IMPACT OF ROAD LANE NARROWING TRAFFIC CALMING TREATMENTS ON SPEED AND VOLUME

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ABSTRACT

The objective of this study was to measure the effectiveness of a coloured slurry seal traffic calming treatment, used to "narrow" lanes of a road, in reducing driving speeds and traffic volume on residential streets. A before-and-after study with a comparison group was used to measure the effect of the treatment on the average 85th percentile and average traffic volume for the treated street. The before-and-after study did not naively consider changes on the treated road but also examined changes that may be taking place in the overall behaviour of traffic. Traffic data for this study was collected from the treatment and control sites prior the traffic measure being installed and then collected one month following the treatment and four months following the completion of the treatment installation.

The results of analyzing the average 85th percentile speeds indicate a reduction in vehicle speeds from before to one month and four months after periods. However, the results were found not be statistically significant at a 5 percent confidence level. The results of the study on traffic volume were mixed. The 24 hour average traffic volume one month after implementation of the traffic calming showed a statistically significant increase. It is speculated that a possible reason for this increase might be the novelty effect of the new traffic calming treatment measure, attracting drivers to the treated site to view the treatment. However, four months after application of the slurry was introduced the average 24 hour traffic volume showed a statistically significant decrease from the before period.

INTRODUCTION

In recent years there has been a considerable amount of interest on the part of local jurisdictions and their residents in stopping the progressive negative effects on quality of life caused by street traffic. High traffic volumes and speeds, especially on residential streets, impact residents due to concerns related to safety, noise, and pollution. As a result, many neighbourhood residents and local officials have expressed interest in undertaking traffic calming as a means of decreasing the cars' dominance.

Traffic calming encompasses a series of physical treatments that are meant to lower vehicle speeds and/or volumes. Treatments can create physically impact the movement of traffic or can present a visual impression that certain streets are not intended for high speed or cut-through traffic. Traffic calming has the potential to improve safety for pedestrians and reduce noise and pollution levels. Examples of these measures include bulb outs, speed humps, chicanes, and traffic circles *(1)*.

Speeding and cut-through traffic in residential areas are two major concerns for residents and traffic engineers in many suburban communities in Canada. Many local governments have aggressively pursed various physical treatments in the residential areas in order to slow down and reduce traffic in residential areas. The Town of Richmond Hill in Ontario has implemented a traffic calming measure for a major collector street. The treatment consisted of the application of coloured slurry seal asphalt cement along the outer edges (curbside) of the road in order to provide a visual narrowing effect of the travelled portion of the pavement. The width of the application was 1.2 metres along the east and west sides of the street. The treatment was a thin overlay on the existing pavement, and the effect of the application would only be that to the motorists' the operational width of roadway would appear narrower by 2.4 metres. The treatment did not physically prohibit travel on the new surface. The intent of the treatment was to reduce the perceived lateral clearance in the travelled lanes, urging motorists to travel at speeds consistent with the posted 50 km/h speed limit on the road. Thus, the perceived reduced lateral clearance zone would heighten the motorists' awareness and act as a physical calming measure.

The coloured slurry is seal asphalt cement mixed with fine aggregate, which have both been coloured a shade of red/plum that when installed along the sides of the road surface contrasts with the other asphalt surface, acts as a visual cue to motorists that the road is narrower than it actually is. The seal was poured as a liquid over top of the existing asphalt surface to a depth of approximately 5 millimetres thick and did not reduce road surface friction or impair the operating characteristics of the existing surface.

Several research efforts have been conducted to evaluate the impact of traffic calming strategies on driver behaviour, traffic flow and speed. However, most of these studies used a naïve or simple before and after studies *(2, 3, 4, 5 and 6)* for their evaluation procedure. As will be explained throughout of his paper, a simple comparison of the data from before to after period does not cover the real changes in the treated sites.

This paper evaluates the impact of the traffic calming strategy on traffic volume and speed. Specifically, a before-and-after study designed with a comparison group was used to measure the effect of the treatment on the average 85^{th} percentile speed and traffic volume for the treated corridor. Traffic data was collected from the treated and control sites prior to the traffic calming measure being installed and then in two "after" periods; immediately following the treatment as well as four months following the completion of the treatment installation.

METHODOLOGY

Conceptual Overview

The before-and-after study is used to determine the effect of the countermeasure by measuring the difference in the average 85^{th} percentile speeds and average traffic volume before and after the modification within the corridor. It is important that the before-after study not naively consider changes on the treated road but also examines changes that may be taking place in the overall behaviour of traffic. This assessment of the comparison group is critical in ensuring that other factors which may be influencing driver behaviour, and may be changing as time passes, are taken into account when assessing the impact of the traffic calming treatment. To address these external casual factors, a comparison group was selected in order to estimate the average traffic volume and average 85^{th} percentile speed that would have occurred at the treated sites if the treatment had not been made.

The basic assumptions for this method are:

- With the exception of the traffic calming treatment, the overall factors that affected speed and traffic volume have changed in the same way from before the implementation of the treated and the comparison groups; and
- The changes in the various factors influence the speed and traffic volume of the treated and the comparison groups in the same manner *(7, 8)*.

Statistical Analysis

The approach used for this study follows methodology that was originally formulated and validated by Hauer *(8)*. The statistical analysis methodology for a before-and-after study with comparison group must be explained in terms of both the observed counts and their expected values. Accordingly, the expected 85^{th} percentile speed and traffic volume in the after period for the treated sites without improvement, π, can be predicted as the observed counts in the before period for the treated group, K, by the ratio of the observed counts after the improvements to the observed counts at the comparison sites, r_c, as follows:

$$\pi = K \times r_c \quad (1)$$

$$r_c = \frac{\left(N/M\right)}{\left(1+\left(1/M\right)\right)} \quad (2)$$

where

N = Observed counts for comparison group in after period;
M = Observed counts for comparison group in before period;
K = Observed counts for treated group in before period; and
L = λ = Observed counts for treated group in after period.

The variance of π can be calculated as follows:

$$VAR\{\pi\} = \pi^2 \times \left(\frac{1}{K} + \frac{1}{M} + \frac{1}{N}\right) \tag{3}$$

The effect of treatment can be evaluated by comparing λ and π using the "index of effectiveness":

$$\theta = \frac{\left(\lambda / \pi\right)}{\left(1 + \left(VAR\{\pi\} / \pi^2\right)\right)} \tag{4}$$

The standard deviation for θ is calculated as follow:

$$\sigma\{\theta\} = \theta \times \left(\frac{1}{\lambda} + \frac{VAR\{\pi\}}{\pi^2}\right)^{0.5} \tag{5}$$

When $\theta < 1$, the treatment is effective; when $\theta > 1$, the treatment is not effective. Percent change in the expected measure can be calculated as follow:

$$R = 100 \times (1 - \theta)$$

DATA

The data used for this study was collected from three different time periods:

- **Before period:** Before implementation of traffic calming (May 31, 2005);
- **Immediate after period:** Approximately one month after implementation of traffic calming (June 28, 2005); and
- **After period:** Approximately four months after implementation of traffic calming (September 29, 2005).

Both treated and comparison data collection location sites were chosen to be representative of streets that may be impacted by a change in traffic volumes as a result of the coloured slurry seal asphalt treatment along the corridor. The comparison sites were also selected because of their similar landscape along with low density residential homes and their proximity to the treated site.

The data collection was completed using Nu-Metrics traffic counters placed at the nine selected locations. Three of the data collection locations were on the corridor, which received the slurry application, with the other six data collection locations along the aforementioned adjacent streets surrounding the treated site. The adjacent streets chosen were similar to the corridor and serve a collector road function in the neighbourhood.

The data collection lasted 24 consecutive hours at each location simultaneously and includes such characteristics as speed, vehicle classification, headway and weather. The data was recorded in 15 minute intervals.

With a treatment date set for June 1st, 2005, the before data was collected from 12:00 am May 31st, 2005 until 12:00 am June 1st, 2005. The after data was collected during two periods. The first collection date was immediately following the road surface treatment installation, between the hours of 12:00 am June 28th, 2005 and 12:00 am June 29th, 2005. At this time of the year the local High Schools were vacant as classes had been dismissed for the summer, however, the local elementary school was still occupied with students for the final days before summer vacation.

The second date the data was collected after the treatment was installed, running from 12:00 am September 29th, 2005 and concluding at 12:00 am September 30th, 2005. All data collection dates were weekdays. Of note, prior to the final data collection the Town of Richmond Hill applied solid white edge lines to the road surface delineating the travel portion of the corridor from the slurry treated portion. Table 1 provides summary information on traffic volumes and speeds for the data collected for this study.

ANALYSIS

As indicated in the introduction part of this study, the main goal of this study was to evaluate the effect of traffic calming measure on vehicle speed and traffic volume. The average 85th percentile speed and average traffic volume were used as measures for accomplishing this task. The 85th percentile is the speed at which or below 85% of the free flowing vehicles are travelling. The 85th percentile speed is representative of overall traffic behaviour on a road and is the value most commonly used in assessment of traffic data. For this reason, among others, the 85th percentile speed data was captured and analyzed as part of this study.

The data was divided into a 24 hour total, AM Peak period and PM Peak period. The AM Peak period is from 6:00 AM to 9:00 AM. The PM Peak period is from 3:30 PM to 6:30 PM.

Speed Analysis

Table 2 shows the average percent changes for the 85th percentile speeds for treated and comparison sites for each period. As can be seen from the Table, the treated sites experienced speed reductions during the immediate after period". However, the 85th percentile speeds for treated sites increased for the after period for 24 hours and the PM Peak. Table 2 shows the results from a simple before and after study without considering the speed changes in the comparison sites. As we see in the following paragraphs, the results of before and after study with comparison group is different and reflects the true changes in the average 85th percentile speeds from the before to the two after periods.

Table 3 depicts the results of the before and after study with comparison group for average 85th percentile speed changes from the before period to the immediate after period. The results for Table 3 indicates that immediately following the slurry application the average 85th percentile speeds saw little change. While the data reveals reductions in the range of 6 to 7 percent for each of the three time periods studied, these changes were not found to be statistically significant at 5 percent confidence level since the calculated t-statistics were less than the t-critical (1.96). The standard deviations for each time period, as shown in Table 4, were high enough to sway the results so much so that formulating a conclusion would be unfounded.

The data collected four months after (After Period) the treatment date reveal a very small change in the 85th percentile speeds as shown in Table 4. The standard deviations create reasonable doubt as to the reliability of the data. The results of t-test confirm that none of the changes in the average 85th percentile speed are significant at 5 percent of confidence level.

Traffic Volume Analysis

The percent change in average traffic volume for treated and comparison groups are shown in Table 5. As can be seen, the average 24 hour traffic volume for comparison sites for immediate after period decreased by 5.57% and for after period decreased by 2.42%. On the other hand, the average 24 hour traffic volume for treated sites has increased from the before period to the immediate after period by 1.64% but then decreased by 8.44% for after period. However, as explained previously, these figures are not drawing real percentage changes in average traffic volume for the treated site since we cannot naively compare the data from before period to the one for after period.

The results of before-and after study with comparison groups indicate that immediately after the slurry treatment took place the corridor the average traffic volume increased marginally, for all AM, PM and 24 hour periods as shown in Table 6. Although the standard deviations are high, the results still reveal that volume increases were occurring. The result of the t statistic test confirms that there is an increase of 7.6% in the 24 hour traffic volume with standard deviation of 3.6%. The result is statistically significant at 5% confidence level.

Table 7 shows the results of before and after study for four months after the slurry treatment application. The results reveal that the corridor has seen an overall reduction in traffic volume. These results are despite an actual increase in volumes during the AM Peak period for the treated group in Table 1. However, once the volumes were evaluated against the comparison group, which also saw similar increases and decreases in traffic volume, the treatment appears to have dissuaded some motorists from using the corridor. It must be noted here that although the average traffic volume during the PM Peak period shows a reduction of 4.9%, the standard deviation is about 10.8% which indicates that in some cases the traffic volume might increase as a result of standard deviation. The result of the t-test confirms that the reduction for the 24 hour traffic volume is statistically significant at 5% confidence level.

CONCLUSIONS

The primary goal of this project was to evaluate the effect of the implementation of traffic calming measures on vehicle speeds and traffic volume along a major collector street in the Town of Richmond Hill, Ontario. The treatment consisted of the application of coloured slurry seal asphalt cement along the sides of the road in order to provide a visual narrowing effect of the pavement in order to reduce vehicle speeds without significantly reducing traffic volume. A before-and after study using comparison group method was conducted to accomplish this task. Traffic volume and speed data were collected before, one month after (immediate after), and four months after (after) implementation of the slurry.

The results of analyzing the average 85^{th} percentile speeds indicate a reduction in vehicle speeds from before to immediate after and after periods of between 0.8 % and 7.7 %. However, the results were found to not be statistically significant when comparing “before” and “after” average 85^{th} percentile speed data.

The results of the before and after study on traffic volume were mixed. The traffic volumes one month after implementation of the traffic calming treatment showed increases. It is speculated that a possible reason for this increase might be the novelty effect of the new traffic calming treatment measure, attracting drivers to the corridor to view the treatment. However, four months after the application of the slurry was introduced, the traffic volumes showed reductions from the before period.

Consideration could be given to the continued study of the impact of the traffic calming treatment. A study one year after implementation of the slurry on the corridor could be conducted. The study should not only include the effect of traffic calming on the traffic operation of the corridor but also must investigate the effect of this treatment on the safety of this corridor. Also, it is recommended that a questionnaire survey to local residents and motorists who drive along the corridor on a daily basis of the effectiveness of this project, be conducted.

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TABLE 1 Descriptive Statistics of Data

Type of Sites	Number of Locations	Time Interval	Before Period		Immediate After Period		After Period	
			Average Traffic Volume	Average 85th percentile Speed	Average Traffic Volume	Average 85th percentile Speed	Average Traffic Volume	Average 85th percentile Speed
Treated	3	AM Peak	634	53.8	527	50.4	651	51.7
		PM Peak	532	52.2	548	51.0	456	54.5
		24-Hours	5,795	52.6	5,890	50.8	5,306	53.6
Comparison	6	AM Peak	412	55.8	311	54.6	477	55.3
		PM Peak	241	55.2	220	55.6	216	56.2
		24-Hours	2,649	55.5	2,502	55.5	2,585	56.2

Note: *AM Peak is from 6:00 AM to 9:00 AM*
PM Peak is from 3:30 PM to 6:30 PM

TABLE 2 Percent Changes in Average 85th percentile Speeds from "Before Period" to "Immediate After Period" and "After Period"

Types of Sites	Time Interval	Percent Change From Before Period to Immediate After Period	Percent Change From Before Period to After Period
Treated	AM Peak	-6.32%	-3.90%
	PM Peak	-2.30%	4.41%
	24-Hours	-3.42%	1.90%
Comparison	AM Peak	-2.15%	-0.90%
	PM Peak	0.72%	1.81%
	24-Hours	0.00%	1.26%

TABLE 3 Percent Changes in Average 85th percentile Speeds from Before Period to Immediate After Period Using Before and After Using Comparison Group

Description	AM Peak	PM Peak	24-Hours
Expected average 85th percentile speed without treatment for treated group in after period (π)	51.7	51.6	51.7
Observed average 85th percentile speed for treated group in after period (λ)	50.4	51.0	50.8
Variance of π (VAR{π})	147.0	147.0	147.1
Variance of λ (VAR{λ})	50.4	51.0	50.8
Index of Effectiveness (θ)	0.923	0.936	0.931
Standard Deviation of (θ)	0.252	0.256	0.255
Percent Change (R)	7.7% reduction	6.4% reduction	6.9% reduction
t-statistics	0.30	0.25	0.27
Significant?	No	No	No

TABLE 4 Percent Changes in Average 85th percentile Speeds from Before Period to After Period Using Before and After Using Comparison Group

Description	AM Peak	PM Peak	24-Hours
Expected average 85th percentile speed without treatment for treated group in after period (π)	52.4	52.1	52.3
Observed average 85th percentile speed for treated group in after period (λ)	51.7	54.5	53.6
Variance of π (VAR{π})	149.9	149.61	150.16
Variance of λ (VAR{λ})	51.7	54.5	53.6
Index of Effectiveness (θ)	0.935	0.992	0.971
Standard Deviation of (θ)	0.254	0.269	0.263
Percent Change (R)	6.5% reduction	0.8% reduction	2.9% reduction
t-statistics	0.26	0.03	0.11
Significant?	No	No	No

TABLE 5 Percent Changes in Average Traffic Volume from "Before Period" to "Immediate After Period" and "After Period"

Types of Sites	Time Interval	Percent Change From Before Period to Immediate After Period	Percent Change From Before Period to After Period
Treated	AM Peak	-16.88%	2.68%
	PM Peak	3.01%	-14.29%
	24-Hours	1.64%	-8.44%
Comparison	AM Peak	-24.51%	15.78%
	PM Peak	-8.71%	-10.37%
	24-Hours	-5.55%	-2.42%

TABLE 6 Percent Changes in Average Traffic Volume from Before Period to Immediate After Period Using Before and After Using Comparison Group

Description	AM Peak	PM Peak	24-Hours
Expected average traffic volume without treatment for treated group in after period (π)	477.55	485.07	5,470.62
Observed average traffic volume for treated group in after period (λ)	527.33	548.33	5,890.33
Variance of π (VAR{π})	1,647.19	2,488.78	28,422.68
Variance of λ (VAR{λ})	527.33	548.33	5,890.33
Index of Effectiveness (θ)	1.096	1.119	1.076
Standard Deviation of (θ)	0.105	0.125	0.036
Percent Change (R)	9.6% increase	11.9% increase	7.6% increase
t-statistics	0.92	0.95	2.10
Significant?	No	No	Yes

TABLE 7 Percent Changes in Average Traffic Volume from Before Period to After Period Using Before and After Using Comparison Group

Description	AM Peak	PM Peak	24-Hours
Expected average traffic volume without treatment for treated group in after period (π)	731.69	474.79	5,653.20
Observed average traffic volume for treated group in after period (λ)	651	456.33	5,306
Variance of π (VAR{π})	3,268.88	2,406.61	29,939.01
Variance of λ (VAR{λ})	651	456.33	5,306
Index of Effectiveness (θ)	0.884	0.951	0.938
Standard Deviation of (θ)	0.077	0.108	0.031
Percent Change (R)	11.6% reduction	4.9% reduction	6.2% reduction
t-statistics	1.50	0.45	1.98
Significant?	No	No	Yes