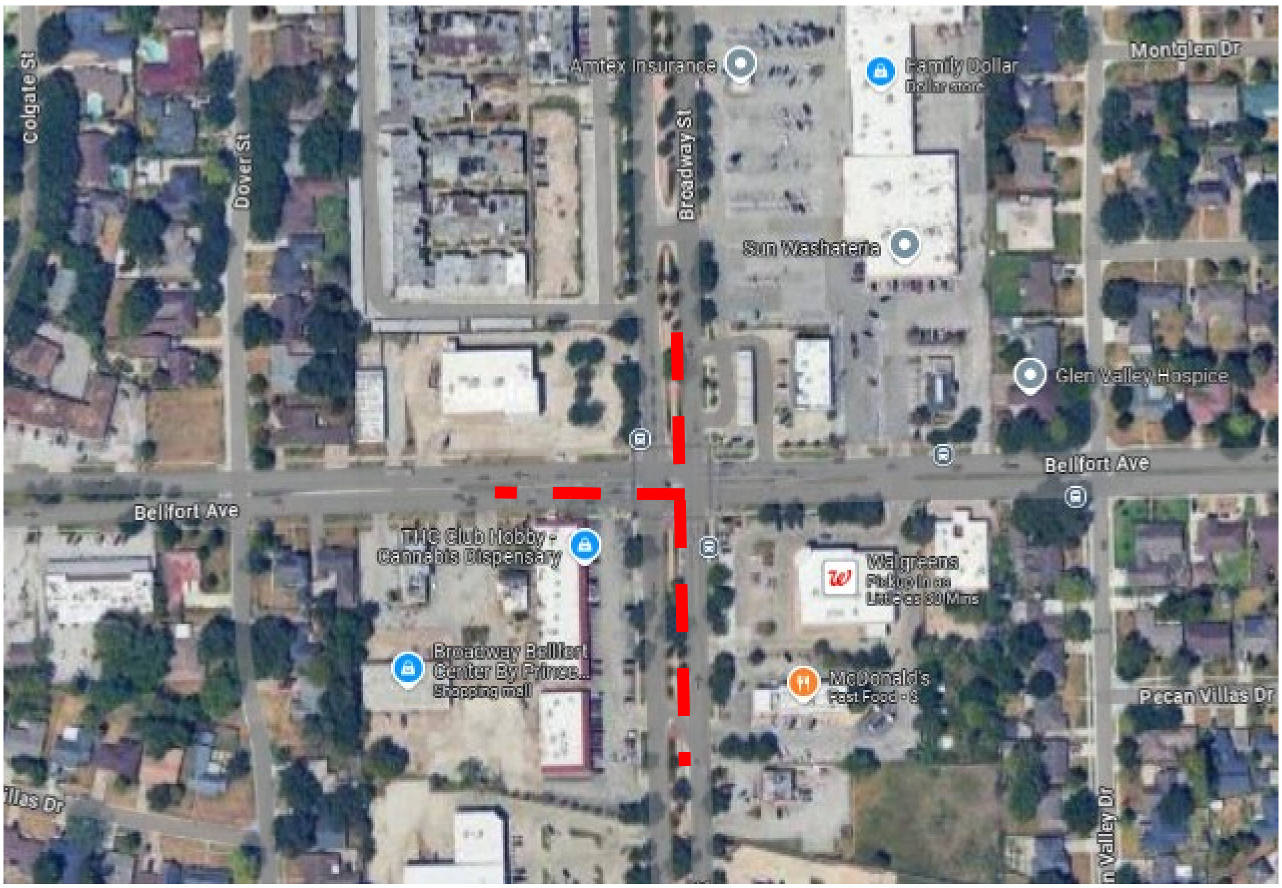


Figure 4-45. Belfort Ave. x Broadway St.

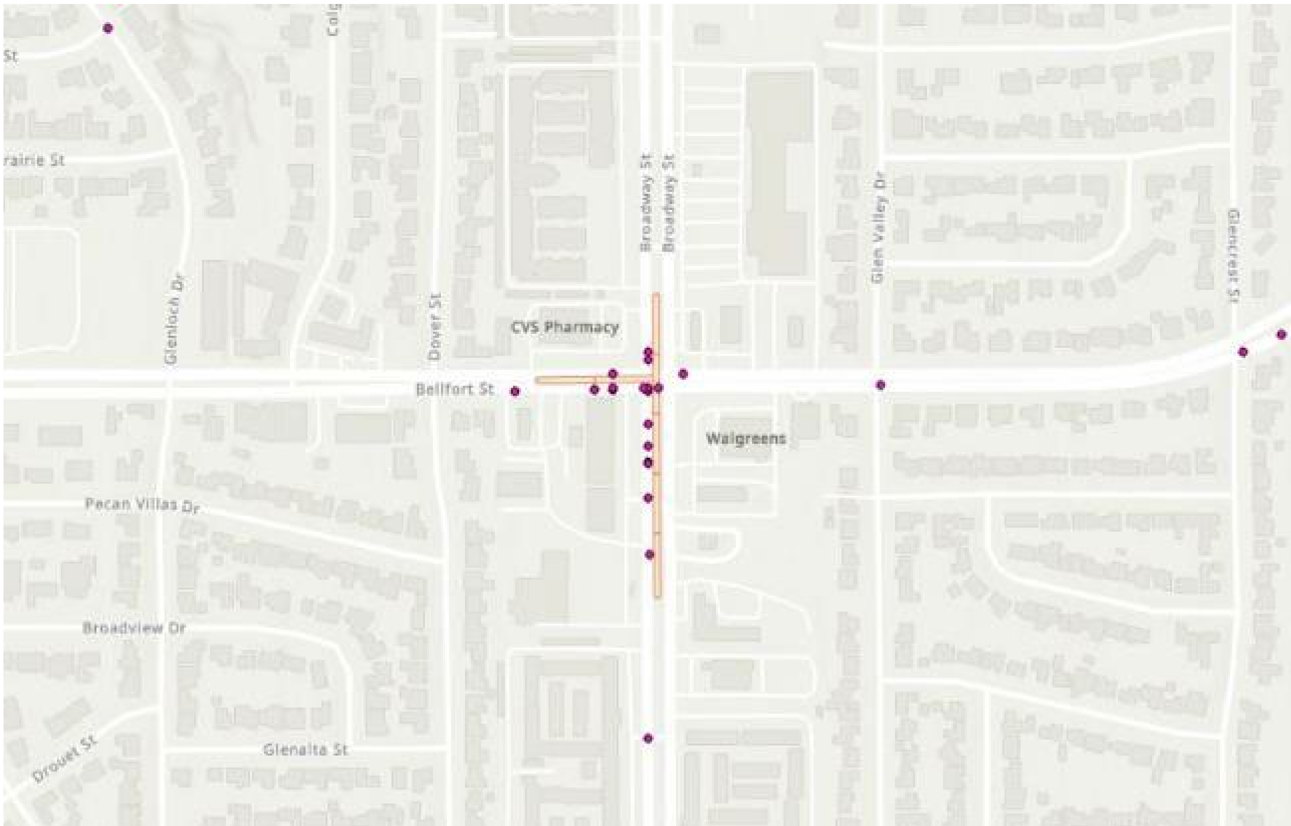


Figure 4-46. Crash map of Belfort Ave. x Broadway St.

CRIS DATA SUMMARY:

- Most crashes occurred on Wednesdays and Thursdays.
- Most crashes occurredin the afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m.
- Among the highest contributing factors are 6 PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID], 1 FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID], FLEEING OR EVADING POLICE [1_ID], FAILED TO DRIVE IN SINGLE LANE [1_ID] and 1 HAD BEEN DRINKING [1_ID].

4. S Gessner Rd. x Town Park Dr. and Sands Point Dr.

Coordinates: 29°42'56.2"N 95°32'20.2"W

The strip is in a mixed area where one side of the road is fully residential, the opposite sight has the Town Park Plaza, which contains a butcher shop, 99 cents and more stores, a Western Union, and multiple restaurants. There is a Metro bus stop on the side of the plaza.

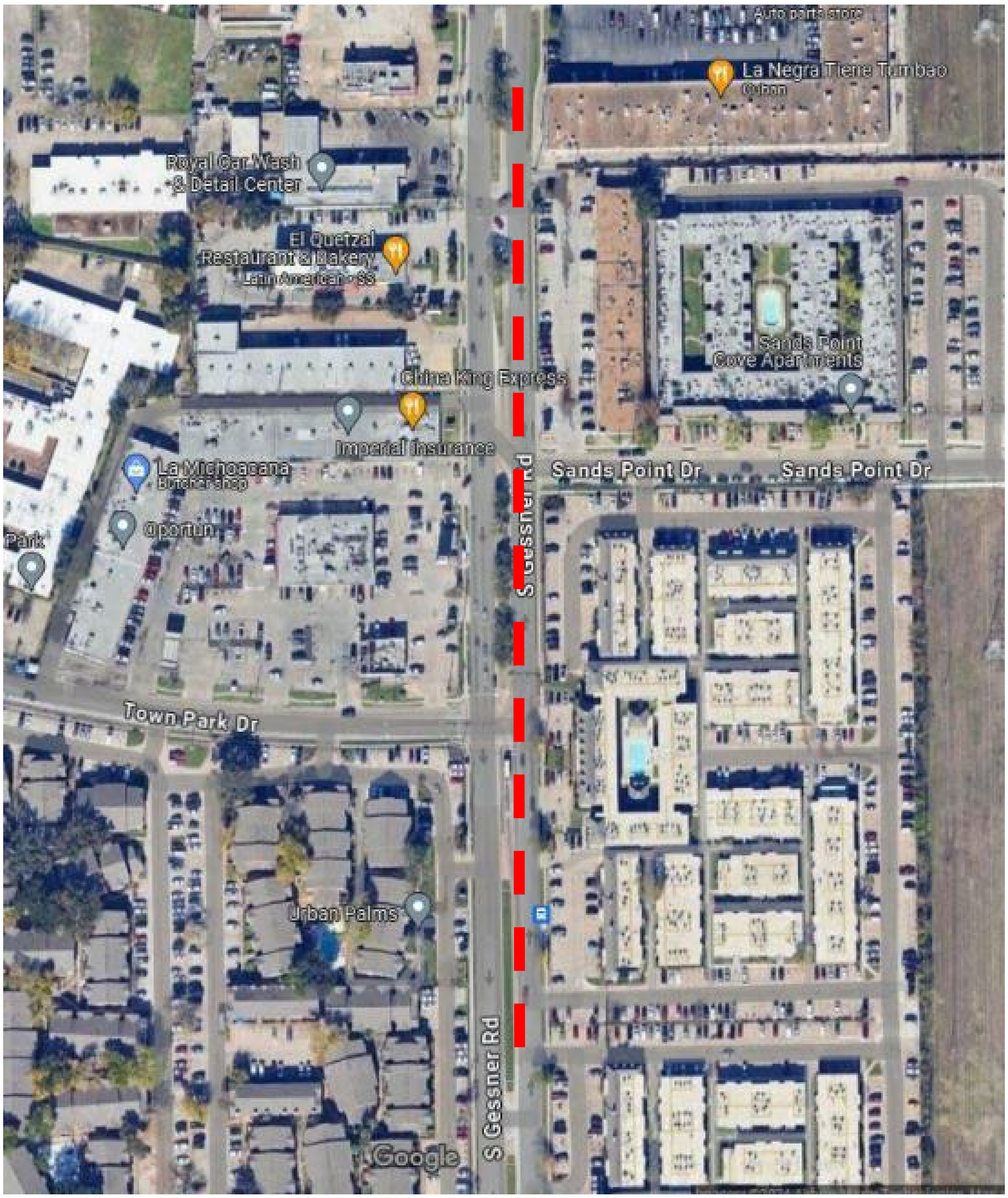


Figure 4-47. S. Gessner Rd. x Town Park Dr. and Sands Point Dr.

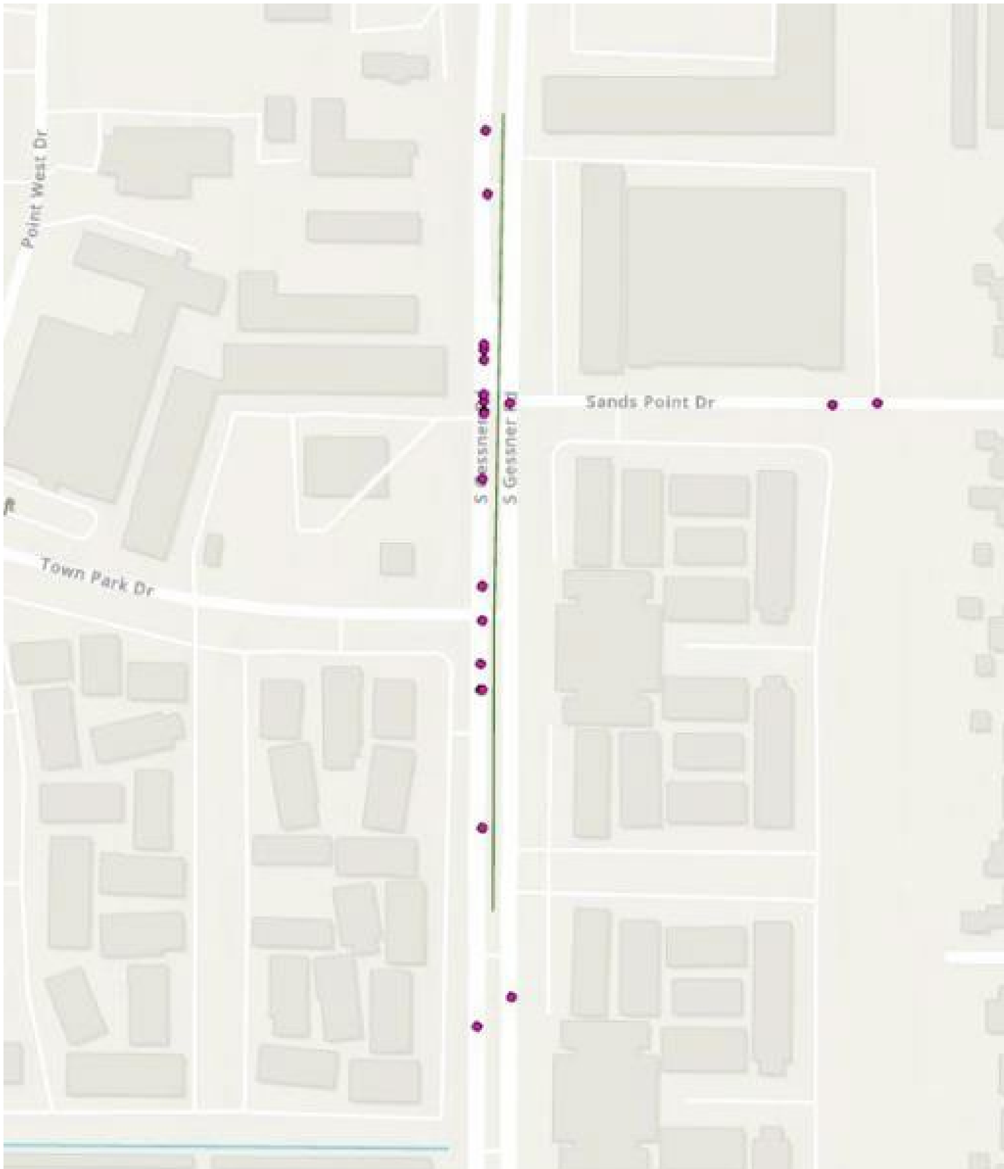


Figure 4-48. Crash map of S. Gessner Rd. x Town Park Dr. and Sands Point Dr.

CRIS DATA SUMMARY:

- Most crashes occurred on Saturday and Sundays.
- Most crashes occurred in the afternoon between 12:00 – 5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m.
- The most common contributing factor is PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID] followed by FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID] and finally INTOXICATED - ALCOHOL [2_ID].

5. Westheimer Rd. x S Voss Rd. and Hillcroft Ave.

Start Coordinates: 29°44'15.1"N 95°30'30.7"W

The strip is surrounded by commercial areas from both sides and contains two shopping plazas. Namely stores such as Ross Dress for Less, Dollar Tree, and Petco. The strip has a number of restaurants and eight Metro bus stops.

Figure 4-49. Westheimer Rd. x S. Voss Rd. and Hillcroft Ave.

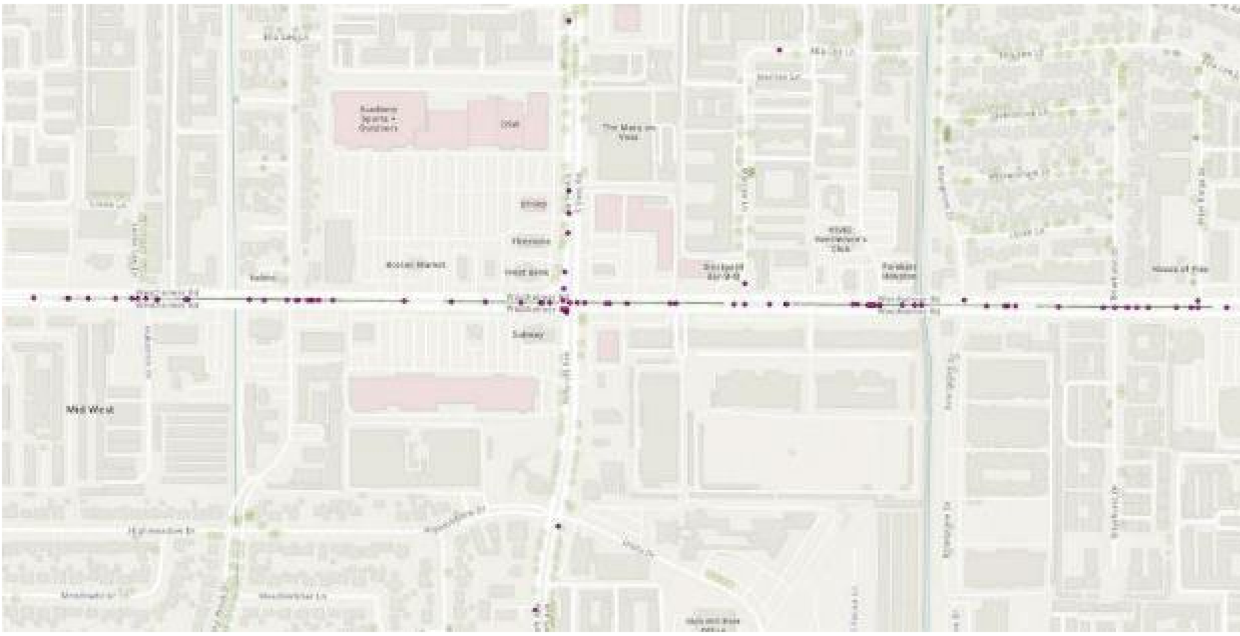


Figure 4-50. Crash map of Westheimer Rd. x S. Voss Rd. and Hillcroft Ave.

CRIS DATA SUMMARY:

- A lot of crashes that occurred almost equally throughout the entire Week.
- Crashed occurred throughout the day. but the majority were at night and afternoon, with still a significant number of crashes occurring after midnight and early morning.
- The contributing factors were a mix of PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID] with some cases having the secondary case of INTOXICATED - ALCOHOL [P1_ID] and finally FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID].

6. I-610 x S. Main St.

The strip is located next to two hotels and an RV park. A medical plaza having a pharmacy and multiple healthcare facilities located opposite to the hotels. A Chevron and a Whataburger also can be noted. There are two Metro bus stops on both sides of the road.

Figure 4-51. I-610 x S. Main St.

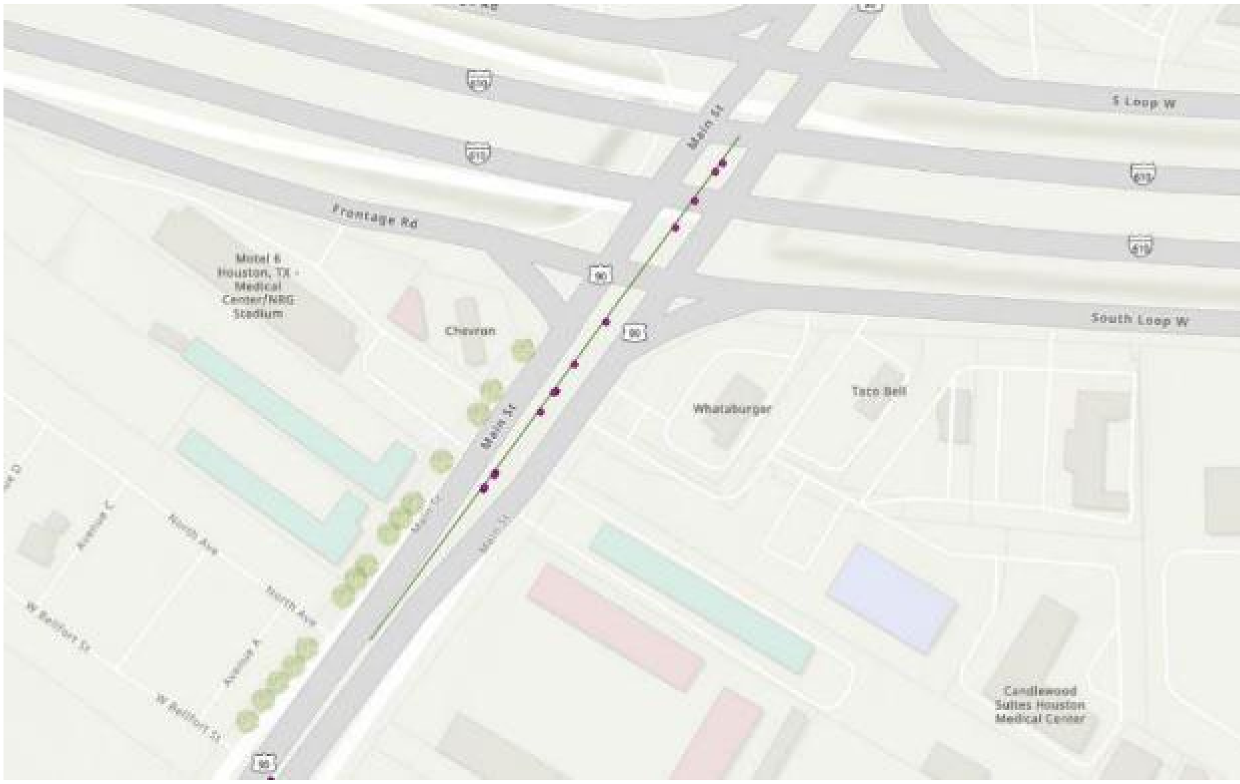


Figure 4-52. Crash map of I-610 x S. Main St.

CRIS DATA SUMMARY:

- Most crashes occurred on Fridays and Wednesdays.
- Most crashes occurred in the afternoon between 12:00-5:00 p.m. And at night between 8:00 p.m. – 12:00 a.m.
- The ost contributing factor across the whole strip is PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID].

7. Main St. x Richmond Ave. and Wheeler St. (MB)

Coordinates: 29°44'03.9"N 95°22'57.9"W

The strip has Houston Neuropsychiatric clinics, an ion prototyping lab, and Midtown Terrace Suites. The strip is also located near Wheeler Metro station and two metro bus stops.

Figure 4-53. Main St. x Richmond Ave. and Wheeler St.

Figure 4-54. Crash map of Main St. x Richmond Ave. and Wheeler St.

CRIS DATA SUMMARY:

- Most crashes occurred on Tuesdays and Wednesdays.
- Most crashes occurred in the afternoon between 12:00-5:00 p.m. and some crashes occurred in the early morning, 6:00-8:00 a.m.
- The highest contributing factor was PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID].

8. Airport Blvd. x Dover St.

Coordinates: 29°39'28.3"N 95°16'48.3"W

The strip is located near an airport mainly surrounded by airport parking lots; nearby Aviation Institute of Maintenance and Quality Suites can be noted. Two Metro bus stop on both sides of the road.

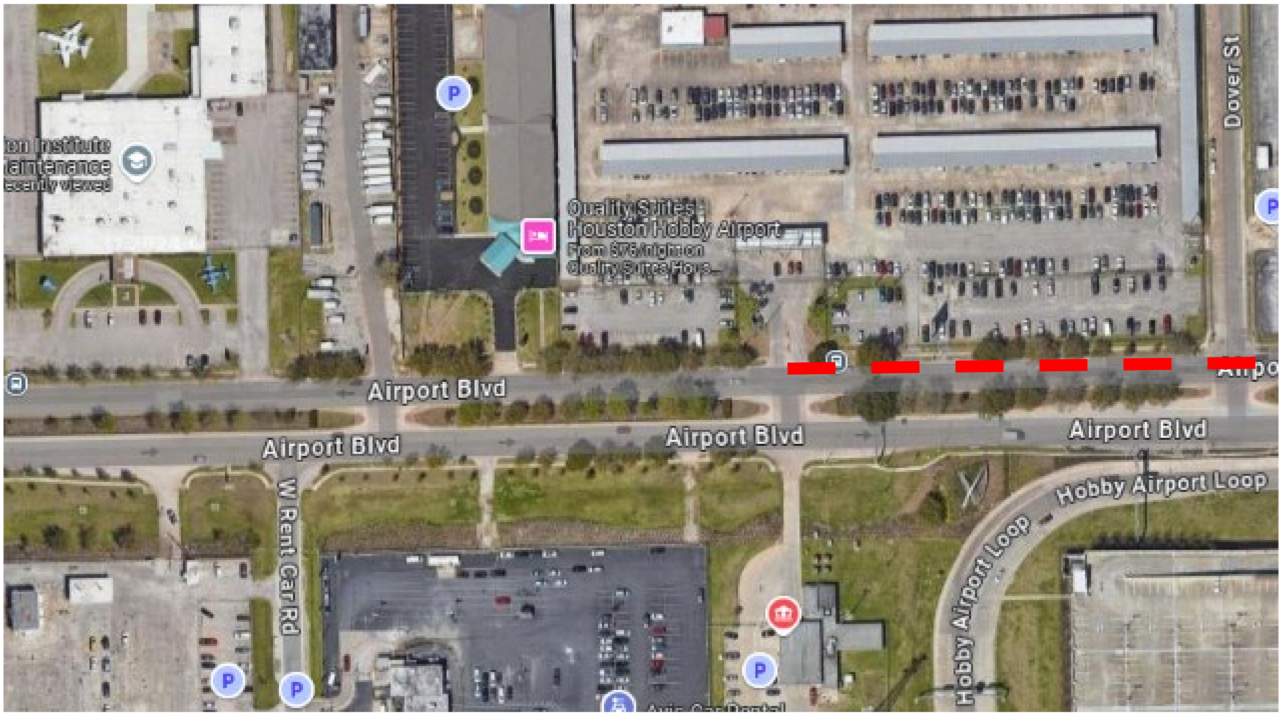


Figure 4-55. Airport Blvd. x Dover St.

Figure 4-56. Crash map of Airport Blvd. x Dover St.

CRIS DATA SUMMARY:

- Most crashes occurred on Sunday and Friday
- Most crashes occurred at Morning between 6:00 a.m. – 12:00 p.m. and in the afternoon between 12:00 – 5:00 p.m. with a smaller number of crashes occurring in the morning.
- Contributing factors include PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID], FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID] and DRIVER INATTENTION [1_ID].

9. Airline Dr. x Sylvester Rd.

Coordinates: 29°48'49.3"N 95°22'57.0"W

The strip is located near a mixed-use area and has relatively fewer activities. The main notable landmarks are Big Texas Dental Exxon Gas station, a Jack in the Box, and Fiesta Inn. Two Metro bus stops can be noted.

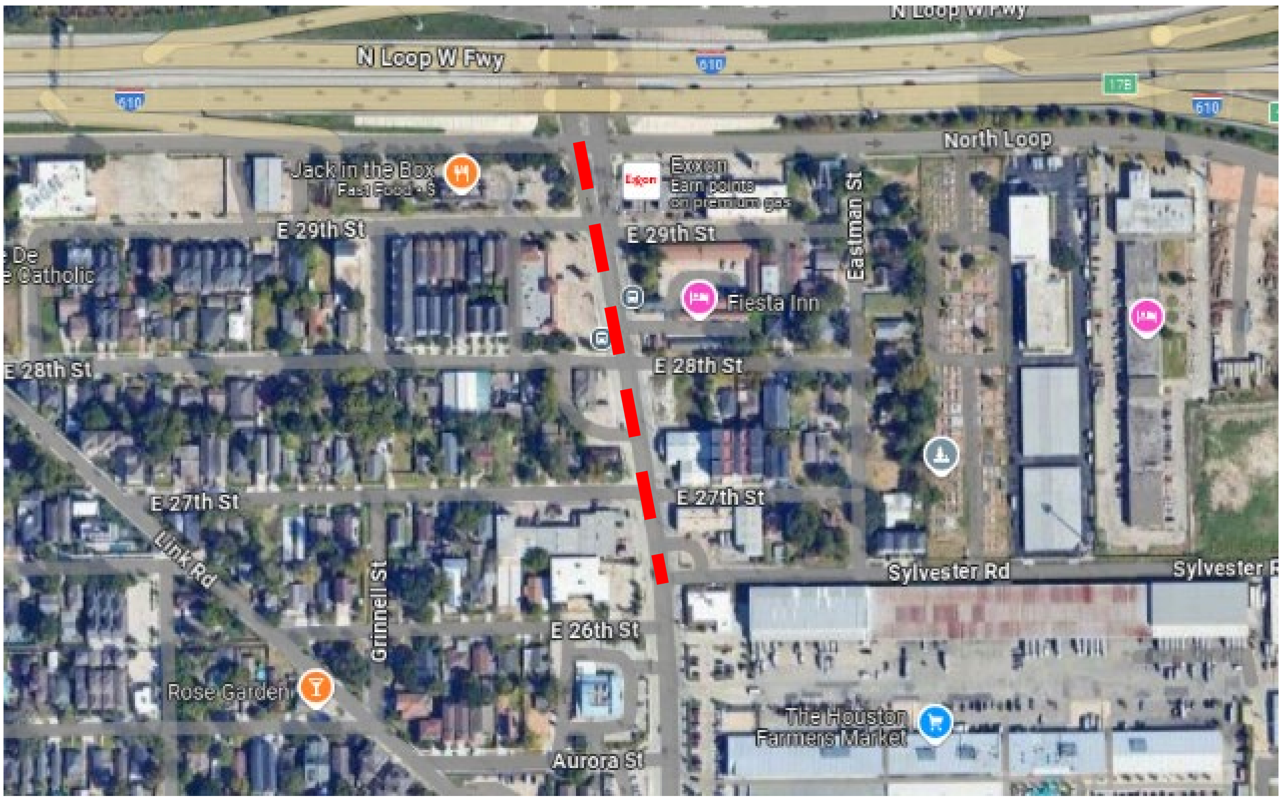


Figure 4-57. Airline Dr. x Sylvester Rd.

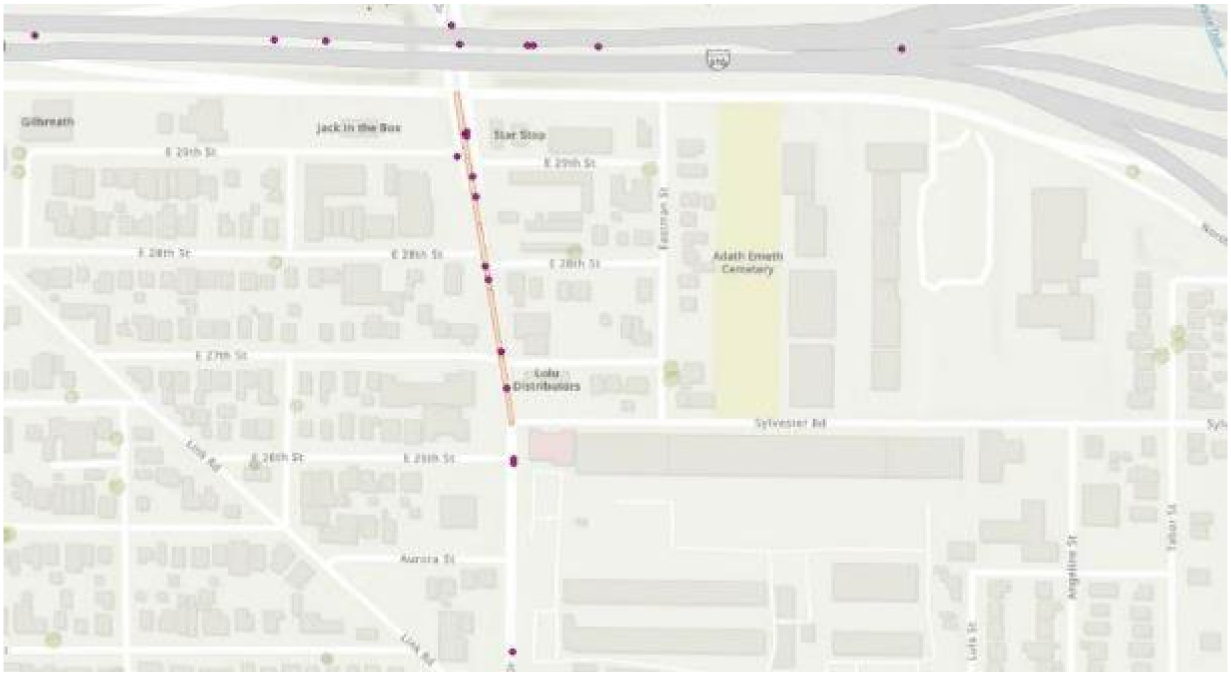


Figure 4-58. Crash map of Airline Dr. x Sylvester Rd.

CRIS DATA SUMMARY:

- Most crashes occurred on Tuesdays and Thursdays.
- Most crashes occurred in the morning between 8:00-11:00 a.m. and at night between 8:00 p.m. – 12:00 a.m.
- The most common contributing factors are 5 PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID] and 1 FAILED TO YIELD AND STOP RIGHT OF WAY - TO PEDESTRIAN [1_ID].

10. Federal Rd.

Coordinates: 29°46'37.6"N 95°13'06.7"W

The strip is in a mixed-use area. With a plaza containing PLS check cash, a restaurant, and a laundromat, the opposite side has a flea market, La familia auto insurance, and Tax Services.

Figure 4-59. Federal Rd.

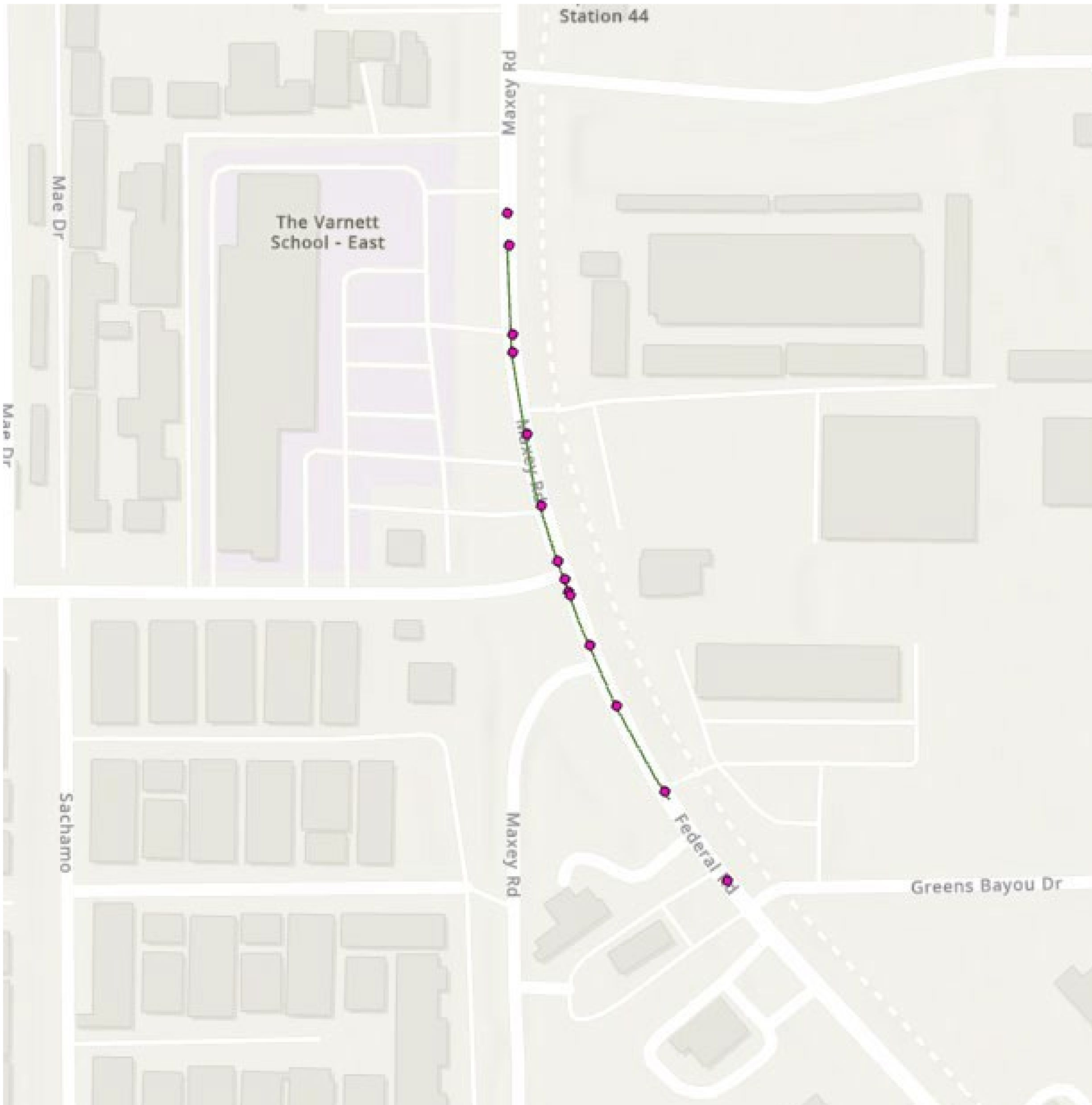


Figure 4-60. Crash map of Federal Rd.

CRIS DATA SUMMARY:

- Most crashes occurred on Saturdays and Sundays.
- Most crashes occurred in the afternoon between 12:00-5:00 p.m. and at night between 8:00 p.m. – 12:00 a.m.
- The ost common contributing factor is PEDESTRIAN FAILED TO YIELD AND STOP RIGHT OF WAY TO VEHICLE [1_ID] with a secondary factor INTOXICATED - ALCOHOL [2_ID].

SITE ASSESSMENT METHODOLOGY

This section summarizes the assessment methodology conducted to evaluate road characteristics and pedestrian/driver behavior at a specified location. The assessment methodology aimed to gather detailed information on the physical layout and conditions of the road, as well as to observe and record interactions between pedestrians and vehicles. Intersection information is included to help provide the needed context for understanding midblock jaywalking and other phenomena related to midblock crashes.

ROAD CHARACTERISTICS

The following road characteristics were assessed:

1. **Two-Way Street? (Y/N)**
2. **Marked or Unmarked Crosswalk?**
3. **Crosswalk Sign at the Intersection (Type)**
4. **Crosswalk Sign in Advance of the Intersection (Y/N)?**
5. **Bulb-out/Curb Extension (Y/N)?**
6. **Number of Travel Lanes Being Crossed?**
7. **On-Street Parking (Y/N)?**
8. **Nearside Bus Stop Near the Intersection (Y/N)?**
9. **Far side Bus Stop Near the Intersection (Y/N)?**
10. **Right-Turn Lane in the direction of the Traffic at the Intersection (Y/N)?**
11. **Left-Turn Lane in the Intersection of Traffic at the Intersection (Y/N)?**
12. **Curb Extension in the Direction of the Pedestrian Crossing (Y/N)?**
13. **Median in the Direction of the Pedestrian Crossing (Y/N)?**
14. **Speed Limit in the Direction of the Traffic Being Studied (miles per hour)**
15. **School Zone or Specific Land Use.**
16. **Quality of Pavement.**
17. **Marking Quality.**
18. **Signals Exist?**
19. **Illumination Exist?**
20. **Road Characteristics.**
21. **Signage Quality.**
22. **Vegetation and Trees Blocking Sign (Y/N)?**
23. **Pedestrian Buttons Functional (Y/N)?**

PEDESTRIAN AND DRIVER BEHAVIOR

The assessment also focused on various aspects of pedestrian and driver behavior, including:

1. **Number of Cars That Drove Through Crosswalk Without Yielding and stopping (Total)**
2. **Driver Yielded to the Pedestrian? (Y/N)**
3. **Group Size**
4. **Number of Pedestrians at the Curb**
5. **Physical Disability (wheelchair/walker/other): Record if the Pedestrian Has a Physical Disability**
6. **Number of Pedestrians Attempting to Cross the Intersection During Observation Period**
7. **Directions of Pedestrian Crossings: Marked Crosswalk vs. Jaywalking**
8. **Number of Occasions First Car Stopped for Waiting Pedestrian**
9. **Mean Length of Time Pedestrians Waited to Cross in Seconds**
10. **Pedestrian Gender**
11. **Driver Behavior Based on Group Size: Individual vs. Two or More Pedestrians**
12. **Driver Behavior Based on Vehicle Type**
13. **Bus Stop Activity/Usage**

In addition, notes were recorded for each hotspot location on specific observed patterns/behaviors that were observed for that hotspot.

RECORDING METHODS

Driver/pedestrian behavior on the road was recorded using REDTIGER 4K dash cams Figure 4-61 through a vehicle while posted up on different parts of the hotspot segment. Based on CRIS data, most crashes occurred in the afternoon and night. The observations focused on the mentioned time ranges, for a period of 1.0 to 2.0 hours. In the afternoon and the night. The camera is usually pointed at the strip; if pedestrian activity is focused elsewhere in the vicinity, the focus is then changed to that area Figure 4-62 shows recorded jaywalking behavior exhibited by pedestrians.

Figure 4-61. Dash cam REDTIGER 4K.

Figure 4-62. Pedestrian jaywalking recorded at midblock.

The pedestrian jaywalking is then assessed, and a pattern map is made of the common directions the pedestrians are jaywalking to and from as shown in Figure 4-63.

Figure 4-63. Example of pedestrian jaywalking pattern map.

SAN ANTONIO SITE ASSESMENT RESULTS

1. Fredericksburg Rd x Babcock Rd

DATE: 5-17-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (black, white contrast)
Crosswalk sign at the intersection (Type):	Signaled, Press button device all directions
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 (1 left turning lane, 1 right turn lane)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	40 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists and works
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Morning	Night
Time Start	8:30 AM	8:30 PM
Time End	11:00 AM	11:03 PM
Temperature	68 degrees °F	80 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	Mostly 1	Mostly 1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	Approx. 8 Comply 6 Jaywalked	Approx. 7 Comply 10 Jaywalked
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20 - 30 secs	20 - 30 secs
Pedestrian gender	Mostly male	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N/A	N/A
Bus stop activity/usage	2 or 3 at all 4 bus stops	1 or 2 at all 4 bus stops

Observation Notes:

In the morning, Cocina Mexicana experienced a significant queue of traffic on the street, and it had the highest number of people jaywalking to and from the restaurant. At night, most jaywalking occurred from Goodwill to Burger King and the nearby VIA bus stop. The skewed intersections at both Vance Jackson Rd. and Babcock Rd. possibly contribute to crashes at the intersection, as pedestrians often find themselves in the driver's blind spot while they turn.

Figure 4-64. Pedestrian jaywalking patterns at Fredericksburg Rd. x Babcock Rd.

2. Bandera Rd. x Zachry Dr.

DATE: 5-19-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	N/A
Crosswalk sign at the intersection (Type):	N/A
Crosswalk sign in advance of the intersection (Y/N):	N/A
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	7 (3 in each direction and a turning lane)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	40 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Visible
Signals exist	N/A
Illumination	Exists and works
Road characteristics	Flat
Signage quality	Only speed limit signage, good condition
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	N/A

Pedestrian/Driver behavior:	Morning	Night
Time Start	3:30 PM	8:30 PM
Time End	5:30 PM	10:00 PM
Temperature	93 °F	86 °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	N	N
Group size	Mostly 1	mostly 1 (1 size of 2)
Number of pedestrians at the curb	0	0
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	16 Jaywalk	12 Jaywalk
How many pedestrians attempted to cross the midblock/intersection during your observation period?	0	0
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	15~-0 secs	10-15 secs
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	Mostly male	Mostly male
Pedestrian gender	N	Pedestrians with kids waited longer
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N/A	N/A
Bus stop activity/usage	1 or less at both bus stops	1 or less at both bus stops

Observation Notes:

Pedestrians crossing the road waited longer during the afternoon due to higher traffic volumes. At night, 12 pedestrians crossed to Bandera Express from Oaks Apartments, with two instances involving children. Bandera Express appears to be the preferred destination for Oak’s residents seeking drinks and snacks. Most pedestrians used the turning lane as a refuge. The bus stops seemed to be underutilized, and the frequency of buses was low. Overall, drivers, both day and night, appeared to comply with the posted speed limits.

Figure 4-65. Pedestrian jaywalking patterns at Bandera Rd. x Zachry Dr.

3. SE Military Dr. x Spur 536 and Roosevelt Ave.

DATE: 5-22-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Normal white zebra crossing)
Crosswalk sign at the intersection (Type):	Signaled, Press button device all directions
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 (1 left turning lane, 1 slip right turn lane)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	40 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Slightly faded
Signals exist	Y
Illumination	Exists and works
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	N (only 4/8 were functional)

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	4:00 PM	8:30 PM
Time End	6:15 PM	9:45 PM
Temperature	95 degrees °F	86 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	N/A
Driver Yielded to the pedestrian? (Y/N):	Y (all right turning vehicles)	N/A
Group size	Mostly 1 (1 size of 3 and 1 size of 4)	Mostly 1 (1 size of 2)
Number of pedestrians at the curb	1 - 3	Mostly 1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	1
How many pedestrians attempted to cross the midblock/intersection during your observation period?	Around 25 Comply 6 Jaywalked	Around 13 Comply 1 Jaywalked
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	2 (At the slip lanes)	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	21 secs - 47 secs (worst case around 70 secs)	Around 20 secs
Pedestrian gender	3/4 male and 1/4 female	mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	3 or less at all 3 bus stops	1 or less at all 3 bus stops

Observation Notes:

In one instance, a pedestrian crossed the road diagonally on a green light, with cars yielding and stopping in both directions. Most crossings occurred back and forth between McDonald's and Exxon, near another bus stop. In most jaywalking instances, pedestrians waited for vehicles at the double yellow lines. There were fewer than three cases of jaywalking to and from the Exxon bus station, and a couple of cases of jaywalking occurred at the McDonald's bus stop. Some bus stops had signs that read "USE INTERSECTION."

Figure 4-66. Pedestrian jaywalking patterns at SE. Military Dr. x Spur 536 and Roosevelt Ave.

4. Rittiman Rd. x I-35 Frontage Rd.

DATE: 6-11-2024, 6-12-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Black and white contrast zebra)
Crosswalk sign at the intersection (Type):	Signaled, Press button device all directions
Crosswalk sign in advance of the intersection (Y/N):	N/A
Bulb-out/Curb extension (Y/N):	N/A
Number of travel lanes being crossed:	5 (1 turning lane)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N/A
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N/A
Curb extension in the direction of the pedestrian crossing (Y/N):	N/A
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	40 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Good
Signals exist	N/A
Illumination	Y (LED)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	N/A

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	5:00 PM	9:00 PM
Time End	6:33 PM	10:36 PM
Temperature	87 degrees °F	81 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	Y and N (one case of swerving 2 case yield and stop)	N/A
Group size	Mostly 1 (1 size of 2 and a dog)	Mostly 1
Number of pedestrians at the curb	Mostly 1	Mostly 1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	26 Jaywalked	18 Jaywalked
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	N/A	N/A
Pedestrian gender	Mix of both	A mix of both majority male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	3 or less at both stops	1 or less at both bus stops

Observation Notes:

Higher pedestrian activity was observed at night. Despite the presence of overhead lighting, the areas where jaywalkers crossed were darker, making them hard to see. There was significant jaywalking activity at night from Taco Cabana to Qubed Suites within a short period. Many jaywalkers used the elevated separator median as a refuge to cross the road during the afternoon and night. The strip had no intersections but many unsignaled driveway entrances to restaurants and gas stations. Homeless people were gathering under the I-35 bridges, and multiple beggars were spotted jaywalking, with one case of a beggar obstructing traffic. In many cases, both pedestrians and cyclists used the turning lane as a refuge. In the afternoon, pedestrians were more likely to sprint across the midblock crossing. One observed case involved a pedestrian disembarking from a bus stop on the Qubed side and jaywalking to Taco Cabana.

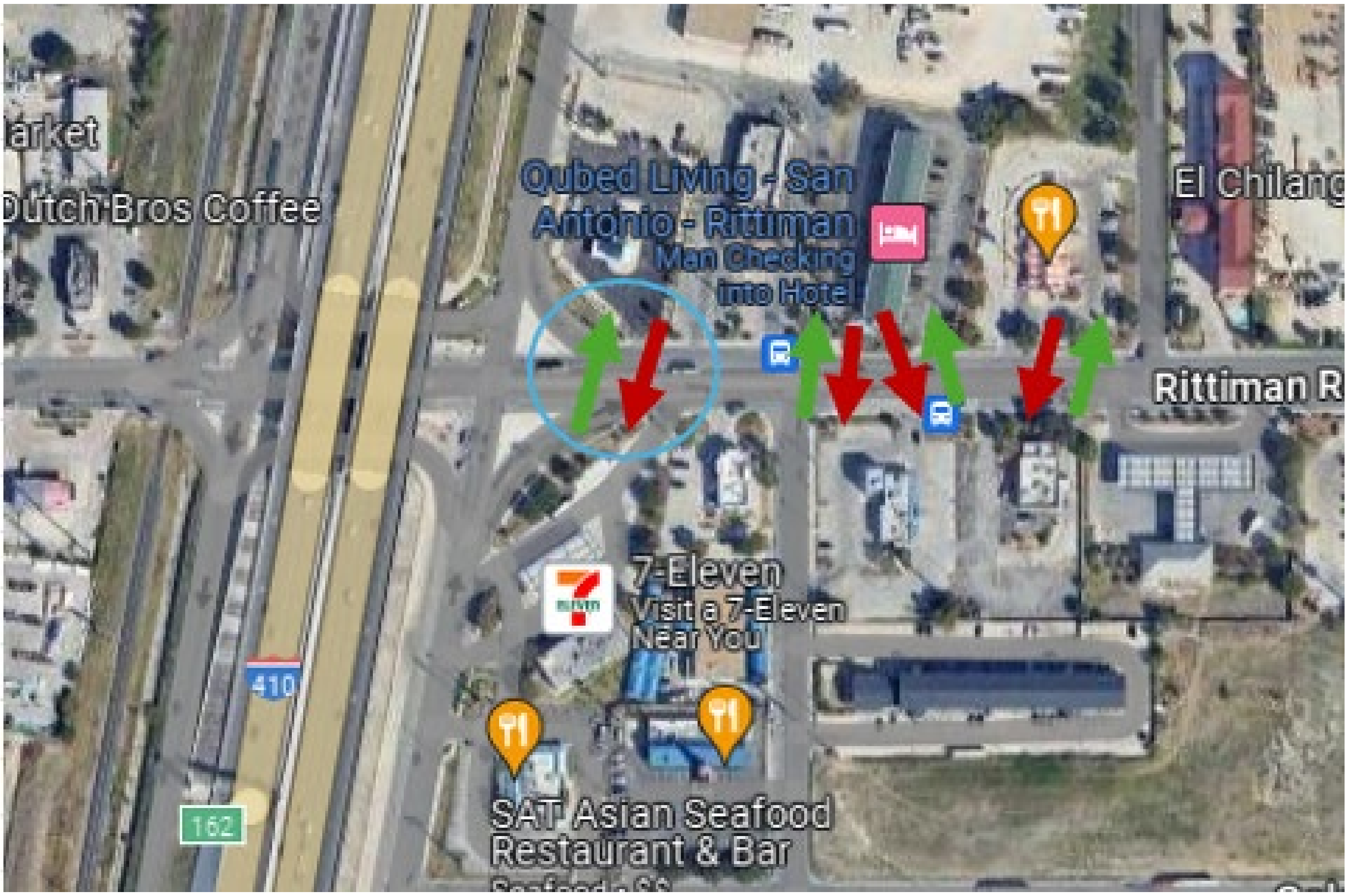


Figure 4-67. Pedestrian jaywalking patterns at Rittiman Rd. x I-35 Frontage Rd.

**The light blue circle marks the median pedestrians used to cross.*

5. S Zarzamora St x W Mayfield Blvd and SW Military Dr (Midblock Crossing)

DATE: 6-14-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Black and white contrast zebra)
Crosswalk sign at the intersection (Type):	Signaled press button pedestrian crossing (stop on red) and pedestrian crossing sign
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	7 (1 turning lane)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Faded
Signals exist	Exists, not functional at the time of observation
Illumination	Y (LED)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	N/A

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	5:00 PM	8:30 PM
Time End	6:30 PM	10:00 PM
Temperature	98 degrees °F	98 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	Mostly one	Mostly one
Number of pedestrians at the curb	Mostly one	Mostly one
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	14 Jaywalked	2 jaywalked
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	3 cars yielded to pedestrians using the crossing	2 cars yielded to pedestrians
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	N/A (Crossing buttons not functional)	N/A (Crossing buttons not functional)
Pedestrian gender	Mix of both	Mix of both
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	1 - 2 at both bus stops	2 - 4 more activity at HEB bus stop

Observation Notes:

Numerous pedestrians were observed jaywalking along the midblock crossing, with some specifically jaywalking from the HEB parking lot to Wells Fargo. The turning lane was frequently used as a refuge, with pedestrians jaywalking to the lane and then walking along it until reaching the midblock crossing, where they would cross to the other side. Drivers tend to slow down slightly near the midblock crossing and often yield and stop to pedestrians. However, pedestrians disembarking from buses often cross behind the bus without using the midblock crossing, instead walking alongside it. At night, there was less activity at the crossing but increased activity at bus stops. Despite the midblock crossing being well-lit and making pedestrians using it visible, it is still underutilized.

Figure 4-68. Pedestrian jaywalking patterns at S. Zarzamora St. x W. Mayfield Blvd. and SW. Military Dr.

6. Wurzbach Rd. x Gardendale Rd.

DATE: 6-16-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked crosswalk at the end of the strip
Crosswalk sign at the intersection (Type):	Press button signaled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 lanes
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	35 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Good
Signals exist	Exists And Functional
Illumination	Y (LED)
Road characteristics	Significant Vertical Slope
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	5:00 PM	8:20 PM
Time End	7:00 PM	9:45 PM
Temperature	103 degrees °F	97 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mix of 1 and 2 sometimes 2	Mostly 1
Number of pedestrians at the curb	Mix of 1 and 2 sometimes 3	Mostly 1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	17 Jaywalked	13 jaywalked
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	N/A	N/A
Pedestrian gender	Mostly Male	Mostly Male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	2 or less at both bus stops	1 or less at both bus stops

Observation Notes:

The strip has a vertical slope that could cause visibility issues and longer stopping distances for drivers going downhill. In one case, a pedestrian was observed disembarking at a bus stop and crossing to the gas station opposite. A group of three children was seen rushing from the apartment complex to the gas station and back. Drivers were observed crossing double yellow lines to enter the driveways of apartment complexes and gas stations from the opposite side. There was plenty of pedestrian activity on the sidewalk. The Valero gas station seemed to be a popular destination for pedestrians, particularly those jaywalking from the apartment complex. One case involved a mother and two children disembarking at the Valero bus stop and jaywalking, with the children rushing first to the apartment complex. The lack of turning lanes makes this strip dangerous for both drivers and pedestrians. Despite the presence of LED overhead lights, pedestrians are still very hard to see, especially when wearing darker colors.

Figure 4-69. Pedestrian jaywalking patterns at Wuezbach Rd. x Gardendale Rd.

7. Fredericksburg Rd. x Louis Pasteur Dr.

DATE: 5-18-2024, 6-20-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked crosswalk
Crosswalk sign at the intersection (Type):	Press the button to signal the intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	7 lanes (one turning lane, one left turn)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	45 MPH
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Good
Signals exist	Exists And Functional
Illumination	Y (LED)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:16 PM	8:17 PM
Time End	3:32 PM	9:56 PM
Temperature	90° degrees °F	72 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	None	None
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	1	1
Number of pedestrians at the curb	10	3
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	No	No
How many pedestrians attempted to cross the midblock/intersection during your observation period?	6	15
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	30 secs	30 secs
Pedestrian gender	Mixed	Mixed
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	More	More
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Y	Y

Observation Notes:

The area features wide sidewalks on each side, with clearly visible pedestrian markings and available pedestrian devices. Although bus stops are present, there was minimal pedestrian activity, possibly due to slower service on Saturday. The road was not busy, but some pedestrian activity was observed. Two bus stops are located near intersections or crossing marks, while one bus stop is situated away from the intersection, across from the apartment complex, with pedestrian markings available there. Drivers were observed adhering to the speed limit.

Figure 4-70. Pedestrian jaywalking patterns at Fredericksburg Rd.

8. Marbach Rd. x I-410

DATE: 5-16-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked
Crosswalk sign at the intersection (Type):	Press button devices in all direction
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	2 lanes 1 left turn
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y on 1 side
Far side bus stop near the intersection/Midblock (Y/N):	N/A
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	Y
The median in the direction of the pedestrian crossing (Y/N):	No on Marbach Yes on I-410
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph on Marbach and 45 mph on 410
School zone or specific land use:	N
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists And Functional
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:20 PM	8:20 PM
Time End	3:40 PM	9:00 PM
Temperature	93° degrees °F	77 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb		
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	A walker and a wheelchair	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	Most use crossing marks few jaywalk	Most use crossing marks few jaywalk
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	30 secs	30 secs
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	Mostly male, few female	Mostly male, few female
Pedestrian gender	Yes	Yes
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N	N
Driver speeding (Y/N):	Low	low

Observation Notes:

In this segment, pedestrians do not wait for signals. Homeless individuals gather under the I-410 bridge and do not follow pedestrian devices, often crossing when no vehicles are approaching or during the red signal phase. Jaywalking occurs off intersections, especially near the convenience store, where pedestrians use the median marking lane to wait. Signs and devices are in working and visible condition, with crossing push buttons accessible and located in all directions.

Figure 4-71. Pedestrian jaywalking patterns at Marbach Rd. x I-410.

9. Blanco Rd. x West Ave.

DATE: 5-21-2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Cross marks exist
Crosswalk sign at the intersection (Type):	Pedestrian crossing devices exist – no signs
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 lanes on the west plus a turning lane 6 lanes on Blanco plus a turning lane
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y (at Blanco only)
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y (2 ft curb median on the west)
The speed limit in the direction of the traffic being studied (miles per hour):	40 MPH
School zone or specific land use:	Evidence of students crossing
Quality of pavement	Faded
Marking quality	Good
Signals exist	Y
Illumination	Exists (poor)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:20 PM	8:20 PM
Time End	3:40 PM	9:00 PM
Temperature	90° degrees °F	81 degrees °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	2 or more	2 or more
Number of pedestrians at the curb	2 or more	2 or more
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	N/A	N/A
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	Around 10 secs	Around 10 secs
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	All Genders	All Genders
Pedestrian gender	Pedestrian cross on gaps	Pedestrian cross on gaps
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N	N
Driver speeding (Y/N):	Low	low

Observation Notes:

Traffic operations in the area appear appropriate, with speeds and approach speeds within limits. Street lighting is present, but illumination is poor at the intersection. Pedestrians usually cross at intersections, complying with devices and signals, despite the busy intersection in all directions. Jaywalking is observed across Las Palapas, especially in the area between HEB and Las Palapas, which seems to encourage this behavior. There are no crosswalks at bus stops far from intersections. The strip is located between a middle school and a high school. Additionally, a long waiting line at Dairy Queen extends into the main lane.

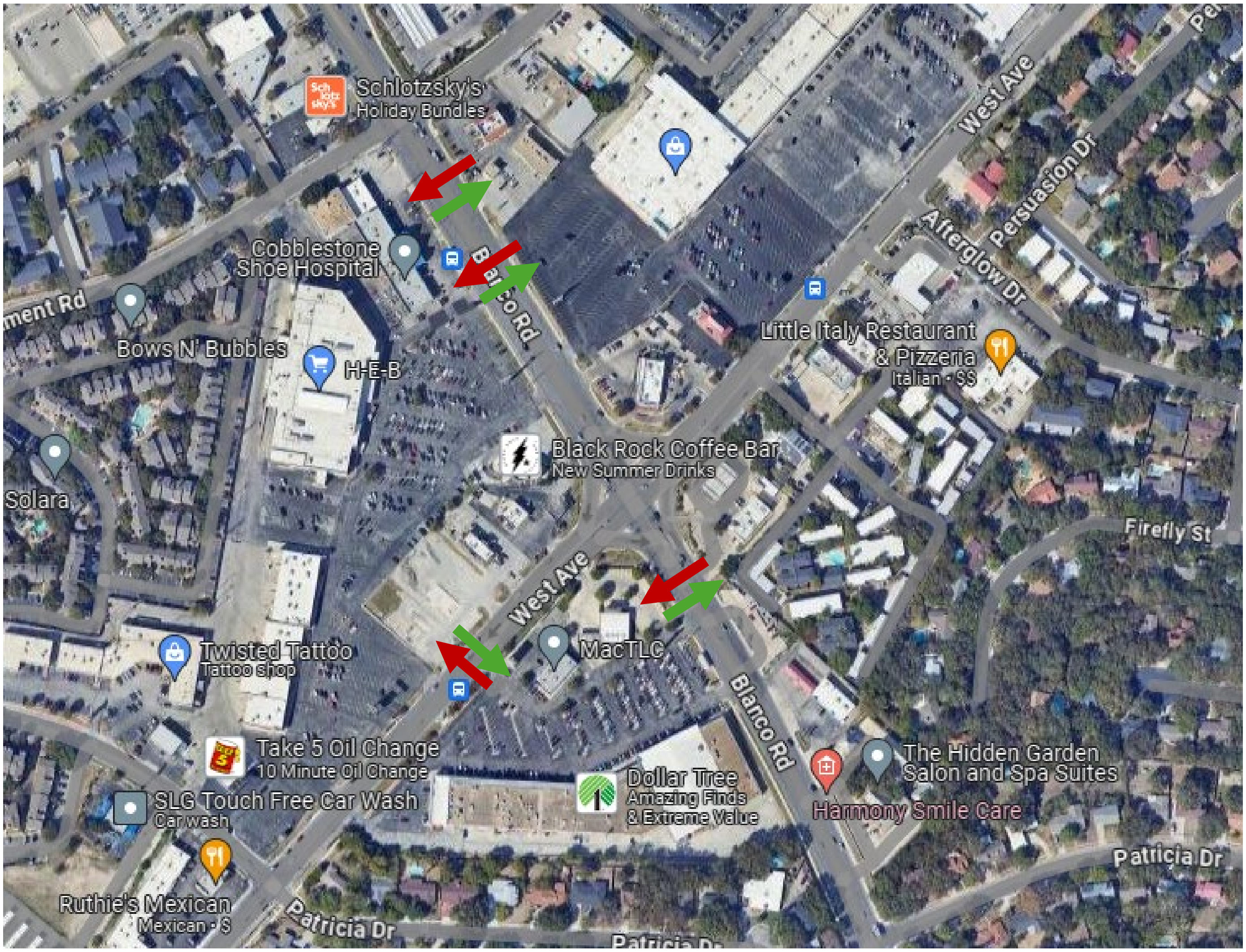


Figure 4-72. Pedestrian jaywalking patterns at Blanco Rd. x West Ave.

DALLAS SITE ASESSMENT RESULTS

1. E. Ledbetter Dr. x Sunnyvale St. and Bonnie View Rd.

DATE: 08/08/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (White zebra crossing)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6+ median (8 at intersection)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	45 mph (20 mph School hours)
School zone or specific land use:	School Zone
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Y
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:05 pm	10:08 pm
Time End	3:06 pm	
Temperature	106 F	
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	Y
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	Mostly 1	Mostly 1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	1
How many pedestrians attempted to cross the midblock/intersection during your observation period?	16 Jaywalking	10 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	1	1
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	Mostly male	All genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	Y
Bus stop activity/usage	Moderate 1-2	Non

Observation Notes:

The strip has a median that the pedestrians use to cross. Multiple Beggers were observed sitting at the median near the Sunnyvale x Ledbetter intersection. Most jaywalking in the afternoon occurred from Gold Star food store to the opposite side. The KFC/Taco Bell and the bus stop next to them had multiple pedestrians jaywalking to and from it, as well as multiple pedestrians dropping at that bus stop then crossing to the other side of the street. Both pedestrian and vehicle activity lowered significantly at night; more speeding drivers were observed at night. In some cases, pedestrians preferred using the median to cross, which took an overall longer time to cross accounting for the time they had to wait at the curb and the median than using the intersection to cross. There is a lack of using the push button even when the intersection is being used, and almost all crossings happened with no right of way. Two pedestrians were observed sprinting across the street, which caused the driver to abruptly stop. Most jaywalking at night occurred from Family Dollar and William Chicken side to Valero gas station side and back.

Figure 4-73. Pedestrian jaywalking patterns at E. Ledbetter Dr. x Sunnyvale St. and Bonnie View Rd.

******The yellow-red circle represents homeless presence.*

2. S. Great Trinity Forest Way x Ohanian Dr. and Murdock Rd.

DATE: 08/08/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Zebra markings)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + Median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	50 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (Bulb)
Road characteristics	Slight Horizontal slope
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	3:10 pm	9:11 pm
Time End	4:10 pm	9:55 pm
Temperature	104 F	96 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	1	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	14 Jaywalking	5 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	All genders	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Non

Observation Notes:

Family Dollar and Hunt food store had several jaywalking cases. The median was used for refuge in most cases. 1 pedestrian was seen pushing a cart from Family Dollar to the food store. High pedestrian and driver activity in the afternoon. Homeless presence focused on Family Dollar and MacDonalds. A similar jaywalking pattern occurred at night. Pedestrians were difficult to see despite the overhead lights.

Figure 4-74. Pedestrian jaywalking patterns at S. Great Trinity Forest Way x Ohanian Dr. and Murdock Rd.

**The yellow-red circle represents homeless presence.*

3. Martin Luther King Jr. Blvd. x S. Ervay St.

DATE: 08/09/2024 - 08/10/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (White Lines)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 + Turning Lane
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (LED)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:22 pm	7:45 pm
Time End	3:22 pm	8:45 pm
Temperature	95 F	87 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	1	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	15 Jaywalking	2 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	14-20 sec	14-20 sec
Pedestrian gender	Mostly male	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Moderate 1-2	Low 0-1

Observation Notes:

Most jaywalking occurred towards the Cash America pawn shop and Good Price Beverage store. Relatively moderate vehicle activity and a lot of pedestrian activity. Twi cases were observed of pedestrians dropping at a bus stop and crossing to the other side away from the intersection. At night, there was very little pedestrian activity.

Figure 4-75. Pedestrian jaywalking patterns at Martin Luther King Jr. Blvd. x S. Ervay St.

4. Maple Ave. x Hawthorne Ave. and Wycliff Ave.

DATE: 08/06/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (White zebra crossing)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 lanes
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph (20 mph School hours)
School zone or specific land use:	School Zone
Quality of pavement	Mostly good but some patches are asphalt paved
Marking quality	Good
Signals exist	Y
Illumination	Y
Road characteristics	Vertical slopes
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	1:40 pm	9:05 pm
Time End	3:21 pm	10:30 pm
Temperature	101 F	97 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	N/A
Group size	Mostly 1 (Sometimes 2)	Mostly 1
Number of pedestrians at the curb	1 or 2	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	10 Jaywalking	5 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	1	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20 sec
Pedestrian gender	Mostly male	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Moderate bus stop activity around 1- 2 pedestrians at bus stop	Low bus stop activity 0 – 1 pedestrian at bus stop

Observation Notes:

Pedestrians on multiple occasions were observed exiting the bus and jaywalking to the opposite side; in one case a jaywalker was observed taunting a vehicle that stopped for them. The frequency of the dart buses is high in this strip. Overall, the strip was very active in the afternoon. There is a combination of overhead and short poles lighting the area at night. Lots of pedestrian activity to and from Cost Plus liquor store. There was noticeable sidewalk activity at night but low jaywalking. For the most part, pedestrians complied with using the intersections to cross. There were some jaywalking cases from the gas pipe to the Valero side. Homeless activity increased at night near the Cost Plus liquor store.

Figure 4-76. Pedestrian jaywalking patterns at Maple Ave. x Hawthorne Ave. and Wycliff Ave.

5. Stemmons Fwy. x Medical District Dr.

DATE: 08/10/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (two white lines)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	3 service lane and 6 + median main lane
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	N
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (Bulb and LED)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	4:15 pm	9:30 pm
Time End	1:55 pm	10:30 pm
Temperature	101 F	95 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	1	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	1
How many pedestrians attempted to cross the midblock/intersection during your observation period?	6 Jaywalking	3 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	Mostly male	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	N/A	N/A

Observation Notes:

The strip seems to be more focused on the service roads and the U turn under the bridge. A larger number of homeless presences can be noticed under the bridge. Multiple crossings to and from the 7-Eleven at the Shell gas station, and at night some crossings were observed towards the Chevron food store; some involved disabled individuals. At night, there was low activity from pedestrians. The area is slightly dark aside from the gas station lights. and the places where most jaywalking occurred had no or low lighting.

Figure 4-77. Pedestrian jaywalking patterns at Stemmons Fwy. x Medical District Dr.

6. Lombardy Ln. and Webb Chapel Rd.

DATE: 08/12/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Zebra markings)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 + Median (5 at intersection)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists but mostly store lights
Road characteristics	Slight Vertical slope on one end
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:10 pm	9:47 pm
Time End	1:55 pm	11:00 pm
Temperature	99 F	94 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	N/A
Group size	Mostly 1 sometimes 2	Mostly 2
Number of pedestrians at the curb	1-3	1-2
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	25 Jaywalking	6 jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	2	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	All genders	Mostly Female
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

The median between Pecan Plaza and Fiesta Mart was used multiple times as a refuge for pedestrians to cross. Multiple crossings from Sky Ile apartments to Buckner Family Hope Center. The area was very active with both pedestrians and vehicles in the afternoon. The strip is well lit by mostly store lights; pedestrians are visible on the pecan plaza/Feista side. The PLS Check cashing seems to be a high priority destination for pedestrians. The usage of the intersection is almost zero. Most pedestrians use the median and always take the shortest path to their destination.

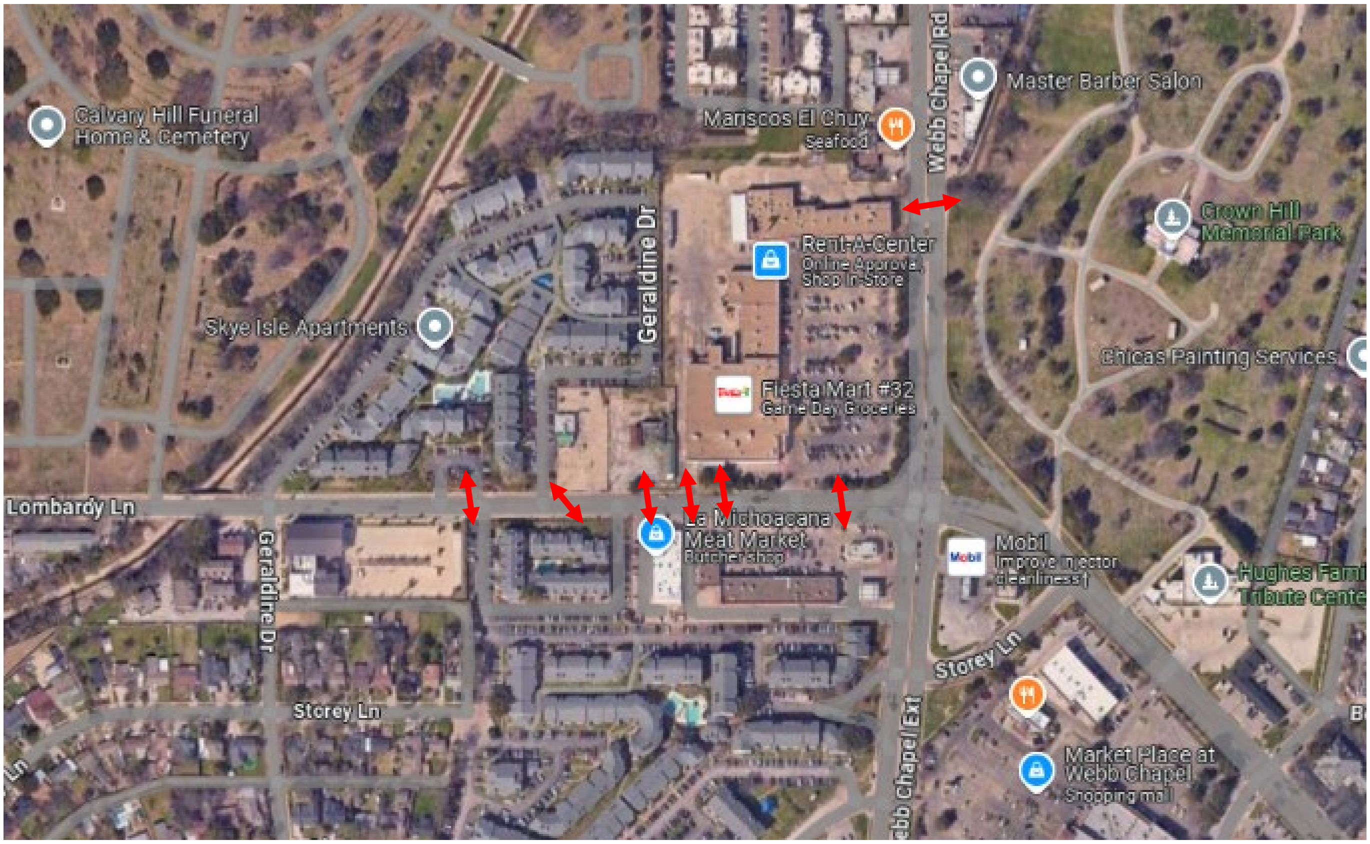


Figure 4-78. Pedestrian jaywalking patterns at Lombardy Ln. and Webb Chapel Rd.

7. N. Buckner Blvd. x John West Rd.

DATE: 08/07/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Two solid white lines)
Crosswalk sign at the intersection (Type):	Press button intersections
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + an elevated median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	40 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good (slight fading in some areas)
Signals exist	Exists
Illumination	Exists (LED)
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	3:10 pm	9:20 pm
Time End	4:11 pm	10:10 pm
Temperature	104F	96 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	Mostly 1	Mostly 1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	9 Jaywalking	6 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	1	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	35 sec	27 sec
Pedestrian gender	Mostly male	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	Y	Y
Bus stop activity/usage	Low 0 - 1	No usage

Observation Notes:

Jaywalking occurred throughout most of the strip and slightly beyond. The median seems to encourage jaywalking as some pedestrians used it to cross despite being very close to the crosswalk. In most cases, it was used when there was a lot of traffic waiting at a red light or if there was a traffic gap. Homeless presence around the 7-Eleven gas station. The strip was busy, and some drivers could be seen speeding. Most jaywalking occurred from 7-Eleven to Ez Trip food store/gas station. In one case at night a pedestrian dropped at a bus stop opposite to 7-Eleven and crossed towards 7-Eleven.

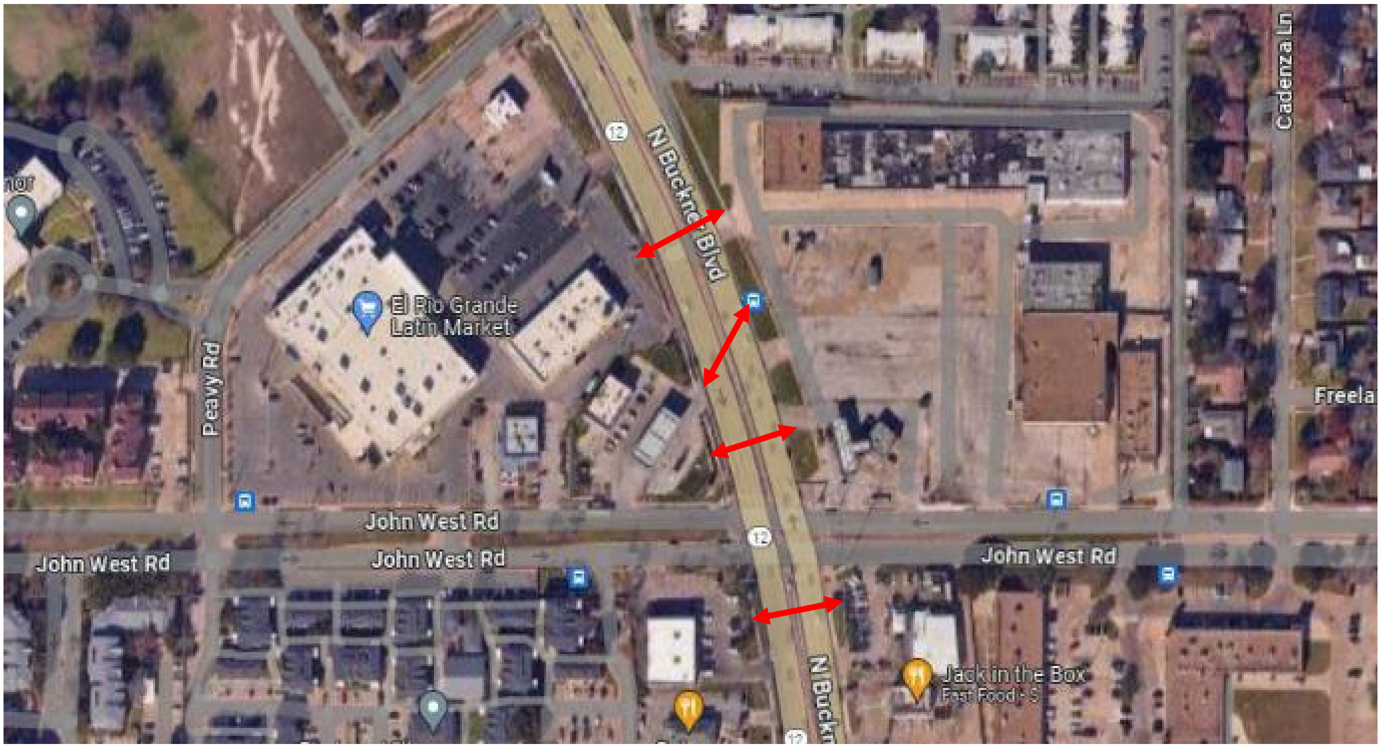


Figure 4-79. Pedestrian jaywalking patterns at N. Buckner Blvd. x John West Rd.

8. Park Ln. x Greenville Ave.

DATE: 08/07/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked
Crosswalk sign at the intersection (Type):	Press button intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 lanes + median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	Y
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph
School zone or specific land use:	School zone
Quality of pavement	Good
Marking quality	Good
Signals exist	Exists
Illumination	Exists
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	1:30 pm	8:30 pm
Time End	2:15 pm	9:10 pm
Temperature	100 F	91 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	2-5	Mostly 1-2
Number of pedestrians at the curb	4 or more	6 or more
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	8 Jaywalking	10 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	30 sec	30 sec
Pedestrian gender	All Genders	All Genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	Y
Driver speeding (Y/N):	N	N
Bus stop activity/usage	N/A	N/A

Observation Notes:

There is a significant amount of jaywalking in various areas around Greenville, particularly involving people crossing to and from the Mobile gas station. A homeless group frequently gathers behind the bus stop near the Plaza Mall on Park Lane, adding to pedestrian traffic. Many jaywalkers are also observed near the bus stop, crossing to reach the supermarket, and there is a large amount of crossing activity around the bus stop in general. Additionally, there is heavy jaywalking on Park Lane, with people crossing toward the bus stop and the nearby DART station.

Figure 4-80. Pedestrian jaywalking patterns at Park Ln. x Greenville Ave.

9. Cedar Springs Rd. x Reagan St. and Knight St.

DATE: 08/07/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Rainbow pattern)
Crosswalk sign at the intersection (Type):	Press button intersection and multiple RFYB midblock crossings across the strip
Crosswalk sign in advance of the intersection (Y/N):	Y
Bulb-out/Curb extension (Y/N):	Y
Number of travel lanes being crossed:	4
On-street parking (Y/N):	Y
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph (20 mph School speed limit)
School zone or specific land use:	School Zone
Quality of pavement	Good
Marking quality	Good
Signals exist	Exists
Illumination	Exists
Road characteristics	Flat
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	Y
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	1:20 pm	10:30 pm
Time End	2:24 pm	11:30 pm
Temperature	110 F	96 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	Mostly 2 - 3
Number of pedestrians at the curb	Mostly 1	Mostly 2 - 3
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	6 Jaywalking	8 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	5
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	28 sec	28 – 30 sec
Pedestrian gender	All Genders	All Genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	No
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0 - 1	Low 0 - 1

Observation Notes:

Jaywalking from Chef House restaurant to Bank of America is the most common. Pedestrians used the midblock crossing but don't seem to use the push buttons to cross. Cedar springs to Kroger multiple jaywalking. Most jaywalkers walked when there was a gap in traffic. Bus frequency was high but mostly for drop-offs. Ample light at night, high number of pedestrian activities. The strip has multiple bars. Most jaywalking at night was between bars.

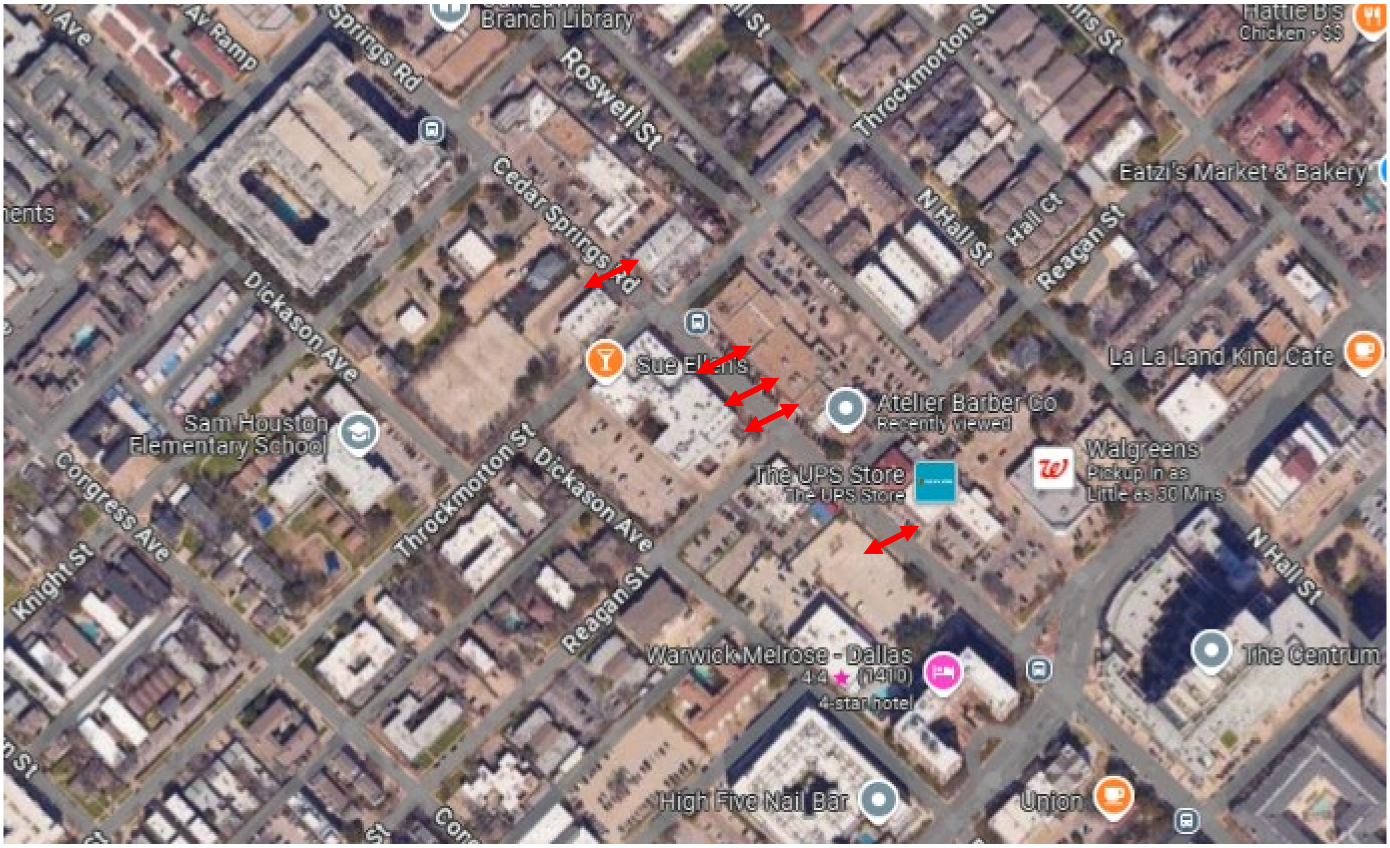


Figure 4-81. Pedestrian jaywalking patterns at Cedar Springs Rd. x Reagan St. and Knight St.

10. W. Northwest Hwy. x Community Dr. and Starlight Rd.

DATE: 08/09/2024 - 08/10/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked (Zebra markings)
Crosswalk sign at the intersection (Type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + Median (8 at intersection)
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	N
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (Bulb)
Road characteristics	Vertical slope on one end
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	12:55 pm	7:45 pm
Time End	1:55 pm	8:45 pm
Temperature	95 F	87 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 2 or more	Mostly 1
Number of pedestrians at the curb	2-3	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	N/A	N/A
How many pedestrians attempted to cross the midblock/intersection during your observation period?	18 Jaywalking	15 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	All genders	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	N/A	N/A

Observation Notes:

In the afternoon a lot of families were observed crossing in groups, mostly from Jack In The Box side. Multiple cases were observed where a pedestrian will take over a minute to cross the street. The strip was well lit from the overhead lights and store lights in the area. The median was used as a refuge when crossing. Most jaywalking occurred from Jack in the back to the chase ATM and back. Jaywalking also observed from 7-Eleven to the Texaco gas station. The road has a vertical slope before the intersection that might cause visibility issues for both drivers and pedestrians, especially if the driver is speeding. Drivers would relatively slow down going up the slope.

Figure 4-82. Pedestrian jaywalking patterns at W. Northwest Hwy. x Community Dr. and Starlight Rd.

HOUSTON SITE ASESSMENT RESULTS

1. Addicks-Howell Rd. x Piping Rock Ln.

DATE: 08/16/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked (two white lines)
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	Y
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + Median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	N
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	45 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (Bulb)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	4:42 pm	10:15 pm
Time End	5:40 pm	11:00 pm
Temperature	97 °F	84 °F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	1	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	3 Jaywalking	1 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	Mostly Male	Mostly Male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	N/A	N/A

Observation Notes:

In the afternoon, pedestrians crossing activity was low, but vehicle/driver activity was high. Crossing through midblock almost seemed impossible unless vehicles were stopped at traffic lights. Some pedestrians were spotted using the thin yellow median as refuge and walked along the median to the crossing where they would cross to the other side. One pedestrian was observed waiting more than two minutes at the curb to cross through the midblock to the median and two more minutes to cross to the other side. At night, pedestrian activity remained low; one pedestrian was observed crossing 4 feet before the crossing. Lighting was present at the crossing, but midblock had low lighting, and most of it came from stores.

Figure 4-83. Pedestrian jaywalking patterns at Addicks-Howell Rd. x Piping Rock Ln.

2. Beechnut St. x Wilcrest Dr.

DATE: 08/17/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked (two white lines)
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + Median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:40 pm	9:55 pm
Time End	1:55 pm	10:55 pm
Temperature	99 F	90 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1, Sometimes 2	Mostly 1
Number of pedestrians at the curb	1-2	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	19 Jaywalking	6 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	20-30 sec	20-30 sec
Pedestrian gender	All genders	Mostly Male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Moderate 1-2

Observation Notes:

In the afternoon, pedestrian crossing activity was mainly to and from Wazobia Market and Rex Plaza and to and from the two bus stops near MacDonald's. Plenty of sidewalk activity and a very busy street. Medians were used in all cases as a refuge and had a relatively low wait time to cross. In one case, a mother with a baby stroller used the U-turn as a refuge to cross. All pedestrians crossed during vehicle gaps, but some dashing was observed. At least three pedestrians were observed crossing to the opposite side after disembarking from the metro bus. Some pedestrians preferred using the median where trees were present, presumably to take shade, indicating that shade might influence where pedestrians choose to cross. At night, the pedestrian activity dropped significantly, but the strip was still busy with vehicles. There was beggar activity at the crosswalk; most jaywalking was focused on the bus stop, and similar to afternoon, multiple pedestrians would disembark from the bus and cross to their residence. The bus stops are well lit, and so were the intersections.

Figure 4-84. Pedestrian jaywalking patterns at Beechnut St. x Wilcrest Dr.

**The yellow-red circle represents homeless presence.*

3. Belfort Ave. x Broadway St.

DATE: 08/20/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked (two white lines and red bricks)
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	2 + one Turning Lane at intersection and Midblock u turns.
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph
School zone or specific land use:	School zone
Quality of pavement	Good
Marking quality	Slightly faded
Signals exist	Y
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:30 pm	9:56 pm
Time End	3:23 pm	10:40 pm
Temperature	101F	97F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	Mostly 1	0
Number of pedestrians at the curb	1	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	5 Jaywalking	N/A
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	1	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	30-60 sec	30-60 sec
Pedestrian gender	All genders	N/A
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

There is a kindergarten on Belfort Ave. Two pedestrians were seen crossing to the other side. On Broadway Street, two pedestrians crossed from the bus stop to the other side using median. One pedestrian came from Melrose to the other side bus stop, rushing to catch the bus. The stirp had a flat tiled median that facilitated crossing; it also had plenty of shade from the planted trees. Although usually the wait time to cross was short, some pedestrians were seen crossing from there.

Figure 4-85. Pedestrian jaywalking patterns at Belfort Ave. X Broadway St.

4. S. Gessner Rd. x Town Park Dr. and Sands Point Dr.

DATE: 08/18/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked (two white lines)
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + Median/U-turn lanes
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	4:07 pm	11:08
Time End	5:20 pm	11:57
Temperature	100 F	90 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	N/A
Group size	Mostly 1, Sometimes 2 or 3	Mostly 1, Sometimes 2
Number of pedestrians at the curb	2-3	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	74 Jaywalking	8 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	4	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	30-60 sec	30-60 sec
Pedestrian gender	All genders	All genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

In the afternoon, pedestrian crossing activity was very rampant. Pedestrians used the median as refuge and crossed on almost every part of the strip. Pedestrians would cross carrying bags, heavy items, trollies, etc. when crossing through midblock. Multiple cases were observed where drivers yielded to the pedestrians. The area had high activity, and there were pedestrians at the curb at any given time. The median had some trees that might prevent the driver from seeing the pedestrian on the median. For the most part, pedestrians would cross during gaps, but some were also observed darting and/or not giving right of way to traffic. The drivers seem to be mindful of the jaywalkers; no speeding was observed. This strip had the highest jaywalking activity per minute so far. The street light poles were not functional; nonetheless, parking lot lights were present, but pedestrians were still very difficult to see, especially if they were wearing dark colors. Hardly any pedestrian used the intersection to cross in both periods. Activity halted at night for both pedestrians and traffic.

Figure 4-86. Pedestrian jaywalking patterns at S. Gessner Rd. x Town Park Dr. and Sands Point Dr

5. Westheimer Rd x S Voss Rd and Hillcroft Ave

DATE: 08/18/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	9 + Median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y – 1 not functional

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	1:40 pm	9:40 pm
Time End	2:20 pm	11:57 pm
Temperature	103 F	92 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	Mostly 1, Sometimes up to 5	0
Number of pedestrians at the curb	3 or more	3 or more
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	2 Jaywalking	5 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	30-45 sec	30-60 sec
Pedestrian gender	All genders	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	Y
Driver speeding (Y/N):	N	Y
Bus stop activity/usage	Medium 2-3	Low 0-1

Observation Notes:

The area along Westheimer features a highly mixed-use strip with commercial stores, shops, restaurants, and apartment complexes lining both sides of the road. The high traffic volume in both directions makes it difficult for pedestrians to jaywalk, especially with the increased speed of vehicles at night. Additionally, the sidewalks in this strip are narrow and often broken, adding to the challenges for pedestrians. On Voss Road, the span between pedestrian crossings is notably long, leading to frequent instances of jaywalking. Pedestrians face significant distances between designated crossing points, making it harder to navigate safely.

Figure 4-87. Pedestrian jaywalking patterns at Westheimer Rd. x S. Voss Rd. and Hillcroft Ave.

6. Main St. x Richmond Ave. and Wheeler St.

DATE: 08/17/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked
Crosswalk sign at the intersection (type):	Electronic with timer
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 under HW 69 5 at main and wheeler
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	N
The speed limit in the direction of the traffic being studied (miles per hour):	30 mph
School zone or specific land use:	N/A
Quality of pavement	Fair
Marking quality	Fair
Signals exist	Y
Illumination	Exists
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	10:40 – 11:15 AM and from 12:45 PM	8:30 pm
Time End	1:30 pm	9:15 pm
Temperature	109 F	96 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	N/A
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	1-2	1-2
Number of pedestrians at the curb	2 or more	3 or more
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	15+ Jaywalking	5 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	N/A	N/A
Pedestrian gender	All genders	All genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	Y
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

The area under the Highway 64 bridge has become a common shelter for many homeless individuals, seeking shade and protection. Jaywalking is frequent in this hotspot, particularly when crossing Main Street, where a nearby bus station increases pedestrian traffic. Many pedestrians are cautious when crossing, but some are slow to cross, even during green traffic signal periods, creating potential safety hazards for both pedestrians and drivers.

Figure 4-88. Pedestrian jaywalking patterns at Main St. x Richmond Ave. and Wheeler St.

7. I-610 x S. Main St.

DATE: 08/17/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	Marked
Crosswalk sign at the intersection (type):	Electronic with timer
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	7 on 610 frontage 10 + median on Main
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	N
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	Y
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Yes on both 610 Frontage and Main St
The speed limit in the direction of the traffic being studied (miles per hour):	45 on 610 Frontage, 40 on Main St
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Good
Signals exist	Y
Illumination	Exists on 610 Frontage under bridge and intersection is not well illuminated
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	3:60 pm	9:00pm
Time End	4:30pm	9:30 pm
Temperature	105 F	92 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	N/A	0
Driver Yielded to the pedestrian? (Y/N):	Y	Y
Group size	0-1	1-2
Number of pedestrians at the curb	2 or more (homeless under bridge)	2 or more (homeless under bridge)
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	0 Jaywalking	3 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	N/A	30-45 sec
Pedestrian gender	All genders	Mostly male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	Y
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

There are homeless camps located under the 610 bridge, with many beggars frequently crossing the intersection between cars. Homeless activity is particularly noticeable near the Whataburger, where jaywalking between the restaurant and the Chevron gas station is common. Additionally, poor lighting near the 610-frontage road creates further safety concerns, especially in areas where pedestrians are crossing at night, making visibility difficult for both drivers and pedestrians.

Figure 4-89. Pedestrian jaywalking patterns at I-610 x S. Main St.

8. Airport Blvd. x Dover St.

DATE: 08/20/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or un-marked Crosswalk:	N/A
Crosswalk sign at the intersection (type):	N/A
Crosswalk sign in advance of the intersection (Y/N):	N/A
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	6 + Median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	40 mph
School zone or specific land use:	School nearby
Quality of pavement	Good
Marking quality	Good
Signals exist	N
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	N/A

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	1:24 pm	11:00 pm
Time End	2:06 pm	11:45 pm
Temperature	103 F	93 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	N/A	N/A
Number of pedestrians at the curb	16 waiting for bus	0
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	0	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	N/A	N/A
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	N/A	N/A
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	N/A	N/A
Pedestrian gender	All genders	All genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	High <6	Low 0-1

Observation Notes:

Despite having numerous parking spots near the airport vicinity, the strip showed no pedestrian crossing activity. There is a significant distance to the nearest crossing signal. The only notable activity was students leaving the Aviation Institute of Maintenance; however, most of them waited at the bus stop, and no crossings occurred. At night, there were no activities observed in the area.

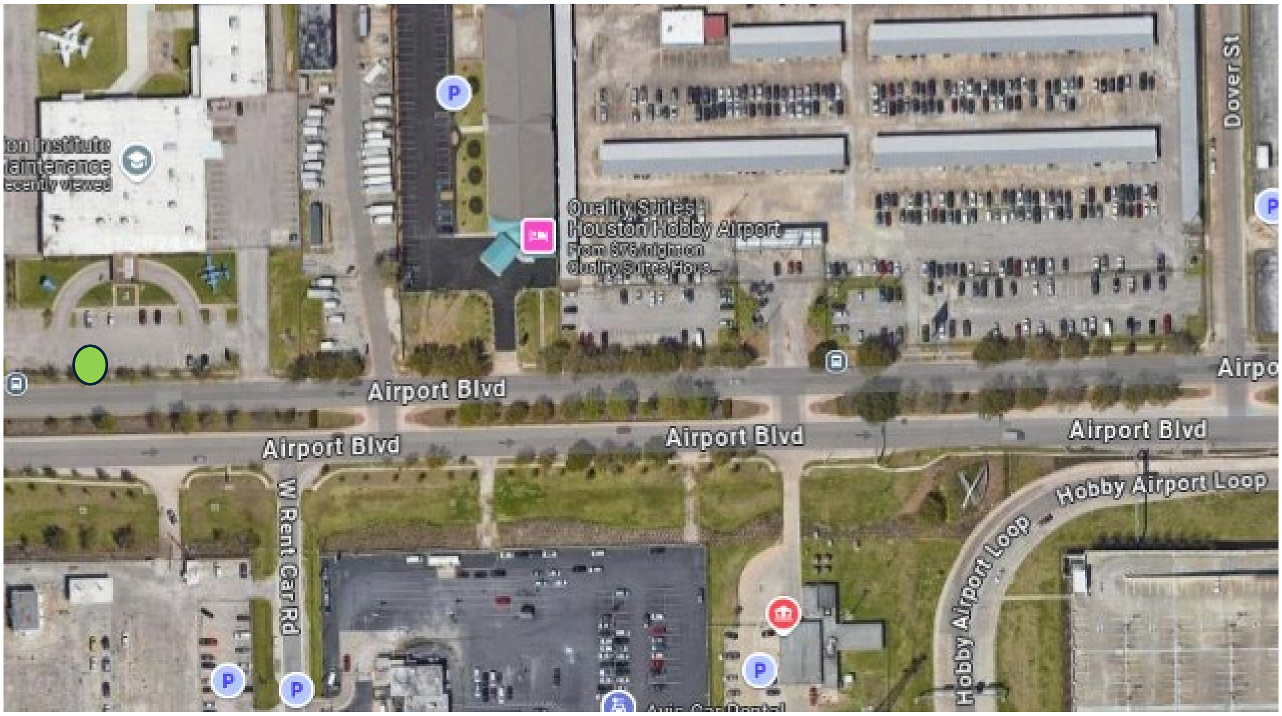


Figure 4-90. Pedestrian jaywalking patterns at Airport Blvd. x Dover St.

**The green circle represents the school bus stop.*

9. Airline Dr. x Sylvester Rd.

DATE: 08/18/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked (two white lines)
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	Y
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 + Turning Lane
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	Y
Far side bus stop near the intersection/Midblock (Y/N):	Y
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	N
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 mph
School zone or specific land use:	N/A
Quality of pavement	Good
Marking quality	Poor
Signals exist	Y
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	2:22 pm	10:08 pm
Time End	3:23 pm	10:42 pm
Temperature	101F	91 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	Y	N/A
Group size	Mostly 1	Mostly 1
Number of pedestrians at the curb	1	1
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	2	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	14 Jaywalking	3 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	5	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	30-60 sec	30-60 sec
Pedestrian gender	All genders	Mostly Male
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	N/A	N/A
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

The afternoon had a high homeless pedestrian activity; multiple homeless people were observed under the bridge. The road had heavily faded road markings, but the pedestrians seem to be familiar with the turning lane location and use it to cross. There are 2 occasions where a homeless person in a wheelchair would be present on the road to beg near the intersection. 3 cases spotted where pedestrians disembark from the bus stop and cross to the opposite side. The minimart at Exxon seems to be the direction all pedestrians head towards. One homeless pedestrian was observed jaywalking multiple times, causing the traffic to stop. On all occasions the traffic stopped/yielded for pedestrians. At night the activity is low from both pedestrians and traffic; the strip was well lit next to the bus stops.

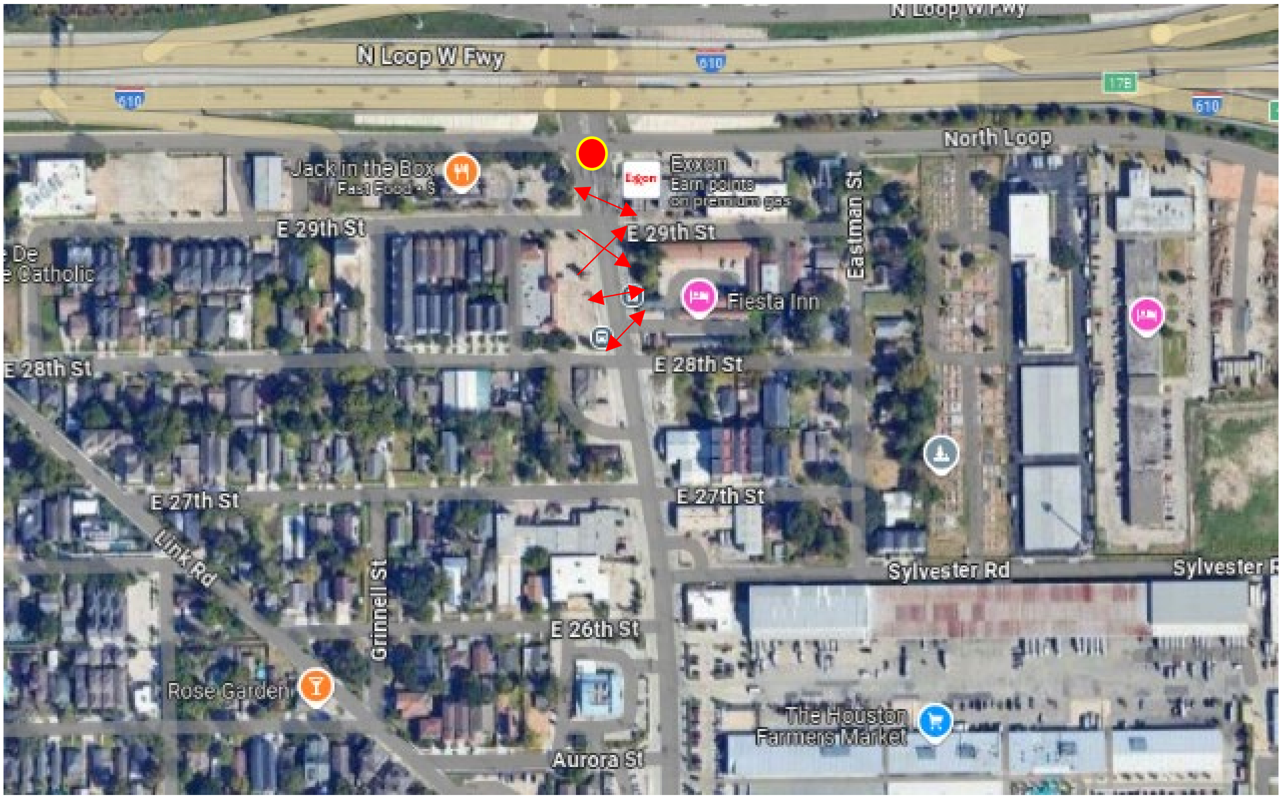


Figure 4-91. Pedestrian jaywalking patterns at Airline Dr. x Sylvester Rd.

**The yellow-red circle represents homeless presence.*

10.Federal Rd.

DATE: 08/18/2024
MODE OF OBSERVATION: IN VEHICHLE/DASH CAM

Road Characteristics	
Two-way street (Y/N)	Y
Marked or Un-marked Crosswalk:	Marked
Crosswalk sign at the intersection (type):	Press button singled intersection
Crosswalk sign in advance of the intersection (Y/N):	N
Bulb-out/Curb extension (Y/N):	N
Number of travel lanes being crossed:	4 lanes, 2 wide shoulders and a Median
On-street parking (Y/N):	N
Nearside bus stop near the intersection/Midblock (Y/N):	N
Far side bus stop near the intersection/Midblock (Y/N):	N
Right-turn Lane in the direction of the traffic at the intersection (Y/N):	N
Left-turn Lane in the intersection of traffic at the intersection (Y/N):	Y
Curb extension in the direction of the pedestrian crossing (Y/N):	N
The median in the direction of the pedestrian crossing (Y/N):	Y
The speed limit in the direction of the traffic being studied (miles per hour):	35 - 45mph
School zone or specific land use:	There is a school but no reduced speed
Quality of pavement	Poor
Marking quality	Poor
Signals exist	Poor
Illumination	Exists (LED)
Road characteristics	Flat surface
Signage quality	Good
Vegetation and trees blocking singe (Y/N)	N
Pedestrian Buttons functional (Y/N)	Y

Pedestrian/Driver behavior:	Afternoon	Night
Time Start	1:00 pm	9:00 pm
Time End	1:45 pm	10:40 pm
Temperature	104 F	93 F
The number of cars that drove through a crosswalk without yielding and stopping (Total):	0	0
Driver Yielded to the pedestrian? (Y/N):	N/A	N/A
Group size	Mostly 1	1-2
Number of pedestrians at the curb	3 or more	3 or more mostly cyclists
Physical disability (wheelchair/walker/other): Record if the pedestrian has a physical disability.	1	0
How many pedestrians attempted to cross the midblock/intersection during your observation period?	1 Jaywalking	4 Jaywalking
On how many occasions out of the number of attempted crossings observed *did the first car stop for the waiting pedestrian?*	0	0
What was the mean length of time in seconds that the Pedestrians waited to cross a certain direction?	35-40 sec	35-40 sec
Pedestrian gender	Mostly Male	All genders
Were drivers more or less likely to stop for Individuals versus two or more pedestrians?	Y	Y
Driver speeding (Y/N):	N	N
Bus stop activity/usage	Low 0-1	Low 0-1

Observation Notes:

The area along Federal Road is home to many food trucks, shops, and restaurants on both sides, but the significant distance between red signal crossings makes it difficult for pedestrians to move safely across the street. There is a flea market across from the school, which has a large parking lot and likely attracts substantial crowds on weekends. The area is also industrial, with a high volume of truck traffic, but it does feature large sidewalks that accommodate both pedestrians and cyclists. Although jaywalking is less common, when it does occur, pedestrians often wait in the median lane before crossing the road.

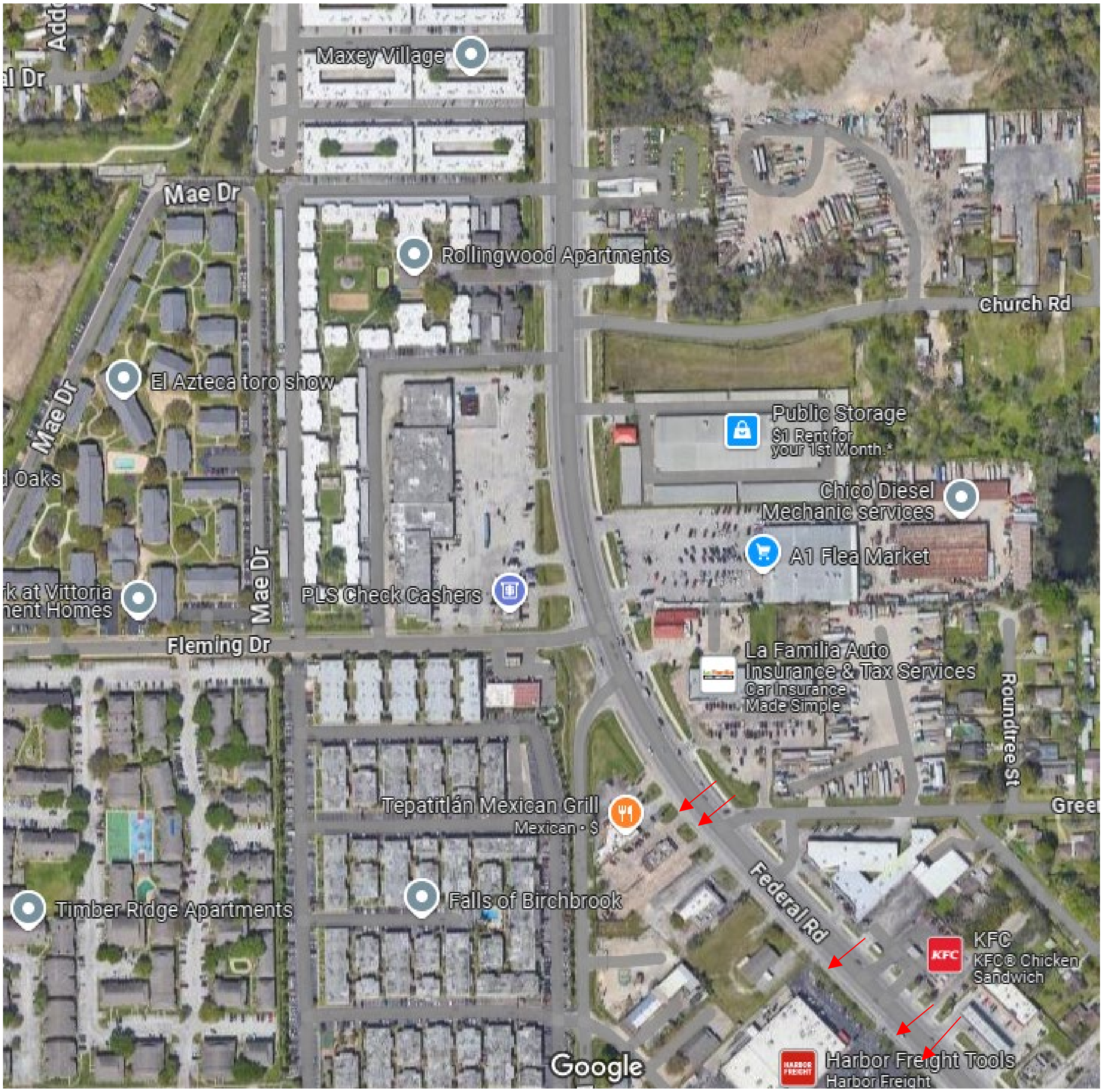


Figure 4-92. Pedestrian jaywalking patterns at Federal Rd.

HOTSPOTS SUMMARY

This section provides a comprehensive summary of the contributing factors observed at various high-risk pedestrian midblocks in the 3 cities. By analyzing pedestrian and driver behaviors, road characteristics, and environmental conditions, we can identify common trends and specific issues unique to each location.

A: SAN ANTONIO SUMMARY

Common Points Across All Strips:

Frequent Jaywalking: Jaywalking is a common issue, especially where pedestrian crossings are inconveniently located or signal timings are long. Many pedestrians use medians or turning lanes as refuge points.

Bus Stop Proximity: Pedestrian activity increases near bus stops, with many pedestrians crossing roads to or from bus stops, often jaywalking due to the lack of nearby crossings.

High Traffic Volume: Many strips experience high traffic volumes, including commercial and industrial vehicles. Drivers often do not yield and stop and stop to pedestrians, especially in midblock crossings.

Insufficient or Poorly Maintained Infrastructure: Crosswalks are present but are sometimes poorly marked or faded. Pedestrian buttons at crossings may not function properly, and street lighting is often insufficient at night, making it harder for drivers to see pedestrians.

Nighttime Activity: While pedestrian activity generally decreases at night, some strips still have notable activity near bus stops and convenience stores. However, poor lighting and jaywalking at night pose significant safety risks.

Driver Behavior: Drivers typically comply with speed limits, but they rarely yield and stop to jaywalking pedestrians, particularly during high traffic times.

Proximity to Commercial Areas: Jaywalking tends to be more frequent near commercial establishments like restaurants, gas stations, and convenience stores. Pedestrians cross directly between these establishments, often without using designated crossings.

Individual Points for Each Strip:

Fredericksburg Rd. x Babcock Rd.

High jaywalking between Cocina Mexicana, Goodwill, and Burger King. The skewed intersection may contribute to accidents, as pedestrians are often in drivers' blind spots during turns.

Bandera Rd. x Zachry Dr.

Jaywalking is prevalent, especially from nearby apartments to Bandera Express. Pedestrians use the turning lane as a refuge, with higher activity at night.

SE. Military Dr. x Spur 536 and Roosevelt Ave.

Pedestrians cross diagonally at intersections, sometimes during green lights. Jaywalking occurs mostly between McDonald’s and Exxon near bus stops, with pedestrians using the yellow lines as refuge.

Rittiman Rd. x I-35 Frontage Rd.

High pedestrian activity, especially at night. Many jaywalkers cross between Taco Cabana and Qubed Suites, using the median as a refuge. Homeless individuals frequently jaywalk.

S. Zarzamora St. x W. Mayfield Blvd. and SW. Military Dr.

Jaywalking occurs between HEB and Wells Fargo, with pedestrians using the turning lane as refuge. Pedestrians often cross behind buses without using the crosswalk.

Wurzbach Rd. x Gardendale Rd.

Jaywalking is common near apartment complexes and gas stations. The strip's slope could cause stopping issues for drivers and visibility issues for pedestrians.

Fredericksburg Rd. x Louis Pasteur Dr.

Pedestrian activity is lower near bus stops, likely due to slower bus service on weekends. Some jaywalking occurs between apartment complexes and bus stops.

Marbach Rd. x I-410

Homeless individuals jaywalk near convenience stores and under the I-410 bridge, often crossing during red signals. The presence of working crosswalk devices has reduced jaywalking in some areas.

Blanco Rd. x West Ave.

Jaywalking is frequent between HEB and Las Palapas. Pedestrians cross midblock, despite the presence of nearby intersections. Poor street illumination at night exacerbates the problem.

B: DALLAS SUMMARY

Common Points Across All Strips:

1. Jaywalking Behavior: Jaywalking is highly prevalent in all strips, with many pedestrians crossing mid-block or ignoring the designated crosswalks. This often happens near high-footfall areas like bus stops, stores, or gas stations.

2. Median Usage: Many strips have medians that pedestrians use as a refuge when crossing, contributing to jaywalking since it provides a sense of safety despite not using the crosswalks.

3. Crosswalk Usage: Despite having marked crosswalks, most pedestrians do not use them. Instead, they choose the shortest route to their destination, often ignoring traffic signals or pedestrian push buttons.

4. Bus Stops and Pedestrian Activity: Bus stops are major points of pedestrian activity, especially during afternoons, with many pedestrians jaywalking directly after getting off the bus.

5. Driver Behavior: Drivers are generally observed to be cautious, with no significant incidents of cars driving through crosswalks without yielding and stopping. However, driver speeding is noted in several strips, particularly during night hours.

6. Homeless Presence: Many strips report homeless individuals, especially in areas near gas stations or food stores, contributing to pedestrian activity and jaywalking patterns.

7. Lighting Conditions: In most strips, lighting is adequate, but in some areas, such as those near gas stations, lighting conditions are low, making pedestrians harder to spot at night.

Individual Points for Each Strip:

E. Ledbetter Dr. x Sunnyvale St. and Bonnie View Rd.

Significant jaywalking occurs near food stores like KFC and Family Dollar. There is high vehicle activity during the day, but it decreases at night. Pedestrians rarely use the push buttons to cross.

S. Great Trinity Forest Way x Ohanian Dr. and Murdock Rd.

Homeless activity and jaywalking are common near Family Dollar and McDonald's. The median is frequently used for refuge when crossing, and pedestrians are difficult to see at night despite existing lighting.

Martin Luther King Jr. Blvd. x S. Ervay St.

Jaywalking occurs mostly near a pawn shop and beverage store. There is moderate vehicle and pedestrian activity in the afternoon, which decreases at night.

Maple Ave. x Hawthorne Ave. and Wycliff Ave.

High pedestrian activity is observed near the Cost Plus liquor store, with frequent jaywalking across from the bus stops. Homeless presence increases at night in this area.

Stemmons Fwy. x Medical District Dr.

There is a noticeable homeless presence under the bridge, and jaywalking to and from 7-Eleven and Shell Gas stations is common. Low pedestrian activity is observed at night, with poorly lit areas.

Lombardy Ln. and Webb Chapel Rd.

This is an active pedestrian area, especially near Pecan Plaza and Fiesta Mart. The median is frequently used for crossing, and PLS Check Cashing is a major destination for pedestrians.

N. Buckner Blvd. x John West Rd.

Jaywalking is prevalent, with the median encouraging mid-block crossings. There is significant pedestrian activity around gas stations like 7-Eleven and EZ Trip.

Park Ln. x Greenville Ave.

High jaywalking occurs near the Mobile gas station and bus stops. Homeless individuals gather near Plaza Mall, and pedestrian activity is concentrated around bus stops and the DART station.

Cedar Springs Rd. x Reagan St. and Knight St.

High pedestrian activity is seen at night, particularly due to multiple bars. Jaywalking occurs between bars and from restaurants to banks, and bus drop-offs are frequent, though pedestrians seldom use the crosswalk push buttons.

W. Northwest Hwy. x Community Dr. and Starlight Rd.

There is high family pedestrian activity near Jack in the Box, and the median is often used as a refuge for crossing. Jaywalking is observed between 7-Eleven and Texaco gas station, with visibility issues due to a slope in the road.

C: HOUSTON SUMMARY

Common Points Across All Strips:

Jaywalking Prevalence: Jaywalking is a frequent occurrence in many areas, particularly where there is a significant distance between crosswalks or red signals. Pedestrians often use medians as a refuge point before continuing across the street.

High Traffic Volume: Most strips experience heavy vehicle traffic, including trucks in industrial areas, which increases the risk for pedestrians. Drivers rarely yield and stop to pedestrians, further complicating safe crossing.

Inadequate Pedestrian Infrastructure: Many strips have poor or broken sidewalks, limited pedestrian crossing signals, and insufficient lighting, especially at night. Some areas have well-marked crosswalks, but jaywalking persists due to inconvenient crossing points.

Homeless Presence: Homeless camps or activities are common near bridges, bus stops, and busy intersections. This contributes to jaywalking and creates additional risks as individuals frequently cross between cars or through busy intersections.

Nighttime Safety Concerns: Pedestrian activity often decreases at night, but inadequate lighting in many areas makes it difficult for drivers to see pedestrians, especially in high-traffic areas or near homeless shelters.

Proximity to Commercial Areas: Many strips are near shops, food trucks, flea markets, or restaurants, attracting large numbers of pedestrians. This contributes to jaywalking, as pedestrians try to cross between commercial establishments on opposite sides of the road.

Individual Points for Each Strip:

Addicks-Howell Rd. x Piping Rock Ln.

Jaywalking occurs at mid-block, with pedestrians using the thin yellow median as a refuge point. Low pedestrian activity at night and functional lighting at crosswalks but poor mid-block lighting.

Beechnut St. x Wilcrest Dr.

Jaywalking is concentrated around bus stops and the nearby Wazobia market. The presence of medians is used as a refuge by pedestrians. There is notable beggar activity near the crosswalk, especially at night.

Belfort Ave. x Broadway St.

Pedestrian crossings occur frequently at the marked crosswalks and medians. Pedestrians use shaded areas to wait, indicating that environmental features influence crossing patterns. The area is near a kindergarten, contributing to pedestrian activity.

S. Gessner Rd. x Town Park Dr. and Sands Point Dr.

This strip has the highest observed jaywalking activity. Pedestrians use medians as refuge and frequently cross carrying heavy items. Drivers generally yield and stop, and lighting is poor at night, making pedestrians difficult to see.

Westheimer Rd. x S. Voss Rd. and Hillcroft Ave.

This is a mixed-use area with commercial activity and apartment complexes. Jaywalking is frequent due to long distances between crosswalks. Sidewalks are narrow and broken, adding to pedestrian challenges.

Main St. x Richmond Ave. and Wheeler St.

Homeless individuals often jaywalk near the bus station. Pedestrian crossing is cautious, but some cross slowly even during green signals, leading to potential hazards.

I-610 x S. Main St.:

Homeless camps are common under the bridge, with beggars frequently crossing between cars. Jaywalking is prominent near Whataburger and Chevron, exacerbated by poor lighting on the 610 frontage road.

Airport Blvd. x Dover St.

Despite significant parking availability near the airport, there is no observed pedestrian crossing activity. Students from the Aviation Institute of Maintenance mostly wait at bus stops.

Airline Dr. x Sylvester Rd.

Homeless activity is high, with some pedestrians jaywalking after disembarking from buses. The area has poorly marked roads but high pedestrian familiarity with the crossing.

Federal Rd.

Although jaywalking is less common here, pedestrians wait in the median to cross the road. The area is industrial, with high truck traffic and large sidewalks, but crossing distances between signals are long.

ASSESSING CRASH REDUCTION TRENDS FOLLOWING MIDBLOCK CROSSING AND COUNTERMEASURES INSTALLATIONS

This section presents an analysis of pedestrian safety improvements following the installation of midblock crossings. Using crash data from before and after the crossings were implemented, the analysis evaluates their impact on reducing pedestrian-related accidents. By comparing crash trends across multiple years, this chapter will assess the effectiveness of midblock crossings in enhancing road safety and provide insights into how pedestrian behavior and traffic conditions have changed as a result.

1. 1695-1699 Culebra Rd.

Coordinates: 29.446182, -98.535880

Figure 4-93. 1695-1699 Culebra Rd. midblock crossing.

This midblock crossing, installed in 2019, is located between two bus stops at 1695-1699 Culebra Rd. The crossing is equipped with yellow yield and stop lights on button press, a zigzag median, pedestrian crossing signs, and overhead lighting to enhance visibility for both pedestrians and drivers. These features are designed to improve pedestrian safety by alerting drivers to yield and stop and providing well-lit paths for crossing, particularly during night hours or low-visibility conditions. Figure 4-94 provides crash trend pre and post the crosswalk deployment.

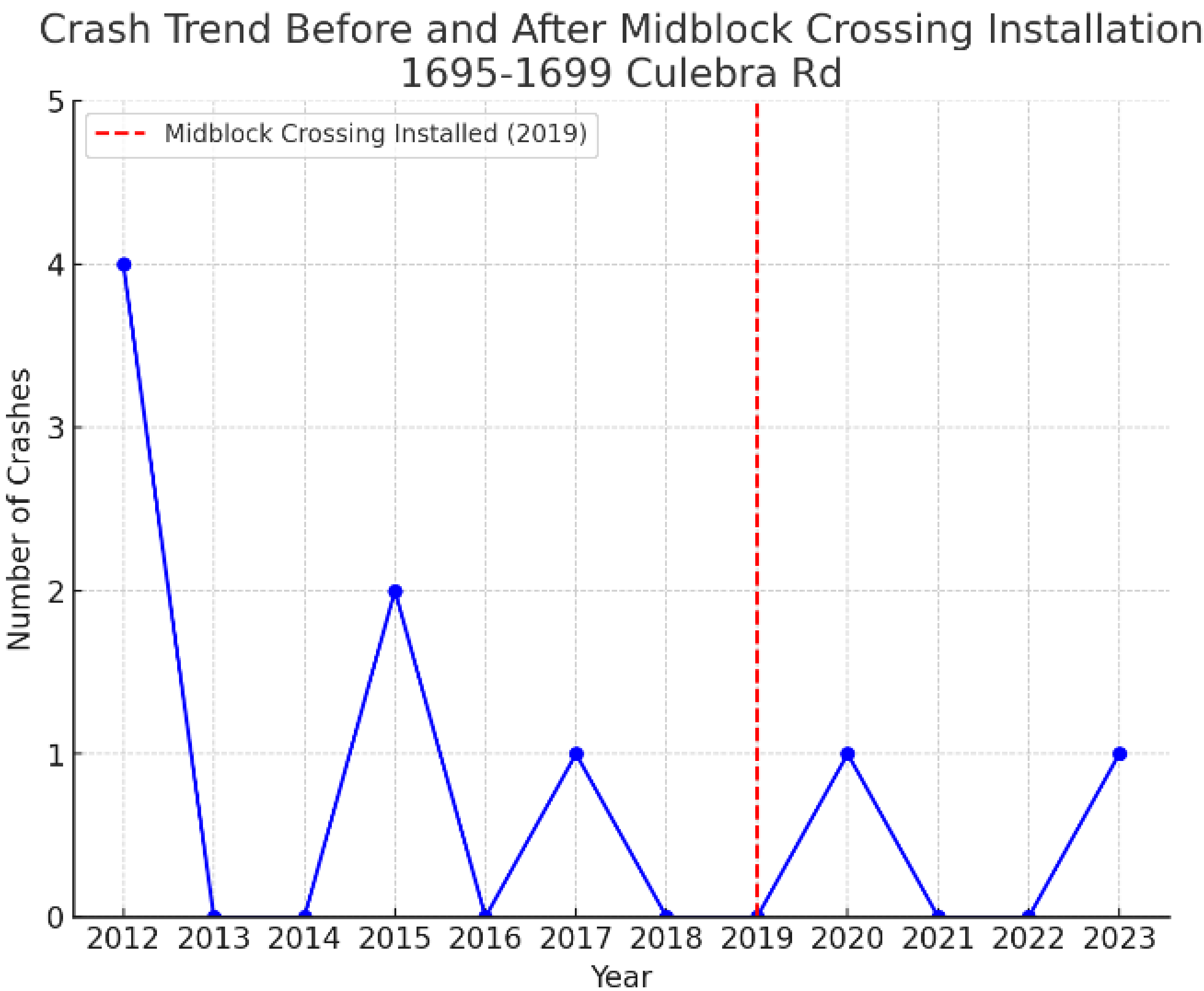


Figure 4-94. Crash trend before and after midblock crossing installation 1695-1699 Culebra Rd.

The chart visualizes the number of pedestrian crashes from 2012 to 2023, with a red dashed line marking the year 2019 when the midblock crossing was installed. Prior to 2019, the number of crashes fluctuated, reaching a peak of four crashes in 2012. After the installation of the midblock crossing, the number of crashes dropped, with only one crash recorded in 2020 and 2023. This suggests a positive impact of the crossing in enhancing pedestrian safety and reducing crashes.

2. 6783-6847 S. Zarzamora St.

Coordinates: 29.360312, -98.534072

Figure 4-95. 6783-6847 S. Zarzamora St. midblock crossing.

This midblock crossing is located between two bus stops, connecting an HEB Plus and a residential area. It is equipped with pedestrian safety features, including a crossing island, pedestrian signs, and overhead lights. In June 2011, a crossing island was installed to facilitate safer pedestrian movement. Later, in March 2022, a Pedestrian Hybrid Beacon (PHB) was installed, which includes a "Stop on Red" feature to improve vehicle compliance and pedestrian safety at the crossing. Figure 4-96 shows the change in crash trends after each treatment installation.

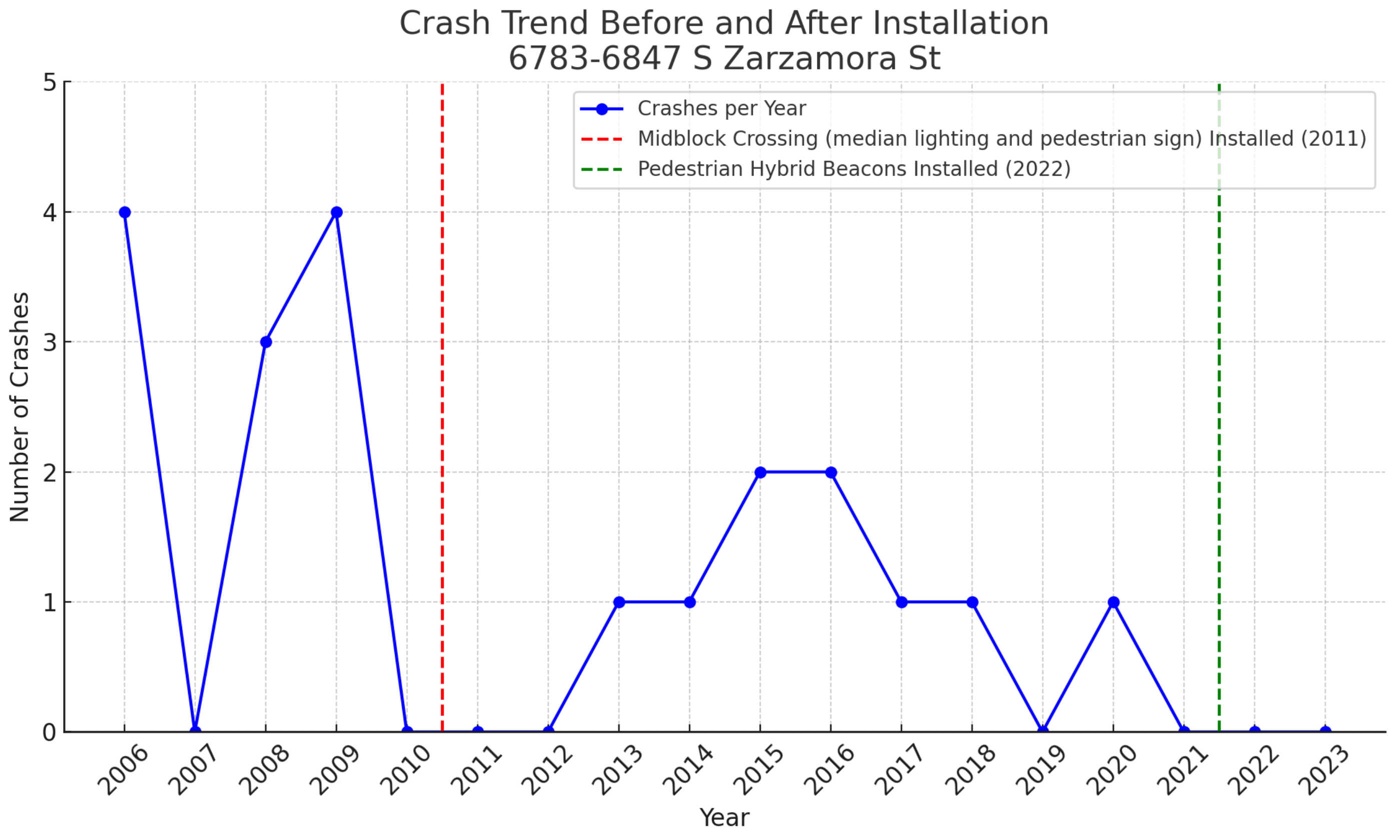


Figure 4-96. Crash trend before and after installation 6783-6847 S. Zarzamora St.

The chart shows a clear decline in pedestrian crashes following the installation of safety measures at 6783-6847 S. Zarzamora St. Before the midblock crossing was installed in 2011, crashes occurred frequently, particularly in 2006 and 2009. After the installation, crashes significantly decreased, with only a few isolated incidents in the following years. By 2020, crashes stopped entirely, and the 2022 installation of Pedestrian Hybrid Beacons may further enhance pedestrian safety. This trend suggests that the safety measures have been effective in reducing crash risk at this location.

3. 9121-9099 Wurzbach Rd.

Coordinates: 29.526649, -98.566736

Figure 4-97. 9121-9099 Wurzbach Rd. midblock crossing.

The midblock crossing was installed in 2018, located between two bus stops, and features a crossing island, pedestrian signs, and overhead lighting to enhance safety. The pedestrian signs have a yellow flashing light that can be activated by pressing the button.

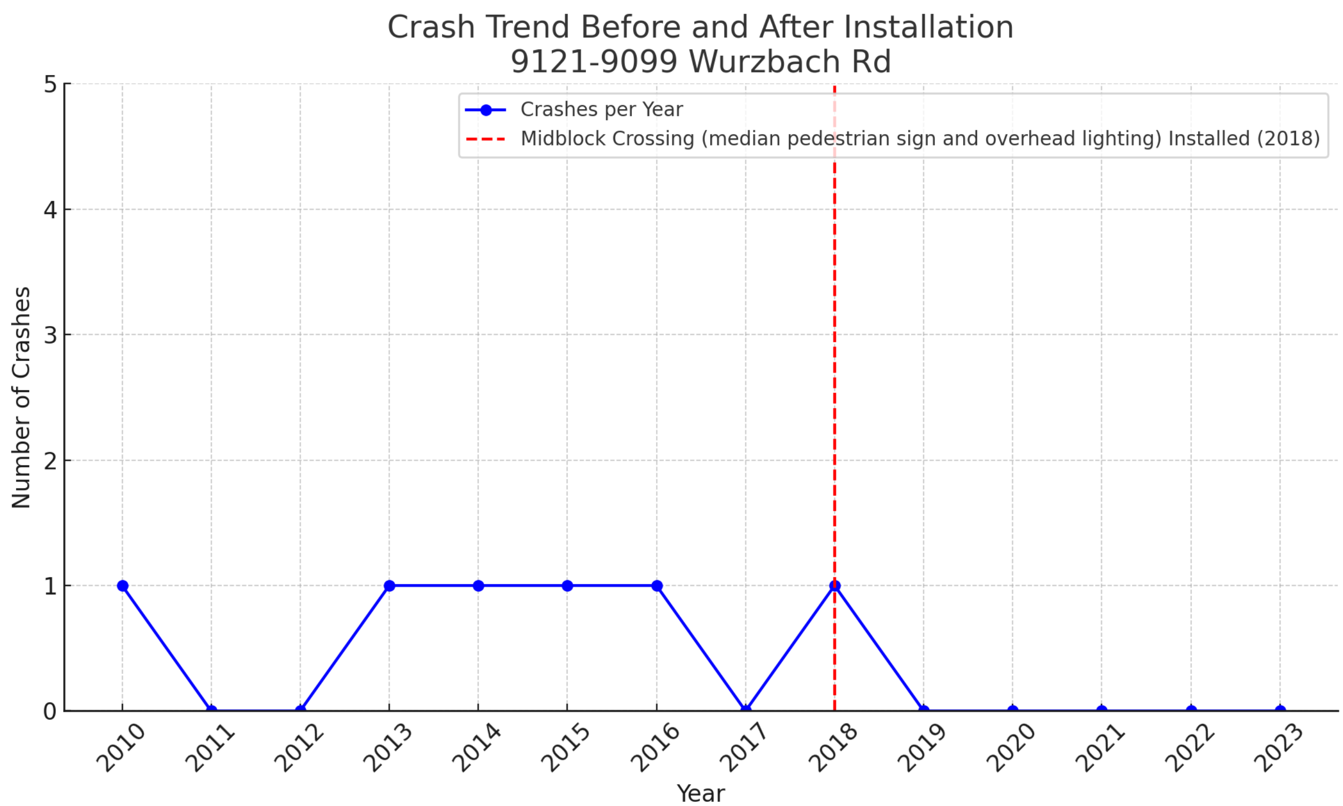


Figure 4-98. Trend of crashes before and after the installation at 9121-9099 Wurzbach Rd.

The chart in Figure 4-98 shows the trend of crashes at 9121-9099 Wurzbach Rd. before and after the installation of a midblock crossing in 2018. From 2010 to 2016, crashes occurred intermittently, with one crash per year in most years. After the midblock crossing was installed in 2018, crashes dropped to zero starting from 2019 through 2023, suggesting that the installation contributed to improving pedestrian safety at this location.

From crash data, it can be deduced that not all midblock crossings were installed in response to crashes; some were implemented proactively in areas where no crashes had previously occurred. These installations aimed to improve pedestrian safety and accessibility, particularly in locations with high foot traffic, like near hospitals or schools, even if there was no history of accidents. Some examples of such mid-block crossings with zero crash records found in San Antonio are now discussed.

4. Floyd Curl Dr.

Figure 4-99. Floyd Curl Dr. midblock crossing medical center.

The midblock crossing on Floyd Curl Dr., installed in November 2017, is located between two medical areas. It features a Pedestrian Hybrid Beacon (PHB), which stops traffic on red to allow pedestrians to cross safely. Additionally, there is a crossing island that provides a safe waiting area for pedestrians, along with overhead pedestrian signs that alert drivers of the crossing. This setup ensures increased visibility and safety for pedestrians, especially in a high-traffic area like a medical center.

5. 8673 Tezel Rd.

Figure 4-100. 8673 Tezel Rd. midblock crossing.

The midblock crossing at 8673 Tezel Rd., installed in May 2019, is situated between a school and a residential area. It features pedestrian signs to alert drivers of the crossing and ensure safer passage for pedestrians, particularly for students and residents in the area. The crossing's placement is strategic, enhancing safety in a location where foot traffic is likely high due to the proximity to both the school and the neighborhood.

6. 3912 Cedar Springs Rd

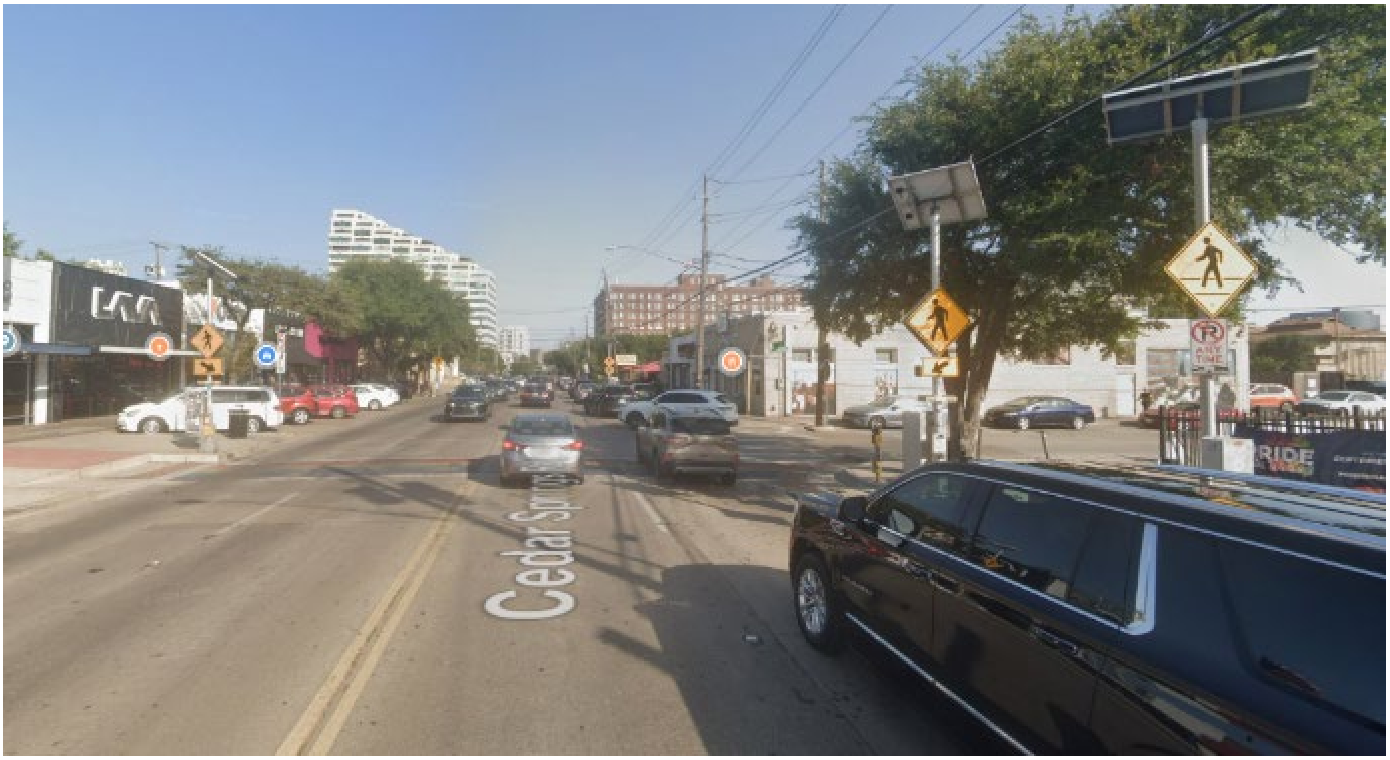


Figure 4-101. 3912 Cedar Springs Rd. midblock crossing.

The midblock crossing, installed in 2008, is located between a cluster of bars, nightclubs, and restaurants, making it a critical pedestrian safety feature in an area with high foot traffic, especially at night. It includes a curb extension, which reduces the crossing distance and enhances pedestrian visibility, as well as a rapid flashing beacon that alerts drivers to the presence of pedestrians. Additionally, overhead lights ensure visibility during nighttime hours, further improving safety for both pedestrians and drivers in this busy nightlife district.

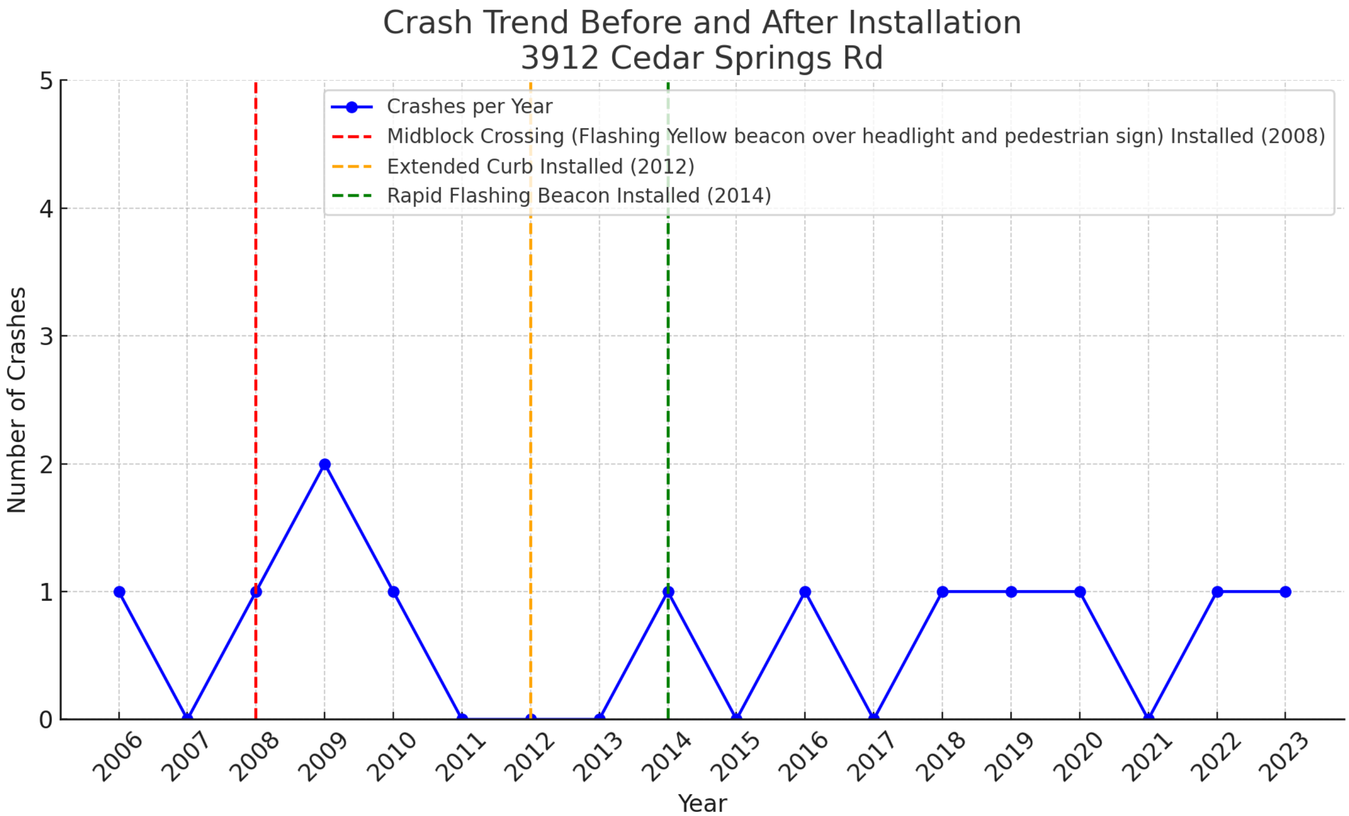


Figure 4-102. Trend of crashes trend before and after installation at 3912 Cedar Springs Rd.

The crash data in Figure 4-102 at 3912 Cedar Springs Rd . shows a reduction in crash frequency and severity after the installation of pedestrian safety measures. Before the midblock crossing in 2008, crashes were more frequent, with two incidents in 2009. Following the installation of the extended curb in 2012 and the rapid flashing beacon in 2014, crashes became less frequent and more isolated, with only one crash occurring per year in the following years. While crashes have not been eliminated, the data suggests these safety measures contributed to reducing both the frequency and intensity of incidents.

CHAPTER 5 : IDENTIFYING MIDBLOCK SAFETY TREATMENTS AND DETERMINING COUNTERMEASURES

INTRODUCTION

Pedestrian midblock crossings – locations where pedestrians cross a roadway at non-intersection points – pose a significant safety challenge worldwide. In the United States, the majority of fatal pedestrian crashes occur at midblock or other non-intersection locations. In 2018, about 74% of U.S. pedestrian fatalities happened outside of intersections. Texas exhibits a similar pattern: approximately 70% of pedestrian crashes statewide from 2017 to 2021 were "non-intersection-related," i.e., at midblock locations (TxDOT, 2023). These midblock events tend to be more severe than intersection crashes because drivers often do not expect pedestrians crossing midblock and may be traveling at higher speeds. (TxDOT, 2023). Moreover, a disproportionate share of Texas pedestrian fatalities occurs on state roadways (on-system arterials), underscoring the need for safety improvements on busy multi-lane roads (TxDOT, 2023). Common factors in midblock crashes include pedestrians crossing where no crosswalk is provided and drivers failing to yield and stop or see pedestrians in time. For example, Texas crash data indicate that in over one-third of pedestrian crashes the pedestrian was cited as failing to yield and stop (often meaning they crossed at undesignated points), accounting for over 2,000 fatalities in recent years (TxDOT, 2023). This highlights the importance of providing safe crossing opportunities and ensuring drivers yield and stop for pedestrians.

Over the past decade, considerable research and practice have focused on improving midblock crossing safety. Transportation agencies at local, state, and national levels have developed a range of countermeasures – from enhanced crosswalk markings and warning devices to pedestrian-activated signals and speed management strategies – to reduce crashes at midblock crossings.

TEXAS PRACTICES AND EXPERIENCE

Texas has faced a growing pedestrian safety problem in its urban areas, with high numbers of midblock crossing crashes in cities like Houston, Dallas, and San Antonio. In response, Texas agencies have prioritized pedestrian safety through strategic plans and systematic improvements. The Texas Pedestrian Safety Action Plan (PSAP), completed in 2023, provides a statewide framework for reducing pedestrian fatalities and serious injuries. PSAP's analysis confirmed that the vast majority of severe pedestrian crashes in Texas occur at midblock locations, often on high-speed arterials. As is shown in Figure 5-1 Specifically, 64% of Texas pedestrian crashes from 2017 to 2021 were at non-intersection locations, and 70% of those crashes were cars headed straight, and many of the fatal crashes were on state-maintained roads (which carry higher speeds and volumes). This over-representation on high-speed corridors indicates a need for targeted midblock crossing interventions on those roadways (TxDOT, 2023).

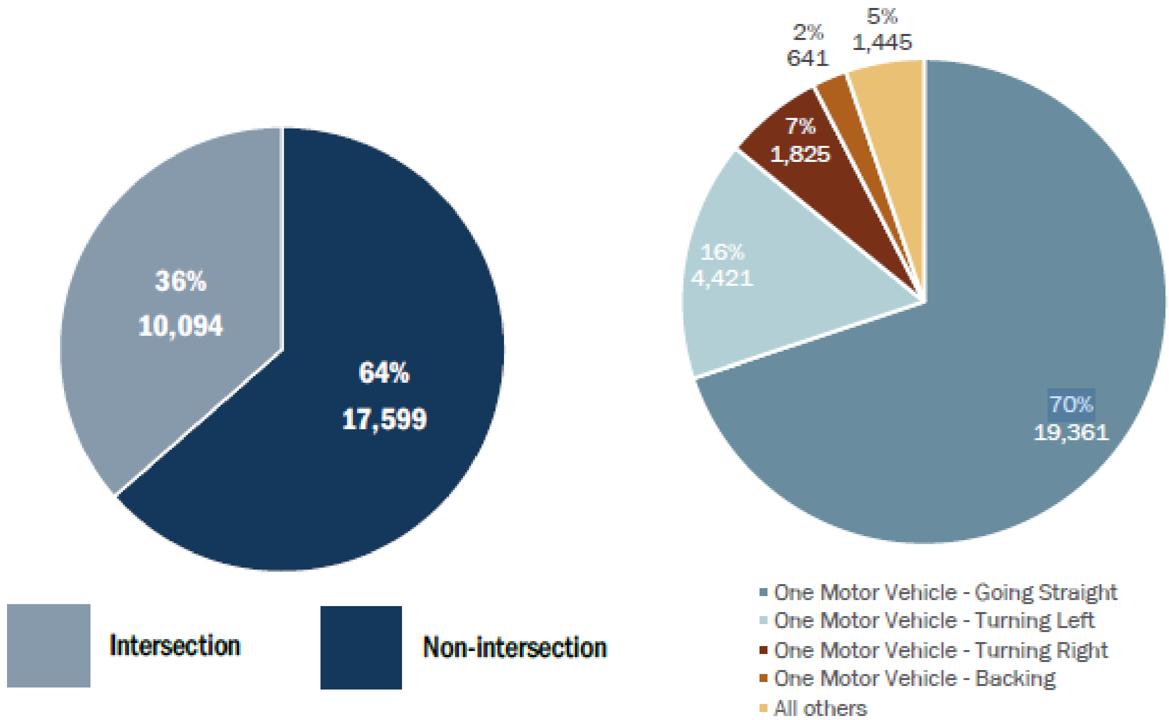


Figure 5-1. Comparison of Non-intersection and Intersection-related Pedestrian Crashes (Left), Comparison of "Manner of Collision" for Pedestrian Crashes (Right). Source: TxDOT PSAP

The Texas PSAP identifies and promotes a toolbox of engineering countermeasures to improve midblock crossing safety. These measures align with Federal Highway Administration (FHWA) recommendations for uncontrolled crossings. Texas categorizes treatments as either active (devices that actively alert or control traffic) or passive (design features that calm traffic or enhance visibility). Active midblock crossing devices include Pedestrian Hybrid Beacons (PHBs) and rectangular Rapid-Flashing Beacons (RRFBs) (TxDOT, 2023). A PHB (often called a "HAWK" signal) is a pedestrian-activated signal that displays a red light (solid or flashing) to stop traffic and allow pedestrians to cross; an RRFB consists of rapid flashing amber lights mounted with a pedestrian crossing sign to increase driver awareness when pedestrians are present; they are usually additionally accompanied by passive treatments such as the example shown in Figure 5-2.

Figure 5-2. Typical RRFB Layout in Combination with Refuge Island. Source: FHP Tampa

Passive treatments include pedestrian refuge islands (median islands that allow a two-stage crossing), in-street pedestrian crossing signs (flexible signs in the roadway reminding drivers to yield and stop for pedestrians), curb extensions ("bulb-outs" that shorten crossing distance and improve sightlines), and raised crosswalks (speed table crosswalks) such as shown in Figure 5-3.

Figure 5-3. Speed Table in Combination with Curb Extension. Source: NACTO

These passive measures improve pedestrian visibility and encourage lower vehicle speeds at crossing locations (TxDOT, 2023). For example, the PSAP cites FHWA's documented effectiveness for certain treatments: installing a pedestrian refuge island can reduce pedestrian crashes by roughly 32%, and a raised crosswalk can reduce pedestrian crashes by ~45% (as derived from national studies) (Blackburn et al., 2018). The plan encourages agencies to combine multiple countermeasures (e.g., high-visibility crosswalk markings plus an RRFB and refuge island) as needed to maximize safety, especially on multi-lane roads.

One of the most impactful measures in Texas has been the deployment of PHBs (Figure 5-4). Texas was an early adopter of PHBs after they gained interim approval in the MUTCD (Manual on Uniform Traffic Control Devices) around 2009. The City of Austin, in particular, has implemented one of the nation's most extensive PHB programs. Austin installed its first PHB in 2009 and by 2023 had installed a total of 111 PHBs, with 140 planned by 2025 (Pagano, E. 2023).

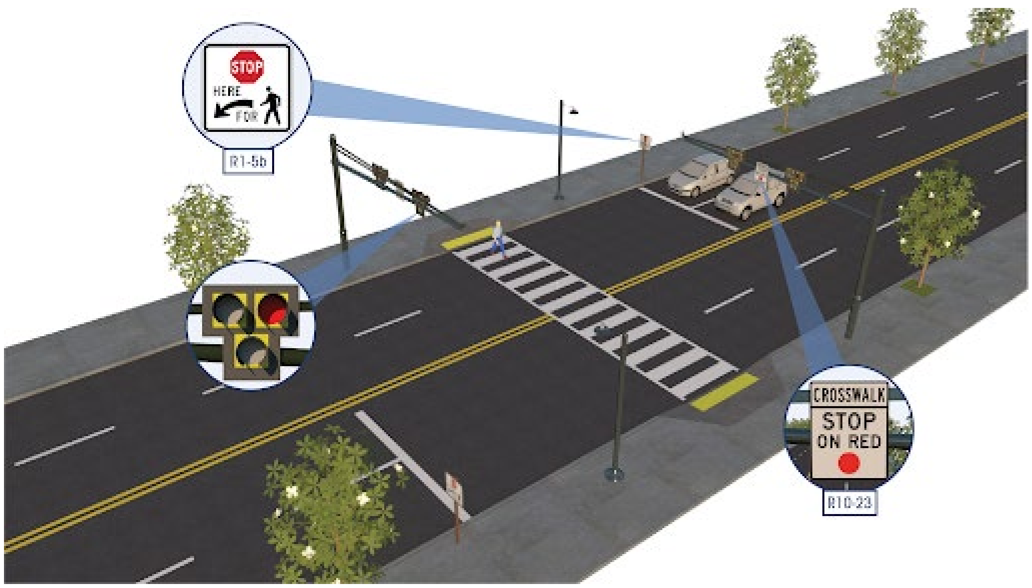


Figure 5-4. Typical PHB Layout. Source: FHWA STEP Countermeasure Tech Sheets

This is the second-highest number of PHBs of any U.S. city (trailing only Tucson, Arizona, where the device was originally developed). Austin's experience demonstrates the effectiveness and community demand for safe midblock crossings. Early on, Austin's Transportation Department relied on citizen requests to identify PHB locations, but in 2015 they adopted data-driven prioritization criteria, considering factors like distance to the nearest signalized crossing, roadway speed and width, pedestrian generators (schools, transit stops), crash history, and equity considerations (Pagano, E. 2023). In 2021, Austin further refined the process with a systemic scoring system to rank crossing needs citywide. This evolution toward proactive identification of midblock crossing needs (rather than purely reactive installation after complaints) is a noteworthy practice. Austin officials report that PHBs have become an "important tool" in addressing an estimated $500 million worth of needed pedestrian safety improvements across the city. While expensive (Austin estimates roughly $200,000 per PHB installed, versus ~$450,000 for a full traffic signal) (Pagano, E. 2023), PHBs are highly effective at getting drivers to stop for pedestrians. Texas researchers note that driver compliance with PHB red signals is typically above 95%, much higher than at unsignalized crosswalks (Fitzpatrick et al., 2023). The safety payoff is substantial: according to an NCHRP study by Zegeer et al. (2017), PHBs on average reduce pedestrian crashes by about 55% (Blackburn et al., 2018). Texas agencies have taken note of this evidence. For instance, in San Antonio, officials secured federal funding in 2022 to add multiple midblock crossings with PHBs and RRFBs along a deadly stretch of Zarzamora Street. Citing FHWA research, the city expects these improvements to yield and stop approximately a 56% reduction in pedestrian crashes on that corridor (San Antonio, 2024), essentially adopting the documented ~55% crash reduction factor for PHBs. This example shows Texas applying national research to local projects and setting quantitative safety targets. San Antonio and other Texas cities (e.g., Houston, Dallas) are also integrating PHBs and other crossing beacons near transit stops and in areas with frequent midblock pedestrian activity.

Rectangular Rapid-Flashing Beacons (RRFBs) and Other Treatments: RRFBs have also been widely used in Texas in the past decade as a lower-cost alternative to PHBs for midblock crosswalks on lower-speed or moderate-volume roads. An RRFB consists of dual rectangular yellow LEDs that flash rapidly in a wig-wag pattern when a pedestrian presses a button (Figure 5-5). They do not produce a red stop indication, but they significantly enhance driver awareness. Texas's PSAP includes guidance for when to install an RRFB versus a PHB (TxDOT, 2023). Generally, PHBs are suggested for higher-speed, multi-lane roads or locations with a history of severe crashes, whereas RRFBs may suffice on two-lane or lower-volume roads where full signalization is not warranted (TxDOT, 2023). Field studies in Texas and elsewhere have found that RRFBs can achieve driver yielding and stopping rates in the range of ~65–85% on average, compared to under 20% yielding and stopping at an untreated crosswalk on a similar road (Fitzpatrick et al., 2023). While slightly less effective than PHBs in commanding driver compliance, RRFBs still can cut crashes nearly in half – a 2017 NCHRP study estimated RRFBs reduce pedestrian crashes by ~47% (Blackburn et al., 2018). Texas has embraced RRFBs, installing them at numerous midblock crosswalks (e.g., near schools, parks, and parking lot crossings of busy streets). During 2017–2018, there was a temporary pause in new RRFB installations nationwide due to a patent issue, but that was resolved, and Texas resumed installations under FHWA's interim approval. By 2020, RRFBs were a common sight in many Texas cities as part of "Safe Routes to School" projects and Vision Zero initiatives. The PSAP implementation tables show hundreds of potential locations statewide where RRFBs are recommended as a systemic improvement (TxDOT, 2023).

Figure 5-5. Example of RRFBs at a crossing sign

In addition to beacons, transportation agencies and municipalities in Texas have systematically added pedestrian refuge islands on wide roads. A raised median refuge allows a pedestrian to cross one direction of traffic at a time, dramatically improving safety on multi-lane roads. TxDOT's roadway design manual now encourages pedestrian refuges on any new or rebuilt arterial where midblock crossings are likely or desired. The safety benefit is well documented: refuge islands can reduce pedestrian crashes by about 32% (Blackburn et al., 2018) and are especially crucial in mitigating the "multiple-threat" crash risk on multi-lane roads (where one driver stops for a pedestrian but a driver in the next lane does not see the pedestrian in time).

Figure 5-6. Example Stop Here for Pedestrians Sign and Advance Stop and Yield Markings (Right)

For similar reasons, advance stop/yield and stop lines along with "Stop Here for Pedestrians" signs (Figure 5-6) have been promoted. By stopping vehicles further back from the crosswalk.

Advance stop and yield and stop markings (placed ~30–50 feet in advance) provide approaching drivers a better view of crossing pedestrians. While previous guidance and research frequently referenced the use of "Yield and Stop Here to Pedestrians" signage and associated advance yield and stop markings, recent legislative and design policy changes in Texas have redefined expectations for driver behavior at pedestrian crossings. The Lisa Torry Smith Act, enacted in 2021, legally mandates that drivers stop and yield to pedestrians lawfully present in marked crosswalks. Failure to comply constitutes a criminal offense. In alignment with this statutory requirement, the 2024 TxDOT Roadway Design Manual (Chapters 18 and 19) now prescribes the use of "Stop Here for Pedestrians" signage in conjunction with stop bars, replacing previous recommendations for yield and stop-based signage (Texas Legislature 2021, 2024). This shift emphasizes a stronger enforcement posture and aims to enhance pedestrian safety by providing clearer visual cues to drivers regarding their legal obligation to stop at designated crossings.

Research cited by Texas (from Zegeer et al., 2017) shows advance yield and stop markings and signs can reduce pedestrian crashes by roughly 25% (Blackburn et al., 2018). The PSAP recommends these, especially at midblock crosswalks on multi-lane roads without signal control. Other visibility enhancements, such as high-visibility crosswalk markings (e.g., ladder or continental striping), are low-cost and have been found to cut pedestrian crashes nearly in half at uncontrolled sites (Blackburn et al., 2018). Texas cities have increasingly moved away from two parallel-line crosswalks to high-visibility patterns at midblock crossings. Similarly, parking restrictions near crosswalks (daylighting) are enforced to prevent parked cars from blocking sight lines – this measure alone can reduce pedestrian crashes by ~30% by improving visibility (Blackburn et al., 2018).

A critical aspect of midblock safety is managing vehicle speeds. Pedestrians face a high risk of serious injury or death when involved in traffic crashes, making speed-reduction strategies critical for improving safety for all road users. As the speed at which a vehicle impact increases, a factor influenced by speed limits, road design, and driver behavior. The likelihood of fatal or severe injury rises steeply in an S-shaped pattern. Research by Rosen and Sander (2009), which analyzed over 2,000 pedestrian fatalities, found that the risk of death was approximately 8% at an impact speed of 31 mph and rose to 50% by 47 mph. Other studies have found similar patterns, though exact risk levels differ (Tefft, 2011).

One study by Tefft (2011) analyzed data from 422 pedestrians (Tefft, 2011) aged 15 and older struck by vehicles from model years 1989–1999 between 1994 and 1998 in the U.S. It presented standardized risk estimates for severe injury and fatality based on impact speed, accounting for factors like age, BMI, and vehicle type, and aligning with national pedestrian characteristics from 2007 to 2009. In this context, serious injury was defined as an Abbreviated Injury Scale (AIS) score of 4 or greater. The AIS is a widely used medical classification that ranks individual injuries on a scale from 1 (minor) to 6 (unsurvivable). An AIS score of 4 indicates a severe injury, such as major head trauma or significant internal bleeding. The study included all fatalities regardless of AIS score. Confidence intervals were shown as dotted lines in the visual representation in Figure 5-7.

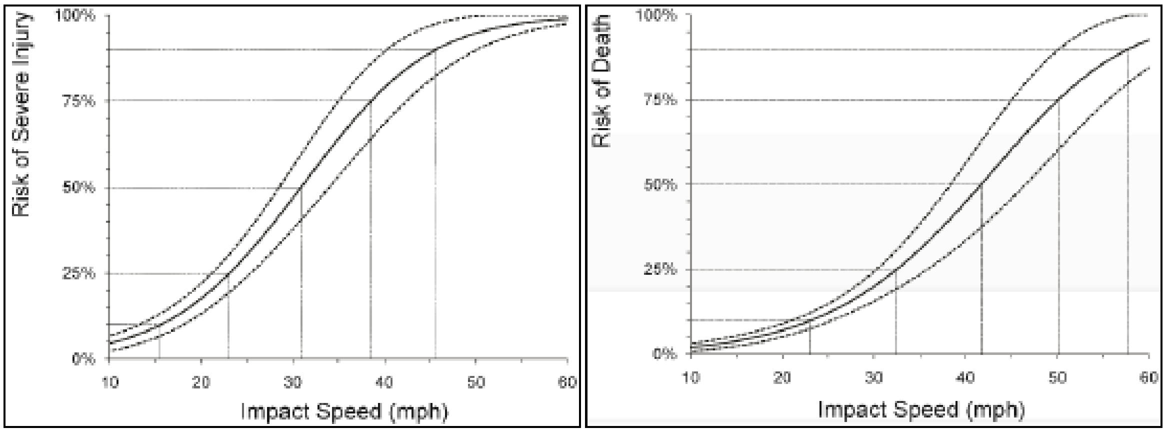


Figure 5-7. Risk of Severe Injury (Left) and Death (Right) in Relation to Impact Speed. Source: (Tefft, 2011)

Texas's approach, consistent with Vision Zero principles, is to use roadway design to slow traffic where pedestrians cross. The strategy includes building raised pedestrian crossings (essentially a flat-top speed hump marked as a crosswalk) on lower-speed roads. Raised crossings force drivers to slow down and have shown an ~45% reduction in pedestrian crashes (Blackburn et al., 2018), while also improving yielding and stopping rates because the crosswalk is more prominent. For example, Austin has used raised crosswalks in downtown and campus areas and plans to expand their use where appropriate. Curb extensions at midblock crossings are another design favored in Texas city street projects – by extending the curb, they narrow the roadway, slow turning vehicles, and reduce the time a pedestrian is exposed in the street. Although difficult to quantify (the FHWA guide lists the crash reduction for curb extensions as "unknown" due to limited isolated data (Blackburn et al., 2018)), they adhere to safety principles by increasing visibility and shortening crossing distance. Texas has included curb extensions as a recommended treatment, especially in urban districts and along roads with on-street parking. Finally, street lighting improvements are an often overlooked but crucial countermeasure. A significant fraction of midblock pedestrian crashes occurs at night; adding overhead lighting at crosswalks can reduce nighttime crashes by ~23% (Blackburn et al., 2018). TxDOT's policies now call for evaluating pedestrian lighting anytime a marked midblock crosswalk is installed on a state road. Many Texas cities have "illuminated crosswalk" initiatives targeting transit stops and other midblock crossings for new lighting. The combined application of these engineering measures – beacons/signals, refuge islands, visibility enhancements, and speed calming – forms the core of Texas's current strategy for midblock pedestrian safety.

In summary, over the past decade, Texas has moved from an ad hoc, reactive approach to a comprehensive, proactive approach addressing midblock pedestrian safety. State and local agencies are leveraging national best practices (often through FHWA's Safe Transportation for Every Pedestrian program) and contributing their experience (such as Austin's PHB program) to systematically implement effective midblock crossing treatments. The emphasis in Texas has been on applying proven countermeasures at scale – hundreds of sites have been identified for improvements – and on integrating pedestrian safety into mainstream roadway design and operation on urban streets.

U.S. NATIONAL PRACTICES AND RESEARCH

Across the United States, the past ten years have seen a strong focus on improving pedestrian safety at uncontrolled and midblock crossings. This effort has been driven in part by alarming trends: pedestrian fatalities nationwide have risen sharply in the last decade, reaching levels not seen in 40 years. In response, federal agencies like the FHWA, National Highway Traffic Safety Administration (NHTSA), and the Transportation Research Board (TRB) have produced extensive research, guides, and campaign initiatives to promote safer crossings. Key national publications in this period include the FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018), NCHRP Report 841 (2017) on developing crash modification factors for pedestrian treatments (Blackburn et al., 2018), and NCHRP Report 1030 (2023), Safety at Midblock Pedestrian Signals (Fitzpatrick et al., 2023a). Additionally, FHWA's Everyday Counts (EDC) program in 2017–2019 featured the initiative "Safe Transportation for Every Pedestrian" (STEP), which actively promoted cost-effective countermeasures for uncontrolled crossing safety to state DOTs. Collectively, these efforts have yielded a consensus on a toolbox of effective midblock crossing countermeasures, as well as a growing body of real-world implementation experience across many U.S. cities and states.

One of the most influential recent guidance documents is FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (Blackburn et al., 2018). This guide – developed by safety researchers (VHB and UNC's Highway Safety Research Center) – synthesized the latest research on various engineering treatments and provided a step-by-step approach for agencies to evaluate and improve midblock crossings. The guide emphasizes a data-driven selection of countermeasures based on roadway context: traffic volume, number of lanes, speed, and site-specific factors (e.g., nearby generators like transit stops).

Installing a pedestrian hybrid beacon has an estimated Crash Reduction Factor (CRF) of 55% for pedestrian crashes; adding a refuge island yields a 32% reduction and an RRFB of about 47%. Even simpler measures like high-visibility crosswalk markings (continental or ladder style) have a documented 48% crash reduction compared to standard parallel lines, and adding advance yield and stop markings and signs contributes to ~25% crash reduction (Blackburn et al., 2018). FHWA's guide packaged these findings into the STEP initiative's promotion of the "Spectacular Seven" (a nickname for seven proven countermeasures): crosswalk visibility enhancements, raised crosswalks, pedestrian refuge islands, RRFBs, pedestrian hybrid beacons, road diets, and signal strategies (TxDOT, 2023, and Blackburn et al., 2018). The STEP program provided technical sheets and workshops to transportation agencies nationwide. Many state DOTs and cities, including Texas as discussed, adopted these measures as standard practice for improving midblock crossings. By 2020, FHWA reported that more than 30 states had systemic projects underway implementing STEP countermeasures at uncontrolled crossings (e.g., installing RRFBs at dozens of high-risk crosswalks or adding refuge islands on multilane urban highways). This nationwide push has significantly increased the prevalence of midblock crossing treatments on U.S. roads in the last decade.

The 2010s saw several rigorous studies evaluating midblock safety measures, providing the evidence base that fed into the guides above. One landmark study was NCHRP Report 841 (Zegeer et al., 2017), which developed Crash Modification Factors (CMFs) for pedestrian treatments at uncontrolled locations (Blackburn et al., 2018). This study analyzed crash data from multiple cities to quantify the impacts of adding specific countermeasures. It also reinforced earlier findings on the importance of combining measures: for instance, a marked crosswalk alone on a multi-lane 40 mph road was associated with no safety improvement or even a higher crash rate unless additional devices (beacons, median islands, etc.) were implemented (Blackburn et al., 2018). This aligns with an earlier FHWA study (Zegeer et al., 2005) that warned against simply painting crosswalks on high-speed, high-volume roads without other enhancements. The recent literature consistently urges that on higher-speed multilane roads, midblock crossings should be made more conspicuous and controllable – either through physical measures that slow traffic (e.g., medians, raised crossings) or through active traffic control (e.g., flashing beacons, signals). Driver yielding and stopping behavior studies also proliferated in the last decade. For example, a 2020 TRB paper by Houten & Lyon tracked yielding and stopping rates at various enhanced crosswalks. It found that driver yield and stop compliance was typically in the 80–90% range at PHB sites (and nearly 100% when the beacon was activated showing steady red), around 80% at RRFB sites, and below 20% at basic unsignalized crosswalks without enhancements (Fitzpatrick et al., 2023). Another study in Minnesota (Hourdos, 2020) compared driver behavior at different beacon setups and noted similar large differentials in yield and stop rates. These studies confirmed empirically what practitioners suspected: devices like PHBs and signals that assign clear right-of-way to pedestrians (a red light for drivers) achieve the highest compliance (Fitzpatrick et al., 2023), whereas passive measures rely more on driver attentiveness and courtesy. Consequently, FHWA and states' guidance began to include thresholds for when a PHB (or even a full midblock traffic signal) is warranted – typically based on pedestrian volumes, traffic volumes, and crossing difficulty (e.g., crossing more than 3 lanes or >12,000 ADT traffic often points to a need for a PHB). The MUTCD 2009 edition had introduced PHBs as an interim device; by the 2020s, proposals were underway (via NCHRP 03-141 and others) to formally incorporate Midblock Pedestrian Signals (MPS) into future MUTCD updates (Fitzpatrick et al., 2023). An MPS in this context is essentially a pedestrian traffic signal at a midblock crosswalk, which may use a flashing red phase to allow drivers to proceed after stopping (similar to a PHB's operation). Notably, such midblock signals are not new – cities like Los Angeles have used them for over 40 years and achieved very high driver compliance (Fitzpatrick et al., 2023). The recent NCHRP Report 1030 (2023) on Safety at Midblock Pedestrian Signals compiled the safety performance of these installations and recommended MUTCD language to encourage their use where appropriate (Fitzpatrick et al., 2023). The push to update national standards reflects the evolution over the last decade from treating midblock crossings as uncommon exceptions to recognizing them as critical elements of pedestrian networks that need appropriate traffic control.

A recent survey of 23 transportation agencies underscored the variety of pedestrian crossing treatments and selection criteria in practice. Although full traffic signals and PHBs were widely used, nearly 80% of surveyed agencies also reported deploying MPSs, particularly in urban corridors where a two-leg crossing can facilitate safer midblock crossing activity. Respondents overwhelmingly cited pedestrian demand and crash history as critical factors in identifying prospective MPS locations, though they also emphasized roadway speed, lane configuration, and opportunities for adding supportive infrastructure such as medians or lighting. Notably, more than two-thirds of these agencies have formally adopted "Vision Zero" or similar safety-first approaches, indicating that MPS selection often aligns with broader policies aimed at reducing fatal and serious-injury pedestrian crashes. The survey further revealed that while MPS operation can be coordinated with adjacent signals to maintain vehicle progression, many practitioners prioritize minimizing pedestrian delay through "hot button" or semi-actuated modes, reflecting a growing commitment to pedestrian-oriented design principles (Fitzpatrick et al., 2023b).

In addition to established countermeasures, the 2014–2024 period saw experimentation with new technologies for midblock crossing safety. Some U.S. cities piloted in-roadway warning lights, which are embedded LEDs in the pavement that flash when a pedestrian is crossing. These were used in the early 2000s in a few places and have had mixed results; RRFBs largely supplanted them due to better visibility and lower maintenance. Another innovation is LED border-enhanced signs, where the pedestrian crossing warning sign has blinking LEDs around its border activated by a sensor – a few cities tried these as an alternative to RRFBs (especially during the RRFB patent hiatus) to increase conspicuity. Automated pedestrian detection has also improved: modern PHB and signal installations often include passive detection (infrared or video sensors that detect a waiting pedestrian) to trigger the beacon or extend crossing time (Fitzpatrick et al., 2023). This addresses situations where a pedestrian might not press a button or where slower walkers need more time. Some midblock crossings in the U.S. now use thermal imaging sensors to detect pedestrians at the curb and begin the PHB activation automatically, making the crossing more user-friendly and minimizing wait times (Fitzpatrick et al., 2023). There is also growing interest in vehicle-to-pedestrian (V2P) communication, though as of 2024 it is still experimental: cars with advanced driver assistance or connected vehicle technology could receive an alert that a pedestrian is in a midblock crosswalk ahead (through roadside units or smartphone apps). While not yet mainstream, such tech could in the future augment midblock safety, especially in low-visibility conditions. Lastly, the U.S. has seen more use of “Pedestrian Safety Zones” and targeted enforcement. Cities like New York, Washington, D.C., and Honolulu identified corridors with frequent midblock crossing accidents and implemented intensive interventions: reduced speed limits, portable electronic signs reminding drivers to yield and stop, and high-visibility police enforcement of crosswalk laws. The NHTSA has documented that high-visibility enforcement campaigns (often coupled with public education) can significantly improve driver yielding and stopping behavior at crosswalks (Bevan et al., 2023). For example, a series of enforcement waves in Florida (2013–2017) resulted in increased yielding and stopping rates and a reduction in pedestrian crashes at treated crosswalks (Van Houten et al., 2017, as referenced in FHWA materials). Such programs underscore that engineering measures work best when complemented by education and enforcement – a comprehensive approach embraced by many U.S. cities’ Vision Zero action plans in the last decade.

The national experience from 2014 to 2024 has solidified a set of best practices for midblock pedestrian crossings in the U.S.: ensure crossings are located and designed appropriately for the context; use high-visibility markings and adequate lighting; provide median refuges on wide roads; install active warning beacons or signals where traffic conditions warrant; manage vehicle speeds through design or regulation (with a target of 30 mph or lower where pedestrians frequently cross, to greatly improve survival odds (Bevan et al., 2023)); and back these engineering treatments with policies and education that reinforce pedestrian right-of-way. The net effect of these efforts is gradually becoming evident. While pedestrian fatalities remain high, cities that have aggressively implemented crossing improvements are seeing localized success. For instance, New York City reported a 36% reduction in pedestrian fatalities on corridors that underwent comprehensive street redesigns, including added midblock crossings and refuge islands (NYC Vision Zero Year 5 Report, 2019). Similarly, Seattle achieved increases in driver yielding and stopping and a drop in collisions after installing 18 RRFBs citywide in a coordinated program (Seattle DOT, 2018). These experiences echo the quantitative research – showing that the right countermeasures can indeed save lives and that widespread implementation is key to making a dent in the statistics.

INTERNATIONAL PRACTICES AND CASE STUDIES

Pedestrian midblock crossing safety is a global concern, and many countries have developed robust measures and policies to protect pedestrians crossing the street. In fact, international practices often informed the U.S. approaches. Concepts like raised crosswalks, pedestrian priority laws at crossings, and area-wide traffic calming originated or were first widely adopted in Europe and elsewhere. Over the past decade, several international trends and case studies have stood out as relevant to midblock crossing safety:

A fundamental principle in countries with strong pedestrian safety records (e.g., Sweden, the Netherlands, and the UK) is managing vehicle speeds to safe levels wherever pedestrians and vehicles mix. The Safe System approach, pioneered in Sweden's Vision Zero and the Netherlands' Sustainable Safety, recognizes that humans are vulnerable and makes it a design priority that collision forces remain survivable. This translates to a simple rule: if pedestrians are expected to cross at-grade, traffic speeds should ideally be at or below about 30 km/h (20 mph). Above that speed, either crossings should be eliminated or grade-separated, or drivers must be controlled (via signals or other means) to ensure pedestrians are not struck at full speed. Many countries have acted on this principle in the past 10 years. Spain implemented a nationwide law in 2021 setting the default speed limit to 30 km/h on all urban streets with a single lane in each direction (Man, 2021; Katerina & Konstantinos, 2024). The rationale, as stated by Spain's traffic authorities, was that cutting the typical urban speed from 50 km/h to 30 km/h could reduce the risk of a pedestrian being killed fivefold (La Moncloa, 2020). This dramatic policy change – a world first at the national level – is expected to significantly reduce pedestrian fatalities in Spain's cities. Paris, France, similarly lowered its citywide speed limit to 30 km/h in 2021 (following the example of many smaller European cities) (ETSC, 2020).

Early evaluations in European cities with widespread 30 km/h zones have indeed shown large safety benefits. A recent review found 30 km/h limits in cities led to reductions in crashes and injuries by around 20–40% (Yannis & Michelaraki, 2024). In London (UK), the adoption of 20 mph zones (with traffic calming) in numerous neighborhoods was associated with a 42% reduction in road casualties, with especially large drops in pedestrian injuries (Grundy et al., 2009). The Royal Society for Prevention of Accidents (RoSPA) noted that the biggest reductions in these zones were in pedestrian casualties – falling by about 54% in 20 mph traffic-calmed zones compared to adjacent areas (RoSPA, 2023). This evidence has spurred wider implementation of such zones across the UK. By 2020, for example, central London and vast swaths of other UK cities had 20 mph limits, and even entire countries (Wales in 2023) have moved to make 20 mph the norm in residential areas (RSA, 2018). These international examples highlight that speed reduction is arguably the single most effective "countermeasure" for pedestrian crossing safety, because a slower vehicle is both more likely to yield and stop and far less likely to cause death or serious injury if a collision occurs (Bevan et al., 2023).

Many countries provide pedestrians stronger legal priority at midblock crossings than is customary in much of the U.S. For instance, United Kingdom law has long mandated that drivers must yield and stop for pedestrians on zebra crossings (marked crosswalks with black-and-white "zebra" stripes and flashing amber beacons, typically located midblock). Similarly, zebra crossings in Germany and much of Europe give pedestrians the right of way, and drivers are conditioned to slow down or stop when someone is waiting to cross. The presence of the distinctive zebra markings and (in the UK) amber Belisha beacons is an established visual cue for drivers to yield and stop. These unsignalized crossings work effectively when traffic speeds are moderate and volumes are not too high.

Countries that use them extensively pair them with other measures: for example, the UK often places zebra crossings on raised platforms in areas with high pedestrian activity, combining priority and speed calming. In the Netherlands, it is common to see raised zebra crossings at the entries to residential areas or near schools – effectively functioning as both a speed hump and a crosswalk. The result is very high compliance by drivers and low crash rates. A European study comparing pedestrian crossing fatality rates in 14 countries found that nations like the UK and Germany – which have extensive pedestrian facilities and stricter yield and stop compliance – had the lowest death rates at pedestrian crossings, whereas countries with less yielding and stopping culture or fewer safety measures (such as Poland and Lithuania) had the highest (Uhlmann, 2021). The study (Uhlmann, 2021) calculated pedestrian crossing fatalities per population and noted an order-of-magnitude difference, implying that infrastructure and driver behavior make a tremendous impact (Uhlmann, 2021). Many high-performing countries have invested in crosswalk visibility: typical enhancements include overhead lighting for every crosswalk, advance warning signs, and sometimes overhead pedestrian crossing signals (flashing beacons).

For example, Sweden in the 2000s undertook a national program to improve uncontrolled crossings – many zebra crossings were removed from roads where they could not be made safe (e.g., higher-speed roads without medians were either given signal control or the crossing was closed), and on remaining crossings, measures like refuge islands, better lighting, and sometimes in-road warning lights were added. The effect was a substantial long-term reduction in pedestrian crashes on those treated routes (Amin et al., 2018). Poland, facing a high rate of midblock crosswalk fatalities, passed new laws in 2021 to require drivers to slow and yield and stop when a pedestrian is approaching a crosswalk (even if not yet in it) and stepped up enforcement and retrofits (e.g., flashing lights at crosswalks). Early indications show these changes have started to bring down the previously high crash rates at Polish crossings (Polish National Road Safety Council, 2022). These examples underscore an international trend: strengthening pedestrian priority laws combined with engineering upgrades. When the law clearly favors the pedestrian and infrastructure supports safe behavior (through visibility and speed control), midblock crossings can operate with a high degree of safety even without full traffic signals.

1. **Signalized Midblock Crossings and Tech Innovations Abroad**

In many countries, the use of midblock pedestrian signals is common, often more so than in the U.S. The UK introduced midblock pedestrian traffic lights (the "Pelican crossing") as far back as the 1960s. A Pelican crossing is a push-button signal that stops traffic with a red light and then flashes amber to allow drivers to proceed once pedestrians have finished crossing. The Pelican has largely been replaced by the Puffin crossing (which stands for Pedestrian User-Friendly Intelligent crossing) in the UK (Figure 5-8). Puffin crossings use sensors to detect pedestrians: they can extend the crossing time if someone (like an elderly pedestrian) is still in the road, and they won't call the red signal if a pedestrian pushes the button and then walks away (canceling the call). Additionally, Puffin crossings place pedestrian "walk" signals on the near side (so pedestrians waiting can see the countdown and do not have to look across the road).

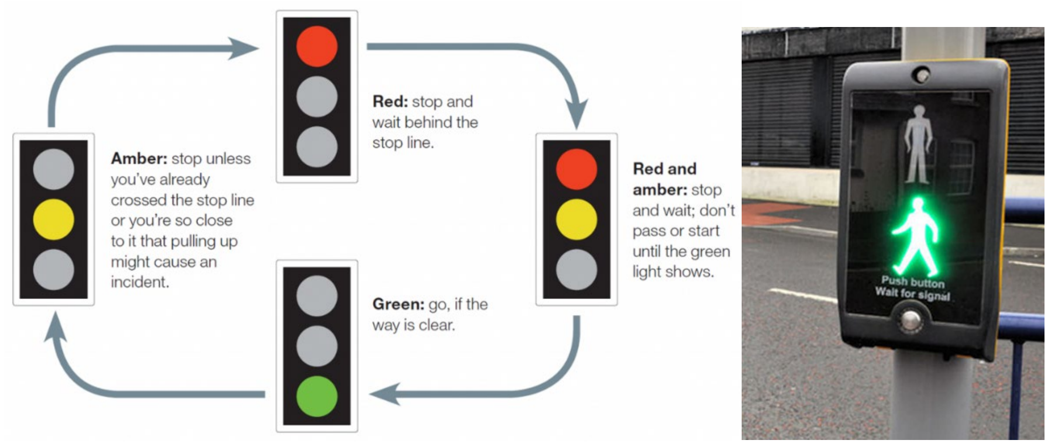


Figure 5-8. Puffin Crossing traffic light sequence (left) push button with walk signal near side (right). Source: TheoryTest.org

These smart midblock signals have been adopted in the UK over the last decade, improving efficiency and safety. Other countries have similar innovations: Australia and New Zealand use midblock signals in urban areas (often called "wombat signals"), sometimes coordinated with neighboring traffic signals to maintain traffic progression. In Japan, near major transit stations or urban centers, one will frequently observe signalized midblock crossings with brief cycle times (to minimize pedestrian delay), recognizing the high foot traffic. These practices show that midblock signals can be integrated into traffic management without causing undue delay, provided timings are carefully set. Modern traffic control systems even allow midblock crossings to be linked into adaptive signal networks. For instance, Barcelona, Spain, as part of its 2015–2020 road safety plan, installed new midblock crossing signals on several large avenues and coordinated them at a 20-mph progression speed – this both calmed traffic and provided regular safe crossing opportunities, contributing to a decline in pedestrian crashes (Ajuntament de Barcelona, 2020 report).

Technology is also playing a role internationally. Intelligent lighting at crosswalks is one example. In some Northern European countries, sensors detect pedestrians at night and automatically boost lighting levels or activate flashing lights as they step into the road. The process reduces energy usage (lights are brighter only when needed) and increases the driver's attention. A pilot in Finland installed LED strips on the road surface that light up in red when a pedestrian is present, effectively creating an illuminated crosswalk (Figure 7-9) – initial results showed improved yielding and stopping, though long-term safety impact is under study.

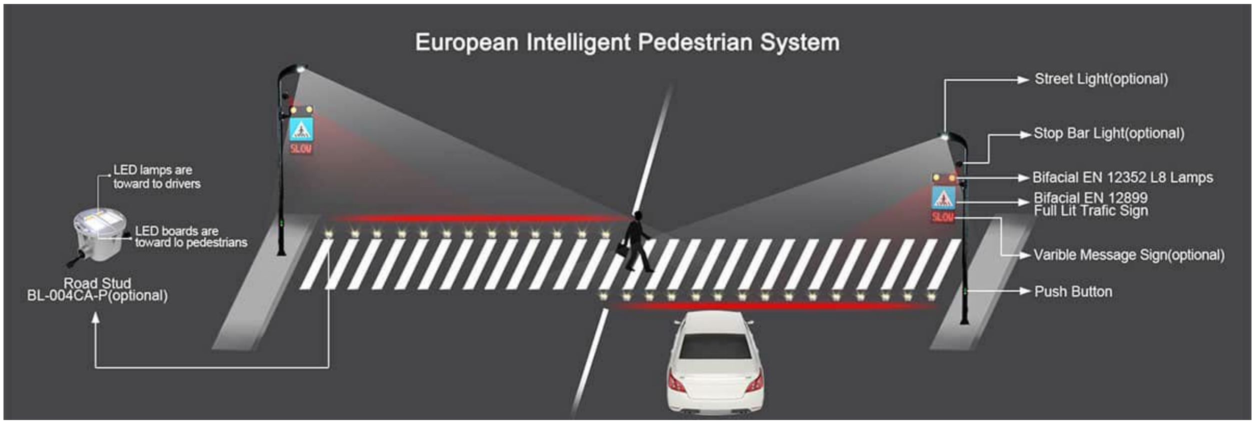


Figure 5-9. European Intelligent Pedestrian System. Source: Ellumin

Vehicle technology in advanced cars (like Volvo's pedestrian detection with auto-braking) is more widely available in high-income countries and can mitigate some midblock crashes, but it is not foolproof. Still, the proliferation of such features, encouraged by European New Car Assessment Program (Euro NCAP) ratings, is expected to globally reduce pedestrian collisions in coming years.

INTERNATIONAL CASE STUDIES – URBAN INITIATIVES

Several cities around the world have earned recognition for innovative pedestrian safety programs in the last decade. An OECD/ITF report in 2020 highlighted seven case study cities – Barcelona, Bogotá, Buenos Aires, Fortaleza, London, New York, and Rotterdam – which have implemented data-driven road safety policies with a focus on protecting vulnerable road users (ESTC, 2020). In Bogotá, Colombia, the city's "Vision Zero" approach led to a number of pedestrian safety measures, including hundreds of new or upgraded midblock crossings, especially around the TransMilenio BRT stations (which often are located at midblock along arterial roads). Bogotá combined these with speed management (e.g., reducing speed limits from 60 km/h to 50 or 30 km/h in key areas) and saw a significant decrease in pedestrian fatalities. By 2019, pedestrian deaths citywide had dropped about 32% from a 2015 baseline (World Resources Institute, 2020). Fortaleza, Brazil, is another success story through its program "Vida Segura". The city installed flashing beacons, high-visibility crossings, and refuge islands at dozens of midblock locations and tightened speed enforcement. From 2014 to 2019, Fortaleza achieved a 40% reduction in pedestrian fatalities (ESTC, 2020), earning international awards for its efforts. A key part of their strategy was community engagement – they ran public campaigns about the new crossings and trained local police to enforce yielding and stopping. Rotterdam, Netherlands, developed a sophisticated risk mapping tool to proactively identify hazardous crossings even before crashes occur. They looked at factors like road layout, traffic volume, and conflicts to flag midblock locations that should be made safer and then systematically added measures there. London and New York, as large global cities, have heavily invested in pedestrian safety as part of Vision Zero commitments. London's Transport for London (TfL) authority published new street design standards (2019) that prioritize pedestrian crossings – for example, mandating raised table crossings on side street entries and encouraging midblock zebra crossings within "Healthy Streets" zones. Meanwhile, New York City installed over 1,500 pedestrian refuge islands and 400+ new crossings (some midblock, some at T-intersections) between 2014 and 2021, targeting areas with long distances between safe crossings (NYC DOT Pedestrian Safety Action Plans). These interventions corresponded with reductions in pedestrian crashes along treated corridors (NYC reported corridors with pedestrian refuge islands had 35% fewer serious pedestrian injuries after installation).

Despite differences in context, several common themes emerge from international experiences. Cities are increasingly aligning pedestrian crossings with where people actually want to cross (desire lines). Rather than forcing pedestrians to walk far out of their way to an intersection, cities provide midblock crossings at popular crossing points (e.g., between transit stops and residential areas). This reduces risky jaywalking. For instance, Dublin, Ireland, added midblock signals in busy tourist areas where large numbers of pedestrians were crossing informally, and it greatly improved compliance and safety. Effective programs often treat an entire corridor or area, not just one crossing. If a road is known for pedestrian crashes, international best practice is to implement a suite of changes – add multiple crossings or upgrade all existing ones, reduce the speed limit, adjust signal timings, etc. – to create a consistently safer environment. Globally, agencies emphasize the importance of monitoring and evaluation. The use of before-and-after studies, conflict observations, and community feedback is important to refine crossing treatments. For example, Oslo, Norway, piloted dynamic lighting at crosswalks and, after mixed results, chose instead to invest more in raised crossings and strict speed enforcement. They only knew to pivot because they carefully evaluated crash and conflict data. A supportive legal framework (such as yield and stop-to-pedestrian laws) and public awareness are vital. Some countries combine new infrastructure with public campaigns – for instance, in 2019 France launched a national campaign on pedestrian priority ("Sécurité Piéton") alongside installing more automated speed and red-light cameras at crosswalks. The lesson is that technology and design flourish best in a culture that values pedestrian safety.

The literature and practices collectively demonstrate that effective midblock crossing safety programs employ a multifaceted approach. Engineering measures are the backbone, informed by evidence and tailored to context; enforcement and education amplify their effectiveness; and policies that reduce vehicle speeds and enhance pedestrian priority create an environment where safe crossings are the norm, not the exception. By learning from both domestic and international experiences, transportation agencies can continue to innovate and implement strategies that make midblock pedestrian crossings significantly safer. The past decade has produced a wealth of guides, research data, and on-the-ground results – the challenge for the next decade will be scaling up these treatments to systematically eliminate the peril of uncontrolled pedestrian crossings. Given the progress in Texas, the broader U.S., and numerous global cities, there is cause for optimism that midblock crossing safety will steadily improve, saving lives and advancing the goal of streets that serve and protect all users.

IMPROVING PEDESTRIAN MIDBLOCK CROSSING SAFETY: A SHORT SURVEY

This summary presents the findings from a survey distributed to transportation professionals across the United States, aiming to understand perspectives on various midblock crossing safety improvements. The survey included questions on common engineering treatments, combinations perceived to be most effective, and key implementation challenges. The feedback offers valuable insight into preferred strategies and underscores the hurdles faced when upgrading pedestrian infrastructure. Detailed charts illustrating these findings can be found in the Appendix.

- **Rectangular Rapid Flashing Beacons (RRFBs)**

Rated 3.38 on a 5-point scale, RRFBs earned moderate support. While experts generally acknowledge that RRFBs outperform simple unsignalized crossings, some find their visibility and driver compliance underwhelming on high-speed, multi-lane roads.

- **Pedestrian Hybrid Beacons (HAWKs)**

HAWKs recorded the highest average score at 4.24, reflecting widespread endorsement. Practitioners commend their effectiveness in prompting driver yielding and stopping and enhancing pedestrian safety. Nevertheless, the high installation costs and warrant thresholds present sizable barriers to widespread deployment.

- **In-Street Pedestrian Crossing Signs**

With an average of 2.57, in-street signs received the lowest rating. Although it is cost-effective for lower-volume, slower-speed corridors, experts observe they often lack the stopping power to significantly influence driver behavior on busier or faster roadways.

- **High-Visibility Crosswalk Markings**

Rated at 2.95, these markings are viewed as a basic but necessary safety measure. Yet many respondents emphasized that, by themselves, markings offer limited protection on higher-speed arterials or multi-lane facilities, necessitating supplementary treatments.

- **Curb Extensions (Bulb-outs)**

With a mean of 3.76, curb extensions help reduce crossing distance and can naturally slow traffic. Their effectiveness, however, can be impeded by concerns over cost, right-of-way availability, and community resistance (e.g., fear of reduced parking or narrower lanes).

- **Pedestrian Refuge Islands**

With a score of 4.19, refuge islands rank near the top. They provide pedestrians with a safe waiting area on wide roads, thereby minimizing exposure to moving traffic. Similar to HAWKs, funding and space constraints can hamper widespread use.

- **Enhanced Street Lighting**

Scoring an average of 3.95, enhanced lighting is widely appreciated for improving nighttime visibility and driver awareness of pedestrians. Respondents stressed that better illumination is vital for reducing crash risks in dark or low-light conditions.

- **Speed Reduction Measures**

Averaging 3.90, traffic-calming methods (e.g., speed humps, raised crosswalks) are generally seen as crucial to pedestrian safety. Yet, their reception often depends on community and political acceptance, with some stakeholders objecting to lower travel speeds.

The single most popular pairing was "HAWKs + High-Visibility Crosswalk Markings." Other frequently cited duos included "Speed Reduction Measures + Enhanced Street Lighting" and "Curb Extensions (Bulb-outs) + Pedestrian Refuge Islands." Overall, respondents emphasized that implementing multiple treatments yields more significant safety benefits than relying on one measure alone.

Funding constraints emerged as the most pervasive roadblock; some respondents noted HAWKs have doubled in cost in recent years. Many also cited the complexity of meeting MUTCD warrant requirements. Additionally, local opposition, whether from businesses or the general public, can impede progress, particularly where design changes involve roadway reconfiguration or reduced capacity. Meanwhile, driver behavior remains a chronic challenge, underscoring the need for both education and enforcement efforts alongside engineering measures.

In short, transportation professionals across the United States see major benefits in robust engineering solutions, especially HAWKs and pedestrian refuge islands, for midblock crossings. However, concerns over cost, warrant thresholds, driver compliance, and local resistance restrict the ability to implement these treatments broadly. Going forward, further research on existing mitigation measures is necessary to refine cost-effective solutions, improve public acceptance, and address persistent issues related to driver behavior and pedestrian safety.

MODELS FOR CRASH FREQUENCY AND CRASH INJURY SEVERITY

Although progress was made towards the development of crash frequency models, and some interesting results have been obtained, the models still are not fully developed and are not yet helpful in identifying effective countermeasures, except to indicate that no countermeasures (as indicated by the CRIS variable TRAFFIC_CNTL_ID = 1, No Control) are associated with an increase in midblock pedestrian crashes, and that adequate street lighting is strongly associated with a reduction in nighttime pedestrian crashes. We propose to finalize the crash frequency models by using a classification and regression tree to identify potential interactive variable terms for the crash frequency models, which might also be useful for the crash severity model. We also plan to add a variable that we expect will allow us to reclaim records that were excluded from the crash frequency models because their length is effectively less than 50 meters. Lastly, we intend to provide a time-series analysis of crosswalks for which the history of development is known.

IMPROVEMENTS IN THE RECORD SETS FOR CRASH FREQUENCY MODELS

Two of the improvements in the record sets for crash frequency proposed in the November 2024 report are the inclusion of rainfall data and the inclusion of more lighting data. These two improvements are now included in the record sets. That report also briefly mentions the inclusion of lighting data even where there are no pedestrian crashes, and since that report, a systematic approach for developing records where no pedestrian crashes have occurred has now been implemented as a third improvement to the records set, thereby more explicitly including in the records the conditions that prevent pedestrian crashes.

As the new records were reviewed and statistically analyzed, a need for two more improvements became apparent. One was the need to more thoroughly define geographic boundaries. The other was the need to consider the records, which, though excluding intersection and intersection-related crashes, nonetheless cross intersections. In total, then, five improvements were made to the record sets.

These improvements were applied not only to the 2006-2023 dataset for which preliminary models were presented in the November 2024 report but also to a dataset restricted to the most recent 5 years of ‘non-Covid’ data: 2017, 2018, 2019, 2022, and 2023, as it is believed that during the years 2020 and 2021, vehicular and pedestrian traffic may have been substantially altered in response to the Covid pandemic. Generating this more restricted dataset was achieved by creating modified versions of several Python Jupyter Notebooks and then re-executing them. These Notebooks and their output files (shapefiles, feature layers in the ArcGIS Pro geodatabase ‘Basic_Mapping_Texas.gdb’; and CSV files) are identified by their names ending in ‘5yr’.

For the first of the five improvements, the inclusion of the rainfall data, hourly rainfall radar data at points separated by 4 km, as shown as black dots in Figure 5-10 below, was converted into the inches of rainfall per year and hours of rainfall per year for each year from 2006 through 2023. The ArcGIS Pro Create Theissen Polygons tool was used to create 4km x 4km grid cells to which were associated each of the 2006-2023 crash frequency records of 50-meter length, as shown in black and yellow, respectively, in Figure 7-10. Time zone conversions from UTC to Central Standard Time and Central Daylight Savings Time were accounted for. The locations of the grid cells remained fixed during the years 2006-2020 and then shifted by approximately 70 meters in the years 2021-2023, and so adjustments were made accordingly. For each of the 50-m crash frequency records, the average depth and hours of rainfall per year over the 18-year period were calculated as the variables ‘rain_inpyr’ and ‘rain_hpyr’ respectively. Further details are in the Python Jupyter Notebook ‘create_grid_cells_XX_XX_rain_shp.ipynb’.

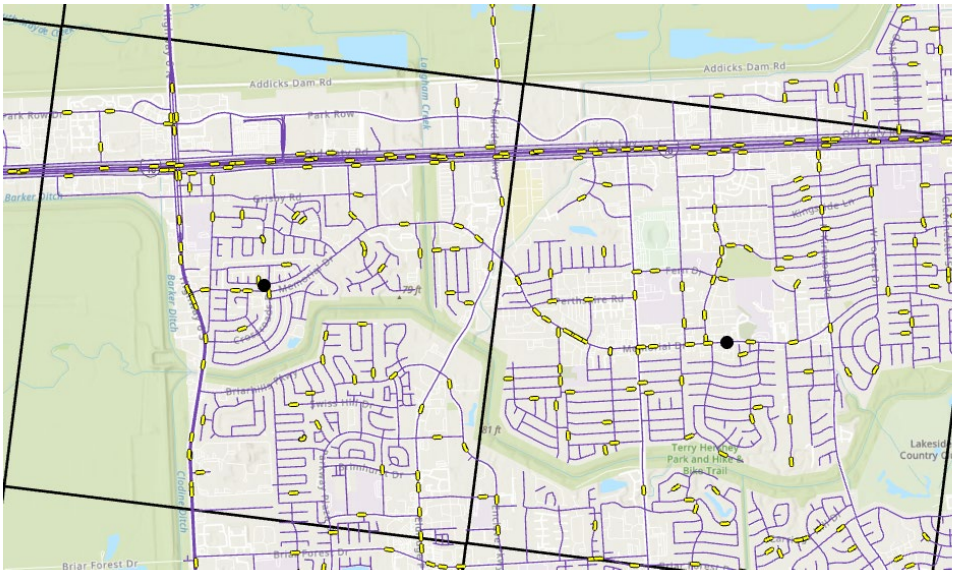


Figure 5-10. Association Between 50-M Crash Frequency Records (Yellow Segments) and 4-km X 4-km Rainfall Grid Cells

For the second and the third improvements (the inclusion of more lighting data and the development of records for which no pedestrian midblock crashes occurred), the CRIS variable ‘LIGHT_COND_ID’ was used not only for the records having at least one pedestrian crash but also for new records that were initiated by randomly selecting from among the other 50-m segments that had been generated when ‘cutting up’ roadway polylines into 50-meter segments but that had midblock crashes (as identified by the CRIS variable INTRSCT_RELAT_ID = 3 or 4) but no midblock pedestrian crashes. The number of such segments randomly selected was equal in number to the number of records containing midblock pedestrian crashes. Then, for these randomly selected records, the value of LIGHT_COND_ID (3 indicating ‘DARK, NOT LIGHTED’ and 4 indicating ‘DARK, LIGHTED’) for each crash was used to estimate the total proportion of years for which the 50-meter segment had adequate street lighting. If there was only one nighttime crash, a value of ‘4’ would lead to the assumption that the 50-meter segment had adequate night lighting for the entire 2006-2023 period, and ‘3’ would mean no night lighting for the entire period. If there were multiple nighttime crashes, and there was a mixture of ‘3’ and ‘4’, then midpoints in time between each crash were used to calculate the proportion of years for which the 50-m segment had nighttime lighting, and this proportion was given the variable name ‘propArtLit’ (proportion of years for which artificial lighting has been available). This same process for calculating ‘propArtLit’ was also applied to the already-existing records having midblock pedestrian crashes to augment the number of available values of LIGHT_CONT_ID and thereby provide a better estimate of ‘propArtLit’.

Furthermore, as part of the third improvement, new records were initiated by randomly selecting from among 50-meter segments that had no midblock crashes (neither pedestrian nor non-pedestrian). The number of such records randomly selected was equal to the number of records having no pedestrian midblock crashes. These records would have no CRIS data available because of no crash occurrence. Hence, no ‘propArtLit’ value would be available. Additionally, the variable with arguably the most countermeasure information, the CRIS variable TRAFFIC_CNTL_ID, would not be available. However, all other data would be available and would help provide a clearer context for understanding the causes of pedestrian crashes.

This third improvement to the records led to the fourth improvement, that of more rigorously defining geographic boundaries. In initiating these records for the third improvement by randomly selecting from among these 50-meter segments having no midblock crashes, care was required not to select from outside the region covered by the CRIS variable City_ID values of '107' (Dallas), '208' (Houston), and '379' (San Antonio). Weeks earlier, when the roadway polylines had been cut into 50-meter segments, the areas for which the selection was done fell within a buffer zone that had been created. That buffer zone substantially exceeded these regions to ensure that census data points, bus stop points, and other items just outside the region but that might influence vehicular and pedestrian traffic inside the region would not be excluded from the study. Therefore, some of these 50-meter pieces would actually fall within regions with City_ID values apart from '107', '208', and '379', and thus would appear to have no associated crashes, while in fact they might have quite a few, including pedestrian midblock crashes. Therefore, CRIS data with neighboring City_ID values were brought into the 'Basic_Mapping_Texas' geodatabase in ArcGIS Pro to ensure that the randomly selected 'no crash' pieces were truly without any crash record. In this process, it was discovered that some of the City_ID values have overlapped. From informal inspection, this overlap seemed to occur with data mostly from the earliest years of the 2006-2023 time period, perhaps due to the official city limit shifting since then. In any case, this overlap would need to be considered not only for the random selection of the 'no crash' 50-meter pieces but also when deciding whether current records having crashes should be included, as the number of crashes for a particular 50-meter piece might be undercounted (if the crashes from earlier years for the piece are actually listed with a City_ID apart from '107', '208', or '379'). To address this overlap issue, lines were manually sketched in ArcGIS Pro to exclude areas of overlap. Because these overlaps were confined only to specific portions of the perimeters, digital GIS data from each of the cities was uploaded to ArcGIS Pro, and the manually sketched lines were merged with this data to form a mask more rigorously defining the area within which all 50-meter pieces must fall to be included in the study, though census data points, bus stop points, etc., falling a bit outside this mask but influencing vehicular and pedestrian traffic within the mask, are also included in the study.

The need for the fifth improvement was recognized while developing one of the crash frequency models. It was found that the degree of curvature of the 50-meter pieces was negatively correlated with the number of midblock pedestrian daytime crashes, sometimes with p-values several orders of magnitude below 0.05, the typical value below which estimates are considered statistically significant. This change was unexpected. However, upon closer inspection, it was discovered that this was likely due to a portion of the records having no daytime pedestrian crashes (and having either nighttime pedestrian crashes or no pedestrian crashes at all) at crossing intersections, and that these records are often associated with some degree of curvature, even if minimal. (The degree of curvature was calculated for all records for which the 50-meter piece had three or more points and assumed equal to the difference in line bearing between the first two points and the last two points.) Such records, although having lengths of 50 meters, are effectively substantially less than 50 meters in length because any pedestrian crash that occurs in the portion crossing or very near the intersection is by definition not midblock. Being in effect substantially less than 50 meters in length, they are on average less likely to have an associated midblock pedestrian crash than those not crossing intersections. Thus, for the final improvement, all 50-meter records that cross intersections were removed.

DEVELOPMENT OF MODELS

Although this progress report does not delve deeply into the mathematics underlying the regression models, some consideration of such math is essential to understanding the decisions made during model development and the results. The crash frequency models are of the log link form, as shown in Equation 1a:

$$\ln(\boldsymbol{\mu}) = \beta_0 + \beta_1 \boldsymbol{x_1} + \beta_2 \boldsymbol{x_2} + \ldots + \beta_n \boldsymbol{x_n} \qquad \textit{(Equation 1a)}$$

where, for our dataset,

$\boldsymbol{\mu}$ is the expected number of midblock pedestrian crashes during daytime (or nighttime, depending on the model),
$\boldsymbol{x_1}, \boldsymbol{x_2}, \ldots \boldsymbol{x_n}$ are the variables, such as “propArtLit”, “rain_inpyr”, etc, and n is the number of such variables in the model, and
$\beta_0, \beta_1, \ldots, \beta_n$ are the intercept and coefficients for each of the independent variables

The sensitivity of $\boldsymbol{\mu}$ to changes in the coefficients and variables is usually easier to understand if both sides of Equation 1a are exponentiated so that it is expressed as shown in here in Equation 1b:

$$\boldsymbol{\mu} = e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n} \qquad \textit{(Equation 1b)}$$

The values of the number of midblock pedestrian crashes for the daytime and nighttime models range from 0, the most common value, to only a handful of records having 3 or 4. The average number of midblock pedestrian crashes per record is between 0 and 0.5. We can see, for example, then, that if the sum of all the terms in the exponent on e reaches 2 for many of the records, the intercept and coefficients are tending to be too high, because e^2 = 7.4, which is far too high. In fact, if the sum of all the terms in the exponent comes out to near or slightly above 0 for most records, and thus with the right side being 1 (because e^0 = 1) or slightly above 1, there again the coefficients are probably too high. We actually expect the sum of the terms on the exponent to be less than 0, or negative, for most records, such as, for example, $e^{-0.7} = 0.5$. Interestingly, as the sum of terms becomes increasingly negative, the expression on the right approaches 0 but never actually reaches 0 and certainly never becomes negative. Despite these subtleties, a simple truth remains for datasets such as ours, where all of the variables never have negative values; positive coefficients indicate that the number of crashes is expected to increase as the variable increases, and negative coefficients indicate that the number of crashes is expected to decrease as the variable increases.

The above discussion is useful in explaining some rather peculiar behaviors of some of the coefficient estimates and p-values, starting with those of the variable MallDist. Table 5-1 below displays some of the results for coefficients in the early stages of building the daytime midblock pedestrian crash frequency model for the most recent 5 non-Covid years (2017, 2018, 2019, 2022, 2023), using the glm function from the R stats package. These are results for when each independent variable is the only independent variable in the model (as opposed to the actual models, which are to include many variables at once). The variables reflect the proximities of schools (SchDist), malls (MallDist), bus stops (BusStpDist), etc., and were calculated according to the formulas presented in the November 2024 report. As schools (or malls, or bus stops, etc.) increase in number and proximity, the value of the variable increases. Not surprisingly, all of the coefficient estimates are positive, as all of these variables suggest the presence of pedestrians, thereby presenting risks of pedestrian crashes. For SchDist the p-value is extremely small (0.000000047), so we are very confident that the expected number of crashes increases as the number and closeness of schools increases. (Although the Poisson distribution was assumed for this, the p-values would unlikely be radically different if another more appropriate distribution had been assumed.) The p-value is also extremely small for bus stops, shops that are not in malls (ShopNMDist), and restaurants. However, for malls (MallDist), we notice a p-value of 0.37, which, being well above the 0.05 typically used as a minimum for recognizing a correlation, would leave us doubting that there is a correlation, at least for this dataset. Yet it is possible that there is a significant correlation that would surface for such a variable in a multivariable model in which other variables would account for a good portion of the variability in the number of crashes, allowing the relatively small but perhaps important contribution of this variable to be revealed. Consequently, we included MallDist and other variables with fairly high p-values in the initial multivariable model. It should be noted that there is also a risk that such variables, especially if they have histograms that are strongly skewed to the right, can be ‘hijacked’ by other variables in the model as the algorithm adjusts parameter estimates to make the model fit the data as tightly as possible. This is, in fact, what seems to have happened with MallDist as the multivariable model was being developed.

Table 5-1. Coefficient Estimates and P-Values for Proximity Variables in the Daytime Crash Model for the 5 Most Recent Non-Covid Years of Data

variable	Coefficient estimate	p-value
SchDist	199	4.7e-08
MallDist	130	0.37
ShopNMDist	237	1.9e-08
BusStpDist	35.3	1.2e-17
RlStpDist	72.3	0.010
HospDist	154	0.29
HotelDist	103	0.011
RestrDist	62.5	1.3e-06

As the multivariable model was being developed, variables with very high p-values were removed one at a time, and it was verified that the AIC (Akaike Information Criteria) value also decreased, an indication that the model is a better fit for the data, without overfitting of the data. Interestingly, during this process, the coefficient for MallDist suddenly became negative, and the p-value became quite low, well under 0.05. Although there could be an explanation for pedestrian crashes actually becoming less likely for a 50-meter segment as the segment draws closer to a mall, all else being considered, one would expect the coefficient to be positive. A closer examination of the variable values indicated that it has an ‘outlier’, an exceptionally high value (almost an order of magnitude higher than the average non-zero MallDist value), for a record in Houston, on University Blvd, for which the crash count is 0. The exceptionally high value is due to the roadway actually passing through a complex of mall buildings. Due to the crash count being 0 for this particular record and the correlation between MallDist and the crash count being weak, as the discussion of Equation 1b suggests, the coefficient of MallDist can be as negative as needed to maximize the overall fit of the model for other records while making almost no difference in the error in predicting the count for this particular record. This record is a rare instance in which a variable was excluded, even though its exclusion increased the AIC value for the model.

Figure 5-11. Record (Yellow Segment) with an Outlier Value of MallDist, in the Midst of Several Mall Buildings (Burnt Umber)

When histograms show variables to be very skewed to the right (i.e., having very many values bunched on the left and then sparsely spread data stretched to the far right), as is the case with MallDist, applying a log transformation can be helpful to the stability of the model and often improves the fit of the correlation, as would be suggested by the structure of Equation 1b. Although this remedy did not work with MallDist, perhaps because over 95% of the values are 0, and nearly all the other values, except for only two outliers, are extremely close to 0, it did seem to be helpful for several other variables. For example, AADT_TRUCK (the annual average daily traffic count for trucks, provided by the TxDOT Roadway Inventory) has the distribution shown in Figure 7-13. The transform log(1 + AADT_TRUCK) was applied to yield and stop a new variable, LogAADT_TRUCK, with the dramatically less right-skewed distribution shown in Figure 7-12. Table 5-2, Figure 5-12 and Figure 5-13 show the dramatic changes that the transformation creates when the variable is the only one in a model for the daytime model. Without the transform, the estimate of the coefficient seems very unreasonable – the expected number of crashes is indicated as decreasing as the truck traffic increases, which seems to contradict common sense. For the transformed variable, the coefficient becomes positive, and with a high degree of confidence (as indicated by the very low p-value).

Table 5-2. Comparison of AADT_TRUCK and Its Log Transform, LogAADT_TRUCK, When Each Variable is the Only One in the Daytime Crash Frequency Model

variable	Estimate of coefficient	p-value
AADT_TRUCK	-9.1e-06	0.14
LogAADT_TRUCK	0.050	0.00002

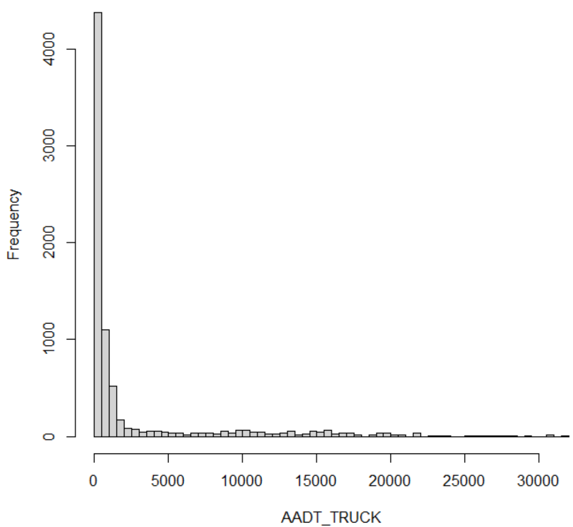


Figure 5-12. Histogram of AADT_TRUCK

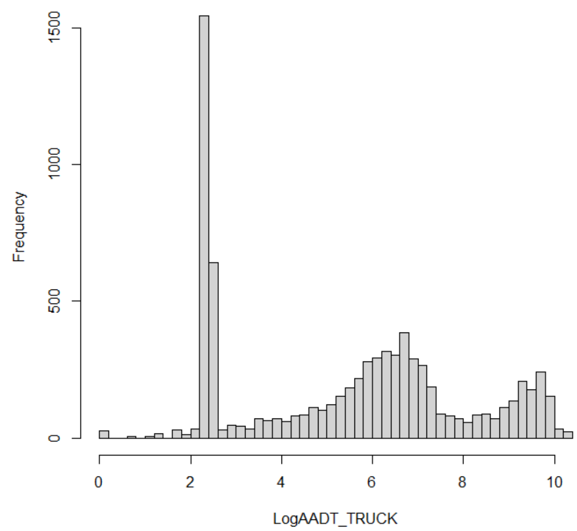


Figure 5-13. Histogram of Log(AADT_TRUCK)

Other variables that were log-transformed for the daytime model because their histograms are right-skewed and for which the p-value for the transform is lower are PCT_CDHV, MOTORCYCLE, and ADT_CUR from the TxDOT Roadway Inventory data; SchDist, BusStpDist, RestrDist, ShopNMDist, and CurveDeg (variables calculated as discussed in the November 2024 progress report); and ce01_tot and cd01_tot from the U.S. census data. The name of each transform is simply 'Log' followed by the name of the raw variable.

Another key step in model development is the elimination of variables that are highly cross-correlated ($|r| > 0.9$) with other variables and do not perform as well as those they are correlated with when they are placed as the only variable in the model. These variables include LogADT_CUR (highly correlated with LogAADT_TRUCK), AADT_SINGL, AACT_COMBI, PCT_CADT, TRK_AADT_P from the TxDOT Roadway Inventory, and all census data variables except ce01_tot and cd01_tot.

Noteworthy is that occasionally variables that are closely related might have opposite signs on their coefficient estimates when appearing in a multivariable model, and one of the signs might be counterintuitive. For example, in the results shown in Table 5-3 below for the most developed daytime models covering the years 2017-2023 exclusive of the COVID years, the coefficient for the variable Log_cd01_tot is negative. However, the net impact of these two coefficients as they would appear in the expression 0.09537*Log_ce01_tot - 0.15417*Log_cd01_tot in the exponent in Equation 1b is overwhelmingly positive, as the histogram in Figure 5-14 shows.

A necessary step in the model development was the merging of some categories for categorical variables, primarily due to the numbers of records in some categories being extremely small, thereby

Table 5-3. Results from the Midblock Pedestrian Crash Frequency Model for Daytime for the Years 2017, 2018, 2019, 2022, and 2023

```
Coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         -1.65790    0.19027  -8.714  < 2e-16 ***
ACES_CTRL1          -1.70866    0.55702  -3.068 0.002158 **
ACES_CTRL2          -0.70672    0.51735  -1.366 0.171932
ACES_CTRL3          -0.37789    0.12776  -2.958 0.003098 **
TRK_AADT_P           0.06324    0.02569   2.462 0.013823 *
PCT_SDHV            -0.10019    0.04474  -2.240 0.025117 *
RDBD_ID_5LGorRG     -0.08725    0.27442  -0.318 0.750539
RDBD_ID_5MISC       -0.89216    0.31287  -2.852 0.004351 **
RDBD_ID_5XG         -0.43429    0.39764  -1.092 0.274759
F_SYSTEM_21          1.15043    0.56810   2.025 0.042864 *
F_SYSTEM_22          1.16841    0.56228   2.078 0.037709 *
F_SYSTEM_23          0.17597    0.10227   1.721 0.085312 .
F_SYSTEM_25or_6or7   0.33245    0.08304   4.004 6.24e-05 ***
LogPCT_CDHV         -0.37465    0.18860  -1.986 0.046987 *
LogSchDist           0.08753    0.04690   1.866 0.062008 .
Log_cd01_tot        -0.15417    0.05572  -2.767 0.005659 **
LogBusStpDist        0.03703    0.01826   2.028 0.042544 *
LogRestrDist         0.05219    0.02853   1.829 0.067331 .
LogShopNMDist        0.15565    0.05068   3.071 0.002133 **
Log_ce01_tot         0.09537    0.05554   1.717 0.085928 .
NoCntlCnt            0.23128    0.06506   3.555 0.000378 ***
FlagOffCnt           0.72427    0.17476   4.144 3.41e-05 ***
StopSnCnt            0.25069    0.13678   1.833 0.066834 .
CtrStrDCnt           0.15599    0.07961   1.959 0.050060 .
XwalkCnt             0.96848    0.17679   5.478 4.30e-08 ***
MrkLnsCnt            0.24000    0.08383   2.863 0.004198 **
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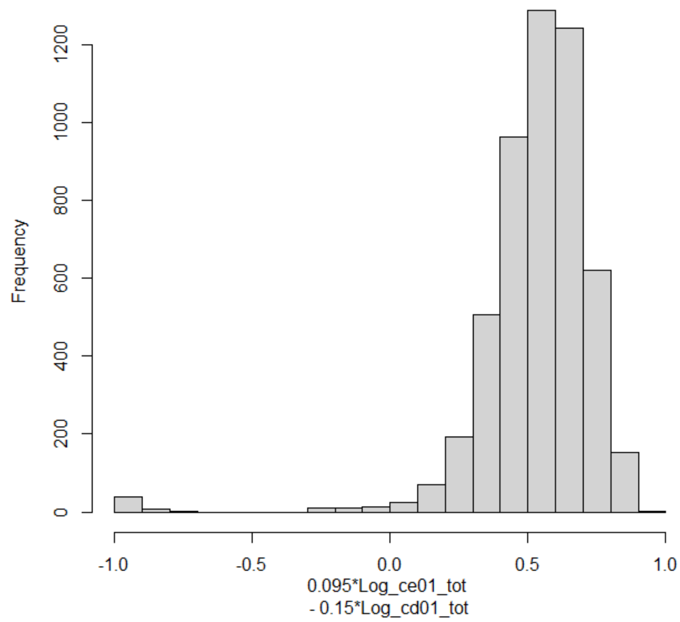

Figure 5-14. Histogram of 0.095*Log_ce01_tot - 0.15*Log_cd01_tot

contributing to model instability. Sometimes, too, categories were merged when their coefficient estimates were very similar, as indicated by the difference in their estimates being a mere fifth or tenth of the standard error in the estimate. In Table 5-3, the TxDOT Roadway Inventory variable RDBD_ID had several categories merged into MISC, mainly because of their small number of records. Also, the categories LG and RG were nearly identical statistically, and so they were merged. The extension '_5' was added to the variable name so as to indicate the degree of merging that the variable underwent in the model development process. Similarly, the TxDOT Roadway Inventory variable F_SYSTEM had categories 5, 6, and 7 merged, and the extension '_2' was added to indicate merging. Another merging was used for other categorical variables as well, but these did not make it into the model shown in Table 5-3.

The decision to include or exclude variables was done manually as much as possible to ensure that the ones left in the model did not present anything unreasonable, as discussed in the above paragraphs. Once that phase was completed, the R function stepAIC was used to automatically test the impact of removing one variable at a time until the AIC is minimized. AIC adds points and thus imposes a penalty for each variable included so that when minimizing the AIC, overfitting is very unlikely. After applying stepAIC, cross-validation was applied to the resulting model. In the cross-validation process, the model was fit to 80% of the records randomly selected as training data, and then the fitted model was applied to the remaining 20% that served as test data. Then McFadden's R^2 was calculated for the training data and for the test data. This exercise was done five times, with a different 20% held out as the test data each time. The five McFadden's R^2 values for the test data were then compared with the five for the training data to see that they were not consistently lower than the ones for the training data, which would indicate overfitting (i.e., including too many variables without adequate care so that the model is chasing random effects rather than representing actual correlations). In general, applying stepAIC successfully prevented overfitting. (NOTE: These training and test sets in cross-validation are temporary and are not the same as the permanent training and test sets. Cross-validation is done within the permanent training set only, while the permanent test set remains unseen until after the model is finalized. The finalized model is then tested once on the permanent test set to see if it performs as well as it did on the permanent training set.

The results in Table 5-3 indicate that the variable NoCntlCnt (which corresponds to the CRIS variable TRAFFIC_CNTL_ID = 1, No Control for the 50-meter segment) is positively correlated with midblock pedestrian crashes during the day. The estimate of this coefficient is 0.23, and the value of the variable is always either 1 (which means the variable '1' was selected at least once for the record) or 0. Now $e^{0.23}$ = 1.3, which, according to Equation 1b, means that having no countermeasure is associated with an increase of 1.3 pedestrian crashes over the 5-year period in the 50-meter piece of roadway (but only if the sum of the other term of the exponent is 0 – in reality the sum is probably near -1, and so the impact is not as great). But we cannot be too quick to assume a causal relationship. For example, we can see that XWalkCnt (corresponding to the CRIS variable TRAFFIC_CNTL_ID = 15, crosswalk), while also taking on a value of 0 (crosswalk not indicated) or 1 (crosswalk indicated), has an even greater coefficient, 0.968. We certainly cannot assume that the coefficient means that the crosswalk causes the pedestrian crashes. One possibility is that crosswalks tend to be placed where pedestrian crashes have already been occurring or are very likely to occur and, while effectively reducing the tendency for pedestrian crashes, do not reduce that tendency to that of low-risk areas. Perhaps an even more likely possibility is in the data collection process. It seems very unlikely that an officer would record the presence of a crosswalk if the crash did not involve a pedestrian. In that case, nearly every time a crosswalk is indicated in the records, it's because a pedestrian crash has occurred. In fact, all the other countermeasures reflecting TRAFFIC_CNTL_ID values (FlagOffCnt, StopSgnCnt, CntrStrpDCnt, MrkLnsCnt) have strong positive coefficients, perhaps suggesting that their marking tends to be triggered by a pedestrian crash. But NoCntlCnt stands in a different light because it is an explicit statement that none of the other countermeasures are present, regardless of whether a pedestrian crash or a non-pedestrian crash occurred.

Table 5-4 below shows results for the nighttime model for the five most recent non-Covid years of the dataset. It was developed using the same procedure as was the daytime model in Table 5-3 but has substantially fewer variables. One reason for the difference might be due to the fact that there were fewer records available, as having a value for 'propArtLit' requires that at least one crash occurred at night. Without a value for propArtLit, which plays an important role in the model, the record cannot be used.

Table 5-4. Results from Midblock Pedestrian Crash Frequency Model for Nighttime for the Years 2017, 2018, 2019, 2022, and 2023.

```
                  Estimate Std. Error z value Pr(>|z|)    
(Intercept)       -1.05320    0.17009  -6.192 5.93e-10 ***
RDBD_ID_5LGorRG   -0.41074    0.22887  -1.795  0.07271 .  
RDBD_ID_5MISC      0.18425    0.13416   1.373  0.16964    
RDBD_ID_5XG       -0.63770    0.38144  -1.672  0.09456 .  
HWY_DES1_32        0.12632    0.07162   1.764  0.07778 .  
HWY_DES1_35or_4   -0.37634    0.09139  -4.118 3.83e-05 ***
LogAADT_TRUCK      0.06016    0.02024   2.972  0.00296 ** 
Log_ce01_tot       0.03049    0.01669   1.827  0.06776 .  
propArtLit        -0.35598    0.06983  -5.098 3.44e-07 ***
StopSnCnt         -0.25927    0.15529  -1.670  0.09500 .  
---
```

Although causal relationships between statistically significant coefficient estimates and the expected number of pedestrian crashes cannot be assumed, in the case of lighting, the relationship seems especially likely to be truly causal. When it is included as the only variable in the daytime model, it displays a positive coefficient with a p-value well below 0.05, suggesting, not surprisingly, that nighttime lighting exists where daytime pedestrian crashes tend to be more likely to occur. The fact that the lighting is then associated with lower pedestrian crash numbers at night suggests that it really causes the reduction.

Other models were also developed for the larger 2006-2023 dataset. Noteworthy is that for the larger dataset, GlareHrs2w (sun glare, as discussed in the November 2024 report) becomes statistically significant, with a positive coefficient. The larger number of records enables this relationship to surface. Conversely, in one of the 5-year nighttime models, rain_inpyr (the average number of inches of rainfall per year) is statistically significant with a positive coefficient, while such is never the case for any of the 2006-2023 models. The higher temporal resolution (5-year averaging instead of 18-year averaging) may be what allows this relationship to emerge, despite the 5-year model having substantially fewer records. GlareHrs2w, however, does not vary from year to year at any location, and so such temporal resolution is not relevant.

STEPS FOR FURTHER PROGRESS

We propose to further develop the crash frequency models by using classification and regression trees (to be developed in R) to identify potential interactive variable terms for the crash frequency models. Attempts to do this in the current models did not noticeably improve the quality of fitting and were difficult and time-consuming, in part due to the numerous categorical variables. This procedure will also be used to improve the crash severity model.

We also propose reclaiming records that contained at least one midblock pedestrian crash but were excluded because their length was effectively reduced by crossing an intersection. Approximately 1/3 of the records were lost because of this. To reclaim the records, we will introduce a variable equal to 1 for such records and 0 for records with no crossing intersections. It is expected that a positive coefficient for this variable will be estimated in the fitting process to compensate for the fact that effectively shortened 50-meter segments would, on average, have higher midblock pedestrian crashes if their length had not been effectively shortened by an intersection.

We will apply time-series analysis to the limited number of crosswalks for which we have obtained historical information regarding their development. Results will be considered for possible improvements to the crash frequency models.

Finally, all the steps that were presented in the November 2024 report (such as using ChooseDist() in R to identify the most appropriate likelihood function) will also be completed.

PEDESTRIAN TREATMENT SELECTED FOR FURTHER ANALYSIS

For the purpose of enhancing pedestrian safety at midblock crossings, we have selected the following treatments for further analysis:

1. Crosswalks – Both with and without accompanying signage, to assess the impact of visual cues and delineation on pedestrian safety.
2. Pedestrian Hybrid Beacon (PHB) – A specific type of traffic signal aimed at improving pedestrian visibility and control at midblock crossings.
3. Rectangular Rapid Flashing Beacons (RRFBs) – A type of rapid-flashing signal designed to increase driver awareness of pedestrian activity at crossings.
4. Midblock Pedestrian Signals (MPS) – Traffic control signals specifically installed at midblock locations to regulate pedestrian crossings and improve safety.

Additionally, we will evaluate the influence of other contextual measures, such as speed limits, lighting conditions, and the presence of pedestrian islands, on the effectiveness of these treatments. This comprehensive analysis will help identify the most effective combination of measures to improve pedestrian safety at midblock crossings.

CHAPTER 6 : DEVELOPMENT OF SAFETY PERFORMANCE FUNCTIONS AND CRASH MODIFICATION FACTORS

INTRODUCTION

The high number of crash records available for this study provides opportunities for both machine learning (such as artificial neural networks) and statistical models (such as count data regression models and ordinal probit regression models). The statistical models are favored for this project because they provide estimates of parameters that directly describe the relationship between variables and crashes, such as the expected increase in the number of crashes due to a unit change in the number of restaurants within a quarter-mile. This method provides a decisive advantage over machine learning models, such as artificial neural networks, which are more of a black box approach, relating variables in ways such that meaningful relationships are not described.

Statistical models are being developed for both crash frequency and crash severity. For crash frequency, count data regression models are being developed, the forms of which depend on the most appropriate likelihood function. For the crash severity, both ordinal probit regression and binomial probit regression models are being developed.

Crash records to be used for building the statistical models were developed in ArcGIS Pro and Python Jupyter Notebooks. These Notebooks have navigable links and other tools that allow for convenient development and review of the combining of CRIS data, bus stop data from various cities, public school data from the Texas Education Agency, etc., to form the records to be used in the statistical models. These models are being developed in R because of its wide array of statistical modeling tools.

USE OF CROSS-VALIDATION AND A TEST SET TO AVOID OVERFITTING

Although we are developing statistical models rather than machine learning models, the modeling will go well beyond the simple default arrangement often found in the literature, in which variables are simply multiplied by a coefficient and then the products summed as the coefficients are estimated. Model performance and explanatory power may be greatly enhanced by transforming some variables (such as taking the logarithm of each value) or developing expressions in which some variables are multiplied or otherwise combined in meaningful ways (such as taking the sine of the degree of curvature and then multiplying it by a variable representing the likelihood of disturbing glare). Because there are numerous permutations of possible arrangements, and many will be tried, it is important to prevent what is commonly referred to as 'overfitting', in which the model is paying too much to random effects rather than actually capturing meaningful relationships. Although various performance measures such as the adjusted R2 and the Akaike Information Criteria (AIC) provide a penalty for each parameter included, these measures protect against the overfitting that would be strictly due to including too many parameters in the current model. They have no way of accounting for the history of the many parameters and expressions previously attempted. To thoroughly protect against overfitting, we are employing a two-stage process, commonly used in machine learning and used in rigorous development of statistical models: cross-validation in the first stage and testing in the second stage.

To ensure both stages are properly executed, the dataset is divided into training records and testing records once the entire dataset has been developed, but immediately before any development of the statistical model begins. A typical split is to have 80% of the records randomly selected for model training and 20% as model testing. This is the split we have made. The test set is to be used only once, at the very end, once we are sure that the model developed with the training data is the best we can do. When the model is finally applied to the testing set, it should perform about as well on the testing data as it does on the training data. If it does not perform as well, then the model is not really valid. One should not then go back to the training data, and make adjustments with the aim to make it better fit the testing data. It would be too late for that.

The cross-validation process greatly reduces the chance of developing a model for the training data that would not fit the testing data. In cross-validation, the training set is randomly divided into five or ten or some similar number of equal portions. We are dividing our training set into five portions. Four of the five portions are randomly selected, and a model is developed to fit these four portions well. Then it is applied to the fifth portion to verify that it fits that fifth portion about as well. In fact, a cycle is established in which each portion is left out while the training occurs on the other four, and then the fifth acts as the test data. For each advancement in the development of the training model, this cycle is run to check that the model maintains its performance on each fifth that had been left out, thereby helping to ensure that overfitting does not occur. Finally, once the modeling team is satisfied with the model, the model is tested on the test data that had been kept 'under lock and key' since the beginning of the modeling process.

USE OF AN APPROPRIATE SPATIAL DIMENSION AND RESOLUTION

The hot spot analysis discussed in Section XX of this report is to be considered in relation to the statistical models. Although the number of crashes within regular polygons (squares or other polygons with equilateral sides – in our case we used equilateral hexagons) was one of the methods of hot spot analysis used in this study, and other studies have also used the number of crashes within such polygons, these polygons have the severe disadvantage of being contrary to the geometry of the roadways, where the crashes actually occur. Thus, if the regular polygon is large enough to contain multiple roadways in parallel, the hot spot analysis might suggest that a particular region is "hot" simply because the total length of roadway in such polygons is very high, even if the number of crashes per unit length of roadway in that polygon is quite low. Dividing the number of crashes in each such polygon by the total length of roadway within it is one way to reduce this distorting effect but still leaves us with sometimes having roadways that are of substantially different properties included in the same polygon, making meaningful analysis difficult.

Using much smaller regular polygons can nearly eliminate the problem of having multiple roadways in the same polygon but still leaves the need to normalize. This is because the equilateral polygons are typically cast as a kind of rigid net over the city (or other geographic area of study) that must have no gaps, and so must maintain the same orientation and row height to consistently abut on all sides. Roadways, meanwhile, vary in spacing and in orientation, so that sometimes they will just barely pass through a corner of a polygon, while, at the other extreme, they may pass along a central diagonal. Each length of passage will tend to be unique, requiring normalization that complicates the development of hot spot analysis and statistical models.

The main advantage of using regular polygons for hot spot analysis is convenience. Arc GIS Pro 3.0's Optimized Hot Spot Analysis tool allows for specifying regular polygon dimensions and generating with just a few clicks results based on each polygon's Getis-Ord Gi* statistic (which takes into account not only the number of crashes within the polygon but also the number within neighboring polygons). But the meaningfulness of the analysis is severely limited for the reasons discussed above, and its results do not lend themselves to cross referencing well-developed statistical models.

The main advantage of using regular polygons for hot spot analysis is convenience. ArcGIS Pro 3.0's Optimized Hot Spot Analysis tool allows for specifying regular polygon dimensions and generating with just a few clicks results based on each polygon's Getis-Ord Gi* statistic (which takes into account not only the number of crashes within the polygon, but also the number within neighboring polygons). But the meaningfulness of the analysis is severely limited for the reasons discussed above, and its results do not lend themselves to cross-referencing with well-developed statistical models.

What is needed is a hot spot analysis that uses a geometry that matches or nearly matches the actual roadway geometry, and then for that same geometry to be used in the development of statistical models. Thus, we are using shapefile polylines of roadway segments maintained by TxDOT. These are of varying length. Some are long enough such that properties such as lighting, the presence of bus stops, etc., would vary substantially over the length, forcing a lumping of available data instead of making full use of the data. Therefore, the segments are cut into 'pieces'. These pieces are not so short that crash points appearing to occur along one piece actually often occur along a neighboring piece. Nor are these pieces so long that they often cross intersections (as the study is for midblock crashes) or often force lumping of substantially differing data values. The length of 50 meters was selected as meeting these needs. The Python coding we developed to cut the polyline into pieces begins at one end of the polyline and then allows the last piece to be less than 50 meters. So, for example, a polyline of length 530 meters will yield and stop 10 pieces of 50 meters and one piece of 30 meters. Each piece is a line having geographic coordinates marking its beginning and end, as well as the coordinates of any vertices that occur in the corresponding part of the original polyline. The number of pedestrian midblock crashes occurring from 2006 through 2023 along each piece was determined, as were moving averages (i.e., the average of the number of crashes occurring at the piece of concern and the number occurring at neighboring pieces). The resulting dataset of line pieces and associated crash counts and their moving averages we refer to in this report as 'crash_count_50m'. The actual numbers of crashes will tend to be higher than those shown in 'crash_count_50m' because about a third of pedestrian crashes do not have geographic coordinates recorded and so cannot be used.

Further details on how crash_count_50m was developed and used in hot spot analysis are discussed in TM 3. How crash_count_50m was used in developing records for the crash frequency and for the injury severity statistical models is discussed below.

CRASH FREQUENCY MODEL

1. Development of Records

The crash frequency model is to represent the number of crashes that occur along a particular length or area throughout a time period of concern. In this project, we are attempting to represent the number of crashes that occur along 50-meter pieces of roadway from 2006 through 2023, and then for the most recent time period, 2019 through 2023. A related study, TxDOT TECHNICAL REPORT 0-7048-1 (Kockelman et al, 2022) develops a model to represent crash numbers along entire roadway segments for the time period 2010 through 2019.

Regardless of the time period and lengths identified, one of the main challenges in developing the records to be used in the model is making use of important information that varies from one crash to another within that particular length or area of concern but cannot reasonably be pooled. Additionally, such information for where crashes did not occur may be unavailable, as the crash is what draws an officer or other person to collect the information at the site of the crash. So, the tendency is to simply leave this information out of the analysis. A satisfactory example of such important information is the lighting condition as indicated by the CRIS 'crash' table column 'Light_Cond_ID'. We see from our summary tables that there is a strong relationship between this variable and pedestrian crashes, yet it does not make sense to simply average the value of this categorical variable from all the crashes along a particular 50-meter piece to provide some representative light condition for the piece. Furthermore, the CRIS data for pedestrian crashes obviously has no light conditions where such crashes did not occur (which is also where lighting might tend to be better), so even if there were a representative value for multiple light conditions where we do have it for various crashes, including it in the model would likely lead to a misrepresentation of the impact of lighting on the crash frequency. A similar difficulty occurs for other important values recorded at the site and time of the crash, such as the weather condition (Wthr_Cond_ID in the CRIS data) and the condition of the surface of the road (wet, dry, ponding of water, etc., as recorded under Surf_Cond_ID in the CRIS data).

Convinced of the importance of somehow including lighting, we tallied the number of crashes in each piece in crash_count_50m into categories of daylight, night, and civil twilight, as is discussed in D.1.b. This methodology allows for separate crash frequency models, one for day and one for night (with the civil twilight category being small in number and excluded from both of these models), as well as one for the total crash count. The lighting variable is thereby eliminated, at least from the crash frequency model for daylight hours. To address the issue for the night model, we attempted to obtain lighting maps from the various utilities but so far have had limited success. We will therefore tap into the abundance of non-pedestrian crash records in the CRIS data (as they outnumber the pedestrian crash records by nearly 100 to 1), and for each 50-meter piece, find the dates and times for each crash having Light_Cond_ID = 3 (Dark, Not Lighted) or 4 (Dark, Lighted). If all happen to be '3', then the piece is considered to be 'Not Lighted' at night for the entire 2006 through 2023 period. If all happen to be '4', then it is to be considered 'Lighted' at night. If there is a mixture of values, then midpoints in times between crashes of differing lighting values can be used to mark transitions to form a weighted average value. In this way the night lighting value would range from 0 (never has had lighting) to 1 (always has had lighting). A more sophisticated representation might be developed if evidence justifies doing so. In any case, this approach can be applied not only to pieces for which there has been a pedestrian crash, but also to pieces where there has been no pedestrian crash.

The above approach for lighting cannot be used for other conditions, such as the weather and the road surface condition, as such values vary too much temporally. However, precipitation radar data at a spatial resolution of 4 km x 4 km and temporal resolution of 1 hour is available for the entire state of Texas for the time period of concern, and has now been processed by the team. We will use this data to represent a value similar to the percent of time that the piece is wet as a variable in the next phase of model development. Although it is not clear that the variability of such values will be significant within any of the three cities, we ultimately hope that the models we develop will be applicable to other locations throughout Texas, and such precipitation data may need to be included to explain differences in such locations. For now, we are simply including in each record 'City_ID' from the CRIS 'crash' tables and 'RainYrly', which is the approximate annual rainfall (in inches) for each of the cities.

The other variables for the model have been developed through work in ArcGIS Pro and Python, as discussed below.

1.a. Work Done in ArcGIS Pro

To begin the process of developing the records, the crash_count_50m data set was imported into ArcGIS Pro. Shapefiles for various public and commercial establishments and other features were also imported. These include hospitals (from the Homeland Infrastructure Foundation-Level Data database), hotels, retail shops, and restaurants (all three from Open Street Map), and schools (from the Texas Education Agency), bus stops and rail stops (from DART in Dallas, METRO in Houston, and Via in San Antonio), and U.S. census employment data.

The ArcGIS Pro Buffer tool was used to create buffers of radii of 0.25 miles, 0.50 miles, and 1 mile around each piece in crash_count_50m. Then, using the Clip Layer tool, the 1-mile buffer was applied to clip the schools layer, the 0.5-mile buffer was used to clip the census layer, and the 0.25-mile buffer was used to clip the hospitals, hotels, retail shops, restaurants, schools, bus stops, and rail stops layers.

The ArcGIS Pro Buffer tool was also used to create a 3-meter rectangular buffer around each piece in crash_count_50m. TxDOT_Roadway_Linework_wAssets and TxDOT_Speed_Limits shapefiles were imported into ArcGIS Pro. The Intersect, Split Line at Point, and Clip Layer tools were used to place pieces of these polylines, along with their attributes, in the same buffer containing the corresponding piece of crash_count_50m.

CRIS data points, though already represented in number in crash_count_50, were re-imported into ArcGIS Pro, with additional information extracted from the CRIS database 'crash' files, and additional variables developed, using Python, as discussed below. These data points were snapped to polylines and made to share the same buffer as crash_count_50.

Also in ArcGIS Pro, the Calculate Geometry Attributes tool was used to generate in crash_count_50m a column indicating the directional bearing from the first point to the last point in each piece, as well as a column indicating the number of points in each piece (as a significant number of pieces have not only a beginning and end point but also vertices carried from the TxDOT Roadway Linework wAssets polylines. These columns are needed for some of the processing to be done in Python, as discussed below.

All layers were stored in a geodatabase in ArcGIS Pro and accessible from a Python Jupyter Notebook.

1.b. Work Done in Python

To begin the process of developing the records, the crash_count_50m data set was imported into ArcGIS Pro. Shapefiles for various public and commercial establishments and other features were also imported. These include hospitals (from the Homeland Infrastructure Foundation-Level Data database), hotels, retail shops, and restaurants (all three from Open Street Map), schools (from the Texas Education Agency), bus stops and rail stops (from DART in Dallas, METRO in Houston, and Via in San Antonio), and U.S. census employment data.

The ArcGIS Pro Buffer tool was used to create buffers of radii of 0.25 miles, 0.50 miles, and 1 mile around each piece in crash_count_50m. Then, using the Clip Layer tool, the 1-mile buffer was applied to clip the schools layer, the 0.5-mile buffer was used to clip the census layer, and the 0.25-mile buffer was used to clip the hospitals, hotels, retail shops, restaurants, schools, bus stops, and rail stops layers.

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CRIS data points, though already represented in number in crash_count_50, were re-imported into ArcGIS Pro, with additional information extracted from the CRIS database 'crash' files, and additional variables developed, using Python, as discussed below. These data points were snapped to polylines and made to share the same buffer as crash_count_50.

Also in ArcGIS Pro, the Calculate Geometry Attributes tool was used to generate in crash_count_50m a column indicating the directional bearing from the first point to the last point in each piece, as well as a column indicating the number of points in each piece (as a significant number of pieces have not only a beginning and end point but also vertices carried from the TxDOT Roadway Linework wAssets polylines. These columns are needed for some of the processing to be done in Python, as discussed below.

All layers were stored in a geodatabase in ArcGIS Pro and accessible from a Python Jupyter Notebook. In Python, the geopandas package was used to read the layers from the ArcGIS Pro geodatabase developed in D.1.a and, by leveraging the buffers, join attributes from various layers to the crash_count_50m layer, with each piece in the layer serving as the basis for a unique record.

Table 6-1 lists columns that were not directly extracted from any dataset but were calculated.

BusDist is a value reflecting the number of bus stops and their distances from the 50-meter piece in crash_count_50m. It is calculated according to the following formula:

$$BusStpDist = \sum_{i=1}^{n} \frac{1}{(15+d_i)^{1.5}} \quad \text{(Eqn. 1)}$$

where

n is the number of bus stops within 0.25 miles of the piece

d_i is the distance from the piece to the bus stop i

The value of $BusStpDist$ increases with the number of bus stops n. Also, it is higher if the bus stop is closer, as indicated by d_i. The exponent of 1.5 is used because the pedestrian traffic to and from the bus stop is not expected to decrease as rapidly as would perfectly radial flow from a point, nor decrease as slowly as would flow from an edge. The value of 15 is provided so that $BusDist$ does not become orders of magnitude higher for small values of d_i. In a similar way were the values of HospDist (for hospitals), RlStpDist (for rail stops in Dallas and Houston, while San Antonio has none), HotelDist (for hotels), RestrDist (for restaurants), and ShopNMDist (for retail shops that are neither malls nor in malls). MallDist and SchDist were also calculated in this way, except that the maximum allowable distances for these are 0.50 miles and 1.0 mile, respectively.

For the retail shops, hotels, and restaurants features, there were actually two layers that had been imported into ArcGIS Pro for each – one of point geometry and one of polygon geometry. Python coding was used to drop from the polygon layer any feature that already appeared in the point layer (as indicated by the name and address of the establishment), and then, for the remaining establishments, replaced each polygon with its centroid, thereby converting the geometry from polygon to point. The one exception to this process is when the shop polygon is actually a mall, and within its boundary contains a shop from the point feature layer. In those cases, the shop was dropped from the point feature layer before the shop (mall) polygon was converted to a point. (In some cases, the conversion from polygon to centroid caused the mall to now fall outside the 0.25-mile buffer. Coding ensured that these few malls were still included.)

The variable c000_tot is based on the 2015 U.S. Census data feature layer. The 'c000' refers to the total number of jobs by which residents represented by the point are employed. As a 0.5-mile buffer was used for this feature layer, 'c000_tot' represents the sum of all the 'c000' values from points falling within 0.5 miles of the piece in count_crash_50m. 'ce01', 'ce02', and 'ce03' are the number of jobs with earnings up to $1,250/mo, from $1,251/mo to $3,333/mo, and more than $3,333/mo, respectively, and with ce01_tot, ce02_tot, and ce03_tot being the sums of these. cd01 is the number of jobs for workers with less than a high school education, cd02 for workers with a high school equivalent but no college, cd03 for workers with some college but no bachelor's degree, and cd04 for workers with a bachelor's degree or higher. Again, the _tot suffix indicates that the values from all the points within the buffer are summed.

The variables *day_crash_cnt*, *night_crash_cnt*, and *twi_crash_count* represent the number of crashes along the piece that occurred during daylight hours, at night, and during civil twilight, respectively. The Python packages *astral*, *datetime*, and *pytz* were used to determine these natural lighting categories based on the geographic coordinates, date, and the hour of the day and minute of the hour.

Table 6-1. Variables Developed for Preliminary Crash Frequency Model.

variable	meaning of variable

BusStpDist	convenient numeric representation of the number of bus stops and their distances (value increases with the proximity of bus stops)
c000_tot	total number of jobs held by residents living near piece of roadway
cd01_tot	number of jobs not requiring high school equivalence education held by residents
cd02_tot	number of jobs requiring high school education (but not higher) held by residents
cd03_tot	number of jobs requiring some college (but not Bachelor's degree) held by residents
cd04_tot	number of jobs requiring Bachelor or advanced degree held by residents
ce01_tot	number of jobs with earnings up to $1,250/mo held by residents
ce02_tot	number of jobs with earnings between $1,251/mo to $3,333/mo held by residents
ce03_tot	number of jobs with earnings of over $3,333/mo held by residents
CurveDeg	degree of curvature
day_crash_cnt	Number of crashes occurring during daylight
GlareHrs2w	The average potential number of hours per day for which the sun would provide disturbing glare to drivers
HospDist	convenient numeric representation of the number of hospitals and their distances (value increases with the proximity of hospitals)
HotelDist	convenient numeric representation of the number of hotels and their distances (value increases with the proximity of hotels)
MallDist	convenient numeric representation of the number of malls and their distances (value increases with the proximity of a mall)
night_crash_cnt	Number of crashes occurring during night
RestrDist	convenient numeric representation of the number of restaurants and their distances (value increases with the proximity of restaurants)
RlStpDist	convenient numeric representation of the number of rail stops and their distances (value increases with the proximity of rail stops)
SchDist	convenient numeric representation of the number of schools and their distances (value increases with the proximity of schools)
ShopNMDist	convenient numeric representation of the number of shops (excluding malls) and their distances (value increases with the proximity of shops)
twi_crash_cnt	Number of crashes occurring during civil twilight

CurveDeg is the estimated degree of curvature for the piece. For pieces in crash_count_50m with only two points, CurveDeg is 0. For pieces with 3 or more points, CurveDeg is the angle formed by the intersection of the bearing passing through the first two points and the bearing passing through the last two points.

GlareHrs2w represents the average number of hours per day the sun is positioned relative to the 50-meter piece such that drivers passing through the piece would encounter disturbing glare, assuming the sky is not overcast. The assessment of whether the driver would encounter disturbing glare is based on Guo et al. (2023), in which the horizontal visual angle is approximately 58 degrees when the sun is low on the horizon but decreases to 0 degrees when the sun rises to approximately 28 degrees above the horizon. The Python packages *pysolar*, *pytz*, and *datetime* were used to create a CSV file for the geographic coordinates at the center of each city to determine for each of the bearings of 0 degrees through 359 degrees, whether each instant in increments of 15 minutes would have an azimuth and altitude value of the sun that would cause disturbing glare. This was done for each day of the year 2015 (and it would not vary noticeably for other years) to give the total number of hours that glare would occur for that bearing. The results were then matched to the bearing for the piece. It was assumed that all roads are two-way, so the actual value is the average of the number of hours for that bearing and the number of hours for that bearing plus (or minus) 180 degrees, hence; the '2w' appears in the variable name.

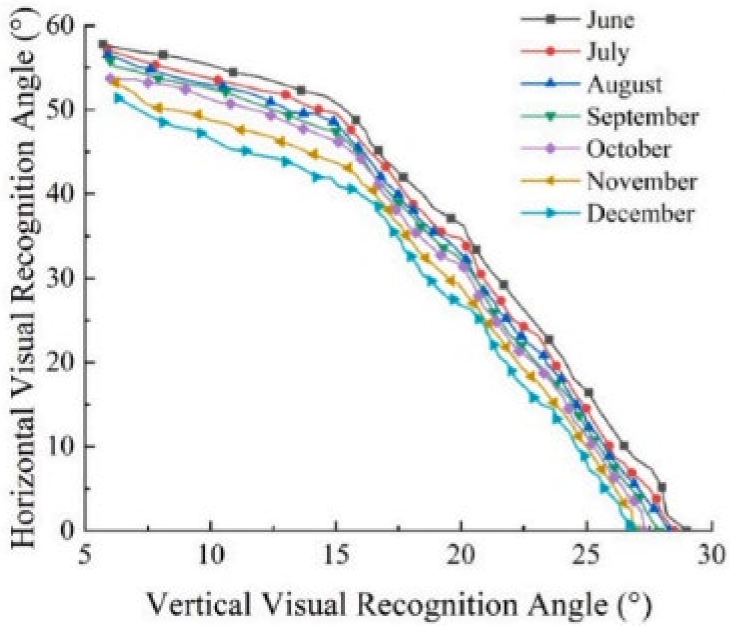

Figure 6-1. Horizontal and visual angles at which drivers encounter disruptive glare. Guo et al. (2023).

Other variables included in the records are from the TxDOT_Roadway_Linework_wAssets and TxDOT_Speed_Limits shapefiles, with names and meanings as defined in the TxDOT Roadway Inventory Specifications document for the year 2022. These are the names of the continuous or otherwise non-categorical variables obtained from these sources, in alphabetical order: AADT_COMBI, AADT_SINGL, AADT_TRUCK, ADT_ADJ, ADT_CUR, ADT_YEAR, D_FAC, HP_VOL_GRP, K_FAC, LANE_WIDTH, MOTORCYCLE, NUM_LANES, PCT_CADT, PCT_CDHV, PCT_SADT, PCT_SDHV, RDBD_ID, S_WID_I, S_WID_O, SPD_LMT, TRK_AADT_P, TRK_DHV_PC. And these are the categorical variables that were obtained from these sources: ACES_CTRL, F_SYSTEM, HSYS, HWY_DES1, MED_TYPE, RDWAY_MAIN, RU_F_SYSTEU, S_TYPE_I, S_TYPE_O, S_USE_I, S_USE_O, SRF_TYPE, SURF_TRE_2. Additional variables were considered but were excluded due to the number of missing values being greater than 30%, a rule-of-thumb threshold for inclusion in data analysis.

One of the issues to be addressed in the creation of records for the crash frequency models is that information tends to readily present itself only where the crashes occur. Yet to attempt to counterbalance this by randomly choosing from among the 50-meter pieces where they do not occur could induce a bias of other sorts. To help ensure fair and adequate representation of zero-count pieces, these pieces with non-pedestrian car crash frequencies similar to frequencies in those having pedestrian crashes will be in significant number in the records. However, these will not be included until we develop the night lighting and road surface water retention variables discussed previously. Currently, the inclusion of a 50-meter piece that has a total count (from day, night, and civil twilight combined) of 0 requires that all three of the following conditions be met:

1. the sum of the total counts (day, night, and civil twilight combined) for the piece and its two contiguous neighbors (from the same original roadway polyline as the piece itself) is 0;
2. the sum of the total count for the piece and its four contiguous neighbors is greater than 0;
3. the piece must not cross an intersection (as such pieces tend to have counts of 0, simply because we are counting only midblock pedestrian crashes).

Based on the first two conditions, the records for which the total crash count is 0 are pieces that are at least one and at most three count_crash_50m pieces away from a piece having a non-zero crash count. As discussed previously, providing additional zero-count pieces that are yet further away may allow for capturing greater variability, providing a more robust model, and will be done in the next phase of model development.

The resulting number of crash records generated for each city by number of crash count totals is in Table 6-2.

Table 6-2. Available records for crash frequency models, by city and count

City	Number of records with total crash count …				Totals
	= 0	=1	= 2	= 3 or more	
Dallas	3,664	4,039	480	149	8,332
Houston	5,568	6,034	727	264	12,593
San Antonio	3,578	4,126	517	141	8,362
Totals	12,810	14,199	1,724	554	29,287

From these 29,287 records, 20% were randomly selected and set aside as test data before beginning the development of the crash frequency statistical models on the train set. The dataset will later be expanded to include a lighting variable and more, and additional records of zero count will be added in the near future, as discussed above. Thus, a seed was set for the 20% random selection to ensure that none of the test records re-enter the training set.

2. Development of Preliminary Crash Frequency Model

The function *glm* in the R package *MASS* was used to develop a preliminary crash frequency model. In the model, all of the variables from the above records were included, such that the actual mathematical relationship appears as follows:

$$y_i = e^{\widehat{\beta}_0+\widehat{\beta}_1 NUM\_LANES_i+\widehat{\beta}_2 HSYS_i+\widehat{\beta}_3 ce01\_tot_i+\widehat{\beta}_4 SchDist_i+\,\ldots+error_i}$$

where

y_i is the number of crashes that have occurred from 2006 through 2023 in the piece i of crash_count_50m

$\hat{\beta}_0$ is the intercept for the model

$\hat{\beta}_1$, $\widehat{\beta}_2$, $\widehat{\beta}_3, etc$ are the coefficients for the variables in the model

$error_i$ is the error in the model and accounts for the difference between y_i (the actual count is in the record) and the predicted count ($e^{\widehat{\beta}_0+\widehat{\beta}_1 NUM\_LANES_i+\widehat{\beta}_2 HSYS_i+\widehat{\beta}_3 ce01\_tot_i+\widehat{\beta}_4 SchDist_i+\ \dots}$)

Sometimes, by default, $error_i$ is assumed to be Poisson distributed in count data regression models, of which this crash frequency model is a type. However, the Poisson distribution may sometimes underestimate the spread of the errors and, in the process, may lead to an underestimation of the p-values, leading to the conclusion that some variables are statistically significant when they actually are not. The most appropriate distribution is to be resolved through the *chooseDist* function of the *gamlss* library in R. At this early stage, however, we are running the preliminary model not only using the Poisson distribution but also using the Poisson-Inverse-Gaussian distribution (through the *gamlss* function in the *gamlss* library), which tends to be on the opposite end of the spectrum from the Poisson distribution. The Poisson distribution tends to assume the most narrow distribution, while the Poisson-Inverse-Gaussian tends to assume the widest.

Table 6-3 below shows selected results for both the day crash count model and the night crash count model, assuming that the errors are Poisson distributed. Only variables having coefficient estimates with p-values less than 0.10 for at least one of the two models are included. The heavily shaded p-values are those that are less than 0.10 for Poisson distribution and which remained less than 0.10 for the Poisson-Inverse-Gaussian distribution.

One can see in Table 6-3 several of the categorical variables have at least one of their categories with a statistically significant difference (assuming a significance level of 0.10 - in a final phase a lower level, such as 0.05, can be used) from a reference category value. These reference category values are not shown in the table, but the R libraries by default select the value that is first alphabetically or, if numbers are used to identify the category, the number with the lowest value. In Table 6-3, the RDBD_ID categorical variable value 'LG' or 'Left Roadbed' has a statistically significant difference from reference category 'AG' or 'Right Frontage Road' in the day crash frequency model. This means that when the RBDB_ID value is 'AG' a value of 0 is used for the coefficient of RDBD_ID for fitting the model to the data, while a coefficient estimated to be 1.442 is used when RBDB_ID is 'LG'. This positive coefficient is telling us the 'LG' tends to contribute to higher crash counts during the day. For the night, the coefficient is negative instead, but the p-value is well above 0.10, and so the estimate for the night crash frequency model is not considered reliable. One could reasonably question why 'AG' should be used as the reference. In the next phase of modeling, the reference value will be specified to be the value with the lowest coefficient, or the highest coefficient, or by some other preferred criteria.

Also, among categorical variables in Table 6-3, S_TYPE_I for the day model has category 1, 'Bituminous Surface (paved)', different from reference category '0' or 'None', but only when the Poisson distribution is used to represent the errors. (Notice that this reference category happens to be reasonable.) The p-value is not bold-faced, indicating that the p-value exceeded 0.10 when the Poisson-Inverse-Gaussian distribution was used, and so the estimate of the coefficient is not robust. However, for the night model, S_TYPE_I has category 2 'Concrete Surface (paved)' maintaining a p-value below 0.10 even when the Poisson-Inverse-Gaussian distribution is used, though it is only slightly below 0.10.

Another categorical variable in Table 6-3 is SURF_TRE_2, which has categories 1918, 2013, and 2021 different from the reference category '0', meaning the 'year' was not provided. This occurs for both the day and the night model, and in most cases the p-value stays below 0.10 even when the Poisson-Inverse-Gaussian distribution is used. HSYS has the category 'TL' or 'Off-System Toll Road' being different from the reference category 'BF' or 'Business FM' for the night model, but only if the Poisson distribution is used. MED_TYPE has categories 5, 6, and 7, which are 'Positive Barrier Flexible', 'Positive Barrier Semi-Rigid', and 'Positive Barrier Rigid', respectively, different from reference category 0 or 'No median' for the night model, and the p-value stays below 0.10 even when the Poisson-Inverse-Gaussian distribution is used. All of the coefficients for these three MED_TYPE categories are negative, indicating that, as expected, these medians are associated with fewer pedestrian crashes at night when compared with roadway lengths having no median.

A minority of the variables were excluded from the model due to the algorithm used in the *glm* function in R's *MASS* library not providing an estimate of the coefficient. Reasons could include high correlation between variables or, in the case of categorical variables, having categories with values that were too few in number. In the next phase, indices will be developed to prevent this issue. However, most of the variables were excluded from Table 6-3 simply because their p-values exceeded 0.10 for both the day count and the night count models.

Table 6-3. Selected results for night and day crash frequency models, with p-values shown for Poisson likelihood function. P-values that are bold-faced remained less than 0.10 when the broader Poisson-inverse-Gaussian likelihood function was applied

Variable	Night Crash Frequency Model		Day Crash Frequency Model	
	Coefficient Estimate	p-value	Coefficient Estimate	p-value
NUM_LANES	2.237e-02	**0.073211 .**	2.554e-02	**0.073667 .**
ADT_CUR	-3.931e-06	**0.000796 *****	-6.682e-07	0.634922
K_FAC	-2.052e-02	**0.012522 ***	-3.646e-04	0.953318
HP_VOL_GRP	1.503e-01	**< 2e-16 *****	5.617e-02	**0.000971 *****
SchDist	-2.166e+01	0.404076	6.045e+01	**7.68e-06 *****
MallDist	-6.294e+02	**0.006437 ****	2.036e+02	0.043611 *
ShopNMDist	-1.030e+01	0.862959	2.070e+02	**3.69e-06 *****
ce01_tot	5.189e-05	0.091641 .	3.525e-05	0.256224
ce02_tot	3.065e-05	0.274372	8.057e-05	**0.000788 *****
cd01_tot	2.081e-04	**0.074538 .**	-8.584e-05	0.449952
cd02_tot	3.343e-04	**0.036708 ***	-1.149e-06	0.992978
cd03_tot	-2.427e-04	**0.014065 ***	*6.312e-05*	0.461598
cd04_tot	1.293e-04	**0.061606 .**	9.483e-05	0.140802
BusStpDist	1.844e+01	**< 2e-16 *****	2.373e+01	**< 2e-16 *****
RlStpDist	9.166e+00	0.498015	3.455e+01	**8.34e-06 *****
HotelDist	-6.246e+01	**0.004933 ****	2.194e+00	0.905115
RestrDist	4.318e+01	**1.59e-10 *****	5.845e-01	0.939458
RainYrly	-7.867e-03	**0.000126 *****	-1.015e-03	0.594437
RDBD_ID LG	1.442e+00	0.062516 .	-1.059e+01	0.956008
S_TYPE_I 1	1.741e-01	0.060679 .	5.570e-02	0.652490
S_TYPE_I 2	2.123e-01	0.475863	8.071e-01	**0.082940 .**

SURF_TRE_2 1918	2.317e-01	**0.005413 ****	1.770e-01	0.123691
SURF_TRE_2 2013	-3.645e-01	**0.001560 ****	-7.902e-01	**6.78e-06 *****
SURF_TRE_2 2021	-5.756e-01	**2.11e-06 *****	-6.318e-01	**0.000134 *****
GlareHrs2w	1.701e-02	0.420126	3.688e-02	**0.065386 .**
CurveDeg	-2.133e-03	0.365244	3.600e-03	**0.039791 ***
HSYS TL	-1.374e+00	0.231617	-2.553e+00	0.082940 .
MED_TYPE 5	-2.195e-01	0.302843	-5.900e-01	**0.047259 ***
MED_TYPE 6	2.603e-01	0.250350	-7.284e-01	**0.044111 ***
MED_TYPE 7	-1.919e-01	0.322839	-5.041e-01	**0.051053 .**

CRASH INJURY SEVERITY MODELS

As in the case of the preliminary crash frequency model, the preliminary ordinal probit model presents a simple structure:

$$y_i = e^{\hat{\beta}_0 + \hat{\beta}_1 SPD\_LMT_i + \hat{\beta}_2 HSYS_i + \ldots + error_i}$$

except that now y_i is not the number of crashes in crash_count_50 that occurred in 2006-2023, but the injury severity level the pedestrian suffers in the crash. The higher the value of y_i, the more severe the injury, with 0 representing NO INJURY and 4 representing KILLED.

1. Development of Records

To develop records for the pedestrian injury severity models, data was taken from the CRIS and the TxDOT Roadway Inventory databases.

From the CRIS data, crashes needed to be those included in the summary charts for midblock pedestrian involved crashes. Also, the crashes had to have only one vehicle and only one pedestrian-involved. This restriction led to the elimination of a small number of records, while allowing for defining a reasonable number of variables well. Data from the ‘crash’, ‘unit’, ‘person’, ‘primary person’, and ‘charges’ tables in the CRIS data were used to develop 61 columns of data. Most columns contain data directly from the tables.

Dozens of variables that were used in the preliminary pedestrian injury models are columns directly from the CRIS tables or are slight modifications of those columns. One of the most common modifications is a regrouping of categorical values, to better support the development of statistical models. For example, ‘Veh_Body_Styl_ID’ from the ‘unit’ tables has 28 categories with at least 1 value, with 6 having only one value, and several having only a few. Values were lumped together to reduce the number of categories to 8, to form a new variable named ‘VBS_group’ (VBS for ‘Vehicle Body Style’). Typically, when a new variable is created by regrouping the original value, the variable name is changed as little as possible, and the suffix ‘_2’ is added. One of the most common types of lumping is simply combining categories such as ‘Not Reported’, ‘Other’, and simply blank cells as ‘Unkown2’, with the ‘2’ indicating that this is not the original value. In many cases, a failure to do such lumping would dramatically reduce the number of records available for analysis.

Also, some variables refer to the pedestrian at times, while at other times referring to the driver. In these cases, when referring to the pedestrian, a suffix of ‘P_2’ was added to the name, while if referring to the driver, simply ‘_2’ was added.

With this nomenclature in mind, the following variables, in alphabetical order, come directly from the CRIS tables or are from the CRIS tables but involve regrouping, with additional details provided in parenthesis: City_ID, ContribFactr (incorporated multiple columns along with re-grouping), Intrsct_Relat_ID, Light_Cond_ID_2, Othr_Factr_ID_2 (incorporated multiple columns along with re-grouping), Prsn_Age_2 (grouping the driver’s age into categories of under 15, 16-19, 20-29, 30-49, 50-64, 65-79, and 80+), PrsnAge_P_2 (grouping of ages of the pedestrian into the categories 0-4, 5-14, 15-19, 20-34, 35-54, 55-74, and 75+), Prsn_Ethnicity_ID_2 (driver), PrsnEthnicityID_P_2 (pedestrian), Prsn_Gndr_ID, PrsnGndr_ID_P_2, Road_Relat_ID_2, Surf_Cond_ID_2, Traffic_Cntl_ID_2, VBS_group (a regrouping of Veh_Body_Styl_ID), Wthr_Cond_ID_2, year (from Crash_Date), Veh_Mod_Year_2

Two of the ‘crash’ table columns, Crash_Date and Crash_Time, are of a format that cannot be entered directly into the statistical model function available in R, and so were re-formatted into separate columns of year, month, day of month, hour of day, and minute of the hour. These dates and times were then used to categorize to help develop two important columns: ‘sun_glare’ and ‘traffic_hr’.

The column ‘sun_glare’ was developed to indicate whether the driver likely faced glare from the sun at the time of the crash. The Python packages pysolar, pytz, and datetime were used to determine the sun’s altitude and azimuth at the time and location of the crash. Then, based on the reported value of the vehicle’s travel direction ('Veh_Trvl_Dir_ID' from the ‘crash’ table), and relationships between visual angles and glare that would impact the driver in field tests discussed in Guo, et al (2023), and whether the sky was overcast (‘Wthr_Cond_ID’ from the ‘crash’ table), a value of 0 (no glare), 1 (glare), or 2 (undetermined). The undetermined case occurs when the value of ‘Wthr_Cond_ID’ is missing or ambiguous as to whether the sun was actually shining, or when the ‘Veh_Trvl_Dir_ID’ value is missing. Worth noting, too, is that ‘Veh_Trvl_Dir_ID’ is reported only to the nearest 45-degrees (0-Due North, 1-Northeast, 2-Due East, and so on). The distribution of reported values is strongly biased towards the values 0, 2, 4, 6, the four cardinal directions, suggesting that ‘Veh_Trvl_Dir_ID’ might be more likely valid closer to 90 degrees or so, and so some of the values of ‘sun_glare’ that are 0 should be 1, and vice versa. In the next phase of development, we will apply the bearing for the piece in crash_count_50m to make necessary adjustments to values from ‘Veh_Trvl_Dir_ID’ and thereby improve the accuracy of the variable ‘sun_glare’.

The column ‘traffic_hr’ was used to categorize dates and times according to how traffic intensity and safety may vary. To create the column ‘traffic_hr’, the dates were placed into four categories: 1) a working day which is followed by a working day; 2) a working day that is followed by a weekend day or holiday; 3) a holiday or weekend day that is followed by another holiday or weekend day; and 4) a holiday or weekend that is followed by a working day. The main reason for having categories 2 and 4 is that people’s behavior during evenings and late nights is dictated more by whether they have work the following day than it is by whether they had work that same day. The Python packages *workalendar* and *datetime* were used to identify the four categories of days. The dates were then assigned values of ‘traffic_hr’ as in Table 6-4 below.

Table 6-4. ID values for the variable traffic_hr

traffic_hr value	meaning
1a	midnight to 2:59 am, the first hours of a workday
2a	3:00 am to 5:59 am of a workday
3a	6:00 am to 8:59 am or 4:00pm to 6:59 pm, rush hours of a workday
4a	9:00 am to 3:59 pm daytime but not ‘rush hours’ of a workday
5a	7:00 pm to 11:59 pm of any day for which the following day is a workday
1b	midnight to 2:59 am, the first hours of a non-workday
2b	3:00 am to 5:59 am of a non-workday
3and4b	6:00 am to 6:59 pm of a non-workday
5b	7:00pm to 11:59 pm of any day for which the following day is a non-workday

Once the columns taken or developed from CRIS data were completed, they were written to a CSV file, which was then imported into ArcGIS Pro. There the data points, which number 13,009, were snapped to the TxDOT Roadway Inventory polylines, using a snap distance of 25 meters. (Visual inspection of the 3 cities shows that a much smaller snapping distance of 10 meters would have excluded almost no records.) Next, Python was used to create a thin buffer around the polylines to capture the snapped points and to merge data from the CRIS data points with data from the TxDOT Roadway Inventory, particularly data that was not already extracted from the CRIS data, including speed limits (SPD_LMT), the type of highway system (HSYS, but requiring some lumping of categories, and so renamed HSYS_2), and the presence of a school zone (SCHOOL_ZN).

Several variables were never obtained from the CRIS and TxDOT Roadway Inventory tables due to the number of missing values exceeding 30%, the rule-of-thumb threshold often used for inclusion in data analysis.

The resulting total number of records available is 13,009. Of these, 80% were randomly selected to serve as the training set for the pedestrian injury statistical models. The other 20% was reserved as test data.

2. Development of Preliminary Ordinal Probit Model

An ordinal regression model is used when the dependent variable has categorical values that are ordered. For our analysis, the dependent variable is pedestrian injury severity level. Its categorical values and their meanings are:

0 NOT INJURED
1 POSSIBLE INJURY
2 NON-INCAPACITATING INJURY
3 INCAPACITATING INJURY
4 KILLED

The categorical values are ordered according to severity and increase with severity, but the numbers do not represent evenly spaced intervals. For example, the value 2 NON-INCAPACITATING INJURY is not halfway between 0 NOT INJURED and 4 KILLED. It’s much closer to NOT INJURED. The fact that the values are categorical and ordered, but not necessarily evenly spaced, leads us to an ordinal model for the regression analysis.

(NOTE: The above values are reassigned from the way they appear in the CRIS Lookup tables. There, for example, 1 is INCAPACITATING INJURY, and so each value of 1 in the CRIS data has been replaced with a 3 for this dataset.)

When developing an ordinal model with the R library oglmx, as was done here, the thresholds between one interval and the next must be either estimated by the library's algorithm or else pre-specified by the user. If the user suspects for example, that a relatively wide range of combinations of variables and their coefficients will lead to 2 NON-INCAPACITATING INJURY while a narrow range of combinations will lead to 1 POSSIBLE INJURY, then one might specify that the threshold between 1 and 2 be set at, say, 1.1. For this preliminary model, two of the thresholds were specified to help anchor the model for realistic values. Furthermore, the heteroskedastic option was utilized so as not to impose a rigid normal distribution on the model errors.

Table 6-5 below shows results for the preliminary ordinal probit pedestrian injury severity model. Only those variables for which the p-value is less than 0.10 are included.

Table 6-5. Statistically significant coefficients for the preliminary ordinal probit pedestrian injury severity model.

Variable	Coefficient Estimate	p-value
City_ID (default reference: 107, 'Dallas')		
208, 'Houston'	0.18	1.6e-10 ***
379, 'San Antonio'	0.20	9.5e-09 ***
VBS_group (default reference: 'bus') 'heavy truck or trailor'	0.61	0.041*
traffic_hr (default reference: 1a, midnight to 2:59 am, the first hours of a work day)		
1b midnight to 2:59am, the first hours of a non-work day	-0.16	0.090.
2a 3:00 am to 5:59am of a workday	-0.21	0.060 .
year	-0.017	3.2e-07 ***
Road_Relat_ID_2 (default reference: 1, 'On Roadway')		
3, 'shoulder'	0.28	0.054 .
Traffic_Cntl_ID_2 (Reference: 1, 'None')		
5, 'Signal Light'	-0.099	0.058 .
Unknown2	-0.11	0.076 .
Othr_Factr_ID_2 (default reference: 3, 'Attention Diverted from Driving')		
10 through 15 lumped together, associated with parking or driveway	0.27	0.014 *
ContribFactr (default reference: 15-18,25,31-39, all lumped together as 'DrivDisSign', driver disregarding sign or failing to yield and stop right of way, but no indication of intoxication or fatigue)		
intoxication	0.28	0.0032 **
pedestrian failed to yield and stop right-of-way	-0.11	-0.11
school bus	0.41	0.066 .
unknown2	-0.076	0.078 .

driver on wrong side of the road	-0.63	0.0061 **
Prsn_Ethnicity_ID_2 (default reference: 1, 'white') 3, 'black' Unknown2	 -0.082 -0.11	 0.016 * 0.081 .
PrsnAge_P_2 (default reference: 0 to 4 years old) 55-74 years old 75+ years old	 0.17 0.16	 0.0079 ** 0.079 .
HSYS_2 (default reference: FM, 'Farm to Market') IH, Interstate Highway	 0.24	 0.0027 **
Veh_Mod_Year_2 (default reference: 2013 or later) pre2013, '2012 or earlier' unknown2	 -0.080 -0.17	 0.015 * 0.0028 **
PrsnGndrID_P_2 (default reference: 1, 'Male') 2, 'Female' unknown2	 0.0019 0.77	 0.94 0.0093 **

3. Development of Preliminary Binomial Probit Model

As model development advances (by, for example, inclusion of transforms of variables and more sophisticated expressions to better represent the relationships between variables), it is anticipated that the ordinal probit model will yield and stop more realistic threshold parameters. Regardless of the ultimate effectiveness of that model, a binomial probit model is worth developing because of its results, especially its confusion matrix (which shows the relative numbers of times each of two broad categories of injury severity are correctly predicted and incorrectly predicted and is further discussed below). The binomial probit model is more commonly referred to simply as the 'probit' model, but in this work we will keep the word 'binomial' to distinguish it from the ordinal probit model.

There are also more tools readily available in R for ensuring that the appropriate likelihood function is used in the binomial probit model. This helps ensure proper model development and ultimately contributes to proper ordinal probit model development.

The dependent or response variable used in the binomial probit model lumps the personal injury severity level variable into two main categories, as follows:

0 NOT INJURED, POSSIBLE INJURY, and NON-INCAPACITATING INJURY
1 INCAPACITATING INJURY and KILLED

The same training set of records that is used in the ordinal probit model is used in the binomial probit model, except, of course, for redefining the response variable values into the two broader categories.

Results for the preliminary binomial probit model are shown in Table 6-6. Only the statistically significant coefficients, based on the p-value being less than 0.1, are shown. The intercept term is included in this model and is statistically significant, but not shown in the table. The dispersion parameter, the adjustment of which does not impact the estimates of the coefficients, was estimated to be 0.67 based on the standard deviation of the predicted values that are normally distributed, as was demonstrated through a histogram plot. Use of this value for the dispersion parameter rather than the default value of 1.00 lowers the p-values, but not dramatically.

Table 6-6. Statistically significant coefficients for preliminary probit binomial crash injury severity model

Variable	Coefficient Estimate	p-value
City_ID (default reference: 107, 'Dallas')		
208, 'Houston'	-0.10	0.0050 **
379, 'San Antonio'	0.084	0.033 *
VBS_group (default reference: 'bus')		
'heavy truck or trailor'	0.82	0.0020 **
Intersect_Relat_ID (default reference: 3, 'Driveway Access')		
4, NON INTERSECTION	0.80	2.6e-06 ***
traffic_hr (default reference: 1a, midnight to 2:59 am, the first hours of a work day)		
3a 6:00-8:59am, or 4:00-5:59pm on working day	-0.22	0.0035 **
4a 9:00am-3:59pm on a working day	-0.33	0.00012 ***
5a 7:00-11:59pm followed by a working day	-0.20	0.0029 **
5b 7:00-11:59pm followed by a non-working day	-0.21	0.0034 **
SPD_LMT (in miles/hour)	0.014	2.8e-08 ***
Wthr_Cond_ID_2 (default reference: 1, 'CLEAR/CLOUDY')		
11, 'CLEAR'	-0.22	0.029 *
Light_Cond_ID_2 (default reference: 1, 'DAYLIGHT')		
2, 'DAWN'	0.30	0.052 .
3, 'DARK, NOT LIGHTED'	0.35	1.4e-10 ***
4, 'DARK, LIGHTED'	0.32	5.4e-11 ***
Unknown2	0.66	0.00010 ***
Road_Relat_ID_2 (default reference: 1, 'On Roadway')		
2, 'Off Roadway'	0.24	2.77e-05 ***
3, 'Shoulder'	0.26	0.088 .
Traffic_Cntl_ID_2 (Reference: 1, 'None')		
11, 'Center Stripe/Divider'	0.28	2.4e-07 ***
2, 'Inoperative (Explain in Narrative)'	0.64	0.045 *
20, 'Marked Lanes'	0.19	1.6e-07 ***
'TooFew2'	0.68	0.025 *
Othr_Factr_ID_2 (default reference: 3, 'Attention Diverted from Driving')		
ParkDriveway	0.61	0.00050 ***
Passing or Changing Lanes	0.44	7.8e-05 ***
Slowing or Stopping	0.53	0.077 .
ContribFactr (default reference: 15-18,25,31-39, all lumped together as 'DrivDisSign', driver disregarding sign or failing to yield and stop right of way, but no indication of intoxication or fatigue)		
impaired visibility	0.40	0.046 *
intoxication	0.80	4.5e-16 ***
pedestrian failed to yield and stop right-of-way	0.38	1.9e-07 ***
Veh_Mod_Year_2 (default reference: model year 2013 or later)		

Unknown2	-0.34	2.6e-05 ***
PrsnEthnicityID_P_2 (default reference: 3, 'Black'	-0.15	0.00023 ***
PrsnAge_P_2 (default reference: 0 to 4 years old) 5-14 55-74 75+ years old	 -0.23 0.34 0.56	 0.031 * 0.00071 *** 4.5e-06 ***
Prsn_Gndr_ID_2 (default reference: 1, 'Male') 2, 'Female' Unknown2	 -0.071 0.28	 0.035 * 0.0036 **
PrsnGndrID_P_2 (default reference: 1, 'Male') 2, 'Female' Unknown2	 -0.18 0.61	 2.0e-09 *** 0.016 *
HSYS_2 (default reference: FM, 'Farm to Market') IH, Interstate Highway SH, State Highway TooFew2 (i.e, categories too few in number to be considered individually)	 0.28 0.30 0.67	 0.00080 *** 0.0034 ** 0.049 *

One of the great advantages of the binomial probit model is that its effectiveness can be easily seen when its results are presented in a confusion matrix. In Table 6-7 below, in the upper left corner, we see that the number 6,079 is the number of crashes for which the model correctly predicted the injury to be 0 (NO INJURY, POSSIBLE INJURY, or NON-INCAPACITATING INJURY). Also, in the lower right corner we see that that in 1,079 crashes the model correctly predicted 1 (INCAPACITATING INJURY or KILLED). The upper right and lower left corner, show the number of crashes for which the model predicted incorrectly. It's encouraging to see that for both levels 0 and 1 the model predicts correctly more than twice as often as it predicts incorrectly, though there is plenty of room for improvement.

Table 6-7. Confusion matrix for preliminary binomial probit pedestrian injury severity model

Prediction	Reference	
	0	1
0	6,079	439
1	2,672	1,079

SUMMARY: ADVANCING THE DEVELOPMENT OF THE MODELS

As discussed above, 4km x 4km radar rainfall data processed for the entirety of Texas will be included to improve the current models but also, and perhaps more importantly, to extend the usefulness of the models to all locations in Texas. Furthermore, as discussed above, the lighting at night is to be incorporated into the records for the crash frequency model.

For all models, continuous variables are to be examined for cross-correlation, and, if necessary, appropriate index variables are to be developed. This will allow for a more robust and clear analysis so that coefficient estimates really do provide estimates of the impact of variables or combined variables. One likely case where this is to be applied is with the census employment data, where the total number of jobs is likely highly correlated with the number of jobs in particular categories.

Log transforms and other transforms of variables are to be considered. Realistic relationships between variables must also be explored. For example, the impact of disturbing glare might be more severe if the driver is passing through a curve.

As the model advances, the chooseDist() function in the R gamlss package is to be applied to ensure that the appropriate likelihood function is being used for the crash frequency model. Plots, as was done with the binomial probit model, will be used to help ensure that the likelihood functions utilized in the ordinal and binomial probit models are realistic. Attentiveness to likelihood functions will ensure that p-values reflect the confidence with which we can attribute statistical significance.

In later stages, the crash frequency model will also be trained and compared with the hot spot analysis and with more detailed information (such as the presence of crosswalks) that the team has collected through visits and in other ways for specific sites in the three cities.

Throughout the processes of developing index variables, transforming variables, developing expressions for combinations of variables, ensuring appropriate likelihood functions, and comparisons with hot spot analysis and more detailed information at various sites, the cross-validation process will be in effect. Only when the training models are fully developed through this process will they finally be tested against the test data set.

PRELIMINARY ATTEMPTS TO LOCATE CROSSWALKS AND ASSESS THEIR IMPACT

As discussed under Task 4 (March 31, 2025 update), initial regression equation models included the CRIS data related to crosswalks, as well as other CRIS data and data from other sources. The CRIS data variable TRAFFIC_CNTL_ID identifies various countermeasures noted at the time and location of crashes, with each crash identified with a unique value of the variable 'Crash_ID'. Of special interest is the value of TRAFFIC_CNTL_ID = 15, for "CROSSWALK". However, there are two main obstacles to using this variable to assess the effectiveness of crosswalks in reducing midblock pedestrian collisions.

The first obstacle is that the number of times that midblock crosswalks are identified in the CRIS data is extremely rare. Of the 1.3 million Crash_ID's in the CRIS records from 2006 to 2023 for Dallas, Houston, and San Antonio and having geographic coordinates with INTRSCT_RELAT_ID = 3 (DRIVEWAY ACCESS, with 0.2 million) or 4 (NON INTERSECTION, with 1.2 million), only 593 have TRAFFIC_CNTL_ID = 15. And of 20 that were randomly chosen for manual inspection in ArcGIS Pro, all appeared to be at an intersection rather than at midblock.

The second obstacle to using the TRAFFIC_CNTL_ID variable for identifying crosswalks is that selection will be biased towards overestimating the average number of pedestrian crashes related to crosswalks. This is mainly because crosswalks that are very effective in reducing the number of crashes are much less likely to appear in the CRIS data than those at which pedestrian crashes are more common. As was explained in Task 4, this caused a positive correlation between pedestrian crashes and the variable intended to represent the presence of a crosswalk in the 50 m piece of roadway. This positive and biased correlation is not unique to crosswalks. It was also detected in Task 4 for TRAFFIC_CNTL_ID = 3, 4, or 18 (indicating the presence of a flagman or officer) and other traffic control measures in Task 4.

Because of these two obstacles, other methods were needed for identifying midblock crosswalk locations. Also, the assessment of impact would be based on the Empirical Bayes (EB) method to develop countermeasure modification factors (CMFs) as discussed in the NCHRP's 2017 report "Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments (2017)", which requires the development of a safety modification function (SPF) to estimate the number of crashes expected to occur at crosswalk sites had there been no crosswalk or crosswalk-related countermeasures.

FINDING MIDBLOCK CROSSWALKS AND THEIR ASSOCIATED TREATMENTS

A total of 71 midblock crosswalks were found for study. The main process consisted of obtaining crosswalk-related information layers from OpenStreetMap and applying Python to extract locations of possible midblock crosswalks. Many of the points identified by this process, when manually inspected in Google Earth, were determined not to be actual crosswalks, and others, though crosswalks, were located too close to an intersection (within 25 meters of the center of the three- four- or five-legged intersection) to be considered a midblock crosswalk, or else were crosswalks on sidewalks passing through a major driveway.

With 71 midblock crosswalks identified by this tedious process, images from Google Earth were reviewed to estimate implementation times of various treatments. The earliest images available are from August 2007 for Dallas, November 2007 for Houston, and October 2007 for San Antonio. The images, though not taken of crosswalks in particular, have been taken at short enough distance intervals to see detailed crosswalk information. The images were taken about once every two years, allowing for time estimates of the installation of various treatments such as pedestrian hybrid beacons (PHBs).

DEVELOPMENT OF RECORDS FOR SAFETY PERFORMANCE FUNCTION (SPF)

One of the processes identified in Task 4 (March 31, 2025 update) is the identification of an appropriate likelihood function as the regression equation modeling neared completion. This modeling acts as the foundation for the SPF. As it turns out, a custom likelihood function would need to be made for the records, and this caused a revision to the approach to generating them.

How exactly this need for a custom-made likelihood function arose is worth some discussion. The process of cutting the polylines in the TxDOT_Roadway_Linework shapefile into 50-meter pieces generates approximately 550,000 records. Most of these, about 330,000, have no midblock crash during the years 2006-2023, and of the remaining 220,000 that do have midblock crashes, only about 17,000 have at least 1 pedestrian midblock crash. To capture the variation in properties represented by these three general categories of records (i.e., records with no crashes at all, records with non-pedestrian crashes only, and records with pedestrian crashes), but while avoiding possibly very long computer run times and increased complications in optimization algorithms, about 17,000 records were randomly selected from the first two categories to match the number in the pedestrian crash category. This reduced the total number of records by tenfold, from a bulky 550,000 to a nimble 51,000.

Unfortunately, while applying the chooseDist() function from the gamlss library in R and plotting results, it became clear that not one of the 32 count data distributions was a reasonable match to the resulting distribution created by this record selection. A custom distribution would need to be created by weighting the records from the first two categories that have been truncated in proportion to the number of records that were excluded. Addressing the resulting complications from this weighting for determining statistical significance of parameter estimates grew beyond the scope of this project, though it may be worth pursuing in future efforts.

Without the exclusion of any zero-count records from the population of concern (i.e., the population of 550,000 records, one for each 50-meter piece of roadway), the only other way to keep the number of records more manageable was to change the population of concern. Limiting the population to only those pieces having at least one pedestrian crash would prove too restrictive, excluding records which might shed light on conditions particularly favorable to eliminating midblock pedestrian crashes. Yet, the 330,000 records where not even one midblock crash (pedestrian or non-pedestrian) has occurred during 2006-2023 are likely in areas of little interest from the perspective of improving pedestrian midblock safety. It was thus decided to define the population as only those pieces having at least one midblock crash (pedestrian or non-pedestrian).

This would provide many records with zero pedestrian crashes to represent relatively safe areas even where vehicle traffic is substantial, while reducing the number of records from 550,000 to 220,000.

To develop the more narrow set of records for development of the SPF for the reference conditions, only records with attribute values similar to those of the 67 crosswalks were included. For example, all the crosswalks are on roadways identified in the TxDOT_Roadway_Linework shapefile as having RU_F_SYSTE (Rural-Urban functional classification system) as having values of U3, U4, U5, or U7. So, all records not having one of these four values were eliminated. Table 6-8 below shows the values for various variables in crosswalks, and for which records not sharing these values were eliminated. All of these variables appear

Table 6-8. Restrictions on records to be used in developing safety performance functions

Variable	Acceptable Values
RU_F_SYSTE	U3, U4, U5, U7
RDWAY_MAIN	1, 4
Speed Limit	20, 30, 35, 40, 45
RDBD_ID	KG
HSYS	LM, SH, SL
MED_TYPE	0, 3
SURF_TYPE	1, 3, 4, 7, 10, 99
HWY_DES1	1, 2, 3
ACES_CTRL	0, 3
NUM_LANES	2, 3, 4, 6
SURF_TRE_2	0, 1918, 3013
ADT_YEAR	2009, 2014, 2015, 2017, 2018, 2019, 2020, 2021, 2022
HP_VOL_GRP	1, 2, 3, 4, 5, 6, 7
LANE_WIDTH	8 - 22

S_TYPE_I	0
S_USE_I	0
S_WID_I	0
S_TYPE_O	0
S_USE_O	0
S_WID_O	0

Due to the scarcity of midblock crosswalks found and the low number of midblock pedestrian crashes available for analysis if the records are for pieces of merely 50-meter length, a second set of records having pieces of 150-meter length was also created, with the expectation of capturing a higher number of pedestrian crashes at the crosswalks for before-after EB analysis. The number of records in the 150-meter set, after filtering as in Table 1, and also excluding the locations of the 67 crosswalks themselves, is 82,000. The number for the 50-meter set is approximately 160,000 (not quite three times as much, though one-third the length, because many of the 150-meter pieces contain only 1 or a few crashes, so that when they are cut into 3 50-meter pieces, some of those shorter pieces now contain no crash and are removed from the 50-meter record set).

Each of the 67 crosswalks was snapped to the corresponding polyline in TxDOT Roadway Linework, and then the polyline was cut at a 75-meter distance along it from the crosswalk point in opposite directions to create a 75-meter piece for the crosswalk that eventually has the SPF from the set of 150-meter records applied to it. Similarly, a 25-meter distance was used to create the 50-meter crosswalk pieces. Actually, with the shorter piece, a few additional crosswalks became available, bringing the total to 71, as a few of the crosswalks had the end of the roadway or other interference less than 75 meters away. The filtering in Table 1 is for the 67 crosswalks used to filter the corresponding 150-meter record set. The filtering for the 50-meter set is nearly identical.

Variables included in the records are as described in the November 2024 submittal and in the March 2025 update. Two more variables are now included. One is ‘tee_or_int’, which is intended to indicate the presence of a tee or other intersection in the piece. As observed in the March 31 2025, update, the 50-meter (and now 150-meter) pieces are intended for midblock pedestrian crashes, but there’s no convenient way to prevent the pieces from crossing intersections, and such crossings have the effect of removing a portion of the length (as no pedestrian midblock crash can occur at an intersection). Excluding such pieces altogether leads to an undesirable reduction of the number of informative records. So now each record is provided with a ‘tee_or_int’ value. A value of 0 indicates no intersection; 1 indicates that 1 tee is in the piece and no other intersection; and 2 indicates either a full intersection (four- or five-legged), or two tees, or anything else more than a single tee. The maximum value for 'tee_or_int' is 2. The regression model would then enable one to decide whether this variable is important and even whether or not to exclude such records after all.

The variable 'tee_or_int' was created by using the 1.25-meter buffers that had been created in ArcGIS Pro around each of the 50-meter and 150-meter pieces to integrate various sources of information in creating the records. These buffers were used to cut the TxDOT Roadway Linework shapefile. If the piece is, for example, a 50-meter run portion of a tee, we would expect that the buffer would contain two polyline pieces, one of 50-meter length and the other of about 1.25-meter length. Python code was written to analyze such combinations of lengths for assessing the presence of tees and other intersections. Figure 6-2 below is an image of a layer of 50-meter records displayed in ArcGIS Pro, each labeled with the value of 'tee_or_int'.

Figure 6-2. **The value of 'tee_or_int' shown for a few 50-meter records, shown as thin white rectangular 1.25-meter buffers. Roadway polylines are yellow**

In Figure 6-2, the values of 'tee_or_int' are correct for each record. A more comprehensive examination shows that they are sometimes incorrect. This is due to several factors, such as polylines not always connecting at intersections, as shown in Figure 5-3, multiple small polylines sometimes forming a single line along a roadway, and other peculiarities. Broadening the buffer can help overcome some of these peculiarities while worsening others. Using a 1.25-meter buffer seemed to be an improvement over the initially tried 3-meter buffer.

Figure 6-3. **50-meter piece incorrectly classified as not having a tee (‘tee_or_int’ label shown as 0), due to polylines not connecting at intersection. The branch of the tee does not fall inside the white rectangular buffer**

To develop a rough assessment of the accuracy of the ‘tee_or_int’ variable, 20 pieces were randomly chosen from each of the three cities, for a total of 60 pieces. And to see how well each type of prediction works, 6 or 7 of each value of ‘tee_or_int’ was chosen from each city. Table 6-9 below shows the resulting confusion matrix. When the actual value is 0, the predicted value is correct 15/16, or 94%, of the time. When the actual value is 2, the predicted value is less accurate, being correct 18/25, or 72%, of the time. Overall, the predicted value is correct 48/60 = 80% of the time for this set. In actuality, for the 50-meter set, the percent accuracy is higher than 80% because most of the actual values are 0, which are the easiest ones to predict.

Table 6-9. Confusion matrix indicating performance of algorithm for identifying tees and other intersections

	Actual value (by manual inspection			
Value of ‘tee_or_int’ predicted by coding		0	1	2
	0	15	2	3
	1	1	15	4
	2	0	2	18

The other of the two new variables is named ‘polylinesS’. This is simply the total number of polylines detected in the 1.25-meter buffer (around the 50-meter or 150-meter pieces) when it cuts the polylines in the TxDOT_Speed_Limits shapefile. The Python coding was written to simply count the number of polylines in each of these buffers. Though similar to ‘tee_or_int’, it is intended to capture the overall complexity of roadway interconnectedness in a freer way. As the value of 'polylinesS' increases, the number of intersections is expected to increase.

After the records were created, any that overlapped the crosswalk records were excluded. Then the remainder were split into a training set (80%) and a test set (20%), with the latter not to be seen any further until the SPF is finalized.

DEVELOPMENT OF SAFETY PERFORMANCE FUNCTION

Identification of Appropriate Distribution Family

As always, the first step after record development in regression analysis is to identify the most appropriate likelihood function family (e.g., negative binomial, Poisson, etc.) for the observed response variable, which, in our case, is the count of pedestrian crashes in the 50-meter (or 150-meter) record. Although the most appropriate likelihood function's parameters (such as mean and standard deviation) will sometimes change as important variables enter the model, many times the family remains the same. One can check to see if the family has changed as the model development progresses, as we did for our SPF, but even if it does, it's essential to begin with the family that best fits the observed response variable.

The fitDist() function from the gamlss library in R was used to calculate the AIC (Akaike information criteria) value for 32 count data distribution families, each applied to the count of pedestrian crashes containing the training set of the 150-meter records (about 65,000 records). The lower the AIC value, the better the fit. Table 6-10 shows the results only for the best fit (SI) and for some important ones often encountered in the literature and that may be potential alternatives to the negative binomial type-2 distribution family correctly identified as appropriate by Ezra Hauer in many of his excellent studies later incorporated into the 2010 Highway Safety Manual and other authoritative resources. Those studies were for stretches of roadway much longer than our 50-meter and 150-meter lengths and for crash categories typically many times larger (in terms of number per year per unit length of roadway) than that of midblock pedestrian crashes. So, it is reasonable to explore the possibilities of other distribution families for our particular work. Although Table 6-10 shows the Sichel distribution to be the best fit, this may no longer be the case as variables are added to the model. Particularly noteworthy is that negative binomial type-1 and negative binomial type-2 have exactly the same AIC value at this stage. That is because both of these distribution families for merely the observed data are based on a single value of the mean (as opposed to the expected mean predicted for each record by the regression equation model), and so the difference in performances between Type-1 and Type-2 does not emerge at this stage.

Table 6-10. AIC values for various count data distribution families fit to the observed data

Distribution Family	AIC for observed data	Number of parameters
SI (Sichel)	54,254.7	3
PIG (Poisson-inverse Gaussian)	54,271.5	2
NBI (Negative Binomial Type-1)	54,394.4	2
NBII (Negative Binomial Type-2)	54,394.4	2
ZINBI (Zero-Inflated Negative Binomial)	54,396.4	3
PO (Poisson)	58,212.7	1

The number of parameters in Table 6-10 provides an approximate idea of how easily the RS (Rigby and Stasinopoulos) fitting algorithm will execute. The SI distribution has 3 parameters (one representing the mean, another the spread, and yet another the shape), and while it ran smoothly for fitting to the observed data, it would not converge within the default limit of 20 iterations of the RS algorithm. Increasing the allowable limit by setting the n.cyc argument in the gamlss() function argument to a higher number was explored as an option, but the convergence time was too long to allow for the development of the model. For SI, fitting only to the observed data, the RS algorithm required 367 iterations to converge. The distribution families with only two parameters were all executed within a few iterations.

In the calculation of the AIC value, the value of the AIC is lowered as the predicted values become closer to the observed values, but a 2-point penalty is added for every parameter that can be adjusted. The absence of such a penalty would allow for the indefinite addition of parameters to achieve a perfect but meaningless fit. Table 6-10 shows that ZINBI, for which the RS algorithm required 81 iterations to converge and which is the zero-inflated version of the negative binomial distribution, is 2 points higher than NBI and NBII. Though not shown in Table 6-10, the zero-inflated versions of SI and PIG were also 2 points higher than their counterparts. This shows that adding a parameter to address any possible zero-inflation does not move the predicted values any closer to the observed values. The observed values are not zero-inflated.

Table 6-11 compares the observed numbers with those predicted by the SI, PIG, NBI, NBII, and ZINBI models. These values are still based strictly on the observed numbers of midblock crashes, with no variables in the SPF model (i.e., the regression model) yet. ZINBI predicted numbers are identical to those of NBI when rounding to the nearest whole number, and so they are not shown. The SI model achieves an excellent fit. It does not exactly match every single observed number, but even if a set of 65,358 values were randomly generated twice from the very same SI model, the distribution of the numbers would not exactly match. In Table 6-11 no systematic error is apparent in the predictions generated by the SI model. Predicted numbers by the SI model are sometimes overestimated a bit and sometimes underestimated a bit for both the lower count values (0 through 6) and the higher count values (7 through 12). The PIG model seems to favor underestimation for count values of 5 through 12, with the one exception being the count value of 9, where its predicted count of 1.2, when rounded, matches the observed count. The NBI model consistently underestimates count values 5 through 12, with the underestimation becoming increasingly severe as the count value increases. At a count value of 5, the NBI model's predicted count is 24.3/42 = 58% of the observed value, and at the highest count value, 12, the predicted number of 0.0068 (which is shown as 0 in the table due to rounding to the nearest tenth) is 0.0068/1 = 0.7% of the observed value. The NBI model has a clear systematic error.

Table 6-11. Comparison of observed numbers and SI, PIG, and NBI predicted numbers of crashes in 150-meter length pedestrian crashes for years 2006-2023

count	observed number	number predicted by SI	number predicted by PIG	number predicted by NBI NBII, and ZINBI
0	58,341	58,344.2	58,362.7	58,375.5
1	5,648	5,643.3	5,543.4	5,396.9
2	941	937.1	1,011.9	1,166.9
3	255	259.9	281.7	300.5
4	87	94.9	95.9	83.6
5	42	40.2	36.4	24.3
6	27	18.7	14.8	7.3
7	8	9.2	6.3	2.2
8	4	4.8	2.8	0.7
9	1	2.5	1.2	0.2

10	2	1.4	0.6	0.1
11	1	0.8	0.3	0
12	1	0.4	0.1	0

Although the absolute difference in predicted and observed numbers at high count values is small even for the NBI, NBII, and ZINBI models (that difference being less than 20 for count values of 5 through 12), the percent difference is what is more reflective in the calculation of AIC and in other statistics, including the p-values of estimates of coefficients of covariates as they are brought into the model. This impacts the decisions on which variables are to be included in the model. In general, p-values corresponding to the less dispersed NBI distribution families will be lower than those of the more dispersed distribution families, which have thicker tails at the higher count values. The less dispersed distribution families will thus tend to be more permissive in accepting variables into the model if based on p-values.

The selection of the appropriate distribution family for the final SPF model is important regarding the before-after Empirical Bayes method outlined in the 2010 Highway Safety Manual and the 2017 NCHRP report for the calculation of the CMF and, ultimately, in the standard error in the estimate of the CMF and related testing of statistical significance. However, as variables were introduced to build the SPF model using the gamlss() function from R's gamlss library, the gamlss() function yielded a warning that the algorithm typically relied upon failed to converge and that a secondary algorithm was being used instead. While an initial inspection indicated that the results were nonetheless reasonable, a more careful inspection revealed inconsistencies. Therefore, R's MASS library was used for development of the SPF. The MASS library does not have an extensive set of distribution family options as gamlss does. We therefore limited ourselves to the negative binomial Type-2 distribution family, using the MASS library's glm.nb() function. Before finalization of the SPF, the residuals of the model will need to be once again analyzed using the fitDist() function in R's gamlss() library, and adjustments made, if necessary.

VARIABLES ELIMINATED DUE TO HIGH CROSS-CORRELATION

Including covariates that are highly correlated with each other can introduce errors in coefficient estimates and their p-values. For each pair of covariates that has a correlation coefficient greater than 0.90, one was removed. Deciding which of the two to remove is based on how well each correlates with the variable 'totPedCnt' and whether the variable is also strongly correlated with other variables. An example of the latter criteria being applied concerns the census data, in which the variable 'cd01_tot', which is the total number of jobs requiring high school education (but not higher) held by residents within a 0.5-mile buffer for the 150-meter piece of roadway, had a correlation coefficient of greater than 0.90 with each of the other 7 census data variables, while none of the other 7 variables shared such a strong correlation with all 7 of the others. Therefore, of the eight census data variables, only ‘cd01_tot’ was kept.

DEVELOPMENT OF LOG TRANSFORMS AND OTHER TRANSFORMS

The numerical variables for consideration as regression model covariates were included in their raw form, and most of them were also included in a log-transformed form. The base-10 log rather than the natural log was chosen to make visual interpretation of coefficient estimates easier. For numerical variables that would sometimes be equal to 0 or less than 1, 1 was added before log-10 transformation to avoid error or extremely large negative transforms. For numerical variables values that tend to be small compared to 1, a multiplier was included so that the non-zero value would not be obscured by the 1. So, for example, the numerical variable BusStpDist, which represents the number and proximity of bus stops, is sometimes 0, and has a maximum value of 0.07, was transformed

Log_BusStpDist = Log10(1 + 100*BusStpDist)

Three of the numerical variables were transformed to categorical variables (otherwise known as ‘factor’ variables in R). One of them is MED_WID, the variable from the TxDOT Roadway Assets dataset representing the width of the median. Only about 0.3% of these were greater than 0. There may be some doubt as to whether some of the 0’s actually represents missing values. In any case, considering that the width of the median might make little difference compared to the presence of the median, this variable was transformed to MED_WID_cat, with a value of 0 for MED_WID is 0, and 1 for MED_WID > 0. Both the raw and transformed forms were included in the model development process. Neither of them proved to be statistically significant.

Another numerical variable that was transformed into categorical is the speed limit, appearing as Speed_Lmt, and obtained from the TxDOT_Speed_Limits shapefile. The coefficient estimate was negative, with a very low p-value, suggesting that pedestrian crashes are less likely as the speed limit increases. This may be true Speed_Lmt_cat is simply a one-to-one categorization for the numerical values, i.e., the category ‘20’ represents a 20 mph speed limit, ‘30’ represents 30, and so on. Replacing Speed_Lmt with Speed_Lmt_cat

The other numerical variable that was transformed into categorical is CurveDeg, which is an estimate of the degree of curvature in the 150-meter length. To calculate this, two line bearings were first calculated. Python code was written to calculate the line bearing for the line passing through the first two points of the 150-meter piece and then for the last two points of the 150-meter piece. CurveDeg was then set equal to the difference between these two bearings as an approximation for the actual degree of curvature. The reason for transforming it into categorical, as CurveDeg_cat, is the suspicion that the relationship between it and the probability of the crash is very non-linear, but in a way not captured by a log-transform. The raw CurveDeg variable, as well as CurveDeg_cat and the log transform Log10(1 + CurveDeg), were all included in the model development process, and all had a very strong tendency to remain in process, even when all three were included simultaneously, as the stepGAIC process eliminated other variables one at a time.

Another transform utilized for numerical variables is a power transformation. This transformation was attempted only when both the variable and its log-transform survived the stepGAIC() elimination process and appeared in the equation with opposite signs. These opposite signs suggest that a power transformation with an exponent between 0 and 1 might be a more appropriate representation of the variable's impact on midblock pedestrian crashes. This proved to be the case for the variables SchDist and CurveDeg. For SchDist, the variables SchDist and Log_SchDist were both replaced with the single variable $SchDist^{0.3}$, but written as SchDist_z in the formula. For CurveDeg, the variables CurveDeg, Log_CurveDeg, and CurveDeg_cat were all replaced with the single variable $CurveDeg^{0.5}$, written as CurveDeg_z in the formula.

Development Of Interactive Terms

Adding interaction terms can make the regression equation unwieldy when the equation already has as many variables as ours did at this point, especially considering that several of the variables are of the categorical type, which would require each category within that variable to be multiplied by other variables, perhaps even the various categories in some variables. Yet interactive terms can play an important role in improving the predictive power of the model. In particular, multiplying a vehicular traffic variable by a pedestrian traffic variable appears indispensable, as unless both vehicular traffic and pedestrian traffic are present, a pedestrian crash is impossible. To develop interactive terms, the variable ADT_ADJ from the TxDOT Roadway Inventory was considered the best measure of overall vehicular traffic and was multiplied by various pedestrian proxy variables (such as BusStpDist and SchDist, variables that are associated with and increase in value as the closeness and numbers of nearby bus stops and schools increase), and, in a semi-automated process, exponents on each of the factors were optimized. Each of these two-factor interaction terms that proved statistically significant was multiplied by a geometry or other variable (such as CurveDeg, the degree of curvature).

As an additional approach to developing interaction terms, another attempt to identify the most important interactions, classification and regression trees were developed using the rpart, randomForest, xgboost, and partykit libraries in R. Of these, partykit proved the most useful for our purposes. The resulting regression tree showed strong interactivity between ADT_ADJ (a measure of automobile traffic) and BusStpDist (a measure of the proximity and number of bus stops within 0.25 miles of the 150-meter piece). This is as expected. The trees yielded no other substantial information for generating interaction terms. The development of the regression equation for the SPF came to a pause in order to visually inspect pedestrian crossing sites (mostly through Google Street View) and compare them with non-crossing sites with nearly identical SPF predicted values and consider whether additional variables are still lacking. Initial crash modification factors (CMFs) would be calculated alongside this visual inspection process.

CHECKING FOR OVERFITTING BY CROSS-VALIDATION

Although use of the AIC penalty helps reduce the risk of overfitting, the penalty is not severe for large datasets. Therefore, in order to be more confident that overfitting had not occurred, a five-fold cross-validation function was created in R. In this process, our training dataset was divided into five equal folds of approximately 16,000 randomly selected records each. Then the model was fit to four of the folds, referred to as the training set. With the coefficient estimates adjusted and fixed to best fit those four folds, the model was then applied, without adjusting the coefficient estimates, to the remaining fold, referred to as the test set. McFadden's R^2 (which is a measure of the fit of a model to the data but, unlike AIC, is independent of the number of records) was then calculated for both the training set and the test set. This process was repeated until each fold had its turn of being the test fold. Table 6-12 below shows the one run of cross-validation executed for the final model. Although the SI distribution family is to be used for the final model, the development and execution of the cross-validation script for that distribution would prove excessively time-consuming, and so the PIG distribution was used instead. The results in Table 6-12 indicate that the model is not overfit. On average, the average McFadden's R^2 in the testing set is a bit lower than it is for the training sets, but this tends to happen even if the model is underfit (i.e., excluded some parameters that actually should be included) because the fitting of parameters will never be completely free of random effects. The values in the testing set column are more spread because the testing dataset is smaller and, perhaps more importantly, contains some categorical variables with small numbers in some categories. For example, Speed_Lmt_cat has only 51 values in the 20 mph category, and where these fall in the random selection process may have a significant impact on McFadden's R^2 for the test set. Also noteworthy is that the highest McFadden's R^2 in the testing sets, 0.0994, is higher than any value in the training sets. This is nearly impossible for a dataset of this size if overfitting has occurred.

Table 6-12. Cross-Validation results for final SPF model

Fold	McFadden's R^2	
	Training Set	Testing Set
1	0.0959	0.0889
2	0.0931	0.0994
3	0.0957	0.0900
4	0.0952	0.0920
5	0.0952	0.0916

APPLICATION OF CURRENT SPF TO DEVELOP CRASH MODIFICATION FACTORS (CMFS)

As pedestrian crossings were visually compared with non-crossing sites that had nearly identical predicted SPF values as the crossing sites, the need to further enrich the dataset became apparent. However, we now nonetheless calculated CMFs for various categories of treatments, as shown in the Excel workbook ‘calculate_CMFs.xlsx’, which includes an ‘Introduction’ sheet followed by sheets calculating CMFs for various treatment sets, with each sheet’s tab labeled accordingly.

The process for calculating the CMFs closely follows that shown in Section 9.10 of the 2010 Highway Safety Manual but is further explained as follows.

First, in Table 1 on the ‘Introduction’ sheet, the overdispersion parameter is presented for model.3.glmnb. This is the SPF developed according to the process described in the above ‘Development of Safety Performance Function’ section. This overdispersion parameter is the value of ‘k’ used in tables on subsequent sheets and helps account for how spread out the data can be from the mean. The higher the value of ‘k’, the more weight is given to the actual observed values when calculating the CMF. Also provided is the overdispersion parameter for model.8.glmnb. This was a separate SPF that was based on model.3.glmnb but applied only to records for which HP_VOL_GRP = 5 in the TxDOT Roadway Inventory (corresponding to vehicular traffic counts between 10,000 and 20,000). The lower overdispersion parameter shown is used only for the CMF of the last spreadsheet (the one with the ‘CMF_overall_5’ tab).

Table 2 on the ‘Introduction’ sheet shows the total observed midblock pedestrian crash count (‘totPedCnt’) for the entire 18-year period (2006-2023) for each 150-meter length of roadway centered on a pedestrian crossing (‘crossingID’), i.e., 75 meters in each of the two directions along the same roadway that the crosswalk is on. The ‘model.3.glmnb predicted values’ column in Table 2.a are the predicted number of pedestrian crashes in the 18-year period in the 150-meter piece of roadway at the crossing. Similarly, ‘model.8.glmnb predicted values’ are the predicted numbers based on that more restrictive SPF, for which HP_VOL_GRP = 5.

Table 3 on the ‘Introduction’ sheet is simply the number of midblock pedestrian crashes before any countermeasure was implemented (upper table) and the number after the last countermeasure was implemented (lower table). These are based mainly on inspection of Google Street View images. These images are typically available about once every two years for any particular site, so if the upper and lower tables are compared, one will see a gap of ‘NA’ between the last year without a countermeasure and the first year after the last countermeasure. Also, because the image was never known to be taken exactly at the end or the beginning of a year, the year that the image was taken must also be marked as ‘NA’. Finally, in just a few cases, countermeasures were not implemented simultaneously, or the time lapse between images was 3 or 4 years instead of 2, contributing to a higher number of NAs for that crossing.

At the top of each subsequent spreadsheet is Table A, the calculation of a 'naïve CMF'. It is the ratio of the observed crash frequency before the countermeasure to the observed crash frequency after the countermeasure. The observed crash frequency before the countermeasure was calculated as the total number of crashes that were observed in all the crossings of the category of concern and then dividing this total by the total number of years. Similarly, the 'after' crash frequency was calculated.

Table A is followed by Tables B and C, which are basically subsets of the upper and lower portions of Table 3 on the 'Introduction' sheet, based on the more limited set of crossings that had the countermeasures of concern.

The rest of the tables on these spreadsheets very closely follow Section 9.10 of the 2010 Highway Safety Manual. In Step 1, the table shows the number of crashes predicted by the SPF for each year before the countermeasure is calculated. Since the SPF is for an 18-year period, this is simply the SPF predicted value divided by 18. In the last column is the total for the row. So, for example, if there are 7 years before the countermeasure, then the total in this column will be 7/18 of the value predicted by the SPF.

In Step 2, the predicted values of Step 1, along with actual observed values and the overdispersion parameter are used to calculate the expected number of crashes before the countermeasure. The expected number is different from the predicted number. The predicted number is simply that obtained from the SPF. The expected number is intended to take into account some of the limitations of the SPF.

In Steps 3 through 5, the values predicted by the SPF for the years after the countermeasures are provided (but pretending that the countermeasures had actually not been implemented) in the same way as they are provided in Step 1 for the years before the countermeasures. Also r, the ratio of the predicted total crashes before the countermeasures to the predicted total crashes after the countermeasures, is calculated for each crossing. Since these predicted values are constant over the years in this stage of SPF development, this ratio is the same as the ratio of the number of years before the countermeasure to the number of years after the countermeasure. This ratio is applied to the expected number before the countermeasures to get the expected number after the countermeasures, but as if the countermeasures were not actually applied. In other words, the last column in the table for Steps 3 through 5 shows the number of crashes that are expected to occur at the site during the years after the countermeasures as if the countermeasures had not been applied. This expected number takes into account some of the limitations of the SPF.

In Steps 6 through 9, a preliminary CMF (OR_i) is calculated for each site in each row of the table, simply as the ratio of the observed number of crashes in the years after the countermeasure ('Obs crashes in AFTER yrs') to the expected number of crashes had there been no countermeasure ('Nexpected_A'). The CMF is then estimated as the sum of these 'OR_i' values divided by an expression that accounts for variability, as discussed in the Hauer sources cited by the 2010 Highway Safety Manual. This estimate of the CMF is highlighted in yellow and is also referred to as ‘OR’, to be consistent with the Manual.

In Step 10, the safety effectiveness is calculated simply as 100%(1 – CMF).

In Steps 11 and 12 the variance and standard error (square root of the variance) are calculated for the estimated CMF, with the derivation of the formula provided in the Hauer sources cited by the Manual.

In Step 13, the corresponding standard error for the safety effectiveness is calculated. This is simply the standard error in Step 11, expressed as a percentage. This follows from the general rule: If $y = Ax + B$, and A and B are known exactly and are fixed (as 100 and -100 in this case), then the standard error in y is simply A multiplied by the standard error in x.

Finally, in Step 14, the p-value is calculated and highlighted in yellow. The Manual shows a p-value for a two-sided test. Here we are showing it for a one-sided test to more simply compare the estimated CMF with 1. So, for example, on the CMF_RRFBplus sheet, the estimated CMF is 0.55 and the p-value is 0.25, with this p-value telling us that if the estimates of CMF follow the standard bell-shaped curve, about 25% of them would fall above 1, and 75% of them would fall below 1.

CHAPTER 7 : MIDBLOCK PEDESTRIAN SAFETY ACTION PLAN

SUMMARY OF STATES PEDESTRIAN SAFETY PLAN AND GUIDELINES

USDOT Pedestrian Safety Action Plan

The USDOT Pedestrian Safety Action Plan (2020) presented a comprehensive national strategy to reduce pedestrian fatalities and serious injuries. Recognizing that walking is a universal mode of transportation, the FHWA and NHTSA collaborated to identify the causes of increased pedestrian deaths and to recommend targeted solutions. Over the past decade, pedestrian fatalities significantly increased. According to Fatality Analysis Reporting System (FARS) data, pedestrian deaths rose from 4,302 in 2010 to 6,205 in 2019.

The percentage of pedestrian deaths in total traffic fatalities also climbed from 13% in 2010 to 17% in 2019. In 2018, 81% of pedestrian deaths occurred in urban areas, 76% happened in dark conditions, and 74% took place away from intersections. The data also indicated that most incidents occurred between 6:00 p.m. and midnight and predominantly in the fall and winter months. Data revealed that adults aged 50 to 69 accounted for one-third of all pedestrian fatalities. Among children under 14, 17% of traffic-related fatalities involved pedestrians. Data suggested that 59% of deaths occurred on arterial roads, with 38% on principal arterials and 21% on minor arterials. Pedestrian deaths involving SUVs and light trucks rose steadily from 2009 to 2018. Additionally, the AAA Foundation demonstrated how modest increases in vehicle speed drastically heightened the risk of death. For example, a pedestrian's risk of fatality reached 50% at 42 mph and jumped to 90% at 58 mph.

The report also outlined challenges in collecting reliable pedestrian exposure data, as pedestrian trip volumes are rarely measured consistently. Environmental and systemic factors such as poor pedestrian infrastructure, urban sprawl, weather conditions, and inadequate connections to transit further contributed to increased risk. The Safe System Approach proposed by the USDOT emphasized forgiving design principles that account for human limitations. To address these challenges, the report outlined 90 specific actions, including updating the Pedestrian and Bicycle Road Safety Audit Guide, developing scalable risk assessment tools, producing the Safe Transportation for Every Pedestrian (STEP) toolbox, enhancing lighting design guidelines, implementing Pedestrian Automatic Emergency Braking (P-AEB) testing protocols, and deploying vehicle-to-pedestrian communication technologies. Stakeholder engagement was a major component of the plan. Input from over 180 organizations highlighted recurring themes such as the need to reduce vehicle speed through improved laws and infrastructure design, increase pedestrian safety funding, and leverage vehicle technologies like automated driving systems. Specific efforts were made to consider the needs of rural, tribal, and disability communities.

Overall, the USDOT Pedestrian Safety Action Plan provided a detailed, evidence-based roadmap with both immediate and long-term strategies aimed at reducing pedestrian harm. The report emphasized data-informed decisions, coordination across federal and local agencies, and incorporation of stakeholder perspectives to create safer and more inclusive roadways for all users.

TEXAS PEDESTRIAN SAFETY ACTION PLAN

The Texas Pedestrian Safety Action Plan (PSAP) Statewide Summary prepared in 2023 provided a comprehensive analysis of pedestrian crashes across Texas using a combination of systemic and targeted approaches. This initiative was led by the TxDOT in response to the increasing trend in pedestrian-related crashes and aimed to identify high-risk locations and recommend countermeasures to improve safety. The PSAP used five years of pedestrian crash data from 2017 to 2021. It analyzed 27,693 pedestrian crashes, which resulted in 3,426 fatalities, 5,905 serious injuries, and 9,604 minor injuries. Data suggested a clear upward trend in both the frequency and severity of pedestrian crashes over time, despite a brief reduction during the COVID-19 period. Results indicated that the majority of crashes occurred in urban areas, particularly in high-population regions such as the Houston District, which accounted for 27% of all pedestrian crashes even though it only contained 9% of Texas' centerline miles and 24% of its population. Crashes were also analyzed based on roadway system type. Although TxDOT-managed on-system roads only comprised 25% of Texas' centerline miles, they were the site of 36% of all pedestrian crashes and 68% of pedestrian fatalities. A comparison between crash distributions on on-system and off-system roads revealed the disproportionate fatality rates on on-system segments.

The study highlighted critical contributing factors. 52% of all pedestrian crashes occurred in dark or unlit conditions, and among those, 82% resulted in fatalities. About 36% of crashes were attributed to pedestrians failing to yield and stop, resulting in over 2,000 deaths. Distracted behavior and vulnerable age groups were also common; 16% of crashes involved distracted individuals, while 14% involved children under 16, and 10% involved seniors over 65.
The PSAP implemented two types of analysis to identify and prioritize hazardous segments: systemic and targeted. The systemic analysis focused on proactive identification of high-risk roadways based on roadway attributes rather than crash history. A total of 19,045 miles of roadway segments designated as focus facilities were identified, covering 23.6% of on-system miles, yet accounting for 82.2% of pedestrian crashes. These segments were analyzed for the presence of systemic risk factors such as road type, speed limit, and shoulder width. Data suggested that 33% of these miles were identified as having “potential risk,” with some districts like El Paso and Laredo having over 60% of their focus facility miles flagged.

In contrast, the targeted analysis concentrated on historical crash density. Using a sliding window technique, road segments were classified into five tiers of pedestrian crash density: Very High, High, Medium, Low, and Minimal. These tiers were determined based on crash frequency normalized by centerline miles, allowing for an even comparison across the state regardless of roadway context. Data revealed that the vast majority of the state’s roadway network fell into the minimal crash density tier across all severity types. Specifically, for the most severe crashes (K), only 0.9% of Texas’ centerline miles were categorized as Very High, High, Medium, or Low. When considering all crash types (KABCO), only 3.8% of centerline miles fell into these four density tiers, leaving approximately 96.2% in the Minimal category. This distribution emphasized that while serious pedestrian crashes are geographically concentrated, the vast majority of road segments have little or no history of such incidents.

Based on the findings from both analyses, the PSAP proposed a suite of 25 engineering countermeasures and 10 educational or operational strategies. These countermeasures included raised crosswalks, pedestrian refuge islands, leading pedestrian intervals, and traffic calming treatments. Under each strategy, detailed implementation steps, participating organizations, cost and time for implementation, and barriers are identified. These strategies include:

1. Improve awareness and behavior
2. Reduce pedestrian crashes
3. Improve pedestrians' visibility at crossing locations
4. Improve pedestrian networks
5. Improve pedestrian-involved crash reporting
6. Establish vehicle operating speeds to decrease crash severity
7. Develop strategic pedestrian safety plans tailored to local conditions

Implementation of the PSAP involved delivering district-specific pedestrian safety profiles, Excel-based analysis data for planners, and an online PSAP Screening Tool to support decision-making. These outputs are expected to influence future Strategic Highway Safety Plans, guide HSIP updates, and inform MPO safety strategies.

New Jersey Pedestrian Safety Action Plan

The New Jersey Pedestrian Safety Action Plan was developed as a comprehensive response to the state's consistently high rate of pedestrian fatalities and serious injuries. To support a data-driven strategy, the plan set a measurable mission: reducing the number of pedestrian fatalities and serious injuries by 20% over five years. That meant bringing the average annual fatality count down from 141 to 113 and reducing serious injuries from 269 to no more than 215. These goals were formulated based on pedestrian crash data collected between 2006 and 2012, which showed an average of 138 fatalities, 264 severe injuries, and approximately 5,950 pedestrian-vehicle crashes each year.

The demographic analysis accompanying the plan further refined the focus of recommended actions. Most pedestrian fatalities involved adults aged 45 and older, with those over the age of 84 experiencing the highest fatality rate at 3.23 per 100,000 people. Meanwhile, young adults between 18 and 24 also had elevated crash involvement, particularly in non-fatal but serious injuries. Gender disparities were also evident; male pedestrians were involved in over two-thirds of fatal crashes and had a fatality rate more than twice that of females. Similarly, male drivers were more frequently involved in crashes that resulted in pedestrian death or injury. Behavioral and environmental factors emerged as major contributors to crash severity. Drivers' inattention was the leading cause, cited in 30% of fatal and severe crashes. Pedestrian violations, such as crossings where prohibited and darting into traffic, each accounted for 16% of severe incidents. Lighting conditions also played a critical role. About 68% of fatal crashes occurred during dark conditions, and on state highways, the rate rose to 84 percent. Notably, nearly 47% of these dark-condition crashes happened in areas with continuous or spot street lighting, suggesting that the quality or placement of lighting was inadequate.

In response to these insights, the plan proposed a three-pronged strategy: improving governance and data management, fostering behavioral change through education and enforcement, and enhancing pedestrian infrastructure. Actions ranged from creating a statewide pedestrian safety task force to promoting driver and pedestrian education programs in schools and communities to implementing engineering solutions like pedestrian refuge islands, hybrid beacons, and road diets.

Arizona Active Transportation Safety Action Plan (ATSAP)

The Arizona Active Transportation Safety Action Plan (ATSAP) was developed as a comprehensive statewide initiative aimed at improving safety for active transportation users, specifically pedestrians and bicyclists, on Arizona's State Highway System (SHS). The Arizona Department of Transportation (ADOT) created ATSAP concurrently with its 2024 Strategic Highway Safety Plan (SHSP), enhancing coordination between both efforts (ADOT, 2024). ATSAP addressed a significant rise in active transportation fatalities, which increased by approximately 90% despite only a 12% increase in population since 2013. Specifically, pedestrian-involved crashes on ADOT facilities totaled 1,893, representing approximately 11% of all pedestrian crashes statewide but accounting for 22% of fatal pedestrian crashes and 13% of serious injuries. Bicyclist-involved crashes totaled 1,383, representing around 10% of all bicyclist crashes statewide but accounting for 18% of fatal and 12% of serious injury crashes. Key contributors to crashes involving pedestrians and cyclists were identified, including driver distraction, aggressive driving behaviors, inadequate pedestrian and cyclist crossings, poor infrastructure, insufficient enforcement, and inadequate roadway lighting. Pedestrian crashes frequently occurred at night and in mid-block locations, while bicyclist crashes typically happened during the day and at intersections.

The plan established clear goals: a short-term target of reducing life-altering pedestrian and bicyclist crashes by 20% by 2030 and a long-term goal of eliminating these crashes. To achieve these ambitious goals, ATSAP incorporated a Safe System Approach (SSA), promoting comprehensive safety management involving safe road users, vehicles, speeds, roads, and effective post-crash care. ATSAP conducted an extensive analysis of crash data from 2013 to 2022.

An extensive outreach effort included public meetings, online surveys, stakeholder workshops, and targeted engagement with tribal partners. Online survey results highlighted that the public viewed driver distraction and aggressive behaviors as the top contributors to pedestrian and cyclist fatalities, while prioritized strategies included protected crossings, increased law enforcement, and enhanced pedestrian and cyclist facilities. Effective safety education methods were identified, emphasizing social media, freeway message signs, and driver education classes. Policy recommendations from ATSAP included prioritizing safety in ADOT's planning and programming processes, developing pedestrian- and bicyclist-friendly interchange designs updating the Roadway Design Guidelines to improve safety through narrower lane widths, dedicated bike lanes, and pedestrian-friendly features, and signalizing channelized right-turn lanes.

Additionally, ATSAP recommended legislative changes, such as revising distracted driving penalties to include points against a driver's license, aiming to further deter unsafe driving behaviors. ATSAP identified 26 priority locations across Arizona through a detailed crash frequency and risk analysis. Countermeasures tailored to each location ranged from infrastructure improvements to targeted education campaigns.

New York State Pedestrian Safety Action Plan

The New York State Pedestrian Safety Action Plan (2016) provided a comprehensive five-year framework to reduce pedestrian fatalities and injuries by identifying risk factors and implementing data-driven countermeasures. Developed in response to New York's designation as a pedestrian focus state by the FHWA, the plan analyzed 23,722 pedestrian crashes that occurred outside New York City between 2009 and 2013. These incidents resulted in 719 fatalities and more than 7,500 serious injuries. The total estimated economic impact over five years was $5.82 billion, or about $1.16 billion annually (NYSDOT, 2016). More than 88% of crashes took place in urban areas, and 48% occurred at intersections. Despite accounting for only 14% of total roadway mileage, state-owned roads were the site of 24% of pedestrian crashes, suggesting a higher severity rate compared to locally owned roads. The data revealed that 48% of all crashes happened in just 20 focus communities, with Hempstead reporting the highest number of incidents at 2,139. The analysis also showed that 62% of urban crashes involved pedestrians crossing the roadway, with 69% of these crossings occurring at locations without a traffic signal. Data demonstrated that crashes at non-signalized locations were significantly more likely to result in fatalities and serious injuries than those at signalized intersections.

This finding justified prioritizing safety improvements at uncontrolled crossings, particularly in urban areas. The plan recommended systemic engineering measures, including high-visibility crosswalks, pedestrian refuge islands, advance signage, and Rectangular Rapid Flashing Beacons (RRFBs), to be deployed first on state roads and later expanded to local roads through a competitive funding process.

In addition to engineering strategies, the plan proposed educational campaigns and enhanced law enforcement efforts. Public awareness programs included statewide media outreach, multilingual materials, and toolkits for schools and community groups. The enforcement message, branded as "Operation SEE! BE SEEN!," encouraged targeted patrols and law enforcement training in focus communities to improve driver and pedestrian compliance with traffic laws. Efforts were also made to improve data collection and risk analysis through enhancements to New York's Accident Location Information System (ALIS) and the launch of pilot pedestrian counting programs. These upgrades aimed to provide a more accurate picture of pedestrian exposure and crash trends, enabling better allocation of resources and evaluation of countermeasure effectiveness.

Florida Department of Transportation

The Florida Department of Transportation (FDOT) initiated research on pedestrian safety at midblock locations in response to concerning trends indicating an increase in pedestrian injuries at these locations. Between 1986 and 2003, the research analyzed pedestrian injury severity at midblock and intersection crossing locations under varying lighting conditions, including daylight, dark with street lighting, and dark without street lighting (CUTR, 2006).

Analysis of pedestrian crash data from 1986 to 2003, using an ordered probit model, indicated that midblock locations were significantly more hazardous than intersections. Specifically, the odds of a pedestrian fatality at intersections were 49% lower than at midblock locations during daylight, 24% lower under dark conditions with street lighting, and 5% lower in the absence of street lighting. Daylight conditions significantly reduced the likelihood of fatal pedestrian injuries, lowering odds by approximately 75% at midblock locations and 83% at intersections compared to dark conditions without street lighting. Further examination of Florida crash data revealed critical insights into pedestrian injuries at midblock crossings. From 1994 to 2001, midblock locations accounted for 81% of all fatal pedestrian injuries and 73% of non-fatal pedestrian injuries during street crossings. Pedestrian fatalities increased by 5.9% at midblock locations compared to a 20.4% reduction at intersections. Non-fatal injuries also rose by 12.1% at midblock locations, while declining by 4.8% at intersections. The fatality rate per 100 pedestrian injuries was higher at midblock locations (8.2%) compared to intersections (5.6%) in the 1994-2001 period, emphasizing the critical safety issues at midblock crossings.

In addition to identifying critical risk factors, the study proposed comprehensive guidelines for marking midblock crosswalks at uncontrolled locations. These guidelines addressed shortcomings in existing practices by including clear demand criteria, basic safety standards, and treatments for enhancing pedestrian safety. Enhanced treatments such as advanced warning signage, high-visibility markings, and pedestrian-actuated signals were recommended to mitigate risks associated with marked midblock crosswalks. The guidelines were developed based on a review of practices from 28 different localities, professional inputs, and empirical analysis. The research emphasized three major mechanisms through which midblock crosswalk markings potentially increased pedestrian-vehicle collision risks: multiple-threat collisions, pedestrians' false sense of security, and insufficient enhancements beyond simple markings. To counter these issues, the proposed guidelines incorporated safety-enhancing treatments, such as pedestrian refuge islands, overhead pedestrian signs, and automated pedestrian detection systems. Finally, the report recommended ongoing monitoring and evaluation of newly implemented midblock crosswalks to continuously refine and validate the proposed guidelines. By addressing identified risks and improving crosswalk safety standards, FDOT aimed to enhance pedestrian safety significantly at midblock locations throughout Florida.

Regional Pedestrian Safety Action Plan (PSAP)
The 2021 Regional Pedestrian Safety Action Plan (PSAP) prepared by the North Central Texas Council of Governments (NCTCOG) aimed to address the growing number of pedestrian fatalities in the 12-county Metropolitan Planning Area (MPA) centered around Dallas-Fort Worth. This region, which includes over 7.6 million people and is projected to grow to over 11.2 million by 2045, has seen alarming trends in pedestrian safety. The plan aligned with federal, state, and local goals to eliminate traffic deaths by 2050. Between 2014 and 2018, there were 7,072 reported pedestrian crashes in the MPA, with 672 fatalities. The annual fatalities rose from 95 in 2014 to 146 in 2018, a 54% increase.

Crash analysis revealed that 95% of fatal or serious injury crashes occurred in urban settings, 82% occurred at non-intersections, and 80% occurred under dark lighting conditions. Fridays saw the highest number of pedestrian crashes, and most victims were male, especially those aged 23–29 and 52–58. A contributing factor in 42% of fatal crashes was pedestrians failing to yield and stop right-of-way, and 23% involved hit-and-run incidents. Racial disparities were also observed; in Dallas County, Black residents made up 23% of the population but accounted for 33% of pedestrian fatalities. The plan introduced Primary and Secondary Pedestrian Safety Corridors (PPSC and SPSC) based on crash density analysis. Out of 38,229 total centerline miles in the region, only 281 miles (0.74%) were identified as safety corridors, yet they accounted for 30% of all reported crashes. A total of 68 primary and 37 secondary corridors were defined. For example, SL 12 in Dallas had 93 crashes over 9.17 miles (10.14 crashes/mile), while Lamar St. had the highest crash density with 43 crashes over just 1.16 miles (37.22 crashes/mile). In the secondary group, Ferguson/Centerville Rd. had 46 crashes over 8.44 miles.

To support the PSAP's goals, NCTCOG proposed the use of the "Five Es" framework: Engineering, Education, Enforcement, Encouragement, and Evaluation. Policy goals included:

1. Eliminate all serious injury and fatal pedestrian crashes by 2050.
2. Design for all users of all ages and abilities, with a focus on vulnerable users.
3. Prioritize comfort, safety, and directness in facility design.
4. Implement data-driven safety countermeasures.
5. Use Multimodal Level of Service (MMLOS) analysis in roadway planning.

Public feedback was collected through a 2019 online survey of 1,045 respondents. The top barriers to walking were the absence of sidewalks and trails, poor existing conditions, and unsafe driver behavior. Lighting improvements and wider sidewalks were suggested to enhance comfort and safety.

Austin Pedestrian Safety Action Plan

The Austin Pedestrian Safety Action Plan (PSAP) was developed as a comprehensive strategy to address pedestrian safety concerns throughout Austin, Texas. Between 2010 and 2015, nearly 1,900 pedestrian crashes occurred, resulting in 121 fatalities. For every pedestrian fatality in Austin, there were approximately ten serious injuries. These crashes had significant economic impacts, costing Austin an estimated $55 million annually in wage and productivity losses, medical expenses, and other associated costs, potentially exceeding $400 million when accounting for quality-of-life impacts (City of Austin, 2018).

A thorough pedestrian crash analysis was conducted, revealing critical insights into the factors contributing to pedestrian accidents. Key findings indicated that street design significantly influenced crash severity. Specifically, 64% of pedestrian fatalities occurred on roads with speed limits of 45 mph or higher, while crashes were nearly twice as likely to result in serious injury or fatality in areas lacking sidewalks on both sides of the street. The analysis highlighted that pedestrian crashes occurring more than half a mile from the nearest signalized crossing resulted in serious injury or fatality 43% of the time, compared to 22% when crashes occurred within an eighth of a mile of a crossing. The presence of street lighting was associated with an 8% reduction in crash severity probability, emphasizing the necessity for adequate illumination. Six primary behaviors identified as major contributors to crashes were failure to yield and stop (53% of crashes), distraction or inattention (19%), impairment (7%), improper maneuvering (5%), speeding (3%), and failure to stop (2%).

The PSAP highlighted demographic disparities, with minority communities experiencing disproportionately high rates of severe pedestrian crashes. For example, African Americans accounted for 17% of pedestrian crashes despite representing only 7-8% of Austin's population. Non-English-speaking communities and lower-income areas similarly faced higher risks, with the ten census tracts having the lowest percentage of English-only speakers experiencing nearly twice as many severe crashes per capita as tracts with high percentages of English speakers. Older pedestrians were also identified as particularly vulnerable, with those aged 45-54 representing 30% of pedestrian fatalities despite being only 12% of the population. Males and individuals experiencing homelessness were identified as high-risk groups needing targeted interventions.

The plan recommended 21 action items across various categories: engineering, education, enforcement, evaluation, policy and land use, and partnership funding. Engineering recommendations included establishing pedestrian crossing improvement programs, enhancing traffic signals to prioritize pedestrian safety, improving street lighting, and implementing Austin's Sidewalk Master Plan. Key education initiatives included developing targeted educational campaigns and deploying Vision Zero Street Teams for community outreach. Enforcement strategies involved collaboration with the Austin Police Department to target high-risk behaviors through educational and enforcement campaigns. Evaluation recommendations included implementing robust pedestrian counting programs and regularly updating pedestrian crash records to better understand trends and effectiveness of interventions. Policy and land use actions stressed integrating pedestrian safety considerations into city planning processes and prioritizing pedestrian safety in new mobility technologies.

Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
Under the FHWA sponsorship, the "Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations" was developed in 2018. The document served as a resource for state and local agencies aiming to enhance pedestrian safety where traffic signals or stop signs are not present, such as midblock or unsignalized intersections. The guide outlined a six-step process for systematically improving pedestrian crossings at uncontrolled locations. These steps included collecting data and engaging the public, inventorying conditions, analyzing crash types, selecting countermeasures, consulting design resources, and monitoring outcomes.

A foundational premise was that over 70% of pedestrian fatalities occur at non-intersection locations and that proactive, data-driven strategies are necessary to mitigate these risks (FARS 2016). The study emphasized low-cost but high-impact countermeasures. It recommended six core treatments under the Safe Transportation for Every Pedestrian (STEP) initiative: high-visibility crosswalk markings, raised crosswalks, pedestrian refuge islands, pedestrian hybrid beacons (PHBs), road diets, and rectangular rapid-flashing beacons (RRFBs). These countermeasures were matched with specific road conditions such as traffic volume, number of lanes, and speed limits.

The guide introduced a matrix (Table 7-1) to help agencies determine appropriate treatments based on variables such as posted speed limits and vehicle volumes. For instance, a 4-lane road with AADT above 15,000 and speed limits of 35 mph would warrant treatments like pedestrian refuge islands and RRFBs, in addition to visibility enhancements. The guide also provided implementation strategies, such as incorporating improvements during regular street resurfacing and using policy tools like Complete Streets, Vision Zero, and Toward Zero Deaths. It urged agencies to track countermeasure effectiveness using performance indicators like crash reductions, vehicle speed changes, and pedestrian volumes for at least three years post-installation. Finally, the document included technical resources, such as the Manual on Uniform Traffic Control

Devices (MUTCD), the Crash Modification Factor (CMF) Clearinghouse, and case studies from various states. These supported agencies in justifying, designing, and evaluating safety interventions tailored to local needs.

Table 7-1. Application of pedestrian crash countermeasures by roadway feature (FHWA 2018).

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	❶ 2 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6 7 9	① 5 6 7 9	① 5 6 ❾
3 lanes with raised median (1 lane in each direction)	❶ 2 3 4 5	❶ ❸ 5 7 9	① ❸ 5 ❼ ❾	① 3 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❼ ❾	① ❸ 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❾
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	❶ 2 3 4 5 6 7 9	❶ ❸ 5 6 7 9	① ❸ 5 6 ❾	① 3 4 5 6 7 9	① ❸ 5 6 ❼ ❾	① ❸ 5 6 ❾	① ❸ 4 5 6 7 9	① ❸ 5 6 ❾	① ❸ 5 6 ❾
4+ lanes with raised median (2 or more lanes in each direction)	❶ ❸ 5 7 8 9	❶ ❸ 5 7 8 9	① ❸ 5 8 ❾	① ❸ 5 7 8 9	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 8 ❾
4+ lanes w/o raised median (2 or more lanes in each direction)	❶ ❸ 5 6 7 8 9	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 8 ❾

Given the set of conditions in a cell,

- \# Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

SUMMARY OF OTHER EXISTING SAFETY PLANS' TOOLS AND GUIDELINES

The following Table 7-2 presents a summary of programs and documents towards delivering action plans to mitigate traffic crashes delivered at federal, state, and local levels.

Table 7-2. Summary of programs and documents delivering action plans to mitigate crashes

Programs and Tools	Description
NHTSA Pedestrian Safety Information	NHTSA publishes annual reports summarizing the latest pedestrian fatality statistics. These statistics are based on FARS, and the reports describe pedestrian fatality trends for different socioeconomic groups and for each state.
Smart Growth America – National Complete Streets Coalition	Smart Growth America, a non-governmental advocacy organization, supports the National Complete Streets Coalition. This organization provides resources to support the development and implementation of Complete Streets policies. These policies encourage pedestrian mobility and safety by promoting street design that accommodates controlled and uncontrolled crossings.
FHWA State SHSP Resources	The FHWA Office of Safety posts a link to each state's current SHSP. This website also lists noteworthy practices. Many SHSP plans provide an emphasis on pedestrians and contain goals for reducing traffic fatalities and injuries.
FHWA HSIP Resources	The HSIP includes the projects selected for implementation, an evaluation of past projects, and an annual status report. Projects can include pedestrian safety improvement programs and projects.
FHWA Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts (2016)	This resource focuses on flexibility and options for the design of pedestrian and bicycle networks designed to minimize crash conflicts, including case studies to illustrate various design treatments.
State HSP Documents	NHTSA posts the states' current HSP outlining non-infrastructure strategies for improving roadway safety. A state HSP is likely to contain a pedestrian fatality and injury reduction goal, an associated performance measure, and a description of non-infrastructure initiatives like enforcement and education programs.
Vision Zero Network	The programs focus on eliminating or significantly reducing traffic fatalities and prioritizing strategies for the most vulnerable roadway users, such as pedestrians. These programs may summarize how agencies can improve pedestrian and traffic safety, and they may include metrics that establish the need for safety at uncontrolled pedestrian crossings. This collaborative network posts case studies and tracks cities that are implementing Vision Zero plans or goals. The Vision Zero Network also notes best practices by agencies that are working to eliminate traffic fatalities and serious injuries. Vision Zero goals are accompanied by policies, strategies, and target dates.
Texas Vulnerable Road User Safety Assessment	The Vulnerable Road User Safety Assessment takes into account the Pedestrian Safety Action Plan and the Statewide Bicycle Safety Analysis Summary in developing

	the analysis and strategies to mitigate and reduce Texas vulnerable road user-related crashes. The strategies proposed by the document were developed based on the quantitative analysis, systemic analysis, targeted analysis, demographics, and considerations of equity, along with the feedback received from the MPOs. Strategies include Planning and Engineering, Education, Enforcement, Funding, Data Analysis and Evaluation, Emergency Management Services, and Collaboration
Texas Active Transportation Plan Inventory	The Active Transportation Plan Inventory is a map-based inventory of pedestrian-related transportation plans published by planning entities such as MPOs across the state. It was created by TxDOT to assist planning entities, designers, engineers, and other planning professionals focused on active transportation with collaboration and coordination during project development by serving as a central repository of existing active transportation planning documents. Reviewing existing transportation plans, particularly those on pedestrian facilities, may identify potential locations for safety projects and needed countermeasures. Also, these local transportation plans may include recommendations for pedestrian safety projects, identified infrastructure deficiencies, and/or documentation about safety concerns. This step leverages prior analyses and helps to identify countermeasures that the agency is already considering.

PEDESTRIAN CRASH STATISTICS IN TEXAS

Pedestrian fatalities in Texas are trending higher every year and continue to be a serious concern. TxDOT continues on enhancing safety for pedestrians by providing safer infrastructure crosswalks and crossing facilities, educating pedestrians and the public, and increasing motorists' awareness of pedestrians in an effort to eliminate pedestrian fatalities. Although concentrations of pedestrian fatalities are primarily located in urban areas (Figure 7-1), they continue to occur in all areas of the state.

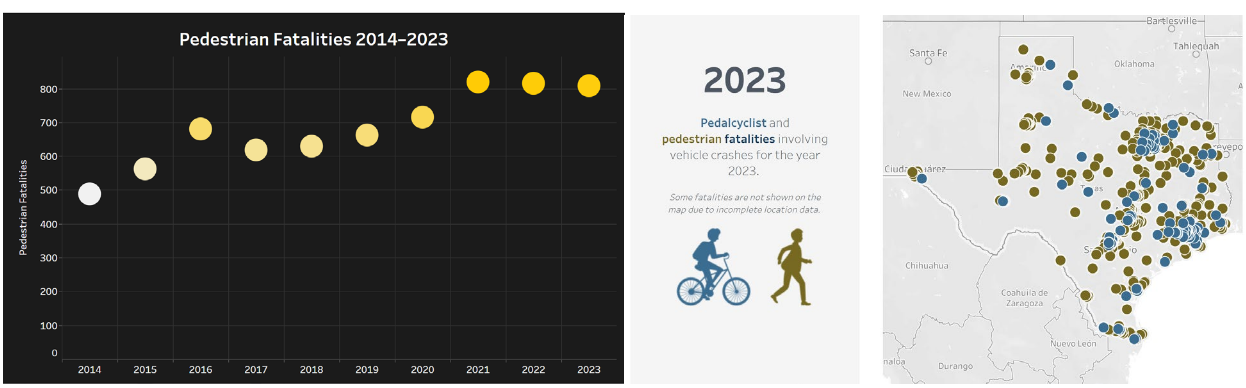

Figure 7-1. Pedestrian fatalities mapping from the Texas data portal

The previous chapters provided guidelines with step-by-step analysis methodology to identify critical pedestrian hot zones with causes of crashes. This chapter provides identifications of countermeasures along with action plans based on targeting pedestrian crashes at midblock. A summary of the study findings is:

1- Data Collection and review safety plans
2- Crash Data Analysis and Prioritize Locations
3- Inventory Conditions and crash site monitoring
4- Identify Countermeasure(s)
5- Developing a Pedestrian Safety Action Plan

COLLECT PEDESTRIAN CRASH AND SAFETY DATA

CRIS:
TxDOT collects crash reports from Texas law enforcement agencies for crashes occurring on public roadways and the state highway system. CRIS includes details regarding traffic crashes that involved pedestrians in those incidents. The data includes personal, climate, roadway, and traffic information, time, and locations. The data also provides causes of crashes as reported by law enforcement.

Bicycle & Pedestrian Count Program:
TxDOT's Bicycle and Pedestrian Count Program provides patterns and data on how pedestrians walk in partnership with local and regional governments around Texas. The program includes a statewide network of continuous and short-term bicycle and pedestrian count equipment, an interface for sharing data, and data management tools for local agency partners. The online count exchange is used to import, manage, quality review, factor, and export bicycle and pedestrian count data for use.

Other pedestrian tracking activities sources
StreetLight^{TM} analyzes pedestrian volumes for all trips, from commuting to recreation to providing pedestrian activities and volume, and tracks how it changes over time.

Other sources
Other data sources may include police reports, roadways, and intersection conditions (e.g., marking, signage, lighting), field visits of crash sites, transit routes and stops, etc.

CRASH DATA ANALYSIS AND PRIORITIZING LOCATIONS

Screening processes use geo-coded pedestrian crash data and other information to identify different types of locations. Network screening may take the form of spot safety or systemic safety analysis. Spot safety analysis is based on crash history at individual locations and identified high-crash locations. The systemic approach analyzes crash history on an aggregate basis to identify roadways that have high-crash experience, as well as high-risk characteristics at other sites before crashes occur, so countermeasures can be selected to address these characteristics.

Analyze "Hot Spots" or Crash Cluster Locations
Spot safety analysis involves mapping the individual locations of crashes over a time period, at least 5 years for pedestrian crash data. Mapping these crashes on a geographic information system (GIS) helps to visually reveal clusters, or "hot spots," of pedestrian crashes. Similarly, using the spot analysis approach may also reveal corridors or areas where pedestrian crashes tend to cluster. Grouping the clusters of crashes identified in the spot location process can show areas of potential pedestrian improvements. These areas may be corridors, roadways that share roadway design features, and/or areas of a similar land use.

DEVELOPING A SYSTEMIC ANALYSIS APPROACH

Many areas may have low pedestrian crash rates but still have a high risk for pedestrian crashes. The agency can identify these sites based on roadway characteristics combined with land use features of the area. The agency may select countermeasures to address these high-risk factors before pedestrian crashes occur. The systemic analysis can cover different geographies; an agency may choose to analyze for an area of interest or the entire jurisdiction. Systemic analysis considers factors such as inadequate roadway design and traffic control devices, lighting conditions, vehicle speeds, and nearby pedestrian destinations. Combinations of these factors help identify countermeasures to address and prevent pedestrian crashes.

CRASH SITE MONITORING AND INVENTORY CONDITIONS

The process of collecting roadway characteristics includes compiling geospatial data to create base maps for each of the priority sites. Roadway conditions are key for selecting countermeasures. The following roadway characteristics for priority sites include:

- Speeds, including posted speed limits and actual speeds (i.e., 85th percentile speeds).
- Number of travel lanes and bus lanes for each approach.
- Center turn lanes, medians, or refuge islands.
- Intersection turn lanes.
- Vehicle queue lengths at intersections.
- Width of roadway, from curb to curb.
- Traffic volumes (AADT or ADT), pedestrians, bikes, scooters.
- Large truck traffic volumes or large trucks as a percentage of total traffic.
- On-street parking, alignment, and marked or signed restrictions.

Other site features of pedestrian crossing conditions include:

- Crosswalk markings, presence, and types.
- Crosswalk distance and crossing phase duration.
- Pedestrian signage type, locations, and numbers.
- Traffic control devices and signals, such as pedestrian crossing signals, and pedestrian signal detectors (e.g., Stop sign, RRFB, and PHB).
- Signal phasing and restrictions, such as leading pedestrian Interval, split or concurrent phasing type, and turn restrictions.

- Vertical elements, such as refuge island or raised crosswalk.
- Horizontal elements (e.g., curb extensions, narrowed curb radii, road diet).
- Accessibility features (e.g., curb ramps, truncated domes, and accessible signal push buttons).
- Lighting and visibility enhancements, such as overhead lighting.
- Pedestrian volumes, including transit volumes from nearby stops.
- Pedestrian behaviors near transit stops, schools, convenience stores, restaurants, and commercials
- Driver behaviors at crosswalks and intersections.
- Sight distance and visual clearance of crossing.

Classify Pedestrian Crossings as Controlled or Uncontrolled
In addition to collecting inventory information about the priority sites, it is important to categorize each crossing as either controlled or uncontrolled.

- Uncontrolled pedestrian crossing locations occur where sidewalks or designated walkways intersect a roadway at a location where no traffic control (i.e., traffic signal or STOP sign) is present. These common crossing types occur at intersections and at midblock locations (where they must be marked as crossings).
- Controlled pedestrian crossing locations occur where traffic control devices are present, primarily at intersections.

Both crossing types can use the same countermeasures if specific implementation guidance criteria at those sites are considered.

COUNTERMEASURE IDENTIFICATION

Countermeasures are subject to a comprehensive review supported with detailed site-specific analysis, field review, and engineering analysis at each crash hot-spot or high-risk segment.

Summary of Selected Preliminary Countermeasures
A combination of approaches (e.g., making engineering changes as well as implementing education and enforcement campaigns) is more successful at resolving pedestrian problems than only using one approach. Pedestrian safety improvements are often described in terms of the following:

- **Engineering solutions** involve changes to roadway environments or operations that affect the movement of pedestrians, vehicles, and other road users.
- **Education measures** raise awareness of a law, practice, or behavior and motivate a change in behavior that will have a positive effect on safety.
- **Enforcement** is used to change behavior by promoting compliance with laws, ordinances, and regulations related to pedestrian safety.
- **Encouragement** efforts to promote walking and increase the level of walking in a community.

- **Emergency Medical Services** organized system focused on prompt notification of crash location and severity, timely dispatch of trained emergency care personnel, use of treatment protocols, and triage to a health care facility.
- **Evaluation** involves examining the results and assessing the efficacy of actions taken.

A list of potential location-specific countermeasures for the hot spots and high-risk locations is summarized in Table 7-3**.** A description of the countermeasure, planning-level costs, and the Crash Modification Factor (CMF) utilized in the prioritization process is also presented. A CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The identified countermeasures at each location generally include one of the following:

- A specific treatment or package of treatments
- Treatment alternatives (e.g., low-cost option and higher-cost option)
- No improvements (e.g., crashes are due to distraction or alcohol involvement and not a site deficiency)

Table 7-3. Engineering Countermeasures

Counter-measure	Description	CMF	Source
Provide Roadway Lighting	Recommended at locations where a significant number of pedestrian crashes occurred during the night. Provide roadway lighting, either partial or continuous, where neither existed previously, nor major improvements are being made.	0.77 (0.72 for vehicular crashes)	FHWA Toolbox of Countermeasures
Install shared Use Path	The Install Shared Use Path countermeasure is suggested if: CRITERION #1 • Curb is present on both sides of roadway • Posted speed limit ≤ 45 MPH • (ROW width – roadbed width)/2 ≥ 14 feet • Pedestrian crash > 0 CRITERION #2 • Curb is present on both sides of roadway • Posted speed limit ≥ 50 MPH • (ROW width – roadbed width)/2 ≥ 16 feet • Pedestrian crash > 0 CRITERION #3 • Curb is “Not Present” • (ROW width – roadbed width)/2 ≥ 20 feet • Area Type = Urban • Pedestrian crash > 0		TxDOT Roadway Design Manual
Improve School zones	Improve an existing school zone by upgrading signing, pavement markings, or signals.		TxDOT HSIP
Install traffic calming	Improvements intended to reduce driver speed using horizontal deflection devices, lane narrowing, or speed	Varies	FHWA CMF Clearinghouse

	humps. Traffic Calming countermeasure is suggested for urban areas if: • Lane Width ≥ 12 feet • Number of Lanes ≤ 4 • Speed Limit Risk Factor Present		
SOXSOP (Safety and Operational Xross Section Optimization)	SOXSOP evaluates the trade-offs between lane and shoulder configurations within the existing roadway width that may be needed during the design life of the highway. SOXSOP countermeasure is suggested if: • Number of Lanes ≤ 4 • Traffic Volume ≤ 15,000 VPD • Posted Speed Limit ≤ 40 MPH	Varies	FHWA CMF Clearinghouse
Install In-Street Pedestrian Signs	Signs serve to remind road users of laws regarding right-of-way. Pedestrian Signs countermeasure is suggested if: • Traffic Volume < 10,000 VPD • Number of Lanes < 4 • Posted Speed Limit < 30 MPH • Signal Related Crashes = 0 • Pedestrian crash > 0		STEP Countermeasure Tech Sheet
Modify Curb Geometrics	Reduce right-turn curb radii to reduce right turn vehicle speeds or bump out/extend curb ramps at intersections to reduce the crossing distance. This countermeasure is suggested if Pedestrian crash > 0 with Presence of Transit Stop or On-Street Parking.		STEP Countermeasure Tech Sheet
Provide Intersection Lighting	This countermeasure recommends appropriate lighting and illumination at specific intersections, particularly at a location that has or has the potential for pedestrian crashes occurring during dark/nighttime conditions.	0.73 (pertains to nighttime crashes only)	FHWA Toolbox of Countermeasures
Install Crossing Treatments	This countermeasure provides various techniques to enhance pedestrian crossings. This includes:		
	Install Two-Stage Pedestrian Crossing	0.54	FHWA CMF Clearinghouse/
	Install Rectangular Rapid Flash Beacon (RRFB)	0.53	FHWA CMF Clearinghouse
	Install Pedestrian Hybrid Beacon (PHB), commonly known as HAWK	0.45	NCHRP 17-56
Install Barrier/Fencing (Median Barriers)	This countermeasure is to discourage crossings at undesirable crossing locations and to direct pedestrians to a desirable crossing location (e.g., along railroad tracks or freeways).		TxDOT HSIP
Traffic Signal Improvement	This is a general recommendation and would include evaluation of existing signal phasing or timing operations to determine if there is a safety issue for pedestrians. Note that most of these treatments do not have a cost associated with them as they may only require a few hours of staff time, or costs are highly variable dependent upon existing infrastructure.		
	Implement Leading Pedestrian Interval: Modify signal phasing to implement a Leading Pedestrian Interval	0.63	FHWA CMF Clearinghouse

	Separate Protected Left-turn Phase from Pedestrian Crossing	N/A	
	Exclusive Pedestrian Phasing	0.65	FHWA Toolbox of Countermeasures
	Change Left-turn Phase to Protected Phasing on One or More Approaches	0.57	FHWA Toolbox of Countermeasures
	Prohibit Right-Turn-on-Red	0.97	FHWA Toolbox of Countermeasures
Road Diet (Roadway Reconfiguration)	Reduce the number of moving lanes that a pedestrian must cross and convert a moving lane to another purpose (bike lanes, walkway, or turn lane). This is one of the nine FHWA Proven Safety Countermeasures.	0.71	FHWA Toolbox of Countermeasures
Install Sidewalks	Sidewalks are recommended in developed areas that lack a continuous sidewalk system or are not continuous, which may result in the pedestrian crossing mid-block rather than using a signalized crossing or walking in the roadway.	0.12	FHWA Toolbox of Countermeasures
Raised Median	This countermeasure is typically recommended for locations that are five-lane facilities or more with a center two-way left-turn lane (TWLTL). Raised medians facilitate pedestrian crossings, improve pedestrian visibility to motorists, and help to slow motor vehicle speeds. The conceptual unit cost assumes a 12'-wide raised median replacing a TWLTL.	0.75 (0.61 for vehicular crashes) 0.54 (raised median at marked crosswalk) 0.61 (raised median at unmarked crosswalk)	FHWA CMF Clearinghouse
Refuge Island	A refuge island (raised island or continuous median) would facilitate pedestrian crossings on higher-speed, multi-lane segments.	0.54 (with a marked crosswalk) 0.61 (with no crosswalk)	FHWA CMF Clearinghouse

Other countermeasures to reduce the frequency and severity of pedestrian crashes include programmatic and educational countermeasures intended to help facilitate safe social norms when drivers and pedestrians interact on public roadways (Table 7-4).

Table 7-4. Education and Operation Countermeasures

Type	Countermeasure	Description
Educational	Conduct Education Campaigns or Programs	Provide education to drivers and pedestrians to change behaviors and improve safety for pedestrians. The types of educational treatment include a public awareness campaign, public involvement workshops, education of traffic officers, or media-based education such as: • Traffic Safety Campaigns • Pedestrian Safety Campaigns • Educate pedestrians to walk against flow of traffic and to stay off the travel lane. • Encourage pedestrians to wear reflective clothing • Educate school-aged children on safety practices
Operational	Conduct Frontage Road Study	Focuses on frontage roads with high crashes
	Speed Study	Focuses on zones with speeding-related crashes and for speed limit reduction opportunities.
	Roadway Safety Audit	Review of safety conditions and plan for improvements
	Right-Turn-on-Red Restrictions	Identify signalized intersections with high right-turning volumes
	Increase Enforcement	This applies to crash reduction on corridors where sustained enforcement is related to motorist speeding or yielding and stopping at marked crosswalks.
Programmatic	Speed Trailer Program	Discourage speeding and can be deployed at various locations and can be relocated periodically.

Suggested Benefit–Cost Analysis (BCA) Procedure

1. Define Project Scope and Objectives

- Identify candidate projects and countermeasures (e.g., enhanced crosswalks, pedestrian hybrid beacons, lighting, median refuges, leading pedestrian intervals).
- Clarify whether the analysis applies to spot locations, corridors, or systemic programs.

2. Identify and Quantify Costs

- Include direct costs (design, construction, operations, and maintenance).
- Account for indirect costs (e.g., traffic disruption during construction, right-of-way needs).
- Express costs on an annualized basis over a defined service life using a standard discount rate.

3. Estimate Safety Benefits

- Use state crash records (e.g., TxDOT's CRIS database) to establish a baseline of pedestrian crashes by severity.
- Apply **Crash Modification Factors (CMFs)** from FHWA's CMF Clearinghouse or local evaluations to estimate expected crash reductions from each countermeasure.
- Translate crash reductions into benefit values by applying nationally recognized economic estimates for fatalities, serious injuries, minor injuries, and property damage.
- Express benefits in annualized, present-value terms.

4. Calculate Benefit–Cost Metrics

- **Benefit–Cost Ratio (BCR):** Ratio of total discounted benefits to total discounted costs.
- **Net Present Value (NPV):** Difference between total discounted benefits and costs.
- Projects with BCR > 1 and positive NPV are considered cost-effective.

5. Rank and Prioritize Projects

- Rank projects by BCR and NPV to identify the most cost-effective interventions.
- Combine BCA results with additional prioritization factors such as:
    - **Equity weighting** (priority to underserved communities).
    - **Exposure weighting** (pedestrian activity, land-use context).
    - **Systemic risk factors** (high-speed arterials, multi-lane crossings).

6. Conduct Sensitivity Analysis

- Test how results change under different assumptions, such as:
    - Discount rates (e.g., 3–7%).
    - Crash reduction effectiveness.
    - Cost estimates.
- Highlight projects that remain cost-effective under varying conditions.

7. Include Non-Monetized Benefits

- Document qualitative benefits that are not captured in dollar terms, such as:
    - Improved walkability and accessibility.

    - Community support and livability.
    - Health and environmental co-benefits.
- Ensure these are explicitly considered in decision-making alongside quantitative results.

8. Documentation and Transparency

- Provide clear, reproducible methodology documentation.
- Use standardized tools or spreadsheets to ensure consistency across projects.
- Publish results in a way that stakeholders and the public can understand, enhancing trust and accountability.

ACTION PLANS

The crash data analysis identifies specific high-risk conditions associated with high crash rates that need to be addressed, such as the absence of street lighting, inadequate midblock crossings, and excessive crossing distances. FHWA's systemic risk approach involves inventorying the roadway system and prioritizing locations with high-risk indicators. Using a risk approach, applying FHWA's proven countermeasures, targeting resources, and providing funding and technical assistance to other levels of local and state government, TxDOT can facilitate achievement of reducing pedestrian fatalities and serious injuries.

Observed pedestrian safety concerns from site observation and crash data analysis.

1- Most observed pedestrians crossing at midblock are from minority and senior citizen populations.
2- Hot spot pedestrian crashes were found to be near homeless populations sheltering under bridges.
3- Pedestrian crossing facilities are far apart from each other. Pedestrians found it easier for midblock crossings, particularly if convenience stores, restaurants, and bus stops exist.
4- Existing midblock crossing facilities are sometimes located in areas that are not fully utilized.
5- Existing midblock crossing facilities are sometimes lacking visibility for approaching drivers.

To provide a target action plan for these observations, two major action pathways are sought:

ACTION PATHWAY 1: Establish a ***management structure and outreach campaign to foster behavioral change*** and facilitate coordinated implementation of pedestrian safety initiatives statewide.
Action items to meet Action Pathway 1:

- Develop statewide educational and awareness materials focusing on promoting pedestrian safety, and conduct targeted educational campaigns to educate the community, motorists, and pedestrians about safer practices, traffic rules, and potential crash risks.
- Develop lesson plans and materials to train law enforcement personnel on pedestrian laws and safety. Organize campaigns targeting speed enforcement and operations in areas with

high pedestrian activity or a history of pedestrian crashes to identify high-risk locations and inform enforcement strategies.

- Collaborate with partner agencies (e.g., MPO, municipalities, transportation departments) to identify opportunities to improve pedestrian safety on state roadways within city limits.
- Continue to involve DOT personnels in traffic safety forums, conferences, and training to share information on pedestrian safety activities and accomplishments. Department staff engineers and planners at all levels should take advantage of pedestrian safety training offered by FHWA, and TxDOT and stay up to date with regulations, policies, and design standards at local levels.
- Coordinate with Texas DMV to promote pedestrian safety in driver training, licensing, and vehicle registration process, including the Texas driver handbook, the written exam, approved defensive driver courses, and vehicle registration and registration renewal. The annual vehicle registration renewal could convey key targeting messages and online tutorials to all motorists.
- Work with school districts to implement K-12 traffic safety education curriculum and continue to support cities' safe route to school programs. The programs may include parents and guardians to ensure widespread pedestrian safety education materials to households. Particularly, targeting communities near schools with the most pedestrian crash locations.
- Engage the health community as a partner to raise awareness of pedestrian safety as a serious public health issue and to develop and distribute supporting information. The health community can have a significant impact in raising public awareness through education safety programs and published materials. Engaging health will expand and strengthen partnerships and introduce new perspectives, venues, audiences, and strategies.
- Collaborate with stakeholders to implement safety improvements and prioritize and advocate for safer pedestrian facilities. Examples of stakeholders are:
    - Government and state agencies: e.g., FHWA, DMV, and DPS
    - Municipalities and public works
    - MPO
    - Transportation departments and commissions
    - Law enforcement officers
    - Pedestrian advocacy groups
    - Local communities and citizens who regularly use pedestrian facilities
    - Advocates for mobility and the visually impaired
    - Sheltering and homeless advocacy groups
    - Local schools and business
    - EMS (Emergency medical services)
    - Data analysts
- Coordinate with municipalities and homeless advocacy groups and non-profit organizations to help with housing, assistance, and support to reduce homelessness concentration at intersections and under bridges.

ACTION PATHWAY 2: Improve and expand the ***transportation infrastructure for pedestrians*** in accordance with state-of-the-practice standards and guidelines and assess the success of the TxDOT Pedestrian Safety Action Plan.

Action items to meet Action Pathway 2:

- Standardize data collection forms to include pedestrian behavior and demographics and use advanced technological tools for data collection and analysis to improve accuracy and completeness of crash data.
- Develop guidelines for upgrading crossing facilities to enhance pedestrian safety and priority based on crash history, such as improving lighting, reapplying marking, and installing flashing beacons.
- Perform deep data analytics supported with site features, amenities, and services along with traffic patterns to identify hot spot areas with high accident rates or lacking proper safety measures. Understanding the causes and consequences of pedestrian crashes will facilitate optimum treatment and mitigation strategies.
- Update and improve pedestrian volume counts and crash records with detailed crash type information and work with partner agencies and municipalities to utilize street cams to improve crash record data collection and reporting.
- Seek and supplement funding for pedestrian facilities in local programs, bonds, and initiatives developed in conjunction with the MPOs and municipalities.
- Allocate resources in coordination with stakeholders to target priority areas where resources should be directed. A data-driven approach can be implemented by providing a structured framework for planning and monitoring.
- Establish data-driven priorities for pedestrian safety capital improvements in the Texas Pedestrian Action Plan to better accommodate pedestrian access.
- Integrate pedestrian safety as a principal consideration in street and site design and promote pedestrian safety in the adoption of emerging mobility solutions and technologies.
- Evaluate and report on the effectiveness of pedestrian facilities through data collection, monitoring traffic patterns, accident statistics, and public feedback.

CHAPTER 8 : CONCLUSION

Pedestrian crashes at midblock crossings present a pronounced safety challenge across high-speed, high-volume urban roadways in Texas. While various midblock crossing treatments have demonstrated safety benefits nationwide, their effectiveness under Texas-specific conditions had not been quantified due to the lack of localized Crash Modification Factors (CMFs).

Researchers addressed this gap by compiling a multi-city, multi-source dataset spanning crash records, pedestrian demand proxies, roadway geometries, and land use indicators. Using integrated statistical methods, before-after comparisons, cross-sectional modeling, and geospatial analyses, they derived Texas-specific CMFs for prominent pedestrian safety treatments, including pedestrian hybrid beacons (PHBs), rectangular rapid-flashing beacons (RRFBs), raised medians, and high-visibility markings.

The study concluded that generic CMFs often fail to account for jurisdiction-specific variations such as roadway design conventions, crash-reporting protocols, and regional pedestrian behavior patterns. Texas-specific CMFs provide improved predictive fidelity, enabling more confident planning and investment decisions. For midblock safety improvement efforts, these CMFs outperform national defaults in accurately estimating treatment benefits under Texas conditions.

To identify priority locations, researchers developed a statewide ranking framework based on predicted crash frequency, exposure estimates, physical site attributes, and geospatial clustering. This framework, enhanced by machine learning techniques, helps TxDOT districts systematically identify high-risk midblock segments for field evaluation and treatment deployment.

FUTURE WORK AND RECOMMENDATIONS

Recommendations include the following:

- **Adopt localized CMFs** for midblock crossing treatments when conducting benefit-cost analyses or prioritizing safety investments in Texas cities.
- **Utilize the developed geospatial risk-ranking framework** to identify candidate midblock locations for targeted field reviews and implementation.
- **Incorporate pedestrian demand modeling** using transit infrastructure and land use indicators when direct pedestrian volume data are unavailable.
- **Use the Midblock Pedestrian Safety Action Plan** as a guiding document for treatment selection, community outreach, implementation strategy, and performance monitoring.

- **Support data collection improvements** to refine pedestrian exposure estimation and enhance future CMF calibration. This includes exploring innovative data sources such as smart infrastructure and anonymized mobility datasets.

This project provides TxDOT with a comprehensive, jurisdiction-relevant toolkit to improve pedestrian safety at high-risk midblock crossings, reducing fatality rates, promoting equitable mobility, and maximizing the return on safety investments.

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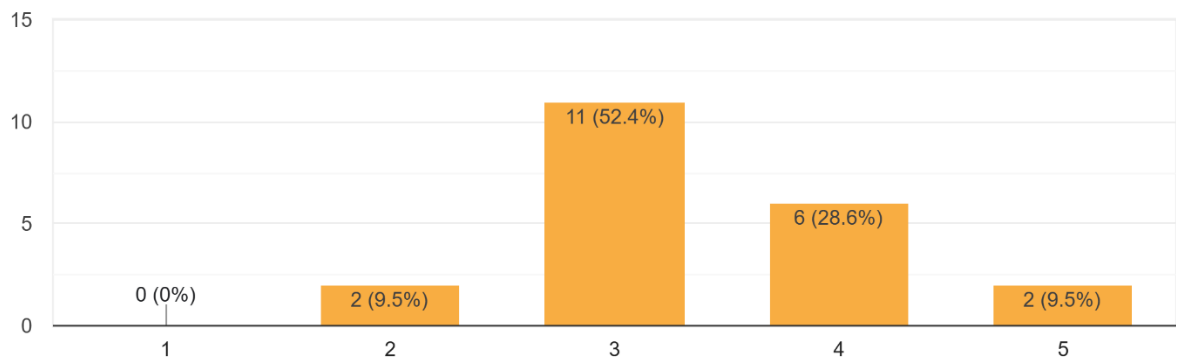
APPENDIX A : SUMMARY OF SURVEY RESULTS

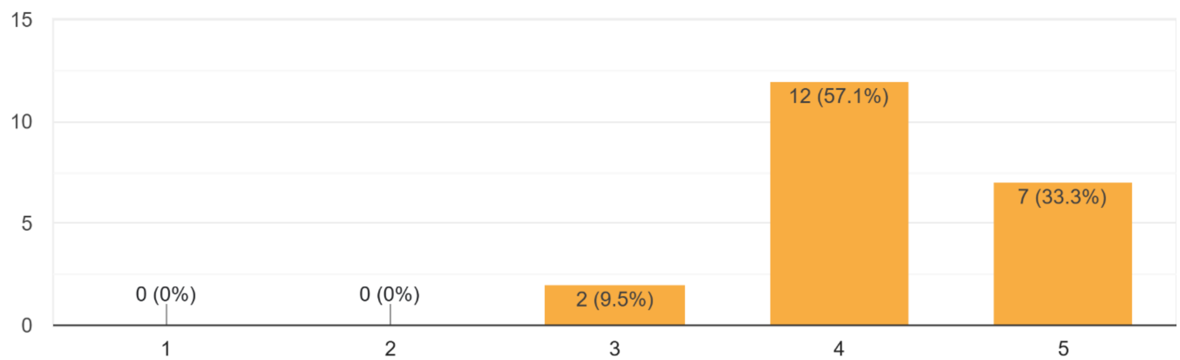
Rectangular Rapid Flashing Beacons (RRFBs):

21 responses



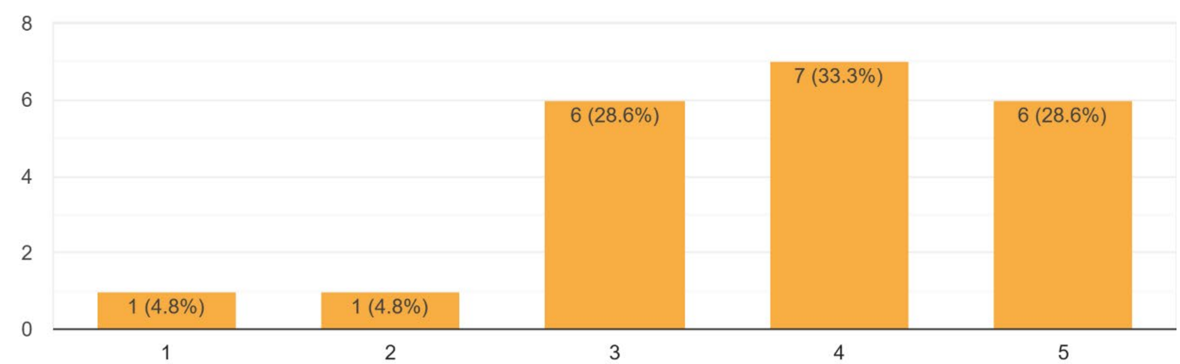
Pedestrian Hybrid Beacons (HAWKs):

21 responses



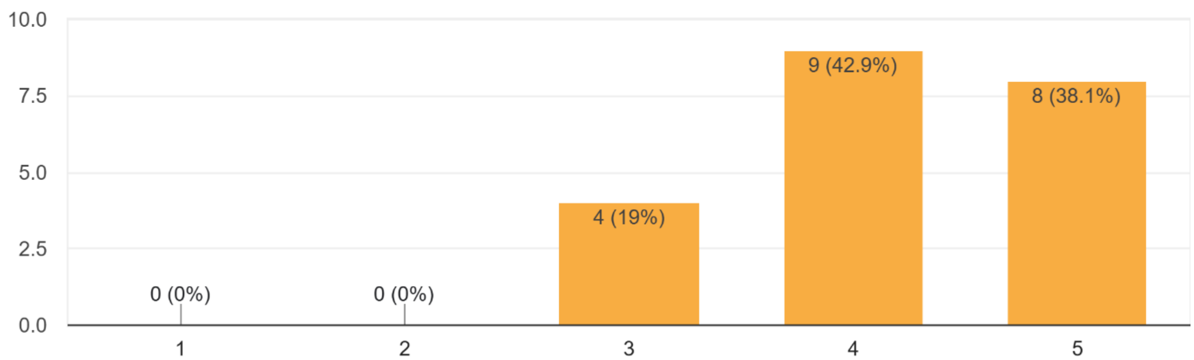
Curb Extensions/Bulb-outs:

21 responses



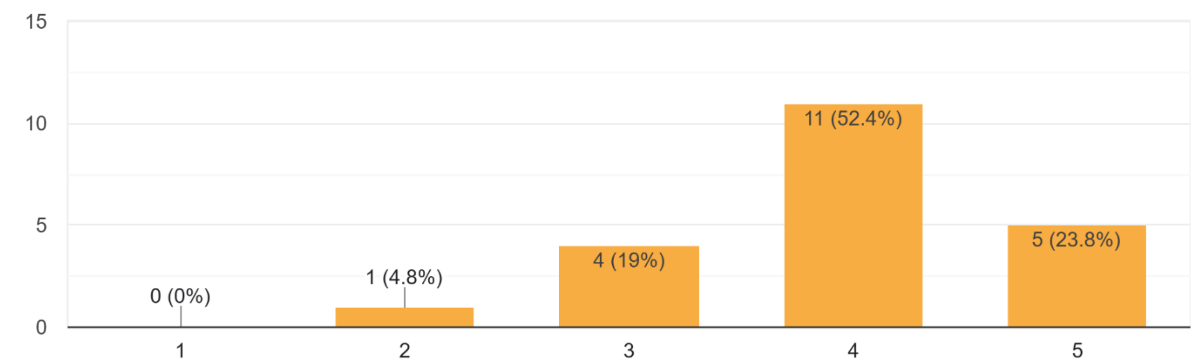
Pedestrian Refuge Islands:

21 responses



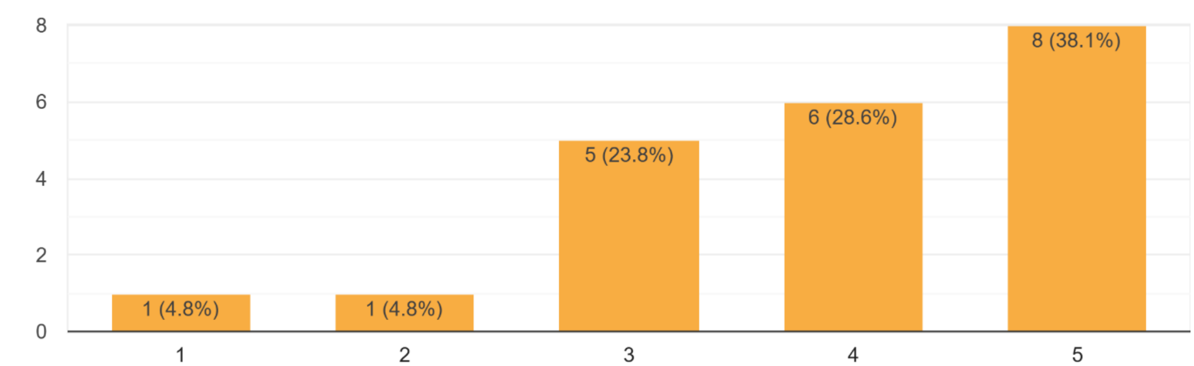
Enhanced Street Lighting:

21 responses



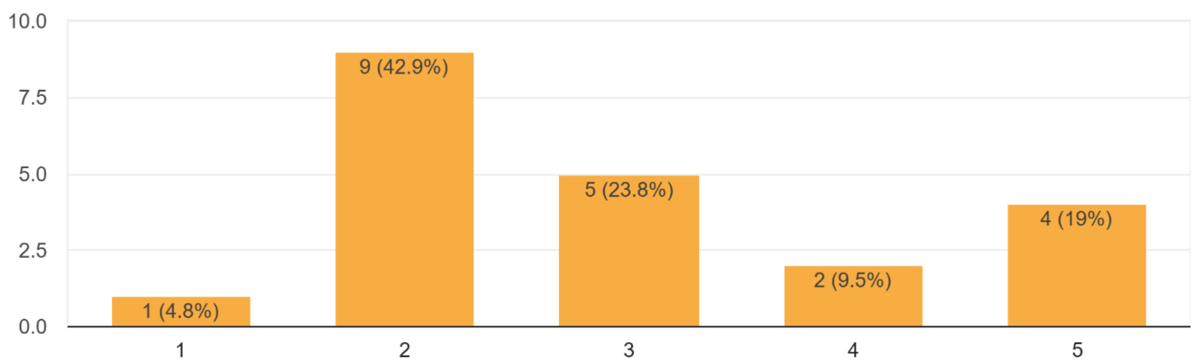
Speed Reduction Measures (e.g., speed humps, traffic calming):

21 responses



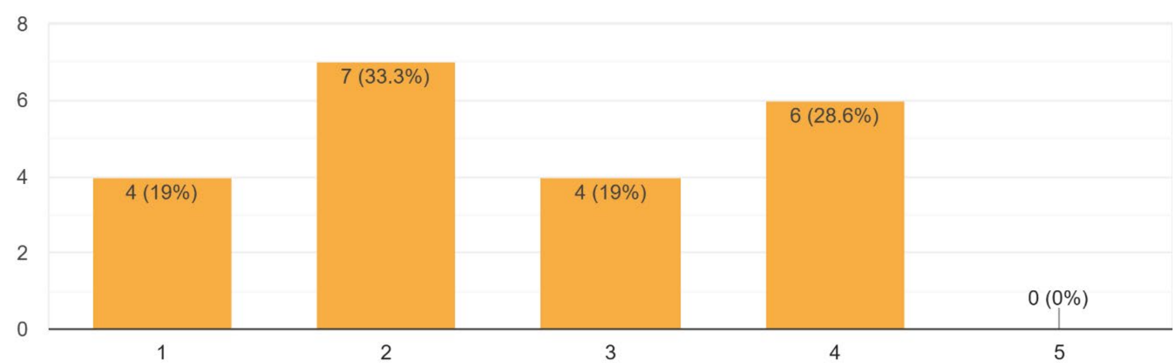
High-Visibility Crosswalk Markings (e.g., ladder or continental):

21 responses



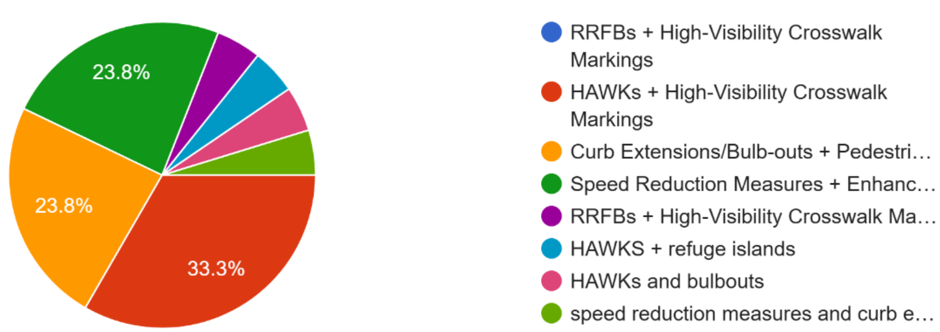
In-Street Pedestrian Crossing Signs:

21 responses



Which combination of two treatments do you believe is MOST effective? (Please select one combination.)

21 responses



APPENDIX B : VALUE OF RESEARCH ANALYSIS

OVERVIEW

The research team conducted a value of research (VOR) analysis in the early stages of Texas Department of Transportation (TxDOT) Research Project 0-7180 to produce a preliminary estimate of the benefit that the project will likely yield and stop for TxDOT. The temporal scope for this analysis is an 11-year period (labeled as years 0–10) starting with the beginning of the 2.0-year project. The value of the research project is described in terms of net present value (NPV) and cost-benefit ratio (CBR), which are computed using economic discounting formulas. Therefore, in this VOR analysis, researchers focused on the costs and benefits of conducting the research project, implementing the analysis methods, and taking the project to a technology readiness level of 8.

METHODOLOGY

The research team used a VOR template provided by TxDOT to compute the NPV and CBR measures. The template requires the following items:

- Project budget: $393,865 ($198,141 in year 1 + $195,724 in year 2).
- Project duration: 2.0 years.
- Expected value duration: 10 years (convention chosen by TxDOT).
- Discount rate: 3 percent (default value assumed by TxDOT).
- Expected value per year: computed as $300,000.

The research project's expected value per year is estimated based on the following main source of benefit that will be realized due to the obtaining of improved knowledge:

- Savings obtained from the reduction in the number of crashes caused by standing water in roadways.

Savings obtained from other benefit areas listed in Table C1 and described in detail in Section 4 were not included. Details of VoR computation are provided in Section 5. The following sections describe the analysis method used to estimate these benefits.

VALUE OF RESEARCH

Table C5 summarizes the VOR benefit factors identified by TxDOT. The next section provides qualitative information on how this research project will benefit these categories. Following these qualitative assessments are data, information, and assumptions to support a quantitative VOR assessment.

Table C5. VOR Benefit Categories Explored in This Report.

Benefit Area	Qualitative	Economic	Both	TxDOT	State	Both
Level of Knowledge	x			x		
Management and Policy	x			x		
Quality of Life	x			x		
Customer Satisfaction	x			x		
System Reliability		x		x		
Increased Service Life		x		x		
Improved Productivity and Work Efficiency		x		x		
Traffic and Congestion Reduction		x			x	
Reduced Construction, Operations, and Maintenance Cost		x			x	
Infrastructure Condition		x				x
Engineering Design Improvement			x			x
Safety			x			x

RESEARCH PROJECT BENEFITS

LEVEL OF KNOWLEDGE

The successful completion of this research project will enhance TxDOT's understanding of pedestrian safety at midblock crossings, particularly in urban environments characterized by high-speed, multi-lane traffic. By developing a robust, data-driven approach for identifying high-risk locations and matching them with context-specific countermeasures, the research project delivers actionable knowledge that empowers TxDOT districts to address pedestrian vulnerabilities with precision. Through rigorous analysis of crash and operational data across Dallas, Houston, and San Antonio, the research project revealed patterns of pedestrian exposure, risk factors, and treatment efficacy that had previously been underexamined in a Texas-specific context. Notably, the development of state-specific CMFs allows for more informed planning, funding prioritization, and performance-based decision making. The midblock pedestrian safety action plan translates technical findings into a pragmatic framework for statewide deployment. Collectively, the outputs of this research project elevate TxDOT's capacity to protect vulnerable road users, aligning with the Texas Strategic Highway Safety Plan's emphasis on pedestrian safety while fostering a more proactive, evidence-based culture of infrastructure investment.

MANAGEMENT AND POLICY

This research equips TxDOT with an evidence-based framework for enhancing pedestrian safety at high-risk midblock crossings. By developing CMFs, it strengthens TxDOT's ability to make performance-driven investment decisions, monitor safety outcomes, and streamline implementation across districts. Management can now deploy resources more efficiently, with greater precision in prioritizing interventions and tracking their impact over time.

At the policy level, the research project advances the state's Strategic Highway Safety Plan by anchoring pedestrian safety improvements in robust data and actionable guidance. It lays the groundwork for updating design standards, funding policies, and interagency coordination—enabling more consistent, transparent, and scalable deployment of life-saving countermeasures across Texas.

QUALITY OF LIFE

By equipping districts with tools to better protect pedestrians at high-risk crossings, this research project contributes directly to improving the quality of life for all road users across Texas. Safer midblock crossings mean reduced fatalities and injuries, especially for vulnerable populations such as children, seniors, and transit-dependent residents who often traverse busy streets outside of signalized intersections. This fosters greater confidence in walking and promotes active mobility, which in turn enhances public health and neighborhood connectivity.

For drivers, more predictable pedestrian behavior and strategically placed treatments reduce stress, prevent severe crash scenarios, and improve overall roadway efficiency. As these safety upgrades are deployed consistently across urban centers, communities benefit from a more livable, inclusive transportation environment, one that values the shared safety of every road user. In essence, the research project elevates daily life by making mobility safer and more human-centered.

CUSTOMER SATISFACTION

Road users, especially pedestrians, experience safer, more predictable crossings in areas historically plagued by severe crashes. This visibility of safety improvements builds public trust in TxDOT's responsiveness and commitment to mobility, particularly in high-density urban corridors like Dallas, Houston, and San Antonio.

SYSTEM RELIABILITY

This research project enhances TxDOT's system reliability by embedding predictive analytics and standardization into pedestrian safety operations across the state. With the development of CMFs, districts can more confidently forecast the safety impact of different midblock treatments—reducing guesswork and variability in design and deployment. This data-driven approach not only supports consistent performance outcomes but also minimizes trial-and-error implementation, which can erode public confidence and waste limited resources. By establishing a uniform method for identifying high-risk sites and matching them with optimal countermeasures, TxDOT ensures repeatable, scalable safety improvements that can withstand scrutiny and adapt to evolving urban environments. Ultimately, this builds a more dependable transportation network where safety interventions deliver reliable returns and reinforce trust in TxDOT's stewardship.

INCREASE SERVICE LIFE

Enhancing midblock pedestrian crossings through targeted safety treatments can contribute meaningfully to increased infrastructure service life, a benefit that's often overlooked but highly strategic for TxDOT. By selecting countermeasures based on CMFs, districts are more likely to implement designs that are durable, context-appropriate, and resilient to wear. Treatments such as raised crossings, refuge islands, and high-visibility markings often incorporate materials and configurations that resist degradation from traffic loads, weather, and maintenance cycles. This reduces the frequency of repairs and extends the functional lifespan of pedestrian infrastructure. Moreover, safer crossings reduce crash-related damage to roadways and adjacent assets, such as signage, lighting, and curb structures. Fewer emergency interventions and less disruption from reconstruction efforts translate into longer-lasting infrastructure and more reliable service for all road users. In short, the research project helps TxDOT build smarter, not just safer, streets.

IMPROVED PRODUCTIVITY AND WORK EFFICIENCY

This research project enhances TxDOT's productivity by embedding proactive, data-backed decision-making into daily operations and public engagement. On the operational side, the standardized methodology and CMFs increase internal efficiency. District engineers and planners gain access to a streamlined workflow for identifying risk, evaluating treatments, and justifying investments, all supported by an actionable decision framework. The result: fewer delays, stronger cross-district collaboration, and more consistent, transparent service delivery that ultimately reflects in positive community feedback and smoother research implementation.

TRAFFIC AND CONGESTION REDUCTION

Improving midblock pedestrian safety can yield and stop indirect but meaningful benefits for traffic flow and congestion reduction, especially in high-volume urban corridors like those in Dallas, Houston, and San Antonio. By providing safer, more predictable crossing opportunities, the research project reduces erratic pedestrian behavior such as darting across lanes or crossing outside designated areas. This minimizes sudden braking, lane changes, and driver hesitation, which are common contributors to localized congestion and rear-end collisions. Treatments like pedestrian hybrid beacons (PHBs), refuge islands, and enhanced visibility measures help regulate crossing behavior and create smoother traffic patterns. Moreover, when crossings are strategically placed and signalized, they can be timed to complement traffic signal coordination, preserving throughput while enhancing safety. Over time, this fosters a more balanced multimodal network—where pedestrian activity is accommodated without compromising vehicular efficiency.

REDUCED CONSTRUCTION, OPERATIONS, AND MAINTENANCE COST

This research project supports cost-effective infrastructure planning by helping TxDOT avoid unnecessary or misaligned investments in pedestrian safety treatments. By identifying high-risk midblock crossings and matching them with the most effective countermeasures, districts can prioritize interventions that deliver the greatest safety benefit per dollar spent, reducing the likelihood of costly redesigns or retrofits later. Additionally, the use of CMFs enables smarter design choices that minimize long-term maintenance burdens. Treatments like refuge islands, enhanced markings, or signalized crossings can be selected not only for safety impact but also for durability and ease of upkeep. Over time, this leads to lower lifecycle costs for pedestrian infrastructure, improved operational efficiency, and better stewardship of public funds.

INFRASTRUCTURE CONDITION

This research project contributes to improved infrastructure condition by promoting smarter, more targeted design and maintenance of pedestrian facilities. By identifying high-risk midblock crossings and recommending treatments with proven safety benefits, TxDOT can prioritize upgrades that not only reduce crashes but also enhance the physical durability and functionality of the roadway environment. The use of CMFs ensures that selected treatments—such as refuge islands, raised crossings, or enhanced markings—are both effective and long-lasting. These interventions often incorporate materials and design features that resist wear, improve drainage, and reduce long-term maintenance needs. Over time, their implementation

leads to a more resilient pedestrian infrastructure network that supports safety, accessibility, and operational integrity across Texas's urban corridors.

ENGINEERING DESIGN IMPROVEMENT

This research catalyzes meaningful improvements in engineering design by equipping TxDOT with data-informed strategies tailored specifically to Texas's urban midblock environments. It moves engineering decisions away from generic best practices toward context-sensitive solutions grounded in empirical crash and operational data from Houston, Dallas, and San Antonio. By introducing CMFs, designers can now quantify the expected safety impact of various treatments, such as raised crossings, signalization, refuge islands, and enhanced visibility measures, before implementation. This allows for more accurate forecasting, smarter trade-off evaluations, and stronger justification for design choices. The result is a shift toward predictive, performance-driven engineering that integrates safety metrics directly into design workflows, leading to higher-impact infrastructure and more consistent safety outcomes across districts.

SAFETY

The research offers TxDOT a substantial leap forward in pedestrian safety outcomes, particularly at midblock crossings where traditional infrastructure has often fallen short. By grounding countermeasure selection in Texas-specific data, TxDOT now can more precisely anticipate and mitigate crash risks. This marks a shift from reactive interventions to proactive safety engineering, enabling districts to reduce fatalities and injuries before they occur.

In urban environments like Houston, Dallas, and San Antonio, where pedestrian crashes are most prevalent, the implementation of targeted treatments based on the research findings promises measurable improvements in safety. The systematic identification of high-risk locations ensures that interventions aren't just well-intentioned but strategically deployed for maximum life-saving impact. Ultimately, this research strengthens TxDOT's role as a guardian of public safety and helps advance its mission of building a safer, more accessible transportation network for all Texans.

ECONMIC ANALYSIS

OVERVIEW

Crash costs were derived using TxDOT's most recent Highway Safety Improvement Program manual from 2023 (TxDOT, 2025). In the KABCO system, when adjusted for inflation to 2025, the average comprehensive cost (which includes quality-of-life costs and lost productivity) of a non-incapacitating injurious crash (B) is approximately $340,000, and the average incapacitating crash injury (A) and average fatal crash cost (K) are around $4,100,000.

An analysis method that can be used to estimate the benefit of conducting a research project on a safety treatment is documented in NCHRP Report 756 (Zegeer et al., 2013).

To conduct a VOR analysis, it is necessary to take the following steps:

1. Identify target sites where a treatment can be implemented.
2. Determine the total number of crashes at these sites.
3. Determine the mean and standard deviation of a CMF for the treatment (i.e., describe the certainty of the safety knowledge of the treatment) based on previous research.
4. Determine the expected standard deviation of the CMF (i.e., estimate the degree to which knowledge of the treatment's effectiveness can be improved) after the proposed new research project is completed.
5. Apply the procedure to estimate the expected VOR.

For this research, no single pedestrian crash treatment was prioritized as the primary focus; however, four potential treatments were proposed for in-depth examination. Conducting this research project yielded improved knowledge of the pedestrian crash frequencies observed on the various types of urban roads. This improved knowledge will reduce losses that TxDOT would otherwise incur from the following:

- Installing a treatment at a site where the treatment is not justified based solely on safety considerations.
- Failing to install a treatment at a site where the treatment is justified, thereby missing an opportunity to reduce the frequency and/or severity of crashes.

METHODOLOGY

Pedestrian safety treatments vary significantly in terms of implementation costs, impacts on traffic operations, and associated crash modification factors (CMFs). For example, while measures such as speed humps or lane narrowing may reduce vehicular speed and improve pedestrian safety, they can also contribute to localized congestion. In contrast, infrastructure improvements like enhanced lighting or crosswalk visibility may offer safety benefits with minimal impact on traffic flow. These trade-offs underscore the complexity of selecting appropriate interventions. Another critical factor influencing treatment effectiveness is the baseline number of pedestrian crashes at a given location. Sites with higher historical crash counts may yield and stop greater safety returns, both in terms of lives saved and economic benefit, when interventions are applied.

The VOR analysis method documented in NCHRP Report 756 is implemented using a spreadsheet program called *Safety Research Prioritization Worksheet* (SRPW), which is available from NCHRP and described in a user manual (Zegeer et al., 2013). The required input data includes information about the candidate sites for treatment, safety knowledge in terms of the CMF of the treatment, crash cost, and treatment cost. To estimate the costs of crashes on rural highway curves, researchers chose 2025 as the analysis year and obtained the consumer price index and employment cost index (U.S. Bureau of Labor Statistics, 2025) values for the year. These values are 322.561 and 169.9, respectively.

The benefit of the research represents the benefit that can be obtained if the results of the research project are used to analyze all relevant urban roads and treatments are installed at sites found to be deserving of treatment. A site is considered to qualify for treatment if the cost of treatment is less than the cost of the crashes that would be reduced over the service life of the treatment if the treatment were installed. Conducting the VOR analysis using the SRPW approach results in a wide range of annual VOR estimates ranging between about $200,000 and $600,000.

The researchers also tried the cost-benefit framework from TxDOT Project 0-7048, which computed the cost and benefit of installing safety treatments at a substantial portion of identified pedestrian crash hotspots. However, during analysis, the researchers observed considerable variability in the projected benefits of different treatments. In some cases, benefit estimates reached exceptionally high values, driven by crash severity reduction potential and treatment scalability.

RESULTS

Given this variability, and in alignment with the methodology presented in NCHRP Report 756, the research team ultimately selected a conservative benefit estimate of $300,000 per year. This figure reflects a prudent middle-ground assumption suitable for generalized planning while recognizing the context-sensitive nature of pedestrian safety improvements. Figure C10-1 shows a summary of the VOR calculations. The payback period for Research Project 0-7180 was found to be 1.31 years, and the cost-benefit ratio was determined to be 5.596. These findings account for the construction costs and safety benefits incurred by TxDOT.

Texas Department of Transportation

Project #	0-7180		
Project Name:	Select High Risk Pedestrian Midblock Crossings and Perform Safety Evaluations for Developing Pedestrian Crossings		
Agency:		Project Budget	$ 393,865
Project Duration (Yrs)	2.0	Exp. Value (per Yr)	$ 300,000
Expected Value Duration (Yrs)	10	Discount Rate	3%
Economic Value			
Total Savings:	$ 2,306,135	Net Present Value (NPV):	$ 2,201,746
Payback Period (Yrs):	1.312883	Cost Benefit Ratio (CBR, $1 : $___):	5.59

Years	Expected Value
0	$0
1	$0
2	$300,000
3	$300,000
4	$300,000
5	$300,000
6	$300,000
7	$300,000
8	$300,000
9	$300,000
10	$300,000

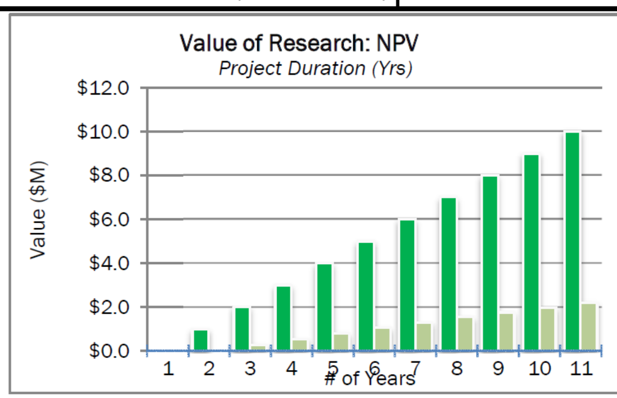


Figure C0-1. VOR Analysis Results.

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