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Research Report

ANALYZING THE IMPACT OF MEDIAN TREATMENTS ON PEDESTRIAN/BICYCLIST SAFETY

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16. Abstract

To improve pedestrian/bicyclist safety, the Maryland Department of Transportation State Highway Administration (MDOT SHA) has identified several high-frequency pedestrian/bicyclist crash locations through the Pedestrian Roadway Safety Audit (PRSA) Program. Recognizing an over-representation of pedestrian crashes related to illegal mid-block crossings, various median treatments have been implemented at target locations. While these countermeasures are generally perceived as effective and beneficial, this study seeks to quantify their impact. The research team applied trend and statistical analyses to assess the effectiveness of installed safety countermeasures. To investigate public opinions on median treatments, on-site surveys of pedestrians, bicyclists, and local businesses were conducted at the identified study locations. Trend analysis showed that median treatments helped reduce rates of various types of crashes at treatment sites, while increased rates were observed at control sites. Statistical analysis showed that median treatments had a significant, positive effect on the reduction total number of crashes and fatalities. Results from the surveys showed that the public believed that treatments were effective at discouraging mid-block crossings. Statistical analysis, trend analysis, and survey results supported the effectiveness of median treatments in decreasing crash rates and saving lives.

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EXECUTIVE SUMMARY

The Maryland Department of Transportation State Highway Administration (MDOT SHA) identified several high-frequency pedestrian/bicyclist crash locations through the Pedestrian Roadway Safety Audit (PRSA) Program. Recognizing an over-representation of pedestrian and bicyclist crashes related to illegal mid-block crossings, various median treatments (e.g., fencing, vegetation planter) and safety enhancement countermeasures were implemented at target locations. While median treatments are generally perceived as effective, this study seeks to quantify their impact and compare the effectiveness of different types of median treatments.

Before and after data were collected at 30 treatment and control sites. Data collected included: vehicle, pedestrian, and bicycle volumes; site geometry; before and after crash counts and severity; and business/community and pedestrian/bicyclist assessment of safety countermeasures. The research team applied trend analysis and statistical analysis to assess the effectiveness of installed countermeasures. The trend analysis focused on the general crash trend. Statistical modeling methods were employed to link bicycle and pedestrian crashes to median treatments and other influencing variables, such as site geometry, traffic volume, truck percentages, pedestrian/bicyclist volumes, traffic control devices, street lighting, and sight distance. The Empirical Bayes methods separated the effect of median treatments from effects of other factors.

To investigate public opinion on median treatments and pedestrian/bicyclist safety, on-site pedestrian and bicyclist surveys were conducted at study locations. The results of these surveys offered valuable insights on (1) pedestrian/cyclist opinions on the existing median treatments; (2) reasons for engaging in illegal mid-block crossing; (3) alternative treatments at the study locations; and (4) other considerations regarding pedestrian/bicyclist safety improvement. The surveys were supplemented with business and community interest group interviews. The results shed light on the socio-demographic factors that may influence attitudes toward the installed median treatments.

Results of the trend analysis showed that treatment sites (where median treatments have been installed) experienced lower or similar crash rates for all crash types after the treatment, while control sites (no median treatments) experience higher crash rates during the same time period. The statistical analysis showed a significant reduction in total crash rates and fatalities because of the treatments. The median treatments installed at the 16 sites have reduced the number of total crashes by 122 (14%), the number of severe crashes by 33 (9%), and the number of fatal crashes by 24 (86%). Survey results showed that more than 50% of pedestrians and bicyclists are likely to cross roads mid-block, but median treatments are effective in discouraging it.

An in-depth examination of high pedestrian/bicyclist crash sites can be the subject of a future study to supplement the PRSA program. Utilizing new technologies to collect pedestrian and bicycle data may also help support the PRSA program and other pedestrian/bicyclist safety programs in Maryland.

1. INTRODUCTION

1.1.Problem Statement

Between 2005 and 2013, pedestrian fatalities constituted 19% of total traffic fatalities in Maryland[1]. Figure 1 shows Pedestrian Fatality Rates between 2005 and 2013. It shows that Maryland fatalities were higher than the U.S. average[1].

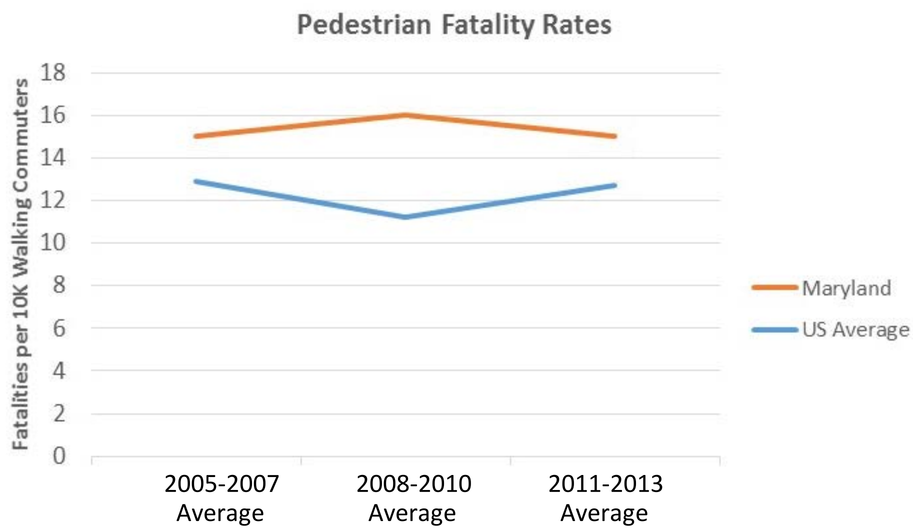

Figure 1 Pedestrian Fatality Rates

Since 2012, the Maryland Department of Transportation State Highway Administration (MDOT SHA) has identified 24 high-frequency pedestrian/bicyclist crash sites through the Pedestrian Roadway Safety Audit (PRSA) Program[2]. Various median treatments, including median fencing, along with other safety-enhancing treatments (sidewalk fencing, median brick planters, and pedestrian islands) were implemented at selected locations over the past 5-10 years; for example, flashing pedestrian signals and median fences were installed near the University of Maryland, College Park campus to reduce bicycle and pedestrian crashes. While these countermeasures are generally perceived as effective, it is valuable to quantify their impact and compare their effectiveness.

1.2.Research Objectives

The study had the following objectives: (1) to conduct a comprehensive scan on the best practices in addressing illegal mid-block crossings and enhancing pedestrian/bicyclist safety; (2) to assemble pedestrian and bicycle safety datasets at locations with recently installed median treatments in Maryland; (3) to apply statistical methods to quantify the effectiveness of installed median treatments; (4) to compare the effectiveness of different types of median treatments; (5)

to investigate human and socio-demographic factors of the illegal mid-block crossing behavior; and (6) to identify methods that can further improve the effectiveness of pedestrian/bicyclist safety countermeasures.

1.3.Research Approach

The study followed a research approach shown in Figure 2.

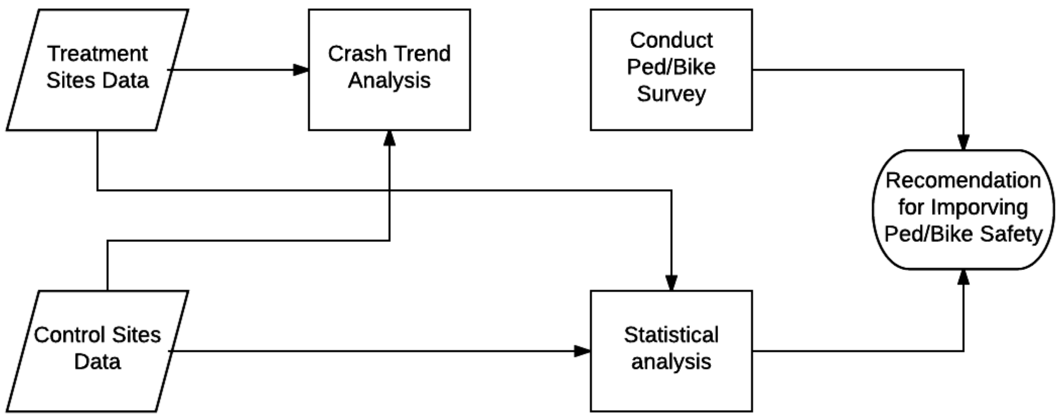

Figure 2: Research Approach Diagram

The approach started with data collection at both treatment and control sites. This data was used in both trend analysis and statistical analysis. A pedestrian/bicyclist survey was conducted at treatment sites to understand the socio/economic factors influencing mid-block crossing and treatment effectiveness. The results of the statistical analysis and findings from the surveys helped evaluate effectiveness of the treatments and provide recommendations for improving pedestrian and bicyclist safety.

2. LITERATURE REVIEW

Median treatments are a popular tool for reducing crashes. While the effect of median treatments might vary on different types of crashes, studies show that they generally have a positive effect on safety. Most median-related studies in the literature pertain to vehicle crashes rather than pedestrian crashes.

Bowman et al.[3] developed a model for estimating the crash counts for both vehicles and pedestrians at median treatment locations. They used a negative binomial approach to estimate the crash counts for three median types, including raised medians, two-way left turn lanes (TWLTL), and undivided cross sections. Parsonson et al. and Gattis et al.[4,5] investigated raised medians and TWLTL types. In general, roadways with raised medians experienced a lower crash rate in comparison with TWLTL.

Many researchers conducted studies on pedestrian behavior and incentives for preventing mid-block crossing. Chu et al.[6] showed that the built environment plays an important role on pedestrian choice for crossing locations. The study also demonstrated that pedestrians are less likely to cross the street illegally when the traffic volume and the crossing distance increase. King et al.[7] showed that the main incentive for illegal mid-block crossing by pedestrians is the potential time savings. Eisele and Frawley[8] investigated the operational and safety effects of median treatments, specifically raised medians and TWLTL cross sections. The results showed that speed, volume, and delays are affected by median treatment installation, and crash rates decreased after the installation.

Before and after studies were conducted to measure the safety effectiveness of various treatments. In these studies, statistics during before and after periods were compared, such as crash counts[9]. The main weakness of these methods is that they neglected other factors affecting crashes that might vary between before and after periods. The effectiveness measures might be inaccurately reported without controlling for these factors. Another deficiency is the fact that they are prone to regression-to-mean bias. To control the bias, the data needs to be collected for a longer period; however, many variables, such as road conditions, traffic volume, and weather conditions may change over time. Therefore, statistical modeling is required to control for these variables.

Generalized linear models (GLM)[10] can be used for that purpose. GLM has many applications in various fields, but applying it to crash modeling needs a special consideration: the crash count is always a non-negative integer. Poisson and negative binomial models are specific types of GLM that generally work well with non-negative integers. Poisson models assume the equality of mean and variance. Studies showed that crash counts are over-dispersed, i.e., variance is generally bigger than mean. Negative binomial models are a more favorable choice when modeling crash counts[11,12].

The Empirical Bayes (EB) method was used recently for safety studies. The method considers crash data both observed at a site and predicted by its safety performance function (SPF). Hauer[9] showed that the best way to model crash counts is by using a multivariate statistical model. Annual Average Daily Traffic (AADT) and geometric features of the roadway are usually used for estimating the SPF. Persaud et al.[13] investigated the effectiveness of roundabouts on reducing crashes by applying the EB method. Fitzpatrick and Park[14] conducted a study for the Federal Highway Administration (FHWA) to measure the effectiveness of the HAWK (High intensity Activated crossWalK) signal on reducing pedestrian crashes. This study used the EB method for several crash types and helped distinguish the treatment effects on different types of crashes.

3. STUDY LOCATIONS AND STUDY PERIOD

3.1. Treatment Sites

The MDOT SHA identified 24 critical high-frequency pedestrian/bicyclist crash locations through the PRSA program. In 18 of these locations, some type of median treatment (fencing, brick planters, pedestrian islands, etc.) was installed. Table 1 summarizes the treatment site information. Sample street views of the median treatment types are available in Appendix B.

Table 1: Treatment Site Information

ID #	District	County	Route	Limit 1	Limit 2	Treatment	Installation Date	Included in Study
1	3	Prince Georges	US 1	Hartwick Road	Knox Road	Median Fencing	Summer 2014	Yes
2	3	Prince Georges	MD 193	MD 650	1st signal to east	Median Fencing	Summer 2010 (approximate)	Yes
3	3	Prince Georges	MD 650	MD 193	1st signal to south	Median Fencing	Summer 2010 (approximate)	Yes
4	3	Prince Georges	MD 201	Riverdale Road	Edmonston Road	Sloped Median Planter	Summer 2007 (approximate)	Yes
5	3	Prince Georges	MD 410	Belcrest Road	PG Plaza Entrance	Median Fencing	Summer 2007 (approximate)	Yes
6	7	Frederick	US 40	Waverly Drive	Willowdale Drive	Median Fencing	Spring 2011	Yes
7	7	Frederick	US 40	Willowdale Drive	Hoke Place	Large Landscaped Median	Done in phases since Summer 2005	Yes
8	3	Montgomery	MD 355	MD 410	MD 191	Sloped Median Planter	2003	Yes
9	3	Montgomery	US 29 NB	MD 410	Wayne Avenue	Sidewalk Planters	Fall 2013	Yes
10	3	Montgomery	MD 650	Lockwood Drive	1st entr. to south	Median Fencing	2005	Yes
11	1	Worcester	MD 528	13th Street	21st Street	Median Planters	Completed Summer 2014	Yes
12	4	Harford	US 40	Joppa Farm Road	Joppa Road	Raised Brick Planters	Completed in 2005	Yes
13	4	Harford	US 40	MD 152	MD 24 Overpass	Raised Brick Planters	Completed in 2009	Yes
14	4	Baltimore	MD 26	Baltimore City line	Brenbrook Drive	TWLTL	December 2007	No

15	4	Baltimore	MD 26	Courtleigh Drive	Washington Avenue	TWLTL	March 2002	No
16	4	Baltimore	US 40	Rolling Road	Shopping Entrance	Rounded Median	May 2001	Yes
17	5	Anne Arundel	MD 648E	Cromwell Light Rail	Shopping Entrance	Sidewalk Fencing	2005	Yes
18	5	Anne Arundel	MD 2	Orchard Road	Ordnance Road	Signing/Pave. Markings	February 2016	Yes

Sites 14 and 15 were not selected in this study because the TWLTL treatment at these sites was not preventing mid-block crossing. Therefore, 16 treatment sites were selected for this study. Information about median condition before the median treatment installation was obtained from archived aerial photos. Appendix B includes some sample aerial photos and Table 2 summarizes this information. It should be noted that for the sites marked with an asterisk the median treatments were installed before 2007, and the before information might not be accurate due to difficulty in extracting information from low-resolution photos.

Table 2: Before/After Treatment Median Condition from Aerial Photos

ID	Current Median Type	Previous Treatment Type
1	Fencing	Median without Fence
2	Fencing	Concrete Median without Fence
3	Fencing	Concrete Median without Fence
4	Sloped Median Planter	Median without Planter
5	Fencing	Median without Fence
6	Fencing	Median without Fence
7*	Large Landscaped Median	Narrow median with concrete
8*	Sloped Median Planter	Narrow median with concrete
9	Sidewalk Planters	Narrow median with concrete
10*	Fencing	Median without Fence
11	Planter	Concrete Median
12*	Raised Brick Planters	Low Grassy Median
13	Raised Brick Planters	Low Concrete Median
16*	Rounded Median	Narrow median with concrete
17*	Sidewalk Fencing	No Median or Fencing
18	Signing/Pave. Markings	Grass/Concrete Median without Added Signage

3.2. Control Sites

An observed trend at treatment sites might not be solely attributed to the median treatments, so control sites were selected and observed to provide a benchmarking safety trend. In this study, control sites immediately upstream or downstream of the corresponding treatment sites were identified, assuming socio-economic factors related to neighborhoods and traffic conditions, such as AADT and speed, which are very similar between each treatment site and its corresponding control site. Table 3 summarizes the control site information.

Table 3: Corresponding Control Site for Each Treatment Site

ID #	District	County	Route	Limit 1	Limit 2	Median Condition
1	3	Prince Georges	US 1	Jefferson Road	MD 410	None
2	3	Prince Georges	MD 193	I-495	Timberwood Avenue	Median Planter
3	3	Prince Georges	MD 650	Ethan Allen Road	Ray Road	Median Planter/ Concrete Lane Dividers
4	3	Prince Georges	MD 201	Upshire Street	Buchanan Street	Concreate Lane Divider
5	3	Prince Georges	MD 410	Editors Park Drive.	23rd Avenue	Grass Median/Concrete Lane Divider
6	7	Frederick	US 40	Old Camp Road	Rock Creek Drive	Grass Median
7	7	Frederick	US 40	Same as 6		
8	3	Montgomery	MD 355	Middleton Lane	Rosedale Avenue	Brick Median with Landscaping
9	3	Montgomery	US 29 NB	Georgia Avenue	Spring Street	None
10	3	Montgomery	MD 650	Powder Mill Road	I-495	Grass/Brick/Concrete Lane Divider
11	1	Worcester	MD 528	28th Street	34th Street	Brick lane Divider
12	4	Harford	US 40	Mohrs Lane	Middle River Road	Jersey Barrier
13	4	Harford	US 40	Same as 12		
16	4	Baltimore	US 40	Geipe Road	Nuwood Drive	Grass Median
17	5	Anne Arundel	MD 3	Georgia Avenue NW	Post 40 Road	None
18	5	Anne Arundel	MD 2	Holsum Way	Ordnance Road	Concrete Lane Divider

Sites 6 and 7 are on the same road within close proximity to each other, and they share a control site. Sites 12 and 13 also share a control site. In total, 14 control sites were selected for this study. Figure 3 shows the location of all treatment and control sites on the map.

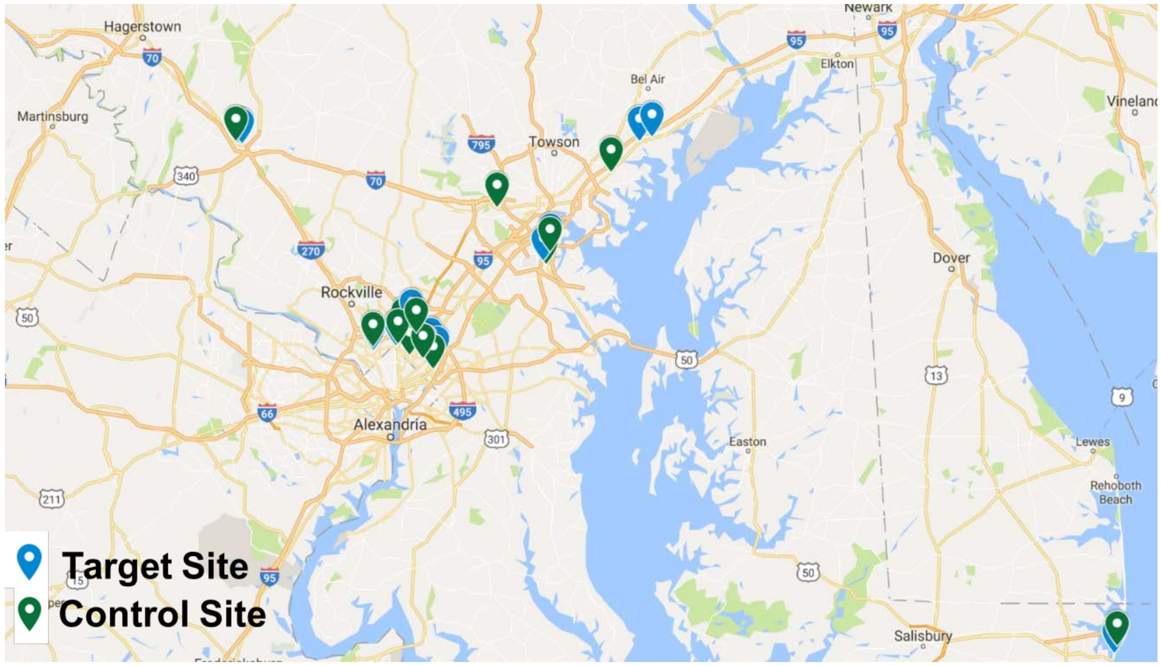

Figure 3: Location of Treatment and Control Sites

3.3.Study Period

The study period was three years before and three years after the median treatment installation at each site. For sites with an installation date before 2013, the after period was shorter than three years. This difference in the length of after periods was considered in the analysis.

4. DATA

Crash data, AADT, pedestrian/bicyclist counts, and design characteristics were among the datasets that had to be collected. This section describes these datasets and their sources in detail.

4.1. Crash Data

Safety improvement can be defined in terms of crash frequency or crash severity. An effective treatment should reduce crash frequency, decrease average crash severity, or a combination of both. Crash data for three years before the installation and each year after the installation was requested from MDOT SHA. Two separate datasets were provided for each site, one with the detailed information of total crashes, and one with the detailed information of pedestrian/bicyclist crashes. Each crash record has detailed information regarding time, location, severity, etc. This study focused on four different crash statistics:

- *Total Crashes:* Total crashes include total crashes regardless if they involved a pedestrian.
- *Severe Crashes:* Severe crashes are total crashes with injuries, including fatal crashes. It was obtained by removing property damage-only crashes from total crashes.
- *Pedestrian/Bicyclist Crashes:* Pedestrian/bicyclist crashes are total crashes involving a pedestrian or bicyclist.
- *Pedestrian/Bicyclist Fatal Crashes:* Pedestrian/bicyclist fatal crashes are all pedestrian/bicyclist crashes that resulted in a pedestrian or bicyclist death.

Table 4 includes crash counts for both before and after periods. Site 17 is not shown because crash counts were zero both before and after the treatment for all crash types. Site 18 is also not shown because the installation date was 2016 and no after period data existed. “T” sites are the target sites, and “C” sites are the corresponding control sites.

Table 5 shows the percent change information. Details of the trend in before-after data is presented in the trend analysis section.

Table 4: Crash Counts for Each Crash Type Before and After the Treatment

Site	Total crashes		Severe Crashes		Ped/Bike Crashes		Fatal Ped/Bike Crashes	
	before	after	before	after	before	after	before	after
T1	45.04	34.56	21.91	19.75	15.82	12.34	2.43	2.47
T2	33.28	27.69	6.66	2.60	0.83	0.00	0.00	0.00
T3	49.13	44.32	17.49	17.73	1.67	5.64	0.00	0.00
T4	140.43	109.81	43.14	32.85	9.31	5.63	0.85	0.94
T5	45.97	64.40	20.04	21.47	3.54	6.31	0.00	0.00
T6	42.24	31.98	27.70	19.47	0.69	4.17	0.00	0.70
T7	51.16	47.19	36.38	34.21	2.27	1.18	0.00	0.00
T8	51.85	69.61	23.61	36.96	4.62	6.16	0.00	0.00
T9	22.23	27.96	2.67	9.32	0.00	1.86	0.00	0.00
T10	42.32	13.69	13.69	6.85	0.00	1.24	0.62	0.62
T11	65.88	59.47	32.94	29.73	5.07	13.72	2.53	0.00
T12	86.14	48.69	53.68	19.98	1.25	0.00	0.00	0.00
T13	178.20	140.25	80.77	74.55	1.28	3.79	0.00	0.00
T16	26.85	29.29	10.37	12.20	3.05	1.22	0.00	0.00
C1	121.37	141.90	27.53	32.57	10.01	0.00	0.00	0.00
C2	102.18	118.46	43.43	50.15	4.26	3.46	0.85	1.73
C3	291.02	235.81	95.33	101.53	15.05	13.92	1.67	0.00
C4	12.92	15.12	5.84	7.08	1.54	1.93	0.00	0.32
C5	115.02	153.95	42.51	57.56	7.50	8.03	0.00	0.00
C6	29.64	22.40	18.86	8.96	2.69	1.49	0.00	0.00
C7	18.46	14.80	10.77	8.22	0.00	1.64	0.00	0.00
C8	54.01	53.51	21.25	22.03	2.66	3.15	0.00	0.00
C9	43.29	41.14	15.19	5.88	1.52	1.18	0.00	1.18
C10	29.64	35.73	13.11	14.52	1.14	4.47	0.00	0.00
C11	82.86	92.76	46.45	54.30	16.32	13.57	0.00	0.00
C12	68.52	49.55	29.52	21.08	2.11	0.00	0.00	2.11
C13	50.03	53.66	21.29	27.90	0.00	3.22	0.00	1.07
C16	59.63	78.95	26.87	31.91	0.84	1.68	0.00	0.00

Table 5: Percent Change in Crash Counts After the Treatment for Each Crash Type

Site	Total crashes	Severe Crashes	Ped/Bike Crashes	Fatal Ped/Bike Crashes	Site	Total crashes	Severe Crashes	Ped/Bike Crashes	Fatal Ped/Bike Crashes
T1	-10.48	-2.16	-3.48	0.034	**C1**	20.53	5.04	-10.01	0.000
T2	-5.59	-4.06	-0.83	0.000	**C2**	16.28	6.72	-0.80	0.878
T3	-4.81	0.24	3.98	0.000	**C3**	-55.20	6.20	-1.13	-1.673
T4	-30.62	-10.29	-3.67	0.093	**C4**	2.20	1.23	0.39	0.322
T5	18.43	1.43	2.78	0.000	**C5**	38.93	15.06	0.53	0.000
T6	-10.26	-8.23	3.48	0.695	**C6**	-7.24	-9.90	-1.20	0.000
T7	-3.97	-2.17	-1.09	0.000	**C7**	-3.66	-2.55	1.64	0.000
T8	17.77	13.35	1.54	0.000	**C8**	-0.50	0.78	0.49	0.000
T9	5.73	6.65	1.86	0.000	**C9**	-2.16	-9.31	-0.34	1.175
T10	-28.63	-6.85	1.24	0.000	**C10**	6.09	1.41	3.33	0.000
T11	-6.41	-3.20	8.66	-2.534	**C11**	9.90	7.85	-2.75	0.000
T12	-37.45	-33.71	-1.25	0.000	**C12**	-18.97	-8.43	-2.11	2.108
T13	-37.95	-6.22	2.51	0.000	**C13**	3.63	6.61	3.22	1.073
T14	2.44	1.83	-1.83	0.000	**C14**	19.32	5.04	0.84	0.000

4.2. AADT

Crashes involve motor vehicles, and traffic volume is an exposure measure that correlates to crash counts. AADT for a road segment at a specific year is defined as the total number of vehicles passing through the segment within the year divided by 365 (number of days in a year).

AADT data for year 2006 and after was obtained from the MDOT SHA website. Highway Performance Monitoring System (HPMS) dataset was used to extract AADT data for years prior to 2006. The HPMS dataset also contained detailed information of road segments, in addition to AADT.

4.3.Pedestrian/Bicyclist Counts

Each pedestrian/bicyclist crash involves at least one pedestrian/bicyclist, and the number of pedestrians/bicyclists using a roadway segment is an exposure measure that correlates to pedestrian/bicyclist crash counts. Many agencies collect vehicle counts, but unfortunately pedestrian/bicyclist count data is rarely available.

In this study, no pedestrian/bicyclist count was available. A team of students was hired to visit each treatment and control site and count the number of pedestrian/bicyclists and observed illegal pedestrian/bicyclist crossings. The counting was conducted over three weeks from

Tuesday to Thursday in September and October of 2016. The team collected data for a minimum of two hours at each site. These counts were converted into average annual counts. The National Bicycle and Pedestrian Documentation Project [15] findings were used to convert hourly pedestrian/bicyclist counts to daily and annual counts. This conversion was done using hourly, weekly, and monthly adjustment factors.

4.4.Geometric Design Data

A review of literature shows that geometric design has significant influence on crashes. Information such as the number of lanes, lane width, and speed limit is required in the development of safety performance functions (SPF). The Empirical Bayes method used in this study predicts the number of crashes using SPFs.

Geometric design data such as the number of lanes, lane width, speed limit, and the distance to transit stations was collected during the site visits.

5. PEDESTRIAN/BICYCLIST SURVEY

Surveys reveal public opinion about the success of treatments and socio-economic factors impacting mid-block crossing. The research team designed three different surveys for pedestrians, bicyclists, and local business owners (see Appendix A), and conducted the surveys at all treatment sites during September and October of 2016. Pedestrians and bicyclists passing through the segment with median treatment installation were surveyed about their socio-demographics, opinion about the success of the treatment, and suggestions for further improvements.

5.1.Pedestrian/Bicyclist Surveys

A total of 63 responses from pedestrians/bicyclists were collected. The surveys include questions about age, gender, and other socio-demographic characteristics of the pedestrian/bicyclist. Pedestrians/bicyclists were asked about the type of improvement they would like to see along the route they were walking/biking. Figure 4 summarizes their answers.

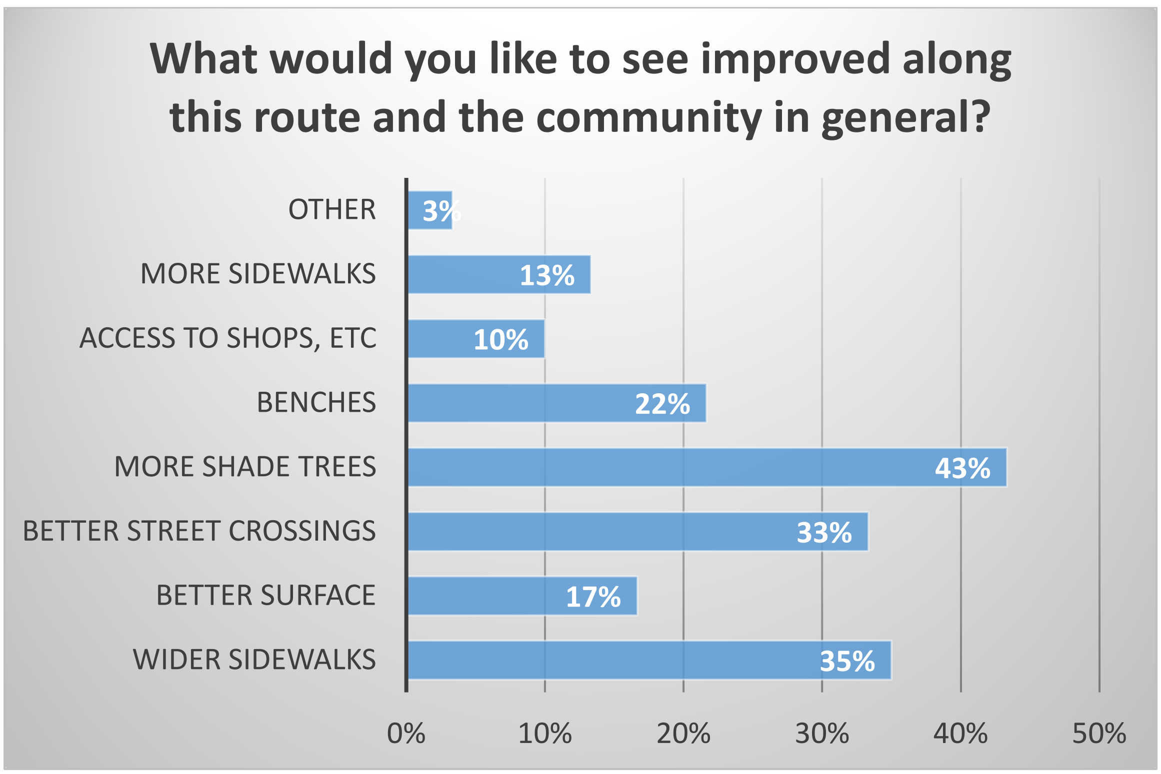

Figure 4: Pedestrian/Bicyclist Opinion about Their Desired Improvement

The results show that wider sidewalks, better street crossings, and more shade trees were the most desired types of improvements. Another important question was related to the most desired type of median treatment. Figure 5 summarizes the answers.

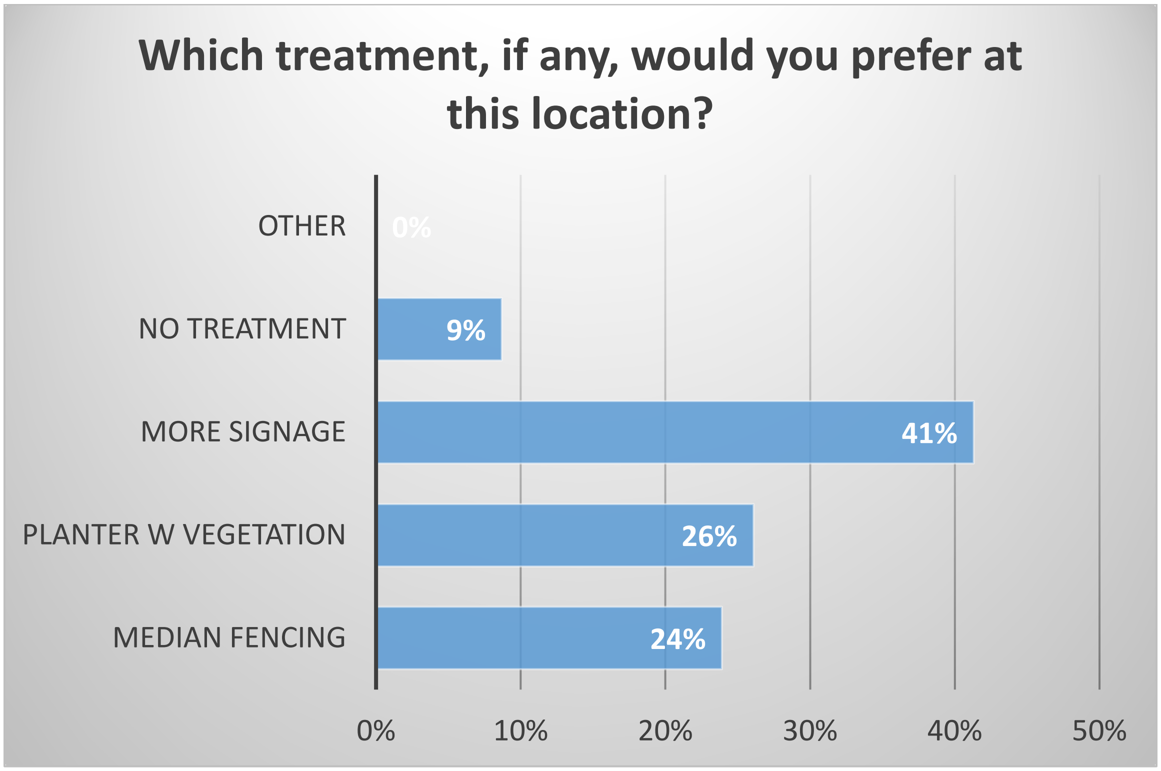

Figure 5: Desired Type of Median Treatment

The results show that pedestrians/bicyclists prefer some type of treatment over no treatment, but they prefer less restrictive types of treatments. One of the most important questions was about the success of current treatments at each site. The results categorized by treatment type are shown in Figure 6.

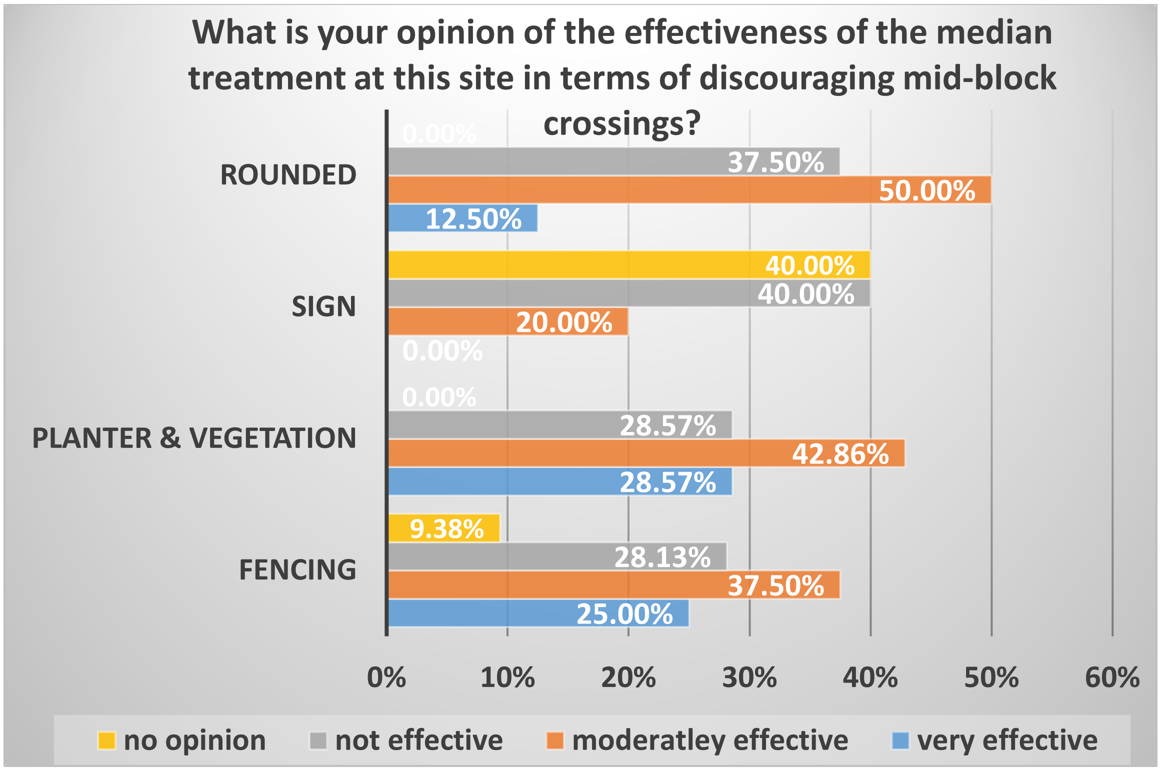

Figure 6: Opinions about Effectiveness of Median Treatment at Each Site

The results show that for all treatment types, more than half of pedestrians/bicyclists think that the treatment is at least moderately effective. Signage has the highest percentage of non-effectiveness, even though it was selected as the most preferred type of treatment in the previous question. Two additional questions were related to mid-block crossings. One asked if the pedestrian/bicyclist is likely to engage in mid-block crossing, and the other asked about the factors influencing mid-block crossing. A summary of the answers can be seen in Figure 7 and Figure 8.

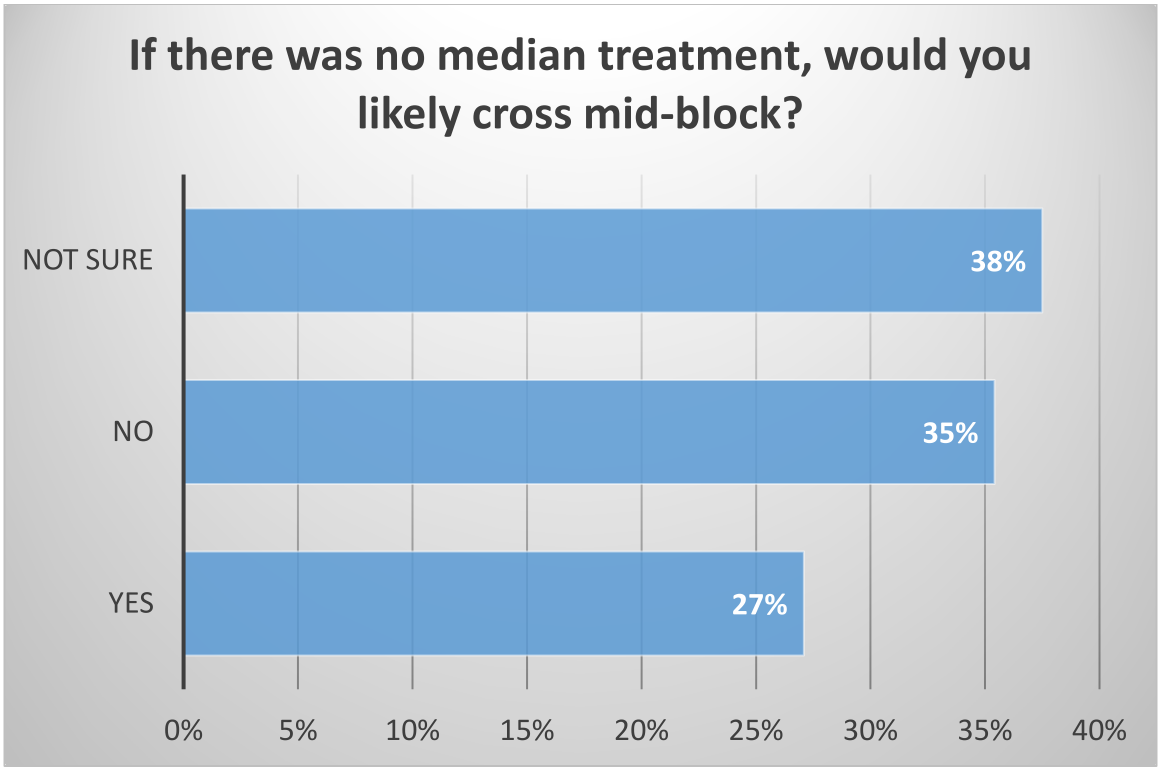

Figure 7: Likeliness of Mid-Block Crossing

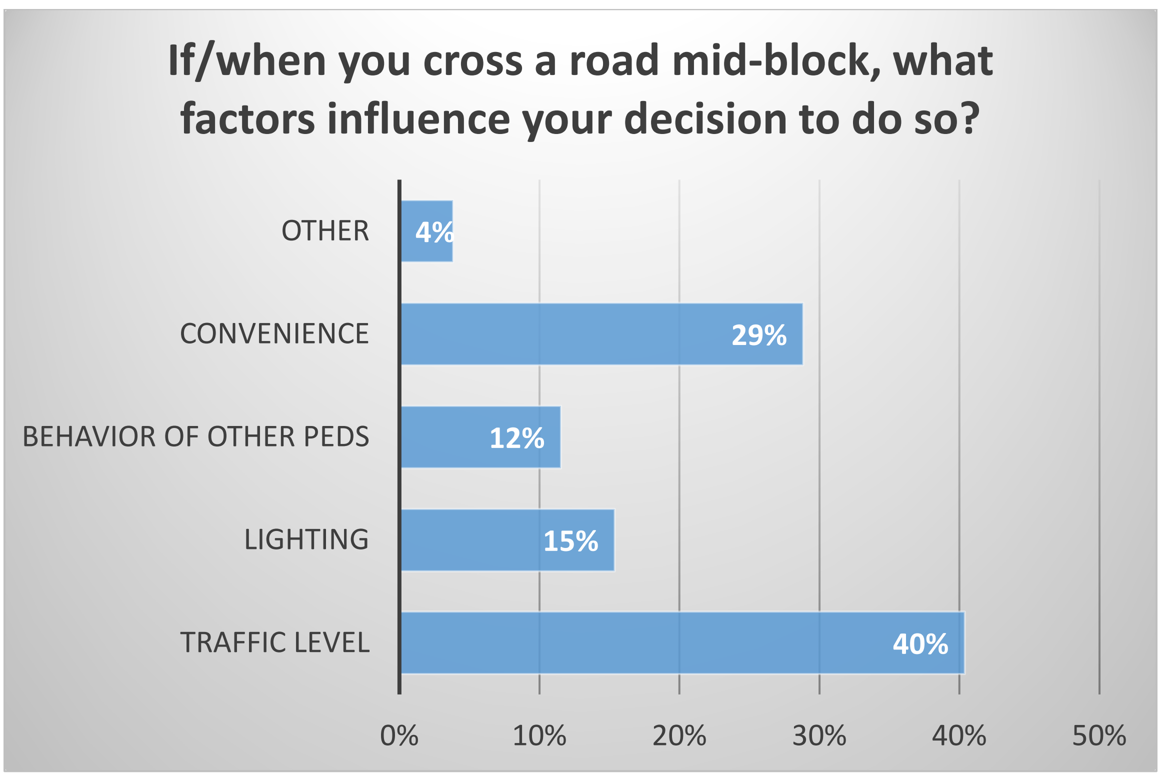

Figure 8: Factors Influencing Mid-Block Crossing

Figure 7 shows that only about 35% of pedestrians/cyclists were sure that they would not cross mid-block. This shows the widespread mid-block crossing behavior among pedestrians/bicyclists, and highlights the importance of discouraging such behaviors by either a treatment installation or education. Figure 8 shows that the main factors influencing the mid-block crossing are traffic level and convenience. Gaker et. al [16] focused on social influences and named the behavior of others as one of the most important factors influencing mid-block crossings. Figure 8 shows a contradicting result that these pedestrians/bicyclists are either not affected by others, or unaware of the significance of others' behavior impact.

5.2. Local Business Surveys

In addition to pedestrians/bicyclists, local business owners were surveyed by the research team about the effectiveness of the median treatment and the impacts on their businesses. Fifteen responses were collected in total. Local businesses were asked if they think their neighborhood has pedestrian/bicyclist problems. Figure 9 summarizes their answers. Less than 50% of local businesses think that their neighborhood is safe for pedestrians/bicyclists.

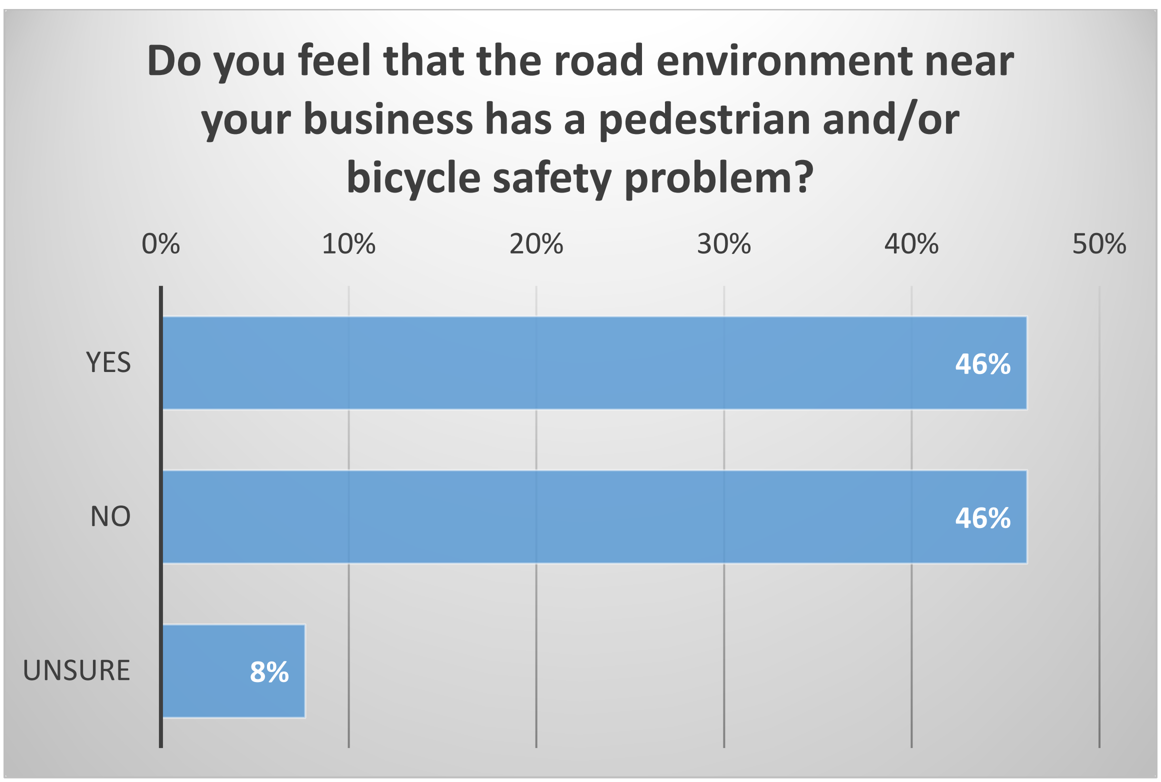

Figure 9: Local Businesses Opinion about Ped/Bike Safety Problems

They were also asked if they observe illegal mid-block crossings near their business. Figure 9 summarizes the answers:

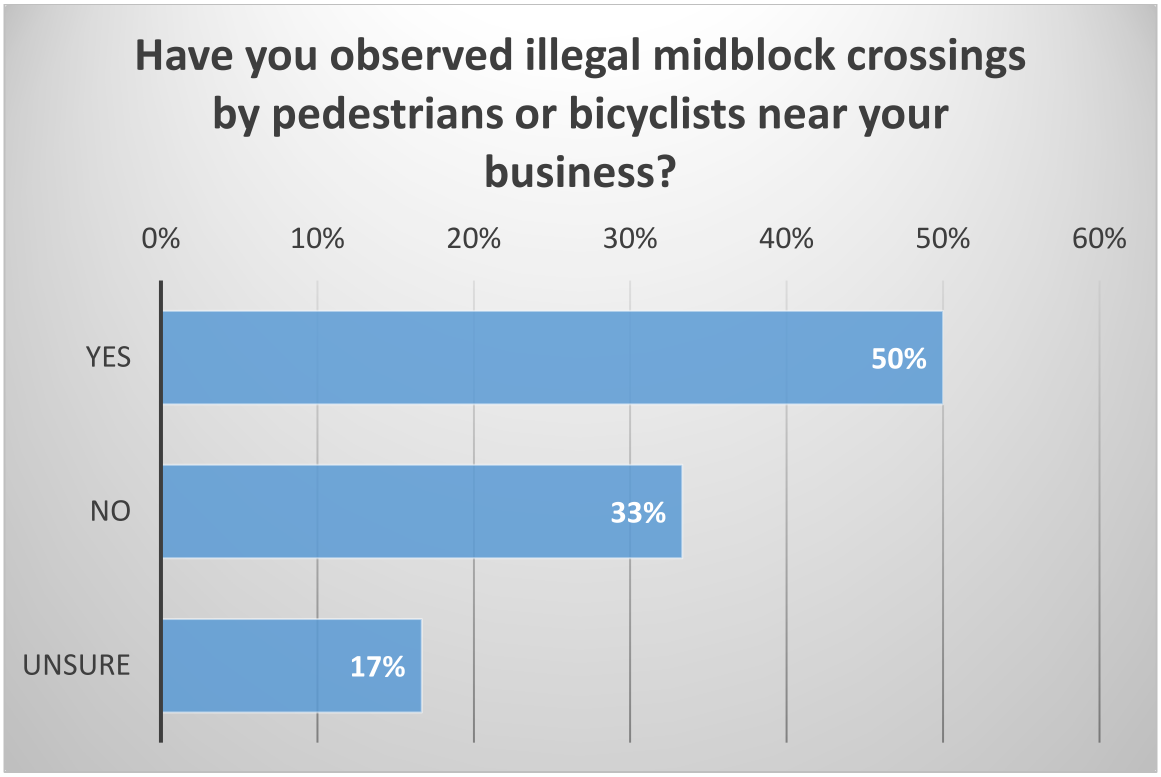

Figure 10: Local Businesses Answers about Observing Mid-Block Crossing

About 50% of businesses have observed nearby mid-block crossings. Similar to pedestrian/bicyclist responses, businesses' responses confirm the widespread mid-block crossing behavior and the importance of discouraging it. In another question, they were asked if they think the median treatment has an impact on pedestrian/bicyclist traffic. Figure 11 summarizes the responses.

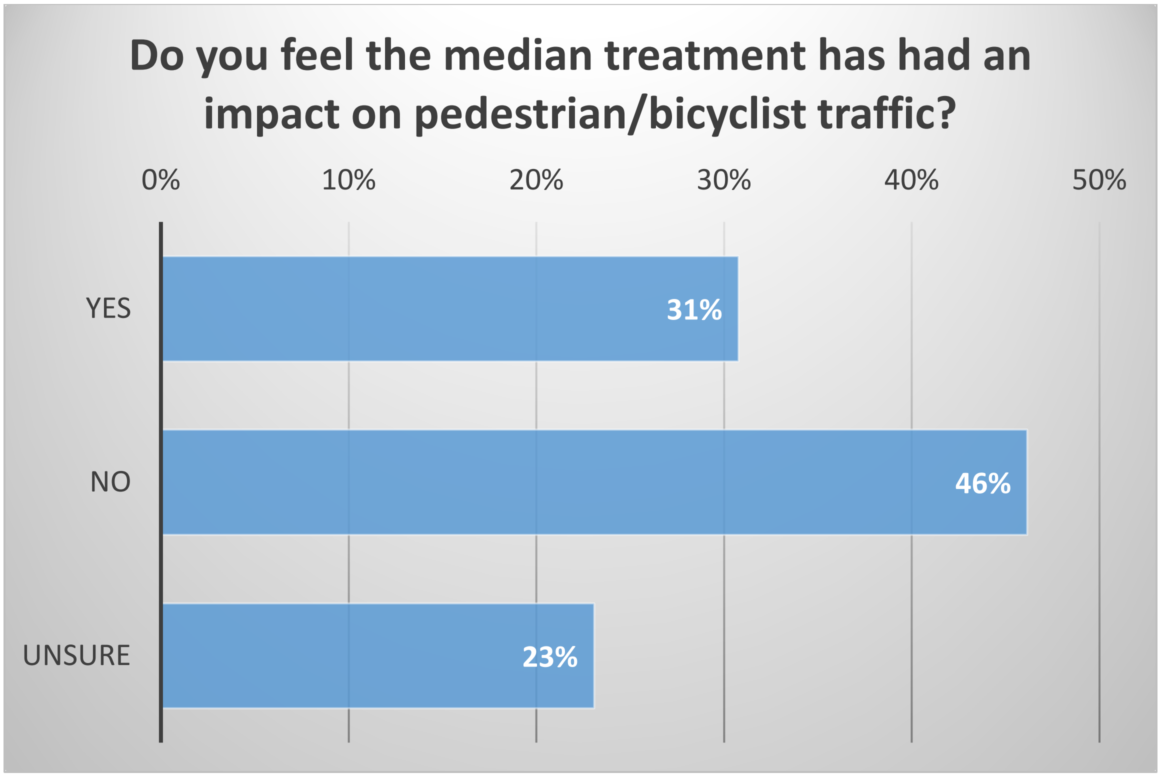

Figure 11: Local Businesses' Opinion about Impact of Median Treatment on Ped/Bike Traffic

Only 30% of businesses think that the median treatment has changed pedestrian/bicyclist traffic. They were also asked about the effectiveness of the median treatment in discouraging mid-block crossings, the same question that was asked of pedestrians/bicyclists. Figure 12 presents the responses.

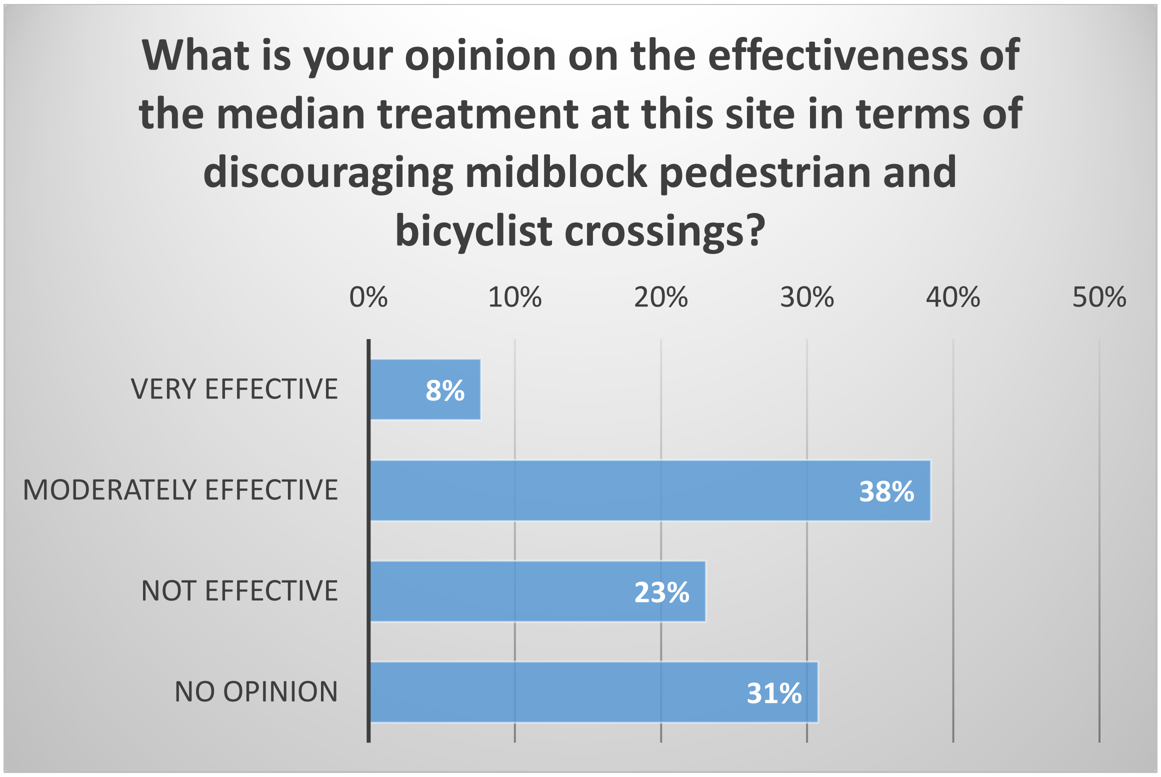

Figure 12: Local Businesses Opinion about Effectiveness of Median Treatments

Less than 25% of local businesses think that the treatments were not effective and more than 45% of local businesses agree that the treatments were effective in discouraging mid-block crossing. Local businesses know the neighborhood and their positive opinion about median treatments offers a good insight that treatments are effective.

6. TREND ANALYSIS

A trend analysis was conducted to demonstrate how the treatments changed the before/after crash trends. Figures 13 through 16 show the before/after trends for four crash statistics. The data for control and treatment sites were aggregated for before and after periods. Site 18 was excluded from the analysis because no data was available for the after period (installation date was February 2016). The aggregate number of crashes was normalized per 100,000 total AADT (simple sum of vehicular AADT and pedestrian/bicyclist counts) and the total number of before or after years.

Many factors could potentially vary from the before period to the after period, which can affect the number of crashes. A decreasing number of crashes may be the result of other factors rather than the treatment. Here a general trend is shown to see what the aggregate data looks like and a statistical analysis is implemented in the next section to single out the impact of median treatments.

Figure 13 depicts the trend of total crashes. There is a 13% decrease in total crashes for treatment sites and a 13% increase for control sites. The numbers on the bars show the normalized crash counts. For treatment sites, there were 4.5 crashes per year per 100,000 total AADT before the installation of treatments, and this number was reduced to 3.9 crashes per year per 100,000 total AADT after the installation. The larger number of crashes at control sites shows that the road was experiencing an increased crash trend. A decreasing trend at treatment sites highlights the effectiveness of the treatments. An improved median makes the road safer for both drivers (fewer distractions) and pedestrians/bicyclists (safer crossing).

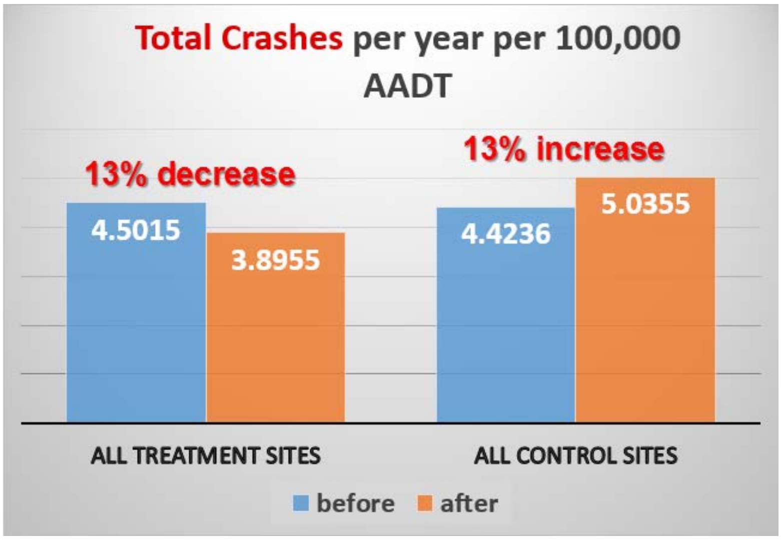

Figure 13: Normalized Total Crash Trend

Figure 14 shows the trend for severe crashes. A similar trend of total crashes was observed and the same explanation applies. There was an 11% increase in severe crashes at control sites, whereas there was a 10% decrease at treatments sites.

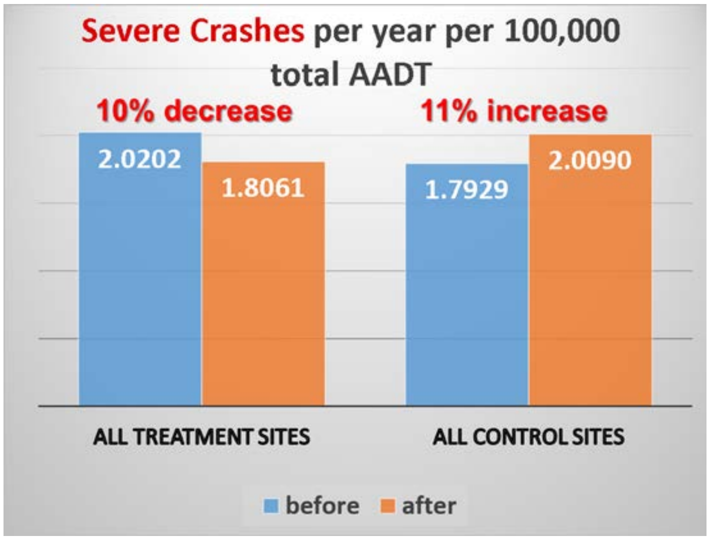

Figure 14: Normalized Severe Crash Trend

Figure 15 shows pedestrian/bicyclist crash trends. Even though the average crash count remained the same at treatment sites, an increasing trend at control sites suggests a positive effect of median treatments on preventing an uptick in crashes.

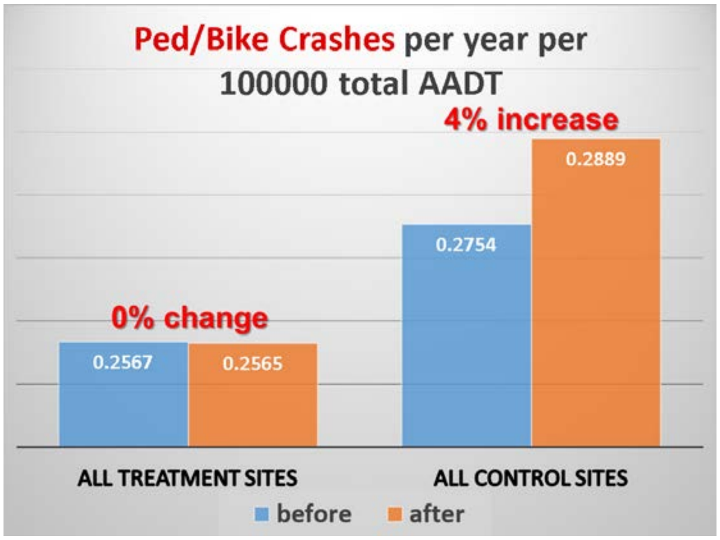

Figure 15: Normalized Ped/Bike Crash Trend

Figure 16 shows the fatal pedestrian/bicyclist crash trend. The counts are about 1% of total crashes, a very small portion of total crashes. The trend strongly suggests that the median treatments are preventing fatal crashes. A **460% increase** occurs for fatal crashes in control sites, whereas a minor decrease is seen in treatment sites. If a statistical analysis confirms the trend, it suggests that median treatments could be an effective tool for preventing fatal crashes and saving lives. Due to drivers' faster speeds between intersections, mid-block crashes are more likely to be severe or fatal for pedestrians/bicyclists. If median treatments can successfully discourage mid-block crossings, fewer fatal pedestrian/bicyclist crashes occur.

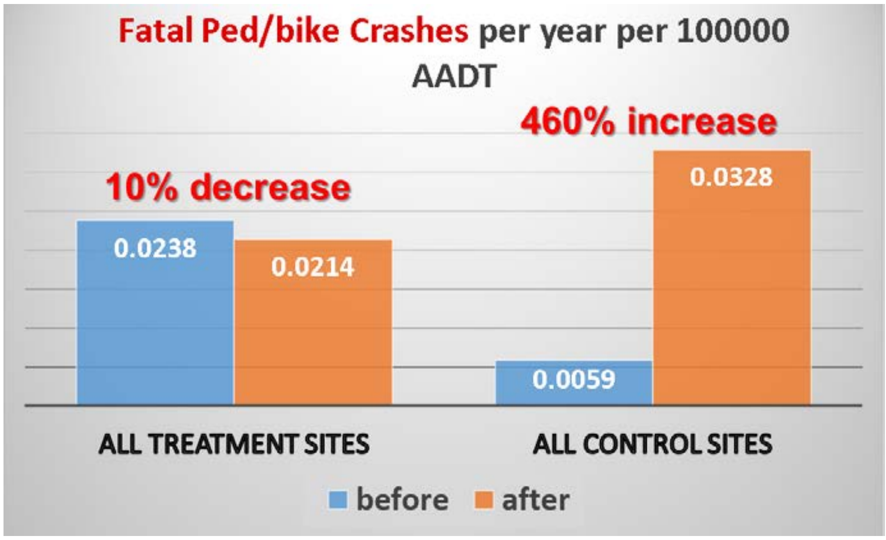

Figure 16: Normalized Fatal Ped/Bike Crash Trend

Nonetheless, the trends are not sufficient for making any conclusion about the effectiveness of the treatments. Other factors might contribute to the trend. A statistical analysis is required to remove the effects of other factors. The statistical analysis results can be found in the next section.

7. STATISTICAL ANALYSIS

The purpose of the statistical analysis is to separate the effect of median treatments from the effect of other influencing factors. The Empirical Bayes (EB) method was found to be the most appropriate method for a before/after treatment effectiveness analysis, especially when the sample size is small. Section 7.1 describes the EB method and section 7.2 presents the results of the statistical analysis.

7.1.Empirical Bayes Model

The EB method estimates the expected number of crashes at a treatment site had the treatment not been installed, and compares the number with the actual observed number of crashes. This comparison shows the effectiveness of the treatment if the actual observed number of crashes is smaller than the expected number of crashes had the treatment not been installed. The expected number of crashes was obtained by developing a safety performance function (SPF), using data from the control sites. SPF development is a type of regression modeling to predict the number of crashes. SPFs are widely used in safety studies. Figure 17 describes the steps of the EB method.

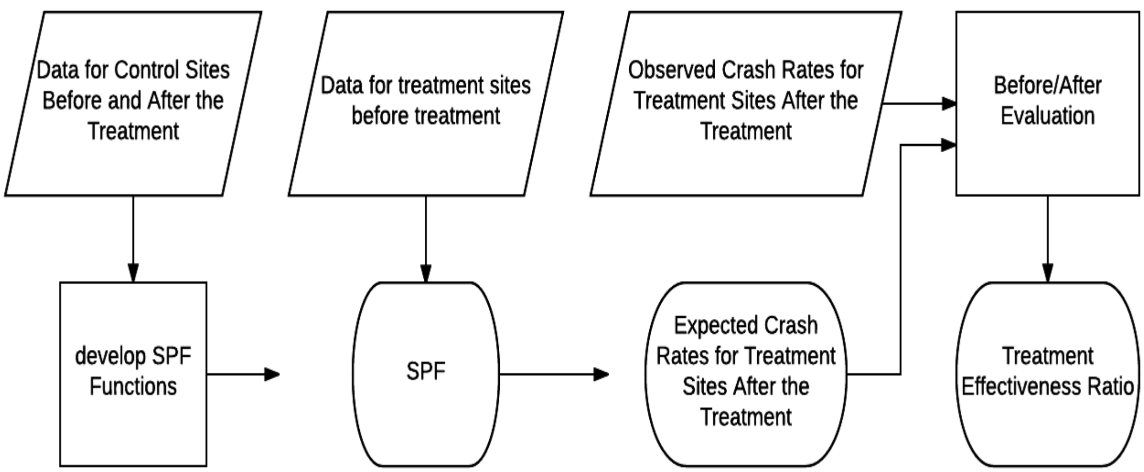

Figure 17: Empirical Bayes Method Steps

The first step is to use the control sites' data to develop SPFs. The dependent variable in SPF is the expected number of crashes. SPF development is usually done using generalized linear models (GLM). Poisson models are the most widely used models for this purpose. As discussed in Section 2, a negative binomial model is a better choice for SPF development as it fits the integer nature of crash counts and relaxes the equality of mean and variance assumption. The model estimation process included the simultaneous estimation of coefficients and over-dispersion parameters. Independent variables for estimating the expected number of crashes can be any known relevant variable. AADT, pedestrian counts, pedestrian illegal crossings, bicycle counts, bicyclist illegal crossings, speed limit, number of lanes, lane width, and near-bars location were selected as the independent variables used for this study. The SPF estimates are per-day crash frequency with number of days used as an offset variable. Expected number of crashes for the entire before-after period can be obtained by multiplying the expected number of crashes per day by the number of days in the period.

Once SPF development is completed, before-treatment data from treatment sites can be inserted into SPF to obtain the expected number of crashes before treatment installations. For each site *i*, the observed before-treatment crashes were combined with the expected crashes using Equation 1.

$$\boldsymbol{B_i = w_i * E(c_i) + (1 - w_i) * c_i} \qquad \textbf{Equation 1}$$

In Equation 1, B_i, is the combined crashes, c_i is the observed crashes, and $E(c_i)$ is the expected number of crashes from SPF prediction. w_i is the weight, obtained by Equation 2.

$$\boldsymbol{w_i = \frac{1}{1 + k * E(c_i)}} \qquad \textbf{Equation 2}$$

In Equation 2, *k* is the over-dispersion parameter of the negative binomial regression. After obtaining the estimate for before-treatment number of crashes, after-treatment number of crashes can be obtained using the adjustment factor of Equation 3.

$$\boldsymbol{F_i = r_{D,i} * r_{C,i}} \qquad \textbf{Equation 3}$$

In Equation 3, $r_{D,i}$ is the ratio between number of days in the after period and number of days in the before period. $r_{C,i}$ is the ratio between SPF prediction for the after period and SPF prediction for the before period. The predicted number of crashes for the after period can be obtained from Equation 4.

$$\boldsymbol{A_i = F_i * B_i} \qquad \textbf{Equation 4}$$

In Equation 4, A_i is the predicted number of crashes for the after period. The variance of this prediction can be calculated using Equation 5.

$$\boldsymbol{Var(A_i) = {F_i}^2 * B_i * (1 - w_i)} \qquad \textbf{Equation 5}$$

After calculating the predictions and variances at each site, the total index of effectiveness can be obtained from Equation 6.

$$\boldsymbol{\theta} = \frac{\sum_{i=1}^{n} o_i}{\sum_{i=1}^{n} A_i\left(1+\frac{\sum_{i=1}^{n} Var(A_i)}{\left(\sum_{i=1}^{n} A_i\right)^2}\right)}$$ **Equation 6**

In Equation 6, i indicates the sites, n is the total number of sites, and o_i is the observed number of crashes at site i after the treatment. If θ is less than 1, the treatment has a positive effect on safety. Percent change in number of crashes can be obtained by Equation 7.

$$\textit{Percent Change in Number of Crashes} = 100 * (1 - \theta)$$ **Equation 7**

The variance of this estimated θ can be obtained by Equation 8.

$$Var(\theta) = \theta^2 * \frac{\left(\frac{1}{\sum_{i=1}^{n} o_i} + \frac{\sum_{i=1}^{n} Var(A_i)}{\left(\sum_{i=1}^{n} A_i\right)^2}\right)}{\left(1+\frac{\sum_{i=1}^{n} Var(A_i)}{\left(\sum_{i=1}^{n} A_i\right)^2}\right)^2}$$ **Equation 8**

7.2.Statistical Analysis Results

The analysis was performed for four crash categories. SPFs were estimated using observed data at control sites. Following the steps described in the previous section, θ and its variance were estimated by Equation 6 and Equation 8. Table 6 shows the results for different crash types.

Table 6: Statistical Analysis Results

Parameters	Total Crashes	Severe Crashes	Ped/Bike Crashes	Fatal Ped/Bike Crashes
L: Number of crashes observed during the period after the treatment is installed	784	360	56	4
π: Predicted number of crashes during the after period, had the treatments not been installed	906	393	49	28
Estimated number of crashes reduced or lives saved	122	33	-7	24
θ: Estimated index of effectiveness	0.86	0.91	1.12	0.14
se(θ) , Standard error of (θ)	0.04	0.06*	0.18*	0.07

*: The result is not significant at 90 percent confidence level

The results for the first three crash categories are favorable. All indices are lower than one, meaning that predicted crash counts are higher than observed counts, which supports the effectiveness of the treatments. For severe crashes, a standard error of 0.06 made the index of effectiveness, 0.91, which is not significantly different from one; therefore, the positive effect of median treatments is not statistically significant. The most significant index of effectiveness is observed in fatal pedestrian/bicyclist crashes. The index is 0.14, which indicates a sharp 86% decrease in fatal crashes, and the improvement is statically significant, even at 99% confidence level. Based on the statistical estimation, the median treatments installed at the 16 sites have reduced the number of total crashes by 122 (14%), the number of severe crashes by 33 (9%), and the number of fatal crashes by 24 (86%). The result for the last category, pedestrian/bicyclist crashes, is not statistically significant. These results show that the treatment has significantly reduced the total number of total crashes (vehicle and pedestrian/bicyclist) and fatal pedestrian/bicyclist crashes, but it has not significantly affected the total number of pedestrian/bicyclist crashes.

The significant positive effect of the median treatment on total crashes is consistent with the expectation and findings of the literature. In terms of pedestrian crashes, trend and statistical analysis showed that median treatment does not decrease crash frequency, but it makes the severe and fatal crashes less probable (i.e. lower fatal crashes). The analysis and survey results made the authors suspect that the median treatment shifts pedestrian crashes from mid-block to intersections. While pedestrians need to observe only one direction of movement at mid-blocks to prevent a crash, they need to pay attention to various turning movements at intersections. However, drivers are more attentive at intersections, and they usually travel at slower speeds. Therefore, improvements are not observed in terms of reduced crash frequency, but in terms of fewer fatal crashes.

8. SUMMARY AND CONCLUSIONS

Median treatments are believed to improve safety for pedestrians/bicyclists. Previous studies showed benefits for both vehicles and pedestrians/bicyclists, but the statistical analysis of such benefits is lacking in the literature. This study seeks to quantify the benefits using trend and statistical analysis to compare crash data before and after median treatments at 16 sites within Maryland. In order to perform before and after statistical analysis, one site immediately upstream or downstream of each treatment site was selected as a control site. In total, 14 control sites were selected, where two pairs of treatment sites share control sites.

The crash data for all 30 sites was provided by MDOT SHA. The study period was three years before and three years after the installation. Pedestrian counts, bicyclist counts, and geometric design data were collected at each site. Pedestrian/bicyclist counts were collected for a minimum of two hours and included the count of legal and illegal crossings. In addition, geometric design information was gathered and pedestrian/bicyclist and local business surveys were distributed.

The surveys were designed to understand social factors influencing mid-block crossings and the public opinion about the effectiveness of median treatments. These surveys were distributed at all treatment sites. In total, 63 pedestrian/bicyclist survey responses and 15 local business survey responses were collected. The analysis of survey results showed that more than 60% of pedestrians/bicyclists were likely to engage in a mid-block crossing. It also showed that more than 50% of pedestrians/bicyclists and local businesses believe that median treatments were effective in preventing or discouraging mid-block crossings.

The trend analysis was conducted to observe the crash trend before and after the median treatment installation. The trend analysis showed that the crash frequency of total crashes, severe crashes, and fatal pedestrian/bicyclist crashes decreased in treatment sites after the treatment, while the same crash statistics increased at control sites. For the total pedestrian/bicyclist crashes, crash frequency stayed the same at treatment sites after the treatment, while it increased at control sites. These observations gave insight on the effectiveness of the treatments, but a statistical analysis is required to confirm it.

Statistical analysis was conducted using the Empirical Bayes (EB) method. The EB method compares the expected number of crashes had the treatments not been installed with the actual observed number of crashes to evaluate the effectiveness of the treatments. In order to predict the number of crashes, safety performance functions (SPF) were developed using generalized linear model (GLM) regression. SPF development involves regressing crash frequencies on observed variables such as AADT, pedestrian counts, speed limit, etc., using data from control sites. Once SPFs were developed, the EB method used the data at treatment sites to obtain the index of effectiveness. Index of effectiveness shows how effective the treatments were in terms of improving safety. The results of statistical analysis showed that the rate of total crashes and pedestrian/bicyclist fatalities had a statistically significant decrease after the treatments. The index of effectiveness for pedestrian/bicyclist fatalities was 0.14 and was significant at a 99% confidence level. This result showed a promising positive effect of median treatments on pedestrian/bicyclist fatalities. The effect on severe crashes and total pedestrian/bicyclist crashes was not significant.

The results of trend and statistical analysis, in combination with findings from surveys, showed that median treatments have a positive effect on total crashes and fatalities. While it demonstrated that median treatments do not decrease the pedestrian/bicyclist crashes, it makes pedestrian/ bicyclist fatal crashes less probable. The authors suspect that median treatments move the location of pedestrian/bicyclist crashes from mid-block to intersections. Crashes at intersections are more likely to happen because of varying turn movements, but they are less likely to be fatal because of lower speeds and higher drivers' attentiveness.

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APPENDIX A

SURVEYS

UMD-PEDESTRIAN SURVEY

Location: ________________________ Date: _____________ Time: ________

Surveyor: ________________________ Weather: ______________________________

(Sunny, cloudy, rainy, windy, hot, and/or cold)

"Excuse me, but may I ask you a few questions? I'm with UMD and we want to learn more about why people walk where they do. This will take less than two minutes and the information will be kept confidential."

1. What is your home zip code?

Home zip code: _____________

2. What best describes the purpose of this trip?

☐ Exercising (a) ☐ Work commute (b) ☐ School (c)

☐ Recreation (d) ☐ Shopping/doing errands (e) ☐ Personal business (medical, visiting friends, etc.) (f)

3. In the past month, about how often have you walked here?

☐ First time (a) ☐ 0 – 5 times (b) ☐ 6 – 10 times (c) ☐ 11 – 20 times (d) ☐ Daily (e)

4. Please check the seasons in which you consider walking a viable travel option.

☐ All Year (a) ☐ Summer (b) ☐ Fall (c) ☐ Winter (d) ☐ Spring (e)

5. What is the total length of this trip (start to finish)? ***(complete one or more of the following)***

***1. Distance**:*_________miles		***and / or***	***2. Time**:*_________minutes
and / or	***3. Origin (zip code)*** __________ *Or location description other than zip code:** ______________________________ ** Address, intersection, landmark, etc.*	***and***	***Destination (zip code)*** __________ *Or location description other than zip code:** ______________________________ ** Address, intersection, landmark, etc.*

6. Will any part of this current trip be taken on public transit?

☐ Yes (a) ☐ No (b)

7. If you were not walking for this trip, how would you be traveling?

☐ Car (a) ☐ Carpool (b) ☐ Transit (c) ☐ Bicycle (d) ☐ I would not make this trip (e)

8. Why are you using this route as opposed to walking somewhere else? ***(please check all that apply)***

☐ Accessible/close (a) ☐ Direct (b) ☐ Lower traffic volumes (c) ☐ Heard about it through friends, media, etc. (d)

☐ Scenic qualities (e) ☐ Level (f) ☐ Personal safety (g) ☐ Connection to transit (h)

☐ Other__________________(i)

9. What would you like to see improved along this route (mark with an 'X') and community in general (mark with an 'O')? ***(please check all that apply)***

☐ Wider sidewalks (a) ☐ Better surface (b) ☐ Better street crossings (c)

☐ More MDOT SHAde trees (d) ☐ Benches (e) ☐ Access to shops, etc. (f)

☐ More sidewalks (g) ☐ Other(h)________________

10. What ethnic group do you belong to? ***(please check all that apply) (optional)***

☐ Hispanic/Latino (a) ☐ African American (b) ☐ Anglo/Caucasian (c) ☐ Asian (d) ☐ Other(e) ______________

11. What is your age? *(optional)*

______________ **years**

12. What is your opinion on the effectiveness of the median treatment at this site in terms of discouraging/preventing mid-block pedestrian crossings?

☐ Very Effective(a) ☐ Moderately Effective (b) ☐ Not Effective (c) ☐ No Opinion (d)

13. If there was no median treatment, would you likely cross mid-block?

☐ Yes (a) ☐ No (b) ☐ Not Sure (c)

14. Do you think a different median treatment would be more effective at preventing mid-block pedestrian crossings? *(please check all that apply)*

☐ Median Fencing (a)

☐ Planter with Vegetation (b)

☐ More Signage (c)

☐ Other(d)

If other, please explain: ____

15. Which treatment, if any, would you prefer to have at this location? *(please see pictures in question 14)*

☐ Median Fencing (a) ☐ Planter with Vegetation (b) ☐ More Signage (c) ☐ No treatment (d)

☐ Other(e)
If other, please explain: ____

15. If/when you cross a road mid-block, what factors influence your decision to do so? *(please check all that apply)*

☐ Traffic Level (a) ☐ Lighting (b) ☐ Behavior of other pedestrians (c) ☐ Convenience (d)

☐ Other(e)
If other, please explain: ____

Thank you for your participation!

UNIVERSITY OF MARYLAND

National Transportation Center

UMD-BICYCLE SURVEY

Location: ___________________________ Date: ____________ Time: ________________

Surveyor: __________________________ Weather: _______________________
(sunny, cloudy, rainy, windy, hot, and/or cold)

"Excuse me, but may I ask you a few questions? I'm with UMD and we want to learn more about why people bike where they do. This will take less than two minutes and the information will be kept confidential."

1. What is your home zip code?

Home zip code: _______________

2. What best describes the purpose of this trip?

☐ Exercising (a) ☐ Work commute (b) ☐ School (c)

☐ Recreation (d) ☐ Shopping/doing errands (e) ☐ Personal business (medical, visiting friends, etc.) (f)

3. In the past month, about how often have you ridden a bicycle here?

☐ First time (a) ☐ 0 – 5 times (b) ☐ 6 – 10 times (c) ☐ 11 – 20 times (d) ☐ Daily (e)

4. Please check the seasons in which you consider bicycling a viable travel option.

☐ All Year (a) ☐ Summer (b) ☐ Fall (c) ☐ Winter (d) ☐ Spring (e)

5. What is the total length of this trip (start to finish)? *(complete one or more of the following)*

1. Distance:_________miles (a)		***and / or***	***2. Time:***_________minutes (b)
and / or	***3. Origin (zip code)***___________(c) *Or location description other than zip code:** ________________________________ ** Address, intersection, landmark, etc.*	***and***	***Destination (zip code)***___________(d) *Or location description other than zip code:** ________________________________ ** Address, intersection, landmark, etc.*

6. Will any part of this current trip be taken on public transit?

☐ Yes (a) ☐ No (b)

7. If you were not biking for this trip, how would you be traveling?

☐ Car (a) ☐ Carpool (b) ☐ Transit (c) ☐ Walking (d) ☐ I would not make this trip (e)

8. Why are you using this route as opposed to riding somewhere else? *(please check all that apply)*

☐ Accessible/close (a) ☐ Direct (b) ☐ Lower traffic volumes (c) ☐ Scenic qualities (d)

☐ Level (e) ☐ Bike lanes (f) ☐ Wider lanes (g) ☐ Separation from traffic (h)

☐ Connection to transit (i) ☐ Heard about it through friends, media, etc. (j) ☐ Other(k) ___________________________

9. What would you like to see improved along this route (mark with an 'X') and community in general (mark with an 'O')? *(please check all that apply)*

☐ Bike lanes (a) ☐ Better surface (b) ☐ Shoulders (c) ☐ Less traffic (d)

☐ Signs/stencils (e) ☐ Better maintenance (f) ☐ Signal detection (g) ☐ Better crossings (h)

☐ Other(i) ______________________________

10. What ethnic group do you belong to? *(please check all that apply) (optional)*

☐ Hispanic/Latino (a) ☐ African American (b) ☐ Anglo/Caucasian (c) ☐ Asian (d) ☐ Other(e) _______________

11. What is your age? *(optional)*

__________________**years**

UMD-BICYCLE SURVEY

12. What is your opinion on the effectiveness of the median treatment at this site in terms of discouraging/preventing mid-block bicycle crossings?

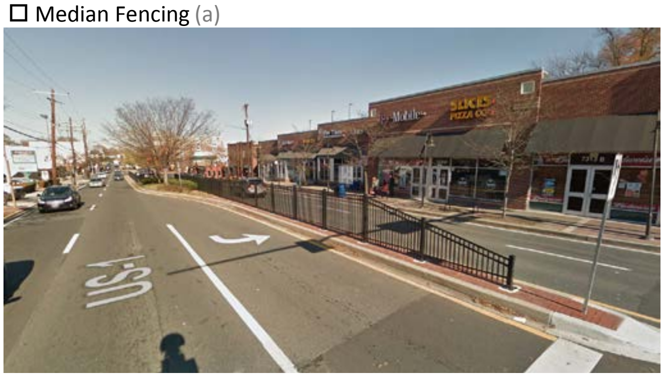
☐ Very Effective (a) ☐ Moderately Effective (b) ☐ Not Effective (c) ☐ No Opinion (d)

13. If there was no median treatment, would you likely cross mid-block?

☐ Yes (a) ☐ No (b) ☐ Not Sure (c)

14. Do you think a different median treatment would be more effective at preventing mid-block pedestrian crossings? *(please check all that apply)*

☐ Median Fencing (a)



☐ Planter with Vegetation (b)

☐ More Signage (c)

☐ Other (d)

If other, please explain: ____

15. Which treatment, if any, would you prefer to have at this location? *(please see pictures in question 14*)

☐ Median Fencing (a) ☐ Planter with Vegetation (b) ☐ More Signage (c) ☐ No treatment (d)

☐ Other(e)
If other, please explain: ____

15. If/when you cross a road mid-block, what factors influence your decision to do so? ***(please check all that apply*)**

☐ Traffic Level (a) ☐ Lighting (b) ☐ Behavior of other pedestrians (c) ☐ Convenience (d)

☐ Other(e)
If other, please explain: ____

Thank you for your participation!

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UMD-LOCAL BUSINESS SURVEY

Location: ___________________________ Date: ____________ Time: ________________

Surveyor: __________________________ Business Name: _______________________

"Excuse me, but may I ask you a few questions? I'm with UMD and we want to learn more about why people bike where they do. This will take less than two minutes and the information will be kept confidential."

1. How long has your business been at this location?

_________________Years

2. Do you feel that the road environment near your business has a pedestrian and/or bicycle safety problem?

☐ Yes (a) ☐ No b) ☐ Unsure (c)

If yes, please explain: ____

3. Have you ever observed illegal mid-block crossings by pedestrians or bicyclists (i.e. jaywalking) near your business

☐ Yes (a) ☐ No b) ☐ Unsure (c)

If yes, please explain how frequently____

4. Do you feel the median treatment has had an impact on pedestrian/bicyclist traffic (i.e. the number pedestrian/bicyclist in using this road)?

☐ Yes (a) ☐ No b) ☐ Unsure (c)

If yes, please explain: ____

5. What is your opinion on the effectiveness of the median treatment at this site in terms of discouraging/preventing mid-block bicycle crossings? (please check all that apply

☐ Very Effective(a) ☐ Moderately Effective (b) ☐ Not Effective (c) ☐ No Opinion (d)\

6. Do you think a different median treatment would be more effective at preventing mid-block bicycle crossings? *(please check all that apply)*

☐ Median Fencing (a)

☐ Planter with Vegetation (b)

☐ More Signage (c)

☐ Other(d)

If other, please explain: ____

7. Which treatment, if any, would you prefer to have at this location? *(please see pictures in question 6*)

☐ Median Fencing (a) ☐ Planter with Vegetation (b) ☐ More Signage (c) ☐ No treatment (d)

☐ Other(e)
If other, please explain: ____

Thank you for your participation!

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APPENDIX B

SAMPLE AEREAL PHOTOS

Sample Aerial Photos

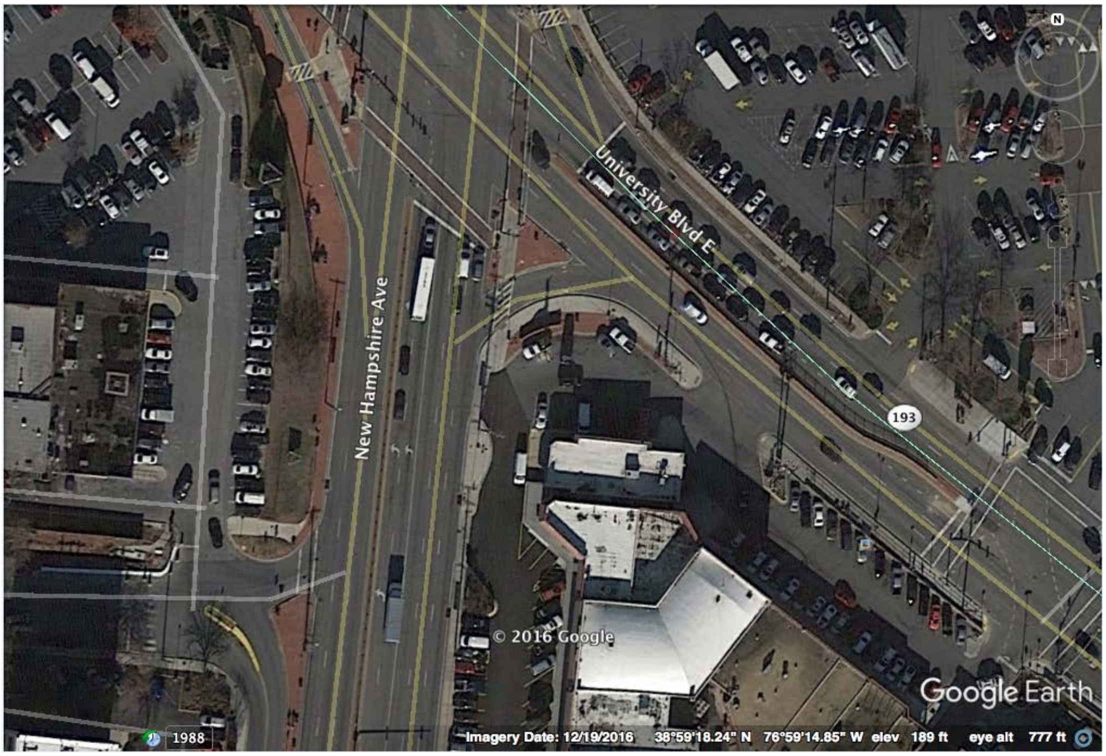

Figure 18: MD 650 and MD 193 (Site #2) - Year 2016

Figure 19: MD 650 and MD 193 (Site # 2) - Year 2002

Figure 20: US 40 and MD 152 (Site # 13) - Year 2013

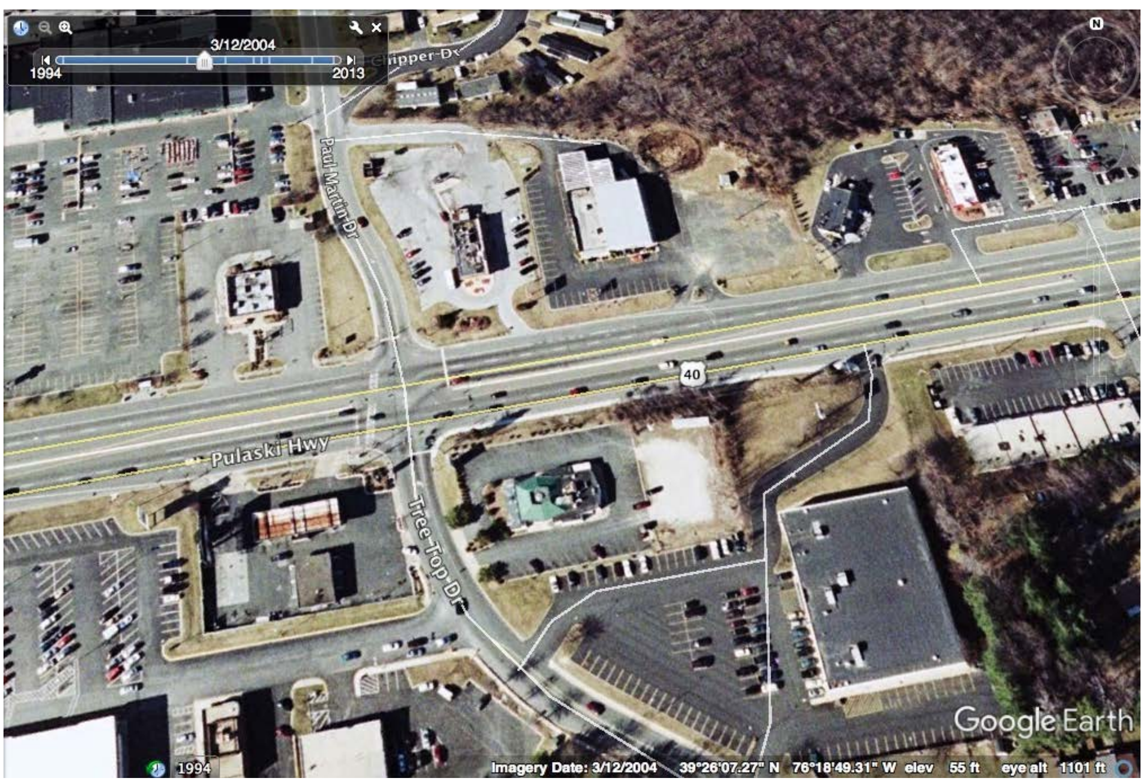

Figure 21: US 40 and MD 152 (Site # 13) - Year 2004

Street View of Different Median types

Figure 22: Fencing College Park- US 1

Figure 23: Planter Riverdale- MD 201

Figure 24: Rounded Catonsville- US 40

Figure 25: Signage Glen Burnie- MD 2