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Impact of the Built Environment on Outcomes for Pedestrians Involved in Accidents 2007-2009

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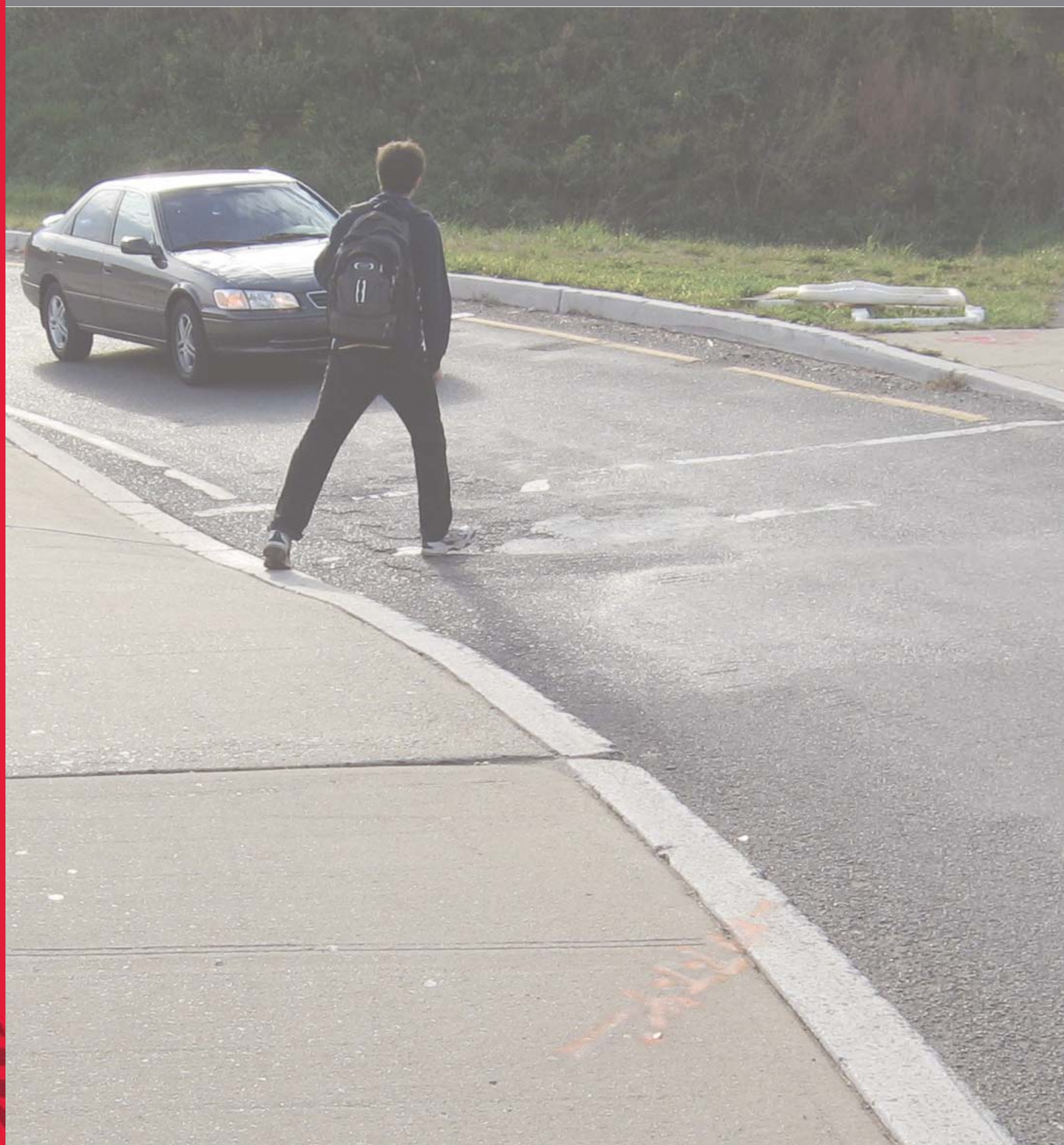


New Jersey Bicycle and Pedestrian Resource Center

Contents

Executive Summary

This report summarizes an analysis of the relationship between built-environment elements and pedestrian crash severity in New Jersey. The built environment, as defined in this report, includes the characteristics of the road, the characteristics of the pedestrian facilities, and the dominant land use of a location. Although it is commonly believed that infrastructure elements such as sidewalks are useful to promote pedestrian safety, very little evidence exists in reality about their impact on safety. This report provides some useful evidence on the relationships between such infrastructure and pedestrian safety.

This report is based on a unique data set compiled by the Alan M. Voorhees Center (VTC) on the built environment of pedestrian crash locations, including road characteristics, pedestrian infrastructure characteristics, and land uses. It was prepared from the observation of crash sites by using Google Street View®. This data set is distinct from other data sets such as Plan4Safety because it includes infrastructure features that are not to be found elsewhere.

In 2010, VTC researchers selected for analysis a total of 6,353 crashes involving pedestrians in New Jersey during the three-year period, 2007-2009, from the Plan4Safety data set maintained by the Rutgers Center for Advanced Infrastructure and Transportation (CAIT). The exact locations of 2,351 of these crashes were successfully geocoded for the compilation of data on built environment characteristics by using Google Street View®. Google Street View® is a relatively new Internet-based technology that allows an observer to view the surroundings of a specific location using 360-degree street-level imagery. By using this technology, VTC researchers recorded the characteristics of the surroundings of each crash site. These characteristics included traffic lighting, pedestrian lighting, sidewalks, crosswalks, buffers, medians, intersections, and land uses in the vicinity of the crash sites.

Data from Google Street View® observations were combined with the Plan4Safety data. Plan4Safety includes a variety of data, including posted speed limits, light or darkness at time of crash, and the demographic characteristics of pedestrians involved in crashes. The data set also includes crash outcomes. Pedestrian outcomes include killed, incapacitated, and lesser or no injury.

The analyses of this data cannot determine the likelihood of crashes occurring at a specific location based on the built environment characteristics because all sites analyzed were sites where a police-reported pedestrian crash occurred. However, the analyses indicate how the built environment characteristics are associated with the severity of crashes (for example, fatality vs. minor injury). In addition to analyzing how a particular characteristic (e.g., sidewalks) is related to crash severity, the analysis also includes an examination of how combinations of the characteristics (e.g., speed and sidewalk) are associated with crash severity.

A fundamental conclusion of this study is that speed is the most important factor determining crash severity. At higher speeds, crash severity is far higher, irrespective of other characteristics of the location. Because of the importance of speed, the analysis in this report of the association between facility characteristics and severity is carried out by first classifying by speed limits at the locations where the crashes occurred. Three speed intervals were used: low speed (25 mph or less), medium speed (30 to 45 mph), and high speed (50 to 65 mph).

The principal findings of the report are as follows:

1. Speed is the most important factor determining pedestrian crash severity outcomes. Higher posted speed limits are associated with a higher likelihood of fatality and more serious injuries. The characteristics of the built environment are less important than speed in influencing crash severity outcomes.

2. Traffic lighting reduces the severity of pedestrian crashes when it is dark, especially where speed limits are 25 mph or less and between 30 and 45 mph.

3. When it is dark, pedestrian lighting reduces the severity of pedestrian involved crashes where speed limits are between 30 and 45 mph.

4. Sidewalks reduce the severity of pedestrian crashes for all speed limits. Sidewalks reduce fatalities more effectively when they are present on both sides of the road than when they are on one side only. However, sidewalks on one side of the road can also be highly effective in reducing overall crash severity, when fatalities and incapacitating serious injuries are compared to less severe injuries.

5. Buffers between sidewalks and the road do not appear to have much of an impact on crash severity for any range of speed limit. There is a clear correspondence between the severity of outcomes for specific buffer types, but much of this is likely due to variations in the posted speed limit associated with different types of buffer.

6. Medians are associated with worse pedestrian crash outcomes when the speed limit is less than 50 mph. The difference between outcomes with and without medians is more pronounced when speed limits are less than 25 mph. Similar to buffers, median types also vary by speed, and therefore some of the difference in crash severity between median types is likely due to variations in speed.

7. Crosswalks do not appear to be associated with differences in fatality rates at any speed limit. However, they appear to be effective in reducing serious injuries where speed limits are high.

8. Crashes that occur at intersections have less severe outcomes than mid-block crashes. For higher speed roads, the distinction between intersection crashes and mid-block crashes is more pronounced in terms of crash severity.

9. In areas with institutional and commercial land uses, crash outcomes are less severe than other types of land uses. However, the differences are primarily due to variations in speed limits in areas with different types of land uses.

10. Finally, various analyses in this report indicate that some of the observed relationships may have been affected by pedestrian exposure. This is a common shortcoming of pedestrian crash analysis, as exposure data is not easily collected.

Introduction

All crashes, including those involving pedestrians, are undesirable. Yet, since crashes do occur despite all the efforts made by various agencies and institutions, understanding crash severity is important. At one extreme, a crash may result in loss of human life, but at the other extreme, a crash may result in no injuries or property damage. Measures that can reduce crash severity are highly useful to preserve life and health. In addition to impacts on life and health, the severity of a crash has serious economic implications. As of 2011, the US DOT values a life lost in a crash at $6,200,000.[1]

In an effort to help in developing appropriate strategies to reduce crash severity, this study analyzes New Jersey crash data to examine the association between built environment characteristics and the severity of pedestrian crash outcomes. The report presents findings from research conducted by the Alan M. Voorhees Transportation Center (VTC) concerning the impacts of the built environment on pedestrian crash severity. The data used in this research are the Enhanced New Jersey Crash Data dataset, compiled by VTC in 2010. The data set is based on geocoded crashes involving pedestrians in New Jersey during the years 2007, 2008, and 2009. The original source of the data set is the Plan4Safety data maintained by the Rutgers Center for Advanced Infrastructure and Transportation (CAIT). The Plan4Safety data set is based on police reports and many of its crash records include the precise location of the crashes. The Enhanced New Jersey Crash Data was compiled by using Google Street View® to record the characteristics of the crash sites, including roadway characteristics (e.g., speed, medians, buffers, traffic lighting), pedestrian infrastructure characteristics (e.g., sidewalks, crosswalks, pedestrian lights), and predominant land uses. For the purpose of the enhanced analysis, Plan4Safety data for a total 6,353 pedestrian crashes throughout the state were downloaded from the CAIT web site. Of these crashes, 2,351 pedestrian records were precisely geocoded to enable enhanced analysis by Google Street View®.

The purpose of this research was to evaluate the potential effects of different components of the built environment on the severity of pedestrian crash outcomes. Although the analysis does not present causal relationships between the built environment and crash outcomes, it shows some clear associations between the two. Three pedestrian crash outcomes are used for the analysis in this study: (a) killed, (b) serious injury or incapacitation, and (c) lesser or no injury. The Plan4Safety data included the following classifications for pedestrian crash outcomes: killed, incapacitated (i.e., serious injury), moderate injury, and complaint of pain. Many of the records were blank, potentially implying that there were no injuries in those crashes (unless those data were not properly recorded by police). For the purpose of the analysis in this report, moderate injury, complaint of pain, and blank records were combined into the category lesser or no injury.

Table 1 shows the representativeness of the records included in the analysis based on crash outcome, gender and age of pedestrians, as well as the posted speed limits at crash sites. Overall 37% of the Plan4Safety records were geocoded and analyzed using Google Street View®. However, the geocoded data set included larger proportions of crashes with serious outcomes (60.5% of fatalities and 45.3% of serious or incapacitating injuries). Crashes with serious outcomes are over represented in the geocoded

[1] http://regs.dot.gov/docs/Value_of_Life_July_29_2011.pdf

data set presumably because more attention is paid to details when police record crashes with serious outcomes compared to less serious outcomes. Gender distribution in the geocoded data set is comparable to the original Plan4Safety data set. Consistency of gender between the two data sets is important because male pedestrians tend to have more serious crash outcomes than female pedestrians.

Table 1. Inclusion of Pedestrian Crash Victims by Outcome, Gender, Age, and Posted Speed Limit, 2007-2009

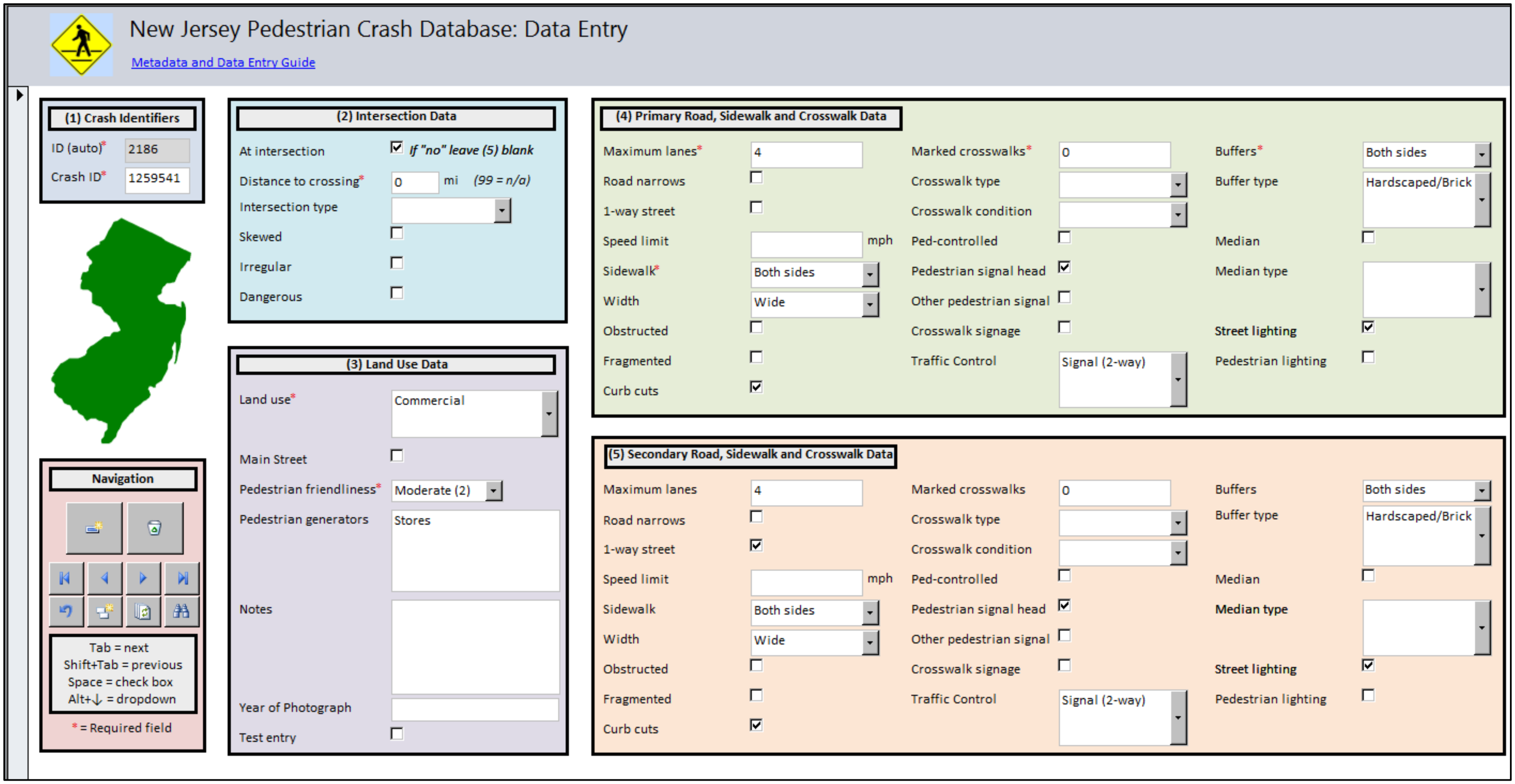
Outcome	Geocoded and Located in Google Street View®		Not Geocoded		Total	
Killed	259	60.5%	169	39.5%	428	100%
Serious Injury / Incapacitated	382	45.3%	462	54.7%	844	100%
Lesser or No Injury	1,710	33.7%	3,371	66.3%	5,080	100%
Total	2,351	37.0%	4,002	63.0%	6,353	100%
Gender						
Male	1,350	36.0%	2,401	64.0%	3,751	100%
Female	1,001	38.5%	1,601	61.5%	2,602	100%
Total	2,351	37.0%	4,002	63.0%	6,353	100%
Age						
Age <= 4 yrs.	35	19.7%	143	80.3%	178	100%
Age 5 to 12 yrs.	190	27.6%	498	72.4%	688	100%
age 12 to 17 yrs.	296	39.9%	446	60.1%	742	100%
age 18 to 24 yrs.	317	37.8%	521	62.2%	838	100%
age 25 to 34 yrs.	300	38.3%	484	61.7%	784	100%
age 35 to 44 yrs.	313	39.2%	485	60.8%	798	100%
age 45 to 54 yrs.	350	39.9%	528	60.1%	878	100%
age 55 to 64 yrs.	251	40.2%	373	59.8%	624	100%
age 65 to 79 yrs.	210	37.9%	344	62.1%	554	100%
age >= 80 yrs.	89	33.1%	180	66.9%	269	100%
Total	2,351	37.0%	4,002	63.0%	6,353	100%
Posted Speed Limit at the Crash Site						
25 mph or less	950	33.1%	1,916	66.9%	2,866	100%
30 to 45 mph	908	68.4%	419	31.6%	1,327	100%
50 to 65 mph	302	77.0%	90	23.0%	392	100%
Speed Unknown	191	10.8%	1,577	89.2%	1,768	100%
Total	2,351	37.0%	4,002	63.0%	6,353	100%

Table 1 shows that the adult age groups and adolescents (age 12-17) are also proportionately represented in the geocoded data set. However, younger children are somewhat underrepresented, presumably because they are less likely to be involved in crashes with serious pedestrian outcomes. Pedestrian crashes in areas with posted speed limits of 25 mph or less are represented fairly proportionately in the geocoded data set compared with the original data set. Pedestrian crashes in areas with posted speed limits between 30 and 45 mph and between 50 and 65 mph are over represented in the geocoded data set. This is also presumably because crashes at higher speed locations are more serious, and therefore their recording is more thorough. Pedestrian crashes in areas with unknown speed limits are underrepresented in the geocoded data set, which is not a problem because these records represent missing data.

Google Street View® allows viewing of 360-degree street level photographs for locations that can be found using Google Maps. Google Street View® screenshots of the geocoded crash sites were taken by VTC researchers and recorded for analysis, at the beginning of the project. By adopting this method, it was possible to minimize changes in the physical characteristics of the crash sites shown in the screenshots because the street level photographs are periodically updated in Street View®. Screenshots were interpreted and data were entered in an Access data entry form, as shown in Figure 1.

The input data consist of crash identifiers, intersection characteristics, adjacent land use, and the characteristics of primary and secondary roads at the crash site. In the Intersection Data section of the data entry form, the data-entry personnel identified whether the crash took place at an intersection and the distance from the nearest intersection. If the crash took place at an intersection, an intersection type was attributed to the record and detailed information about the intersection was recorded. In the Land Use Data section, the data-entry personnel entered data on principal land use types, whether the crash location was on a Main Street or central business district, a pedestrian friendliness rating for the area, identification of pedestrian generators, notes, and the year of the photograph. In the two sections on Primary and Secondary Roads, the road characteristics were entered. The secondary road section was used only if there was an intersection at the crash site. The secondary road data were not used for this research because of the very small number of cases where secondary roads were relevant to the crashes. The two sections on Primary and Secondary Roads include the maximum number of lanes; a variable indicating narrowing of the road; a variable indicating if it was a one way street; effective speed limit; and whether there were sidewalks, crosswalks, buffers between pedestrians and traffic, medians, signals, streetlights, and pedestrian lighting.

Figure 1: Data Entry Form



New Jersey Pedestrian Crash Database: Data Entry

Metadata and Data Entry Guide

(1) Crash Identifiers

ID (auto)* 2186

Crash ID* 1259541

(2) Intersection Data

At intersection ☑ *If "no" leave (5) blank*

Distance to crossing* 0 mi *(99 = n/a)*

Intersection type

Skewed ☐

Irregular ☐

Dangerous ☐

(3) Land Use Data

Land use* Commercial

Main Street ☐

Pedestrian friendliness* Moderate (2)

Pedestrian generators Stores

Notes

Year of Photograph

Test entry ☐

Navigation

Tab = next
Shift+Tab = previous
Space = check box
Alt+↓ = dropdown

* = Required field

(4) Primary Road, Sidewalk and Crosswalk Data

Maximum lanes* 4

Road narrows ☐

1-way street ☐

Speed limit mph

Sidewalk* Both sides

Width Wide

Obstructed ☐

Fragmented ☐

Curb cuts ☑

Marked crosswalks* 0

Crosswalk type

Crosswalk condition

Ped-controlled ☐

Pedestrian signal head ☑

Other pedestrian signal ☐

Crosswalk signage ☐

Traffic Control Signal (2-way)

Buffers* Both sides

Buffer type Hardscaped/Brick

Median ☐

Median type

Street lighting ☑

Pedestrian lighting ☐

(5) Secondary Road, Sidewalk and Crosswalk Data

Maximum lanes 4

Road narrows ☐

1-way street ☑

Speed limit mph

Sidewalk Both sides

Width Wide

Obstructed ☐

Fragmented ☐

Curb cuts ☑

Marked crosswalks 0

Crosswalk type

Crosswalk condition

Ped-controlled ☐

Pedestrian signal head ☑

Other pedestrian signal ☐

Crosswalk signage ☐

Traffic Control Signal (2-way)

Buffers Both sides

Buffer type Hardscaped/Brick

Median ☐

Median type

Street lighting ☑

Pedestrian lighting ☐

Although much of this report is descriptive, an analytical approach was taken to make comparisons when appropriate. Cross-tabulations were used to compare pedestrian crash severity outcomes for a variety of types of infrastructure. The cross-tabulations show the proportion of pedestrians involved in crashes who were killed, seriously injured, or received a lesser or no injury for each type of infrastructure.

Because of the strong relationship of speed with crash severity outcomes, the relationships between infrastructure types and crash severity were analyzed separately for different speed limits whenever possible. Z tests were used to examine whether the differences in the relationships between infrastructure attributes and crash severity were statistically significant. These tests are important for making comparisons because sometimes apparent differences may not be statistically different. For example, in a hypothetical scenario, if 20% of the crashes resulted in fatalities when sidewalks were present whereas 25% of crashes resulted in fatalities when sidewalks were not present, the difference between the two cases although measureable, still may not be statistically significant although 25% is larger than 20%. Following convention in existing literature, a 10% level of significance is used to evaluate the differences. A 10% level of significance means that an observed relationship is likely to be valid 9 out of 10 times. This procedure prevents arbitrary decisions about how to emphasize apparent differences in the report.

Speed

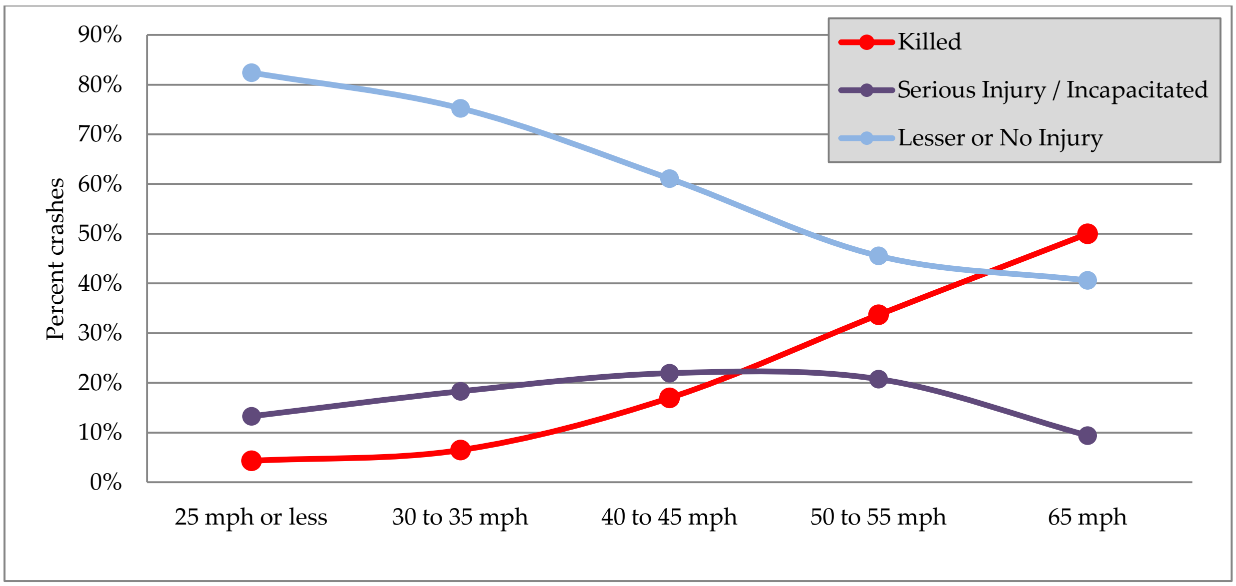
Of all the variables in the combined data set of Google Street View® records and Plan4Safety data, the variable with the clearest and most plausible relationship with the severity of pedestrian crash outcomes was the posted speed limit at the crash location. Table 2 shows that in an area with a 65 mph speed limit, the proportion of pedestrians killed was more than ten times the proportion killed where the speed limit was 25 mph or less (50% vs. 4.3%). Although more pedestrian crashes occurred on low speed roads (<=25 mph), only a small proportion of these crashes resulted in fatalities or serious injuries. While half of the crashes at 65 mph speed limit resulted in pedestrian fatalities, medium speed roads (between 40 and 55 mph) accounted for relatively more serious injuries (42.6%). Using the 25 mph group as the basis for comparison, Z tests were used to examine how the proportion of fatalities increased as speed increased. The tests showed that the likelihood of fatality increased with every level of speed limit increase, with the highest speed limit accounting for the highest likelihood. Although this is also apparent from Table 2, the Z tests confirmed that speed limits above 25 mph increase the likelihood of pedestrian fatalities.

Table 2. Outcome by Posted Speed Limit, 2007-2009

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
25 mph or less	41	4.3%	126	13.3%	783	82.4%	950	100%
30 to 35 mph	34	6.5%	96	18.3%	395	75.2%	525	100%
40 to 45 mph	65	17.0%	84	21.9%	234	61.1%	383	100%
50 to 55 mph	91	33.7%	56	20.7%	123	45.6%	270	100%
65 mph	16	50.0%	3	9.4%	13	40.6%	32	100%
Speed Unknown	12	6.3%	17	8.9%	162	84.8%	191	100%
Total	259	11.0%	382	16.2%	1,710	72.7%	2,351	100%

The information in Table 2 is summarized in Figure 2. The red line (Killed) indicates that the likelihood of a fatality increases with speed in a linear fashion on roads with a speed limit above 35 mph. The reason for the dip of the orange line (Serious Injury/Incapacitated) above 55 mph speed limit is that crash victims are more likely to die than be seriously injured at a higher speed. The slope of the blue line (Lesser or No Injury) indicates that most of the crashes on low speed roads result in minor injuries. The line slopes down from left to right because at higher speeds, victims are more likely to die or suffer serious injuries instead of suffering from minor or no injuries.

Figure 2: Crash Outcomes by Posted Speed



Because of the importance of speed in determining crash severity, many of the tables that follow are stratified by posted speed limit. Three speed categories have been used in the tables: 25 mph or less, 30 to 45 mph, and 50 to 65 mph. This allows speed to be controlled for while the implications of the built environment and pedestrian infrastructure on pedestrian crash severity are examined.

Street Lighting

Street lighting enhances visibility in darkness. For that reason, this discussion on street lighting was restricted to pedestrian outcomes from crashes that occurred only when it was dark (as opposed to daylight). This reduced the number of crashes from 2,351 to 1,090. Two types of street lighting were considered: traffic lighting and pedestrian lighting. The primary purpose of traffic lighting is to increase visibility for vehicular traffic. Traffic lights illuminate roadways and are usually provided at the utility pole height. Pedestrian lights illuminate sidewalks and other pedestrian facilities and are usually provided at lower heights than traffic lights.

Most crashes that occur in the dark occur in the presence of traffic lighting facilities (78% in our sample). This is presumably because there are more pedestrians in areas with lighting than on roads without traffic lights. Although more crashes occur in areas with traffic lights, Table 3 shows that, for the full sample of crashes analyzed for all speed limits, the presence of traffic lighting is associated with a reduction in nighttime fatalities from 23% to 16% and serious or incapacitating injuries decrease from 28% to 17%. This may be an indication that traffic lights in general reduce the severity of pedestrian crashes, due to increases in visibility. However, when the crashes are analyzed separately for each speed limit, the differences do not uniformly follow a pattern.

None of the fatal crashes on roads with a speed limit under 25 mph occurred on roads without traffic lighting. This could be because pedestrians will tend to be more cautious when it is dark or it could also be because of reduced exposure. The fact that only 44 (12%) of the crashes on roads with speed limits under 25 mph occurred in conditions without traffic lights, whereas 313 (88%) occurred in the presence of traffic lights lends support to this hypothesis. Thus both pedestrian caution and limited exposure may be the primary reason for the observed pattern of more fatalities with traffic lights than without traffic lights.

For roads with 30-45 mph speed limits, the proportion of fatal crashes occurring at locations with traffic lights (16.4%) is similar to the proportion of fatal crashes occurring in locations without traffic lights (15.2%). However, pedestrian exposure may be affecting this relationship because 105 (23%) of the crashes occurred in conditions without traffic lights, while 77% occurred when lights were present.

The effect of traffic lighting in reducing fatalities is evident for roads with speed limits of 50-65 mph. Since the total crashes for these speed limits are more evenly distributed for conditions with traffic lights (57%) and without traffic lights (43%) compared to roads with lower speed limits, the effect of exposure is seemingly less important for the relationship between lighting and fatalities. Table 3 shows that 45% of the nighttime crashes result in fatalities when traffic lights are absent, while only 39% of the crashes result in fatalities when lights are present.

Thus, the effect of traffic lights in reducing fatal crash outcomes is obvious for roads with 50-65 mph speed limits, but not for roads with lower speed limits. However, the effect of traffic lights in reducing serious injuries is apparent for all speed limits. For example, of all crashes analyzed, 28% resulted in serious injuries when traffic lights were absent but only 17% resulted in serious injuries when lights were present. Similarly, 32% of the crashes at speed limits at or lower than 25 mph resulted in serious injuries when lights were absent, whereas only 15% resulted in serious injuries when lights were present. A similar pattern can be observed for roads with 30-45 mph speed limits also (33% vs. 19%). The same is true for roads with 50-65 mph speed limit, but the effect of lighting appears to be less than for lower speed roads.

In sum, the data seem to suggest that traffic lighting is beneficial at reducing both fatalities and injuries. The fatality reduction occurs primarily on high speed roads (50-65mph), with little or no effect at fatality reduction on lower speed roads. However, there is a clear pattern that traffic lights reduce serious injuries on all roads.

Table 3. Presence of Traffic Lighting Fixtures in the Dark, by Posted Speed Limit and Outcome

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
No Traffic Lighting	56	23.0%	69	28.3%	119	48.8%	244	100%
Traffic Lighting	136	16.1%	140	16.5%	570	67.4%	846	100%
Total	192	17.6%	209	19.2%	689	63.2%	1,090	100%
25 mph or less								
No Traffic Lighting	0	0.0%	14	31.8%	30	68.2%	44	100%
Traffic Lighting	25	8.0%	46	14.7%	242	77.3%	313	100%
Total	25	7.0%	60	16.8%	272	76.2%	357	100%
30 to 45 mph								
No Traffic Lighting	16	15.2%	35	33.3%	54	51.4%	105	100%
Traffic Lighting	59	16.4%	69	19.2%	232	64.4%	360	100%
Total	75	16.1%	104	22.4%	286	61.5%	465	100%
50 to 65 mph								
No Traffic Lighting	40	44.9%	19	21.3%	30	33.7%	89	100%
Traffic Lighting	46	39.3%	21	17.9%	50	42.7%	117	100%
Total	86	41.7%	40	19.4%	80	38.8%	206	100%
Speed Unknown								
No Traffic Lighting	0	0.0%	1	16.7%	5	83.3%	6	100%
Traffic Lighting	6	10.7%	4	7.1%	46	82.1%	56	100%
Total	6	9.7%	5	8.1%	51	82.3%	62	100%

Although traffic lighting is common in New Jersey, pedestrian lighting is not. As Table 4 shows, only a few crashes (54 out of 1090) occurred when pedestrian lighting was present. This is primarily because of the rarity of pedestrian lights. When all nighttime crashes are considered together for all roads regardless of the speed limit, 18% of the crashes in areas without pedestrian lighting result in fatalities, whereas 5% of the crashes resulted in fatalities when pedestrian lights were present. Similarly, the proportion of crashes resulting in serious injuries is slightly lower when pedestrian lights are present compared to when lighting is absent. Together, this suggests that pedestrian lighting may be effective in reducing crash severity. However, because of the small number of crashes in locations with pedestrian lights, no conclusions can be drawn about the effectiveness of pedestrian lights under different speed limits.

Table 4. Presence of Pedestrian Lighting Fixtures in the Dark, by Posted Speed Limit and Outcome

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
No Pedestrian Lighting	189	18.3%	199	19.2%	646	62.5%	1,034	100%
Pedestrian Lighting	3	5.4%	10	17.9%	43	76.8%	56	100%
Total	192	17.6%	209	19.2%	689	63.2%	1,090	100%
25 mph or less								
No Pedestrian Lighting	23	7.3%	52	16.4%	242	76.3%	317	100%
Pedestrian Lighting	2	5.0%	8	20.0%	30	75.0%	40	100%
Total	25	7.0%	60	16.8%	272	76.2%	357	100%
30 to 45 mph								
No Pedestrian Lighting	75	16.6%	103	22.8%	274	60.6%	452	100%
Pedestrian Lighting	0	0.0%	1	7.7%	12	92.3%	13	100%
Total	75	16.1%	104	22.4%	286	61.5%	465	100%
50 to 65 mph								
No Pedestrian Lighting	86	41.7%	40	19.4%	80	38.8%	206	100%
Pedestrian Lighting	0	---	0	---	0	---	0	---
Total	86	41.7%	40	19.4%	80	38.8%	206	100%
Speed Unknown								
No Pedestrian Lighting	5	8.5%	4	6.8%	50	84.7%	59	100%
Pedestrian Lighting	1	33.3%	1	33.3%	1	33.3%	3	100%
Total	6	9.7%	5	8.1%	51	82.3%	62	100%

Sidewalks

It was hypothesized that the severity of pedestrian crash outcomes would be less when sidewalks are present because sidewalks provide refuge to pedestrians away from traffic. It was further hypothesized that crash outcomes would be less severe when sidewalks are present on both sides of a street. These hypotheses are confirmed by our results. Table 5 shows that, on all roads, 26% of the crashes involving pedestrians resulted in fatalities when no sidewalks were present, compared with 16% when there was a sidewalk on one side of the street, and 6% when there are sidewalks on both sides of the street. All of these differences are significant at the 1% confidence level (meaning that the results are likely to hold 99 out of 100 times), providing strong evidence about the effectiveness of sidewalks in reducing the likelihood of fatalities and injuries.

Table 5. Outcome by Number of Sidewalks and Posted Speed Limit

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
No Sidewalks	124	25.5%	96	19.7%	267	54.8%	487	100%
One Side	32	15.5%	39	18.9%	135	65.5%	206	100%
Both Sides	103	6.2%	247	14.9%	1,308	78.9%	1,658	100%
Total	259	11.0%	382	16.2%	1,710	72.7%	2,351	100%
25 mph or less								
No Sidewalks	0	0.0%	1	3.2%	30	96.8%	31	100%
One Side	5	16.1%	5	16.1%	21	67.7%	31	100%
Both Sides	36	4.1%	120	13.5%	732	82.4%	888	100%
Total	41	4.3%	126	13.3%	783	82.4%	950	100%
30 to 45 mph								
No Sidewalks	30	16.1%	41	22.0%	115	61.8%	186	100%
One Side	20	15.2%	24	18.2%	88	66.7%	132	100%
Both Sides	49	8.3%	115	19.5%	426	72.2%	590	100%
Total	99	10.9%	180	19.8%	629	69.3%	908	100%
50 to 65 mph								
No Sidewalks	90	37.7%	50	20.9%	99	41.4%	239	100%
One Side	7	21.2%	8	24.2%	18	54.5%	33	100%
Both Sides	10	33.3%	1	3.3%	19	63.3%	30	100%
Total	107	35.4%	59	19.5%	136	45.0%	302	100%
Speed Unknown								
No Sidewalks	4	12.9%	4	12.9%	23	74.2%	31	100%
One Side	0	0.0%	2	20.0%	8	80.0%	10	100%
Both Sides	8	5.3%	11	7.3%	131	87.3%	150	100%
Total	12	6.3%	17	8.9%	162	84.8%	191	100%

Speed limits 25 mph or less

Of the 950 crashes analyzed with speed limits of 25 mph or less, 888 (93%) occurred in areas where sidewalks were present on both sides of the street, and 31 more (3%) occurred in areas where sidewalks were present on only one side. Clearly, the differences in crashes reflect pedestrian exposure: More pedestrians are involved in crashes in areas where there are sidewalks because more pedestrians walk in those areas than areas without sidewalks. No pedestrian died in areas without sidewalks presumably because only a small number of pedestrians walked in those areas. This cannot and should not be construed as indicating that not having sidewalks decreases the likelihood of fatal crashes. While no conclusions can be drawn from the data set regarding fatalities, the data show that a significantly smaller proportion of pedestrian crashes result in fatalities when sidewalks are present on both sides of the street

(4%) compared to sidewalks being present on one side (16%). Serious injuries are also slightly lower when sidewalks are present on both sides.

Speed limits between 30 and 45 mph

For speed limits between 30 and 45 mph, 65% (590 of 908) of the crashes occurred on roads with sidewalks on both sides of the street, while another 15% (132) occurred on roads with sidewalks on only one side and only 20% occurred on roads without sidewalks. The larger number of crashes on roads with sidewalks is most likely the result of the presence of more pedestrians on roads with sidewalks. The data in Table 5 show that the proportion of crashes resulting in a fatality is only half in locations with sidewalks on both sides (8%) compared to roads without sidewalks (16%). The proportion of crashes resulting in serious injuries is also slightly lower when sidewalks are present on both sides of the street compared to locations having no sidewalks. Together, this information suggests that having sidewalks on both sides of the street can reduce pedestrian crash severity compared to having no sidewalks.

The difference in crash severity between locations with no sidewalks and having a sidewalk on one side of the street is small, although having a sidewalk on one side of the street seems to lower crash severity slightly. For example, 16% of the crashes in locations without sidewalks resulted in fatalities, whereas 15% of crashes in locations with a sidewalk on one side of the street resulted in fatalities. Similarly, the difference in the proportion of crashes resulting in serious injuries is very small when locations with no sidewalks are compared with locations with a sidewalk on one side of the street (22% vs. 20%).

The data seem to suggest that having sidewalks on both sides of the street may be highly effective at reducing pedestrian crash severity, but having sidewalks on only one side of the street has a small effect. A reason for the effectiveness of sidewalks on both sides of the street may be that motorists are more careful about the presence of pedestrians in such locations. Another reason may be that sidewalks on both sides of the street are usually available in urban areas, where motorists are likely to be more conscious about the presence of pedestrians than in suburban areas where pedestrians are encountered less often.

A clearer picture about the effectiveness of sidewalks emerges when the data are combined for fatalities and serious injuries. From the data in Table 5, one can estimate that the proportion of crashes that resulted in fatalities or serious injuries was 38% for locations without sidewalks, 33% for locations with a sidewalk on one side of the street, and 28% for locations with sidewalks on both sides of the street. This linear declining relationship between the presence and number of sidewalks and crash severity is consistent with our expectations.

Speed limits between 50 and 65 mph

Roads with posted speed limits between 50 and 65 mph usually have less pedestrian traffic and do not have sidewalks. In these data, 79% of the crashes in this speed limit range occurred in areas with no sidewalks, while 11% occurred in areas with sidewalks on one side of the street, and 10% occurred where there were sidewalks on both sides of the roadway. The data show that the proportion of crashes resulting in fatalities is substantially less where there are sidewalks compared to where there are no sidewalks, irrespective of whether sidewalks are present on one side or both sides of the street. Of the pedestrian crashes that occurred in locations without sidewalks, 38% resulted in fatalities, whereas only 21% of the crashes resulted in fatalities when sidewalks were present on one side of the street and 33% of the crashes resulted in fatalities when sidewalks were present on both sides of the street. The analysis cannot explain why the proportion of fatalities is higher when sidewalks are present on both sides of the street compared to when sidewalks are present on only one side of the street.

The data in Table 5 show that the likelihood of serious injuries is substantially lower when sidewalks are present on both sides of the street (3%) compared to when sidewalks are not present (21%). However, the proportion of crashes resulting in serious injuries is slightly lower when sidewalks are not present (21%) compared to when sidewalks are on only one side of the street (24%)

A more consistent picture emerges about the effectiveness of sidewalks in reducing crash severity when fatalities and serious injuries are combined. When combined, 59% of the crashes in locations without sidewalks resulted in fatalities or serious injuries, compared to 45% in locations with a sidewalk on one side of the street and 37% in locations with sidewalks on both sides of the street. This relationship provides a clearer indication that sidewalks are important for reducing the severity of pedestrian crash outcomes.

Buffers

Buffers are areas between sidewalks and the roadway. They include bicycle lanes, shoulders, on-street parking, landscaping, grass, or built surfaces. They separate pedestrians from vehicular traffic and are expected to have a protective effect on pedestrian crash outcomes. Table 6 shows pedestrian outcomes by posted speed limit, with the categories no buffers, buffer on one side of the street, and buffers on both sides of the street. The findings in Table 6 are generally not significant, suggesting no difference in severity outcome based on the presence of a buffer.

It is evident from Table 6 that the proportion of all crashes (irrespective of speed limit) that occur in locations without buffers is slightly higher (13%) compared to where buffers are present on only one side of the street (8%) and where buffers are present on both sides of the street. When fatalities and serious injuries are combined, accident severity is slightly lower where buffers are present compared to where buffers are not present. For speed limits 30-45 mph and 50-65 mph, crashes in locations with buffers on one side seem to result in a lower rate of fatality than having no buffers, but for unknown reasons, fatality rates are higher when there are buffers on both sides of the street compared to where there are buffers on only one side. One reason may be that buffers on two sides of the street are present on wider road segments, where motorists are likely to drive above the posted speed limits.

Some of the inconsistencies between buffers and crash severity may be because different types of buffers are combined together for the analysis in Table 6. When buffers of different types are considered separately, the results may be more consistent with expectations. Buffers may be more effective at reducing the probability of a pedestrian crash than reducing the severity of outcomes; however, this cannot be analyzed with this dataset.

Table 6. Outcome by Number of Buffers and Posted Speed Limit

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
No Buffers	88	12.8%	116	16.8%	485	70.4%	689	100%
One Side	22	8.1%	48	17.7%	201	74.2%	271	100%
Both Sides	148	10.7%	217	15.6%	1,023	73.7%	1,388	100%
Total	258	11.0%	381	16.2%	1,709	72.8%	2,348	100%
25 mph or less								
No Buffers	10	4.4%	31	13.7%	185	81.9%	226	100%
One Side	3	3.2%	11	11.8%	79	84.9%	93	100%
Both Sides	28	4.4%	84	13.3%	518	82.2%	630	100%
Total	41	4.3%	126	13.3%	782	82.4%	949	100%
30 to 45 mph								
No Buffers	34	11.4%	59	19.7%	206	68.9%	299	100%
One Side	12	9.4%	26	20.5%	89	70.1%	127	100%
Both Sides	52	10.8%	94	19.6%	334	69.6%	480	100%
Total	98	10.8%	179	19.8%	629	69.4%	906	100%
50 to 65 mph								
No Buffers	35	36.1%	16	16.5%	46	47.4%	97	100%
One Side	7	22.6%	9	29.0%	15	48.4%	31	100%
Both Sides	65	37.4%	34	19.5%	75	43.1%	174	100%
Total	107	35.4%	59	19.5%	136	45.0%	302	100%
Speed Unknown								
No Buffers	9	13.4%	10	14.9%	48	71.6%	67	100%
One Side	0	0.0%	2	10.0%	18	90.0%	20	100%
Both Sides	3	2.9%	5	4.8%	96	92.3%	104	100%
Total	12	6.3%	17	8.9%	162	84.8%	191	100%

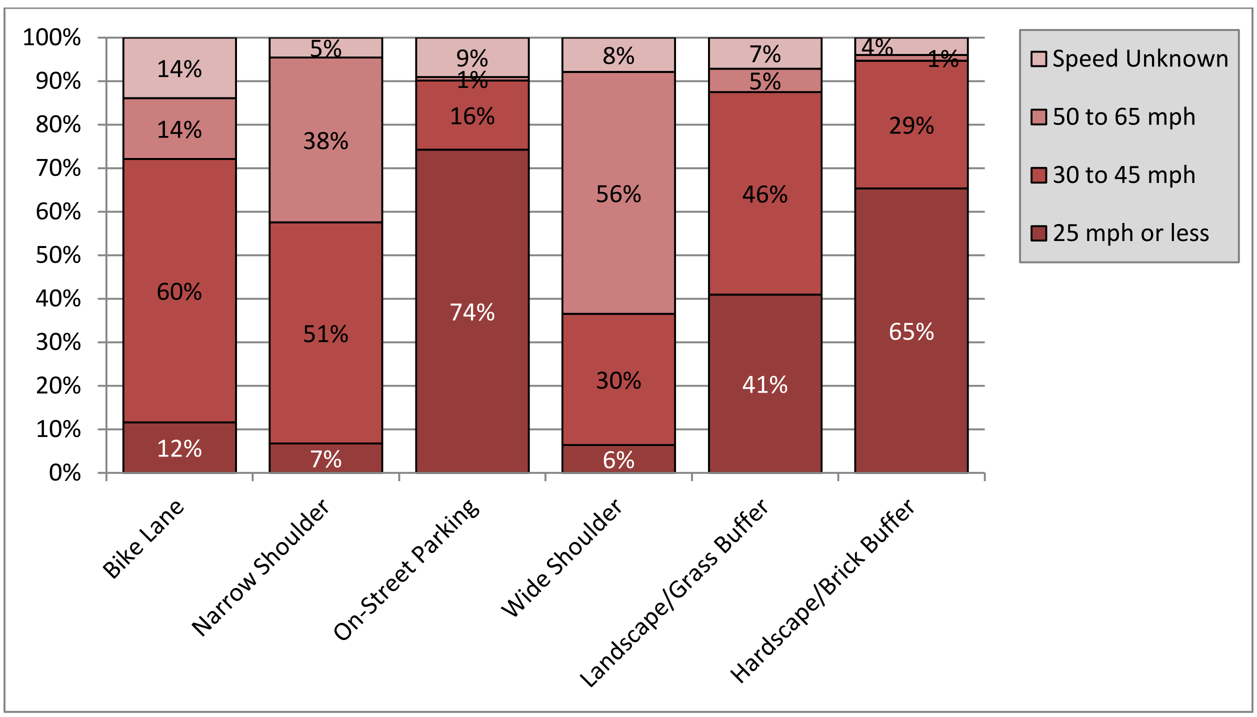
Type of buffer

Table 7 shows pedestrian crash severity outcomes by buffer type. There is considerable variation in pedestrian crash outcomes. Fatality proportions vary from 5% to 27% between buffer types. The proportion of crashes that resulted in serious injury varies from 57% to 83%. The most effective type of buffers appear to be on-street parking because less than 5% of the crashes in locations with on-street parking resulted in fatalities and 12% resulted in serious injuries. In contrast, narrow and wide shoulders appear to be the least effective because between 22% and 27% of the crashes in locations with such buffers resulted in fatalities. The proportion of crashes resulting in serious injuries is also relatively high for shoulders, especially narrow shoulders.

Table 7. Buffer Types by Outcome

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Bike Lane	5	11.6%	6	14.0%	32	74.4%	43	100%
Narrow Shoulder	54	22.7%	49	20.6%	135	56.7%	238	100%
On-Street Parking	27	4.5%	74	12.2%	505	83.3%	606	100%
Wide Shoulder	34	27.0%	21	16.7%	71	56.3%	126	100%
Landscape/Grass Buffer	62	7.6%	132	16.2%	619	76.1%	813	100%
Hardscape/Brick Buffer	5	6.7%	17	22.7%	53	70.7%	75	100%
Total in Dataset							1,662	

Figure 3. Buffer Types by Posted Speed Limit



The relationship between buffers and severity in Table 7 may be affected by speed and other local conditions. That is, the type of buffer present may be a reflection of the type of road or local environment. Figure 3 shows that different types of buffers are present on roads with different speed limits. On-street parking and hardscape/brick buffers are more likely at crash locations with speed limits of 25 mph or less. In contrast, wide and narrow shoulders are on roads with 50-65 mph speed limits. It is possible that much of the apparent distinctions between buffer types and severity outcomes will disappear when speed is taken into account.

Medians

The principal function of medians is to channel the flow of traffic and separate lanes. They are not primarily pedestrian facilities. However, some types of median may present pedestrians with an opportunity to more safely cross a road or, in some instance, act as a barrier to crossing roads. A pedestrian refuge island, a landscaped or grass median or a hardscape or brick median might simultaneously present pedestrians with a safe refuge point, but also can present an opportunity to take risks on a high-speed road. Guardrails and Jersey barriers are designed to be substantial barriers to vehicles crossing into opposing traffic lanes, usually at high speed. These are not generally placed where pedestrians are expected to cross. These medians serve as disincentives to cross. Other median types, such as painted medians and suicide lanes, may present pedestrians with neither a safe haven nor prompt them to take risks. In the data, a total of 483 pedestrians were involved in crashes where the road had a median. Not controlling for speed limits, medians (of all types) seem to encourage risk taking as 22% of pedestrian-involved crashes with a median, resulted in a fatality, compared to only 8% with no median present.

Table 8. Outcome by Presence of Median and Posted Speed Limit

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
No Median	152	8.1%	292	15.6%	1,424	76.2%	1,868	100%
Median	107	22.2%	90	18.6%	286	59.2%	483	100%
Total	259	11.0%	382	16.2%	1,710	72.7%	2,351	100%
25 mph or less								
No Median	35	4.0%	122	13.8%	726	82.2%	883	100%
Median	6	9.0%	4	6.0%	57	85.1%	67	100%
Total	41	4.3%	126	13.3%	783	82.4%	950	100%
30 to 45 mph								
No Median	71	9.8%	140	19.4%	512	70.8%	723	100%
Median	28	15.1%	40	21.6%	117	63.2%	185	100%
Total	99	10.9%	180	19.8%	629	69.3%	908	100%
50 to 65 mph								
No Median	37	34.9%	17	16.0%	52	49.1%	106	100%
Median	70	35.7%	42	21.4%	84	42.9%	196	100%
Total	107	35.4%	59	19.5%	136	45.0%	302	100%
Speed Unknown								
No Median	9	5.8%	13	8.3%	134	85.9%	156	100%
Median	3	8.6%	4	11.4%	28	80.0%	35	100%
Total	12	6.3%	17	8.9%	162	84.8%	191	100%

For the most part, medians are associated with areas where speed limits are above 25 mph. Locations where speed limits are at or below 25 mph account for 14% of the pedestrian crashes in the dataset. Locations with speed limits are between 30 and 45 mph and between 50 and 65 mph accounted for 38% and 41% of crashes, respectively.

Table 8 shows that at locations with posted speed limits of 25 mph or less, proportionately more than twice as many fatalities occur when medians are present compared to when medians are not present (9.0% vs. 4.0%). However, the proportion of serious injuries is less than half when medians are present compared to when medians are not present (6% vs. 14%). Taken together, 15% of the crashes result in fatalities or serious injuries when medians are present compared to 18% when medians are not present. At higher speeds, the presence of medians is associated with higher proportions of fatalities and serious injuries. For example, at the 30-45 mph speed limit range, 15% of crashes result in fatalities when medians are present, while 10% of crashes result in fatalities when medians are absent. At this speed range, the differences in serious injuries are lower between presence and absence of medians. For roads with speed limits of 50-65 mph, the proportion of serious injuries and fatalities is slightly higher when medians are present compared to the absence of medians.

Type of median

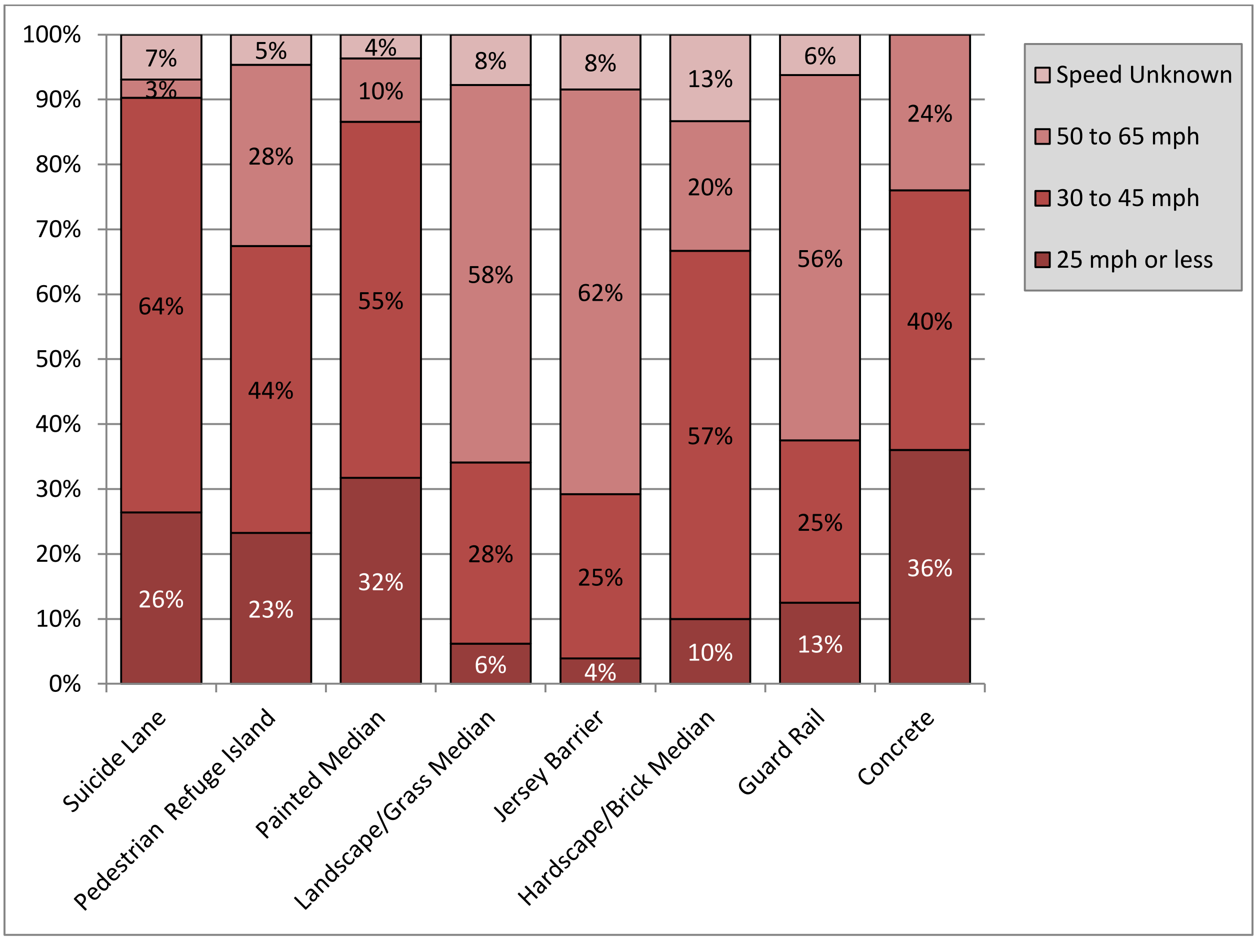
Table 9 shows pedestrian crash outcomes by type of median. The proportion of fatalities is lowest for hardscape/brick medians (only 3%), but highest for guard rails. The proportions shown in Table 9 are very likely affected by type of road and speed. For example, hardscape/brick medians are mainly used in downtowns of urban areas, where speed limits are low and cars travel slowly because of on-street parking. On the other hand, guard rails are commonly used on high speed roads.

Table 9. Median Types by Outcome

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Suicide Lane	9	12.5%	12	16.7%	51	70.8%	72	100%
Pedestrian Refuge Island	5	11.6%	8	18.6%	30	69.8%	43	100%
Painted Median	10	12.2%	14	17.1%	58	70.7%	82	100%
Landscape/Grass Median	35	27.1%	25	19.4%	69	53.5%	129	100%
Jersey Barrier	45	29.2%	27	17.5%	82	53.2%	154	100%
Hardscape/Brick Median	1	3.3%	5	16.7%	24	80.0%	30	100%
Guard Rail	7	43.8%	3	18.8%	6	37.5%	16	100%
Concrete	5	20.0%	2	8.0%	18	72.0%	25	100%
Total in Dataset	117		96		338		483	

Figure 4 breaks down pedestrian crash outcomes by median type and posted speed limit. The median types that have the most pedestrian involved crashes with posted speeds typical of major arterial roads, freeways and turnpikes (i.e. 50 mph or greater) include Jersey barriers (62%), landscaped or grass medians (58%), and guardrails (56%). These median types are associated with the worst pedestrian crash outcomes when medians are present. The median types that are most associated with pedestrian involved crashes are where the posted speed limit is between 30 and 45 mph. These median types include suicide lanes (64%), hardscape or brick (57%), painted medians (55%), pedestrian refuge islands (44%) and concrete medians (40%) and are usually present on arterial roads. The median types most associated with pedestrian crashes on roads with 25 mph or lower speed limits include concrete medians (36%), painted medians (32%), suicide lanes (26%) and pedestrian refuge islands (23%). The median types most commonly associated with pedestrian involved crashes where speed limits are less than 50 mph were generally associated with the best pedestrian outcomes.

Figure 4. Median Types by Posted Speed Limit



However, none of this explains why outcomes involving guard rails are worse overall than outcomes involving landscaped or grass medians or Jersey barriers. Concrete medians are associated with relatively few serious injuries (8%) but relatively large proportions of fatalities (20%) and pedestrians who escape serious injury or death (72%). The proportion who escape serious injury or death is similar to the median types associated with crashes where speed limits are below 50 mph but the proportion of fatalities is intermediary between landscaped or grass medians and Jersey barriers on the one hand and suicide lanes, painted medians, and pedestrian refuge islands on the other. There appears to be an association between the large proportions of pedestrian involved crashes that occur where posted speed limits are over 50 mph or at or below 25 mph.

Crosswalks

Crosswalks give pedestrians a measure of control at intersections. In New Jersey drivers are required by law to yield to pedestrians at crosswalks. However this requirement did not take effect until 2010 so it is not reflected in our data. Despite this, it is expected that the presence of crosswalks will be protective for pedestrian outcomes in crashes. The crosswalk variable is binary indicating the presence or absence of crosswalks.

Table 10. Outcome by Presence of Crosswalks and Posted Speed Limit

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
No Crosswalks	200	13.2%	267	17.6%	1,049	69.2%	1,516	100%
Crosswalks	59	7.1%	115	13.8%	661	79.2%	835	100%
Total	259	11.0%	382	16.2%	1,710	72.7%	2,351	100%
25 mph or less								
No Crosswalks	26	5.3%	66	13.4%	399	81.3%	491	100%
Crosswalks	15	3.3%	60	13.1%	384	83.7%	459	100%
Total	41	4.3%	126	13.3%	783	82.4%	950	100%
30 to 45 mph								
No Crosswalks	72	11.0%	134	20.4%	451	68.6%	657	100%
Crosswalks	27	10.8%	46	18.3%	178	70.9%	251	100%
Total	99	10.9%	180	19.8%	629	69.3%	908	100%
50 to 65 mph								
No Crosswalks	95	35.7%	55	20.7%	116	43.6%	266	100%
Crosswalks	12	33.3%	4	11.1%	20	55.6%	36	100%
Total	107	35.4%	59	19.5%	136	45.0%	302	100%
Speed Unknown								
No Crosswalks	7	6.9%	12	11.8%	83	81.4%	102	100%
Crosswalks	5	5.6%	5	5.6%	79	88.8%	89	100%
Total	12	6.3%	17	8.9%	162	84.8%	191	100%

Without controlling for posted speed limit, the presence of crosswalks is associated with proportionately fewer fatalities (7% vs. 13%) and fewer serious injuries (14% vs. 18%). However, when controlled for the posted speed limit, there are no significant differences for any of the comparisons except serious injuries at 50-65 mph speed limits. The presence of crosswalks at this speed limit is associated with lower serious injuries (11%) when crosswalks are present compared to when they are not present (21%).

Intersections

Intersections are places where motorists and pedestrians negotiate the right of way and where conflicts occur most often between the two. Because of the potential for conflict, it is likely that more pedestrian crashes occur at intersections than at mid-block locations. However, because of the lower effective speed of vehicles stopping and turning in intersections, crash severity is likely to be lower at intersections than mid-block. The data show that 8% of all crashes result in fatalities when they occur at intersections but 14% of crashes result in fatalities when they occur at mid-block. The difference in fatality rate is the highest for 50-65 mph speed limits, as 24% of the crashes result in fatalities when they occur at intersections but 39% result in fatalities when they occur at mid-block. At this speed limit range, serious injuries are also proportionally less at intersections than at mid-blocks (16% vs. 21%). In sum, the data show that the crashes that occur at intersections are less severe overall on high-speed roads, but the differences are minor for lower-speed roads.

Table 11. Outcome by Presence of an Intersection and Posted Speed Limit

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Total Dataset								
Not at Intersection	172	13.9%	227	18.3%	840	67.8%	1,239	100%
At Intersection	87	7.8%	155	13.9%	870	78.2%	1,112	100%
Total	259	11.0%	382	16.2%	1,710	72.7%	2,351	100%
25 mph or less								
Not at Intersection	15	3.9%	56	14.4%	318	81.7%	389	100%
At Intersection	26	4.6%	70	12.5%	465	82.9%	561	100%
Total	41	4.3%	126	13.3%	783	82.4%	950	100%
30 to 45 mph								
Not at Intersection	61	11.5%	114	21.4%	357	67.1%	532	100%
At Intersection	38	10.1%	66	17.6%	272	72.3%	376	100%
Total	99	10.9%	180	19.8%	629	69.3%	908	100%
50 to 65 mph								
Not at Intersection	90	38.8%	48	20.7%	94	40.5%	232	100%
At Intersection	17	24.3%	11	15.7%	42	60.0%	70	100%
Total	107	35.4%	59	19.5%	136	45.0%	302	100%
Speed Unknown								
Not at Intersection	6	7.0%	9	10.5%	71	82.6%	86	100%
At Intersection	6	5.7%	8	7.6%	91	86.7%	105	100%
Total	12	6.3%	17	8.9%	162	84.8%	191	100%

Land Use

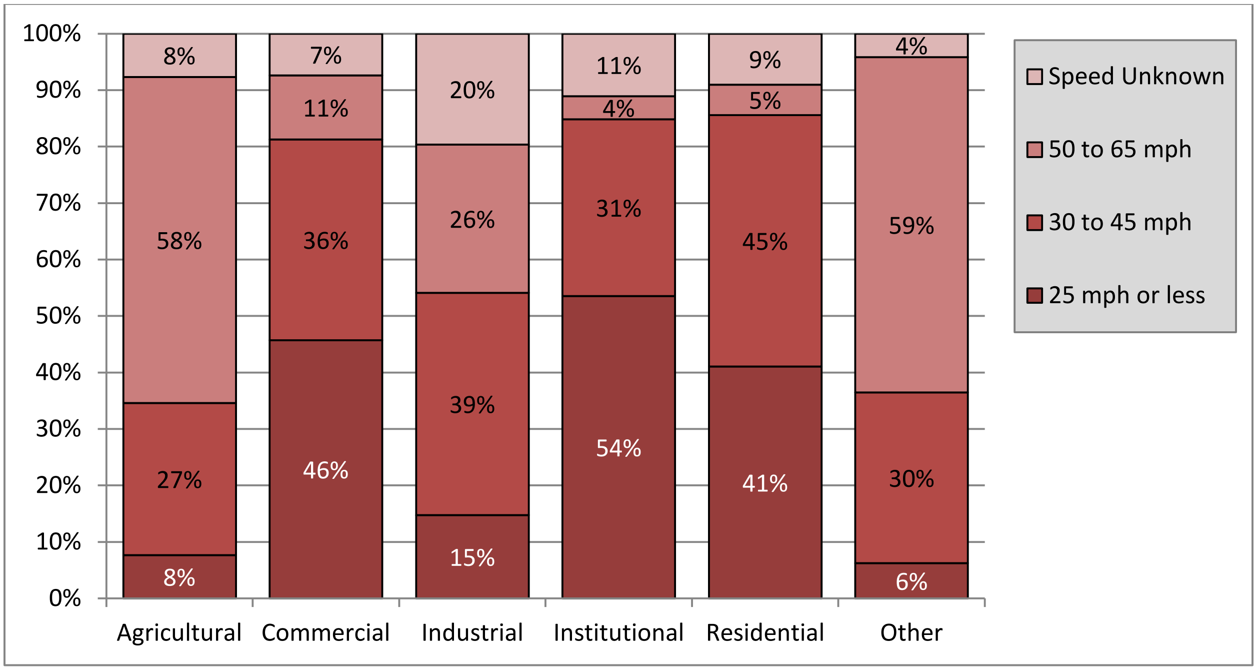
This section compares pedestrian crash outcomes by primary land use classification of the crash location. All comparisons are made with commercial land uses as the reference category. Generally the comparisons of the proportions killed are significant while the serious injury comparisons are not significant. Table 12 shows that the proportion of crashes resulting in fatalities is lowest in areas with institutional land uses (e.g., schools, government buildings, etc.), followed by commercial areas. In contrast, fatality rates are highest for roads with agricultural land uses. Institutional and commercial areas also show a lower rate of serious injuries compared to agricultural use. A potential reason for the differences between land uses in crash severity is that the types of roads (and speed limits) are different in areas with different types of land uses.

Table 12. Outcome by Primary Land Use Classification

	Killed		Serious Injury / Incapacitated		Lesser or No Injury		Total	
Agricultural	14	26.9%	11	21.2%	27	51.9%	52	100%
Commercial	124	8.9%	212	15.3%	1,051	75.8%	1,387	100%
Industrial	15	24.6%	9	14.8%	37	60.7%	61	100%
Institutional	3	3.0%	12	12.1%	84	84.8%	99	100%
Residential	74	10.3%	132	18.3%	515	71.4%	721	100%
Other	31	32.3%	14	14.6%	51	53.1%	96	100%

Figure 5 shows the posted speed limits for the primary land use types. The highest speed limits are found in agricultural areas with 58% of pedestrian involved crashes associated with posted speed limits between 50 and 65 mph and only 8% with posted speed limits of 25 mph or less. The second highest speed limits are found in industrial areas where 26% of pedestrian involved crashes occurred where posted speed limits are between 50 and 65 mph and 15% occurred where posted speed limits are 25 mph or less. The lowest posted speed limits were associated with pedestrian involved crashes that occurred on roads with institutional land uses. Only 4% of crashes occurred where the posted speed limit was between 50 and 65 mph but a majority of pedestrian involved crashes (54%) occurred where posted speed limits were 25 mph or less. The 4% figure for high speed limits is a virtual tie with residential land use (5%). The comparisons of proportions of pedestrian involved crashes that occur where there are low speed limits and high speed limits between commercial and residential land use are inconclusive. The nominal proportions for commercial land use are higher than for both lower and higher speed limits. Even if the differences are statistically significant they offset each other. A conservative approach requires that the rank between both uses for speed limits be declared a tie. Thus, much of the effect of land use on pedestrian involved crash outcomes appears to be due to the speed of traffic, rather than the land use *per se*.

Figure 5. Posted Speed Limit by Primary Land Use Classification



Conclusions

The analysis presented in this report has addressed the impact of road and pedestrian infrastructure on the severity of crash outcomes, specifically whether the outcome is a fatality or serious or incapacitating injury. The key findings are as follows:

1. Speed is the most important factor determining pedestrian crash severity outcomes. Higher posted speed limits are associated with a higher likelihood of fatality and serious injuries. The characteristics of the built environment are less important than speed in influencing crash severity outcomes.

2. Traffic lighting reduces the severity of pedestrian crashes in darkness, especially where speed limits are 25 mph or less and between 30 and 45 mph.

3. When it is dark pedestrian lighting reduces the severity of pedestrian involved crashes where speed limits are between 30 and 45 mph.

4. Sidewalks reduce the severity of pedestrian crashes for all roads, regardless of the speed limit. Sidewalks reduce fatalities far more effectively when they are present on both sides of the road than being present on only one side of the road. However, sidewalks on one side of the road can also be highly effective in reducing overall crash severity, especially when fatalities and serious injuries are combined for evaluation.

5. Buffers between sidewalks and the road do not appear to have much of an impact on crash severity at any range of speed limits. There is a clear correspondence between severity outcomes for specific buffer types, but much of this is likely due to variations in the posted speed limit associated with the use of different types of buffers.

6. Medians are associated with worse pedestrian crash outcomes when the speed limit is less than 50 mph. The difference between outcomes with and without medians is more pronounced when speed limits are less than 25 mph. Like buffers, median types also vary by speed, and therefore some of the difference in crash severity between median types is due to variations in speed.

7. Crosswalks do not appear to be associated with differences in the likelihood of a fatal pedestrian crash outcome at any speed limit. However, crosswalks appear to be effective in reducing serious injury outcomes at high speed limits.

8. Intersection crashes result in less severe outcomes than mid-block crashes. On higher speed roads, mid-block crashes result in substantially more fatalities than pedestrian crashes at intersections.

9. In areas with institutional and commercial land uses, crash outcomes are less severe than other types of land uses. However, the differences are primarily due to variations in speed limits in areas with different types of land uses.

10. Finally, various analyses in the report indicate that some of the observed relationships may have been affected by pedestrian exposure. Unfortunately, data on pedestrian activity is not readily available, so it is not possible to fully control for exposure.