Safer Streets: The Measured Effectiveness of Hartford's Citywide Traffic Calming Program

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Abstract. The City of Hartford, Connecticut made an innovative move in 2005 when it developed a comprehensive citywide traffic calming master plan – the first of its kind in the United States. This plan, and the process used to develop it, was presented at the 2005 ITE Technical Conference and Exhibit. Two years later, as this ambitious plan is gradually implemented, the city is collecting "before" and "after" data for many of the traffic calming devices so that their impact on vehicular safety can be measured and so that future deployments may be validated. This paper presents a case study on the effects of deploying road diets on crash frequency. Roads that were placed on road diets were compared to similar roads that did not receive any treatments. The Empirical Bayesian (EB) method was used to predict the "expected" crash rate during the "after" period without implementation based on the control sites. The observed "before" crash rates, the crash rate expected without improvement, and the observed "after" crash rate were compared and discussed.

1. INTRODUCTION

The Neighborhood Traffic Calming Master Plan (Plan) reflects the City of Hartford, Connecticut's commitment to take a proactive approach towards calming traffic on its streets. Believed to be the first of its kind in the nation, the Plan encompasses each of the City's fourteen residential neighborhoods. It shows proposed traffic calming treatments at intersections and blocks which have been identified as being in need of treatment due to issues with speeding, cut through traffic, pedestrian safety, and other traffic-related challenges. It is intended to serve as a blueprint for future traffic calming deployments throughout the City. City staff has used the Plan to incorporate traffic calming treatments as part of ongoing construction activities and routine maintenance work, as well as to identify locations in need of improvement that are eligible for state and federal grants.

2. PLAN DEVELOPMENT

The traffic calming plan was developed through a "bottoms-to-top" process in which over 1,000 City residents and stakeholders participated. The City's consultant, Urban Engineers, Inc., (Urban) conducted focus sessions with groups uniquely impacted by traffic: emergency service providers, senior citizens, transit personnel, merchants, and the disabled. Meeting with these groups prior to the general public allowed the project team to understand specific ways in which the Plan could better address the needs of these groups. For example, the team had the opportunity to discuss with several disabled citizens the benefits of installing two ramps at each intersection corner instead of Hartford's traditionally deployed single ramp. Working with emergency service providers, the team was also able to identify primary response routes on which vertical deflection treatments should be avoided.

Following the focus groups, Urban conducted two charrettes, or workshops, in each neighborhood. During the first or opening charrette, the project team gave a presentation on the benefits of traffic calming, the tools available to treat City roads, and how these devices can best be used. The attendees then participated in an activity where they identified characteristics of their neighborhood which they would like to see enhanced. The stakeholders then listed traffic-related concerns and voted on the identified issues that they felt were the highest priority for treatment. For the final activity of the opening charrette, the residents divided into groups of six to ten persons. Each group was given a map of the neighborhood on which they identified treatments they would like to see used to address their concerns. A spokesperson from each group presented the results of their brainstorming session to the remaining members of the audience. In many cases, the separate groups had very similar visions of the neighborhood's streets.

Urban then field checked each of the locations discussed during the opening charrettes to determine if the requested traffic calming treatments could be built and whether or not they would have the desired effects. If it was determined that the treatment proposed by the community would not work, Urban then identified a more appropriate solution. The community input, along with volume, speed, crash, and geometric data were used to generate a neighborhood map identifying all recommended improvements. The neighborhood traffic calming plan was presented to each community during its second or closing charrette. At that time, stakeholders were given an opportunity to critique the plan and identify additional concerns. Following the closing charrettes the neighborhood plans were finalized and compiled to create the block-by-block citywide Traffic Calming Master Plan.

3. ROAD DIETS

To date numerous treatments have been implemented as a direct result of the Traffic Calming Master Plan including mini-roundabouts, curb extensions, speed tables, parking chicanes, bicycle lanes, and several "road diets". A "road diet" involves eliminating excess travel lanes without changing the width of the road. This is accomplished by re-striping the road, adding parking lanes and – if possible – bicycle lanes. It also includes adding a shared median left-turn lane.

The remainder of this paper will focus on safety benefits of five of Hartford's first arterial roadways to be placed on road diets: Wethersfield Avenue, Franklin Avenue, Maple Avenue, Tower Avenue, and North Main Street. Each of these street were reduced from four travel lanes (two in each direction) to two travel lanes (one in each direction) separated by an alternating left turn lane (see Figure 1). Parking lanes and bicycle lanes were also included on some of the post-diet streets.

The road diets prohibit aggressive drivers from passing slower vehicles, instead allowing more prudent drivers to set the speed of a queue. Because the number of turning lanes at intersections was not reduced, there was little to no impact on the capacity of the streets. Speed measurements made before and after the road diets were implemented show that these streets achieved 85th percentile speed reductions of up to six miles per hour. On average, speeds were reduced by over three miles per hour.

Figure 1 -- Wethersfield Avenue Before and After Road Diet

3. STUDY METHOD

Two types of analysis were used to quantify the safety benefits of the road diets. The first was a simple “before and after” analysis, the other was the Empirical Bayesian (EB) method developed by Hauer (Hauer, 1986). The simple “before and after” analysis compared the number of crashes per month as well as the number of crashes per million vehicles at the study sites before and after treatment. “Before and after” analyses are straightforward and simple. However, they are somewhat flawed because of bias associated with regression to mean. Regression to mean occurs when a treatment is implemented as a direct result of a high crash rate. Often the high crash rate is in part due to the random nature of crash occurrences meaning it will decrease with time, with or without treatment. However, a site with high crash rates caused in part by random fluctuation are more likely to be treated, and when the treatment is analyzed using the simple “before and after” method its benefits are exaggerated. Had the road diets been selected for treatment based solely on pre-treatment crash rates, regression to mean would likely introduce some bias into the “before and after” analysis. Because public input played a larger role in the decision to implement road diets it was unclear whether regression to mean bias would be present. An indirect regression to mean bias may be present if public perception was influenced by a fluctuation in crashes at the study sites.

Simple “before and after” analyses can also be misleading because they do not take time trends into consideration. “After” period crash rates may be lower due to vehicular improvements such as the introduction of antilock brakes and collision avoidance systems. Some crashes which at first may appear to be the result of geometric roadway improvements may in fact be a result of such trends. Like regression to mean bias, time trend bias can be mitigated through use of the EB analysis method.

The EB method utilizes data from control sites along with "before" treatment study site data to predict the crash rate at the study site during the "after" period had no treatment occurred. Thus, study site crash rates with and without treatments for the same time period can be compared and the regression to mean and time trend biases are eliminated.

4. DATA COLLECTION

4.1 Study Sites

The portions of each arterial, i.e., Franklin, Main, Maple, Tower and Wethersfield treated with road diets constituted our study sites. The study site characteristics and their implementation information are summarized in Table 1. Road diets were installed on Main, Maple, Tower and Wethersfield during September and October of 2003 while they were implemented approximately six months later on Franklin Avenue. The length of the road diets ranged from 0.6 to 2.06 miles.

Study Site	Road Diet Length (miles)	AADT		Implementation Date
		2002	2003 and After*	
Franklin Ave.	1.70	12925	12925	4/16/2004
Main St.	0.61	11050	11050	9/17/2003
Maple Ave.	2.06	10050	10000	9/17/2003
Tower Ave.	1.43	11800	12530	10/24/2003
Wethersfield Ave.	1.95	12050	12450	9/22/2003

* *AADT was collected for the year of 2002 and 2003. The AADT of 2004, 2005 and 2006 was assumed to be the same as the one in 2003.*

Table 1 Study Sites

A summary of all crashes occurring within the study sites from the years 2002 to 2006 was obtained from the City of Hartford. For each study site, separate crash databases were created for the periods "before" and "after" implementation. Table 2 provides the before and after crash counts for each study site. It clearly shows that crash counts varied substantially among each study site before the road diets were made. Tower Avenue experienced relatively few crashes while Wethersfield Avenue experienced a much greater crash frequency.

Study Site	Before Period	Months Before	# Crashes Before	After Period	Months After	# Crashes After
Franklin Avenue	01//01/02 - 04/16/04	28.5	159	04/16/04 - 09/30/06	28.5	124
Main Street	01//01/02 - 09/17/03	22	89	09/17/03 - 09/30/06	35	72
Maple Avenue	01//01/02 - 09/17/03	22	45	09/17/03 - 09/30/06	35	88
Tower Avenue	01//01/02 - 10/24/03	23	30	10/24/03 - 09/30/06	34	50
Wethersfield Avenue	01//01/02 - 09/22/03	22	171	09/22/03 - 09/30/06	35	209

Table 2 Study Site Before and After Crash Counts

Traffic volumes were used to compute the crash rates corresponding to each crash count. The volumes used were based on the total AADT of vehicle entering the study site. Volume data for all study sites was collected by Urban and by the City of Hartford using Automatic Traffic Recorders. Where multiple counts were available, the results were averaged in order to obtain a single AADT for the roadway. Table 3 shows the total traffic volume for each study site during the "before" period and after implementation.

Study Site	Before Period	Volume Before	After Period	After Volume
Franklin Ave.	01//01/02 - 04/16/04	10,792,375	04/16/04 - 09/30/06	11,567,875
Main St.	01//01/02 - 09/17/03	6,873,100	09/17/03 - 09/30/06	12,243,400
Maple Ave.	01//01/02 - 09/17/03	6,238,250	09/17/03 - 09/30/06	11,080,000
Tower Ave.	01//01/02 - 10/24/03	7,990,820	10/24/03 - 09/30/06	13,419,630
Wethersfield Ave.	01//01/02 - 09/22/03	7,660,150	09/22/03 - 09/30/06	13,732,350

Table 3 Study Site Before and After Volume

4.2 Control Sites

Twelve control sites were used to adjust for the time trend and regression-to-mean effects, as described in the Empirical Bayesian (EB) method in Section 3. These segments on State highways, ranged from a half mile to more than three miles in length and were selected based on their geometry and land use characteristics. Each control site had characteristics similar to that of the Hartford study sites prior to the road diet implementation (i.e. four travel lanes in an urban environment). The twelve control sites were applied to each study site.

Control Site	Length (Miles)	Volume					Crash Counts					
		2002	2003	2004	2005	2006*	2001	2002	2003	2004	2005	2006*
Rt.10	0.91	17,150	17,150	17,150	17,150	17,150	73	89	93	75	90	80
Rt.5	0.81	19,300	19,300	19,300	19,300	19,300	146	86	74	69	84	26
Rt. 58	0.96	19,700	20,500	20,500	20,500	20,500	9	16	13	12	8	12
Rt. 113	1.1	15,450	14,650	14,650	14,650	14,650	58	47	55	58	52	36
Rt.99	1.26	15,000	15,000	15,000	15,000	15,000	47	40	40	23	60	26
Rt.1(1)	3.03	21,800	21,800	21,800	21,800	21,800	287	296	298	307	289	187
Rt.1(2)	1.52	16,020	16,020	16,020	16,020	16,020	155	159	134	167	137	108
Rt.1(3)	0.46	18,900	18,900	18,900	18,900	18,900	58	69	55	53	59	48
Rt.1(4)	0.89	17,400	17,400	17,400	17,400	17,400	40	27	17	27	18	13
Rt.1(5)	2.99	15,200	15,500	15,500	15,500	15,500	266	252	248	220	233	157
Rt.1(6)	1.53	21,350	21,250	21,250	21,250	21,250	335	218	235	207	207	131
Rt.1(7)	2.57	22,033	21,800	21,800	21,800	21,800	150	165	143	171	133	107

** The 2006 study period was from January 01, 2002 to September 30, 2006*

Table 4 Control Sites

Table 4 summaries the volumes and crash counts of each study year for each control site. A summary of all crashes occurring at the control sites for the years 2002 to 2006 was obtained from ConnDOT's Accident Experience database. This database contains information on all crashes that occurred on State maintained roads including the exact milepost of the collision, the time and date of the collision, the prevailing roadway and weather conditions and other factors influencing the crash. Crash rates from these control sites were used to estimate "expected without improvement" crash rates for the study sites. The crash data for all comparison sites during the entire study period (01/01/2002 – 09/30/2006) can be used to estimate the study sites' expected crash rate without treatment. This estimate which is based on more data, rather than only one or two years of "before" data at the study sites, is more accurate.

5. RESULTS

5.1 Before & After Analysis

a) Comparison of Crash Rates (Number of Crashes Per Month)

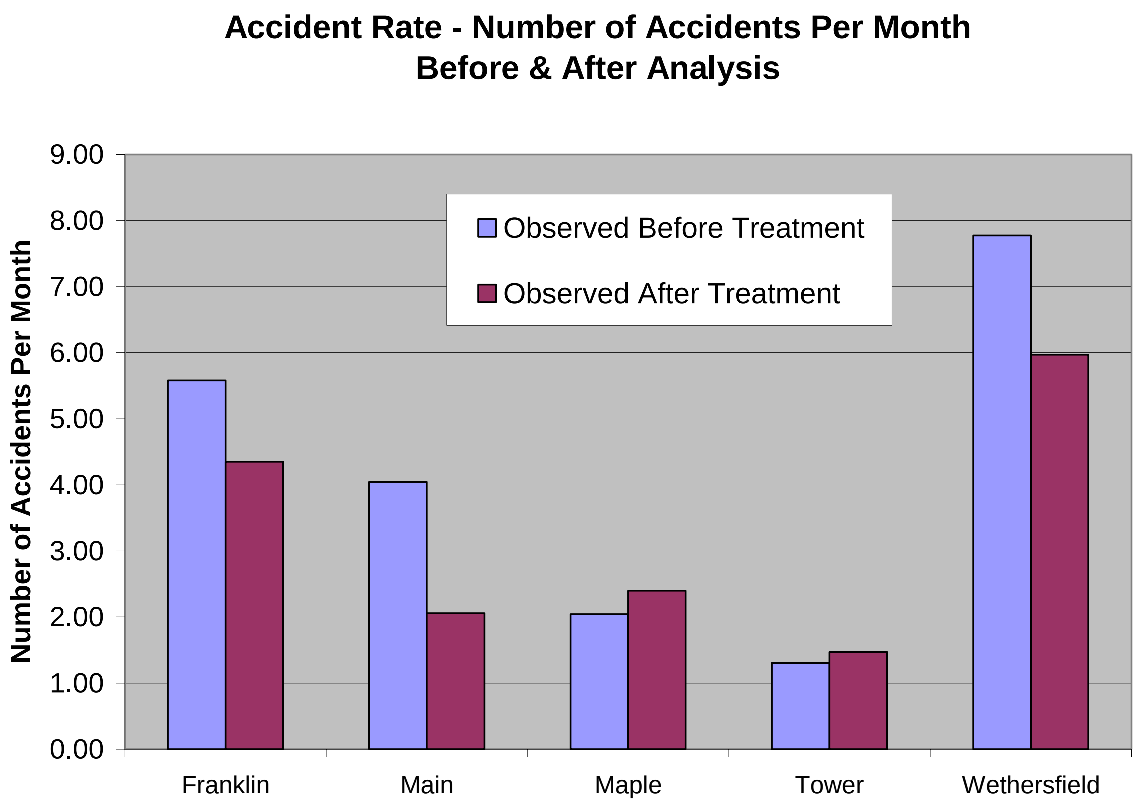

Figure 2 Before & After Comparisons of Number of Crashes Per Month

Figure 2 shows a simple "before and after" comparison of the number of crashes per month. Based on these results, Franklin Avenue, Main Street, and Wethersfield Avenue experienced a significant decrease in the number of crashes per month following the implementation of the road diets. Tower Avenue and Maple Avenue experienced little change in the number of crashes per month. The fact that the road diets had little impact on crash frequency at these intersections may be related to these streets having the fewest collisions to start with. Maple Avenue and Tower Avenue averaged between one to two crashes per month prior to treatment compared to four on Main Street, more than five on Franklin Avenue and nearly eight on Wethersfield

Avenue. Thus, Maple Avenue and Tower Avenue had fewer opportunities for crash reduction. Tower Avenue had the lowest crash rate due in large part to the few number of intersecting streets and driveways thereby reducing conflicts with turning vehicles.

b. Comparison of Crash Rates (Number of Crashes Per Million Vehicles)

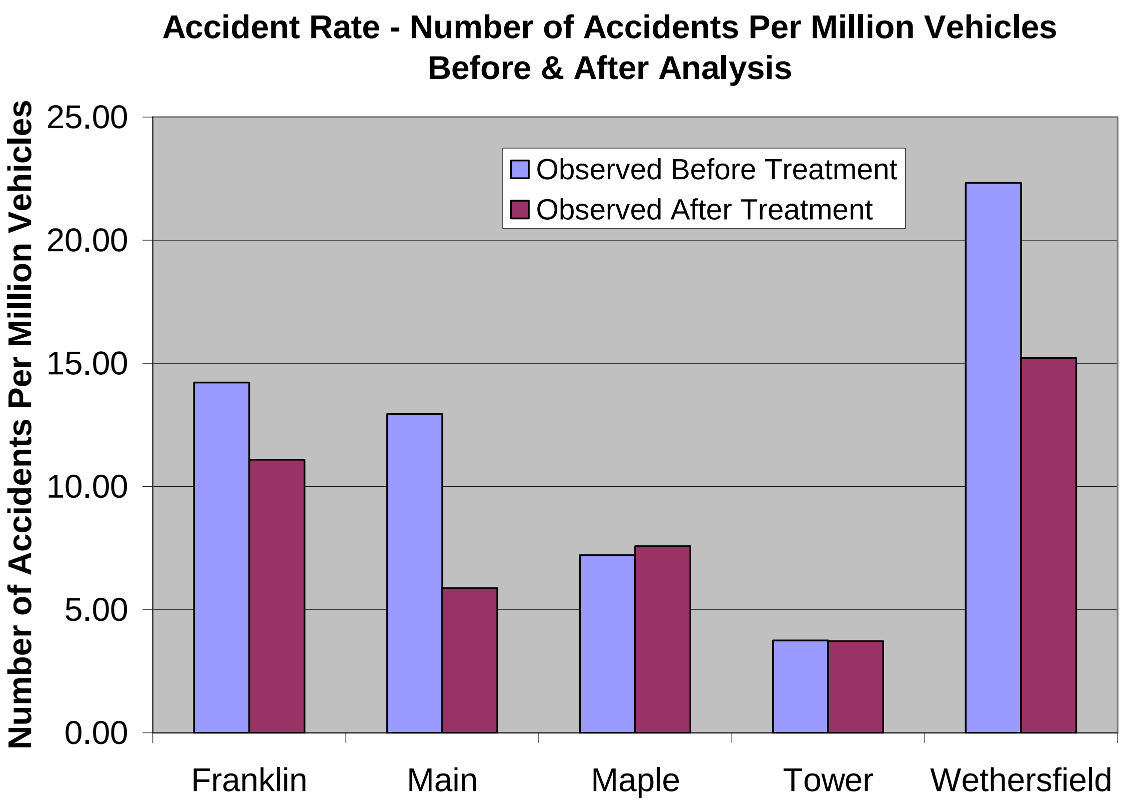

Figure 3   Before & After Comparisons of Number of Crashes Per Million Vehicles

Figure 3 demonstrates crash rates per million vehicles before and after road diets were implemented. The results are consistent with the comparison of the number of crashes per month. Again, Franklin Avenue, Main Street, and Wethersfield Avenue experienced a significant crash reduction following the road diet implementation, while crash rates on Maple Avenue and Tower Avenue showed little change. This crash rate comparison may be the most accurate as it takes into consideration increases in volume which occurred over the period for which data was collected.

5.2 EB Method

With the EB method, the number of collisions "expected without treatment" is predicted based on the crash experiences of control sites, shown in Table 4. Because these control sites were selected without any knowledge of their crash history, the regression to mean effect will not impact the results. These “expected” rates were then compared with the actual “after” period crash rates and reduction factors were computed to evaluate the success of the road diet installations. Crash rates for each study site were calculated in terms of crashes per million vehicles per mile. Figure 4 shows the observed “before” crash rates, the crash rate expected without improvement, and the observed “after” crash rate for all crashes occurring within the boundaries of the study sites. The results are consistent with the ones drawn from the “before and after” analysis.

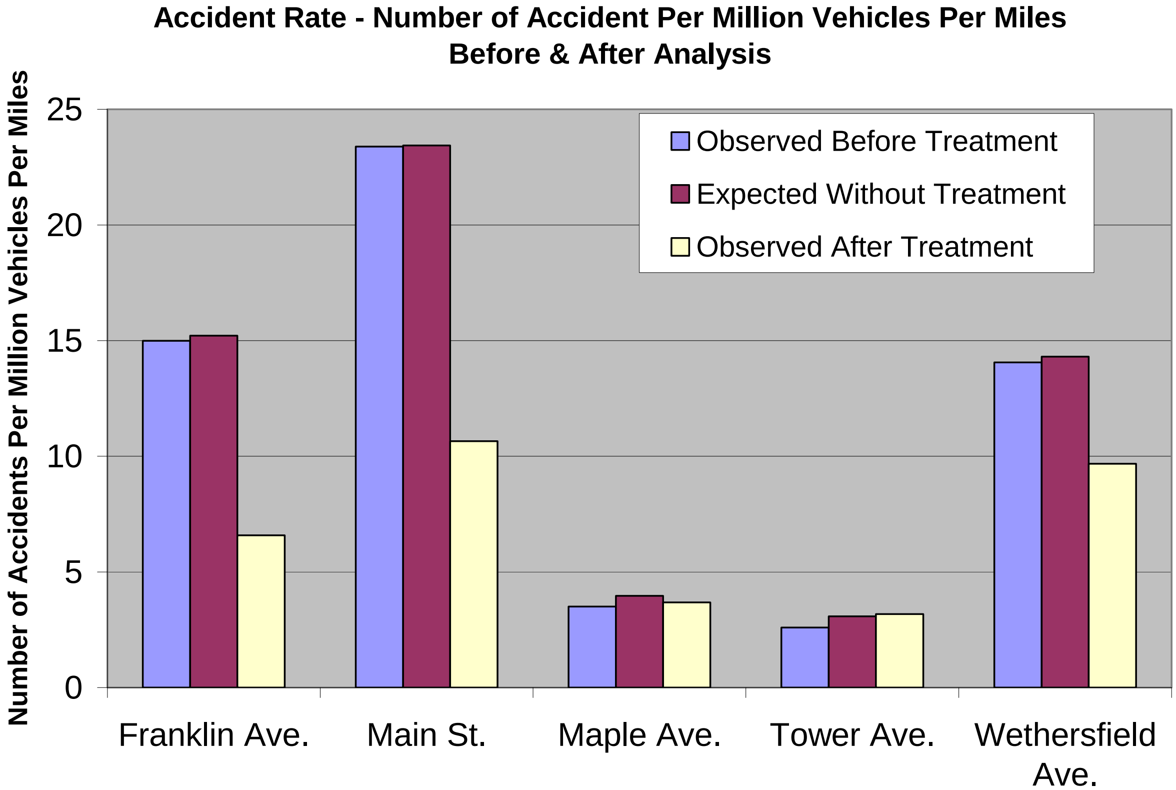

Figure 4 Crash Rate Comparisons using EB Method

	Crashes per Million Vehicles			
Study Site	**Observed Before Treatment**	**Expected Without Treatment**	**Observed After Treatment**	**Percent Crash Reduction**
Franklin Ave.	14.99	15.21	6.58	56.7%
Main St.	23.38	23.43	10.65	54.6%
Maple Ave.	3.50	3.96	3.68	7.3%
Tower Ave.	2.59	3.08	3.17	-3.1%
Wethersfield Ave.	14.05	14.30	9.67	32.4%

Table 5 Crash Rates and Reduction Factors

Table 5 details these crash rates and the corresponding percent crash reduction which was calculated by applying the following equation:

$$RF = \frac{(N_{Exp} / V_{Before}) - (N_{Obs\_After} / V_{After})}{N_{Exp} / V_{Before}}$$

Where,

RF: crash reduction factor,
N_{exp}: expected number of crashes without treatment,
N_{Obs_After}: measured number of crashes after treatment,
V_{before} *or* V_{after}: traffic volume per million vehicles before or after treatment,

Franklin Avenue, Main Street, Wethersfield Avenue, and Tower Avenue experienced crash reduction rates of 56.7%, 54.6%, 32.4%, and 7.3% respectively, while Tower Avenue experiences a negligible increase in the crash rate. At each study site the “expected without treatment” crash rate is slightly higher than the “observed before treatment” crash rate. Had mitigation to mean or time trend bias been present in the simple “before and after” analysis, the “expected without treatment” rate would have been lower. The lack of a significant regression to mean effect may indicate that public perception of these roads as being unsafe was not influenced by a fluctuation in crash rates. Residents who attended traffic calming charrettes and identified these roads as being dangerous may have been equally concerned with vehicle speeds as they were with crash history. The lack of any apparent time trend bias is likely due to the fact that the study period included only five years. This was apparently not enough time for improvements in vehicle design to significantly improve safety as measured in terms of collision frequency.

Due to the absence of these biases a simple “before and after” analysis is recommended for future studies aimed at measuring the benefits of traffic claming devices implemented through the Hartford Traffic Calming Master Plan. The simple “before and after” analysis requires less data collection and the results appear to be void of bias.

6. CONCLUSIONS AND RECOMMENDATIONS

Both the simple “before and after” analysis and the EB method study exhibit consistent results. Franklin Avenue, Main Street and Wethersfield Avenue experienced large reductions in crash rates after the road diet improvements were installed. The road diets had little effect on the crash rates at Tower Avenue and Maple Avenue. This is attributable to Tower Avenue and Maple Avenue having low crash rates initially and, in the case of Tower Avenue, few conflict points. A further analysis of the impact of road diets on crashes on these two roadways may be warranted.

It is believed that the large reduction in crash rates on Franklin Avenue, Main Street and Wethersfield Avenue was due primarily to the decrease in speeds achieved from implementing road diets on these streets. Speeds at the study sites were reduced by up to six miles per hour, with an average reduction of three to four miles per hour. The road diets also prevented aggressive drivers from passing more prudent drivers.

Both a simple “before and after” analysis and an EB method analysis were performed in order to identify any bias associated with regression to mean and time trends. The results indicate that neither of these biases were present. Because of the absence of these biases and the relative simplicity of a simple “before and after” analysis, the simple “before and after” analysis is the preferred method of evaluation.

Factors such as crash type and injury severity were not analyzed in this study due to the limited nature of the available data. However, such an analysis would provide additional insight into the benefits of road diet implementation. It is recommended that these factors be analyzed in future studies.

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