

# **DRIVER SPEED COMPLIANCE WITHIN SCHOOL ZONES AND EFFECTS OF “40” PAINTED SPEED LIMIT ON DRIVER SPEED BEHAVIOURS**

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## **ABSTRACT**

Two speed surveys were conducted on nineteen school zone sections on roads surrounding twelve Primary/High Schools within the Perth metropolitan area. The first survey was done during the period June to August 2001, prior to 40 km/h pavement speed limit markings, and the second was conducted in November 2001, one month after the treatment. Speed data analysis indicated that on both occasions mean speed was 6 km/h less during the 40 km/h speed limit periods than during the 60 km/h period, 49 and 55 km/h, respectively. Similarly, the differences in the 85<sup>th</sup> percentiles were approximately 4km/h, 60 km/h compared to 64 km/h. Driver compliance to the 40 km/h speed limits was found to be very low when compared to the speed limit of 60 km/h. The percentage of vehicles travelling in excess of 10 km/h above speed limit during the 40 km/h periods was approximately 49% compared to 5% during the 60 km/h period. The best compliance was observed between 8:00 and 9:00 a.m. and the worst one between 7:30 and 8:00 a.m. Comparison of driver speed behaviours in terms of statistical indices such as mean speeds, 85<sup>th</sup> percentiles and proportions of drivers travelling through the zones showed no statistical differences between the two surveys, before 40 km/h speed limit markings and after implementation of the markings. The study found that the 40 km/h speed limit markings had no significant effect on driver speed behaviours in addition to the effects inflicted on drivers by the standard regulatory signs. However, the findings of this study should not be generalized to apply to all school zones located on different types of roads, characterized by high volumes, different functionality, higher speeds or traffic composition. It is recommended that the findings of this study should not, in general, be used as an argument against the 40 km/h speed limit markings within the school zones, but as a case for justification in being more selective in considering the sites for the treatment.

## **INTRODUCTION**

Despite the lack of evidence suggesting substantial traffic safety benefits arising from painted speed limits on pavement surfaces (Donald, 1997), the speed limit markings have been used in WA and some other states as a supplementary means of reinforcement of speed limits at sites where there are reasons to believe that the provision of regulatory signs alone is not adequate. Uber (1992) confirmed that the use of painted numerals had minimal effects on driver speed behaviours, and suggested that the effects may be increased if the painted speed limit signs were also used as repeaters. The pavement speed limit markings are usually installed at the start of new speed zones, more often on high speed rather than low speed roads, at the approaches to urban areas or hazardous road sections.

Pavement speed markings within school zones have been used on ad hoc basis in other states, however no known studies have been reported on the effects of the markings to support traffic safety benefits arising from their installations in addition to the standard school zone speed limit signage.

Western Australian experiences indicate that, for some unidentified reasons, drivers do not generally comply with the 40 km/h speed limit within the defined school zones. Ideally, if compliance is defined as the speed of up to 10 km above the speed limit then the satisfactory compliance rate would be similar to the one applicable to the 60 km/h local Access Roads, estimated at 95 % (Radalj, 2001). Considering that the school zone speed limit applies at specific times of the day and days of the year and the zones being within the road sections of higher speed limits, it is quite unrealistic to expect that the compliance would be as high as the compliance observed on the roads containing the zones. It was suggested that additional signage in terms of pavement markings would result in a significant increase in the compliance rate.

An experimental trial has been conducted on a sample of schools in order to evaluate effects of 40 km/h speed limit pavement markings on driver speed behaviours within school zones on local roads surrounding schools. The speed limit on the roads selected for the trial under normal circumstances is 60 km/h, with the exception that the speed limit of 40 km/h applies to some sections of the roads at the times when school children are likely to travel to or from school. The speed limit of 40 km/h applies only within defined school zones on the school days between 7.30 and 9.00 a.m. and 2.30 – 4.00 p.m., excluding weekends, school and public holidays.

The objective of the trial was to assess changes in driver speed behaviours within the school zones accounted for by the pavement 40 km/h speed limit markings in addition to the effects associated with the standard school zone speed limit signs, erected at the start of the sections to which the limit applies. Potential road safety benefits of the pavement markings were measured in terms of differences in speed indices between the periods before and after installation of pavement markings.

The speed limit markings are non-regulatory signs on the pavement that provide supplementary warnings to drivers about the speed limit that applies within the zones they are entering into. These supplementary speed warning signs provide additional information to the standard school zones signage for the purpose of increasing driver alertness to the change in speed limits that drivers are expected to comply with during the morning and afternoon school zone time periods. It is anticipated that the findings of the trial will be useful for making decisions on the utilisation of these speed limit markings as traffic safety measures on a state-wide basis.

## **METHODOLOGY**

The design of the trial has been based on the “before/after” study model by which two sets of vehicle speed data, before and after implementation of speed markings, were collected and compared on a number of indices to assess effectiveness of the markings on driver speed behaviours. Both sets of data were collected prior to the implementation of 50 km/h speed limits on local roads, December 1 2001. It was anticipated that another sample of speeds would be taken on the same location six months after the introduction of the 50 km/h speed limit. One of the objectives of the post 50 km/h speed sampling is to assess relative effects of the speed limit on driver speed behaviours within the school zones when legal speed limit is reduced by 10 km/h.

### **Sample**

The sample consisted of nineteen locations within school zones, on 60 km/h local roads surrounding ten Primary Schools and two Senior High Schools within the City of Belmont. Each survey location was chosen as a point on a road within the school zone as close as possible to the mid-point of the 40 km/h section in order to maximize capture of most likely vehicle speeds the drivers would travel on through the zones in both directions.

The baseline, “before”, speed data were collected between June and August 2001. Each location was surveyed for a minimum period of one day such that each school day of the week would be represented in the total sample of vehicle speeds recorded during the school zone periods. The second, “after”, speed survey was conducted in November 2001, at least one month after installation of speed pavement markings. For each of the locations in the trial, the second survey was taken at the same points on the road sections within the school zones. Vehicle classifiers were used to collect the speed data.

In order to control for differences in vehicle speeds between days of the week and times of the day the data were collected in both surveys over the same consecutive time periods and on the same days. Each school day, Monday to Friday, was represented in the samples.

## **ANALYSIS AND DISCUSSIONS**

In attempt to control for the differences in vehicle speeds that may vary between the days and times of the days at the survey locations, only the data collected within the common time periods of the same days of the week were included in the analysis. All non-overlapping data were discarded from both sets of data. The data collection periods ranged from 10.03 to 73.48 hours. Each period included at least one morning and one afternoon school zone time period.

A number of indices were estimated from the speed data collected in the two surveys. Two distributions of speeds derived from each of the surveys were examined and compared with respect to a number of parameters: (a) distribution of speeds during 40 km/h speed limit periods, and (b) distribution of speeds during the normal 60 km/h time periods. Analysis of the speed data collected before and after implementation of 40 km/h speed limit pavement markings is presented in the sections below.

For the purpose of estimation of effects of painted speed limits within the school zones, only vehicle speeds exceeding 10 km/h with the headway of 4 or more seconds were included in the statistical analysis. Vehicles travelling less than 10 km/h were assumed to be travelling at those speeds due to dropping or picking up children along the road sections within the zones. Likewise, it is assumed that vehicles travelling with the headway less than 4 seconds were constrained to the speeds of the traffic flow rather than to “free” speed flowing traffic conditions, providing no opportunities for speeds higher than the vehicles in the flow.

### **Baseline Survey Speed Data Analysis**

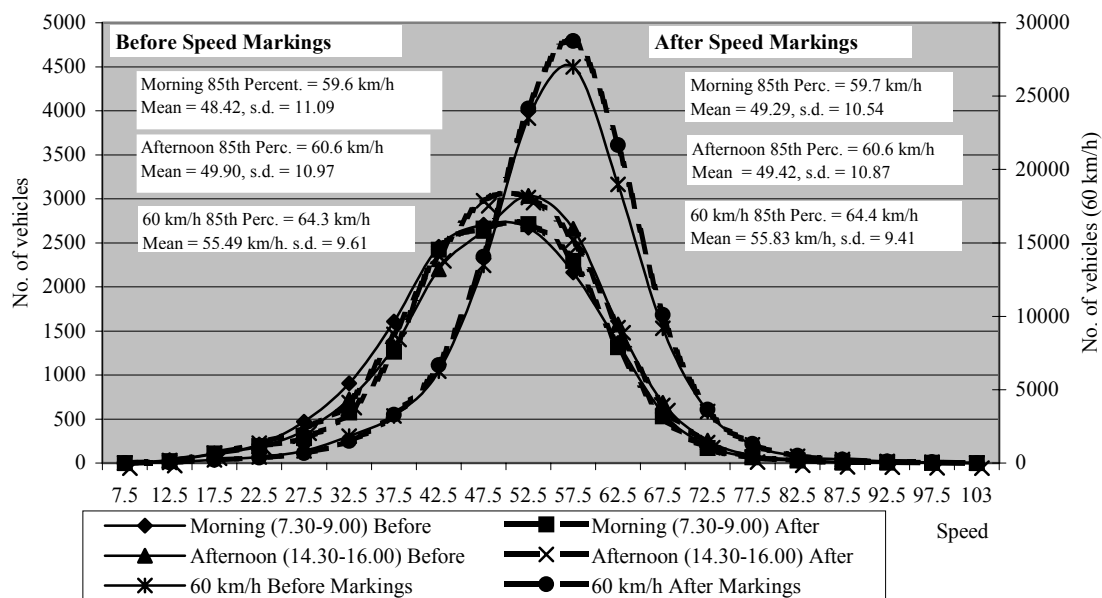
The speed surveys at the nineteen locations within the school zones of the twelve schools resulted in 202472 vehicle details (excluding bicycles), of which 142006 satisfied the set criteria of travelling 10 or more km/h with a headway of 4 or more seconds. The reduced sample of vehicles was divided into two groups with respect to

time of day: the sample of vehicles recorded during the school zone time periods, 7.30-9.00 a.m. and 2.30-4.00 p.m., and the sample of vehicles recorded during the times other than the school zone times. The total numbers of vehicles in the groups were 31474 and 110532, respectively. Speed distributions for the 60 km/h and 40 km/h time periods are presented in Figure 1.

#### School Zone Periods Before Speed Limit Markings

Comparison of the two school zone 40 km/h periods indicated that the mean speed for the afternoon period, 2.30 – 4.00 p.m., was 1.5 km/h higher than for the morning period, 7.30 – 9.00 a.m., 48.42 vs. 49.90 km/h ( $t = 11.86$ ,  $d.f. = 31472$ ,  $p < 0.0001$ ). Similarly, the afternoon school zone time period had experienced 85<sup>th</sup> percentile of vehicles speeds 1 km/h higher than the morning period, 60.6 km/h vs. 59.6 km/h). Distribution of speeds for the morning and afternoon school zone time periods as well as for the 60 km/h time period are presented in the Figure 1.

**Figure 1. Distribution of vehicle speeds during the morning and afternoon 40 km/h speed limit periods, and other 60 km/h periods within school zones**



#### Comparison between 40 km/h and 60 km/h Periods Before Speed Limit Markings

The speed data analysis shows that there were significant differences in mean speeds between the speed limit periods, 40 km/h and 60 km/h. Mean speed for the 40 km/h periods was found to be more than 6 km/h less than the mean speed for the normal 60 km/h speed limit periods, 49.17 km/h compared to 55.49. Similarly, 85<sup>th</sup> percentile differed by approximately 4 km/h, 60.1 vs. 64.3 km/h.

The compliance rates to the speed limits within the school zones, 40 km/h and 60 km/h, were significantly different between the two speed limits operational time periods. The 60 km/h time period compliance rate with respect to the speed up to 10 km/h above the speed limit was significantly greater ( $X^2 = 44118.16$ ,  $d.f. = 5$ ,  $p < 0.0001$ ) than the rate for the 40 km/h speed limit, 94.91% compared to 50.00% (see Table 2, below).

**Table 2. Speed compliance rates to the speed limits of 40 and 60 km/h within school zones before 40 km/h speed limit markings**

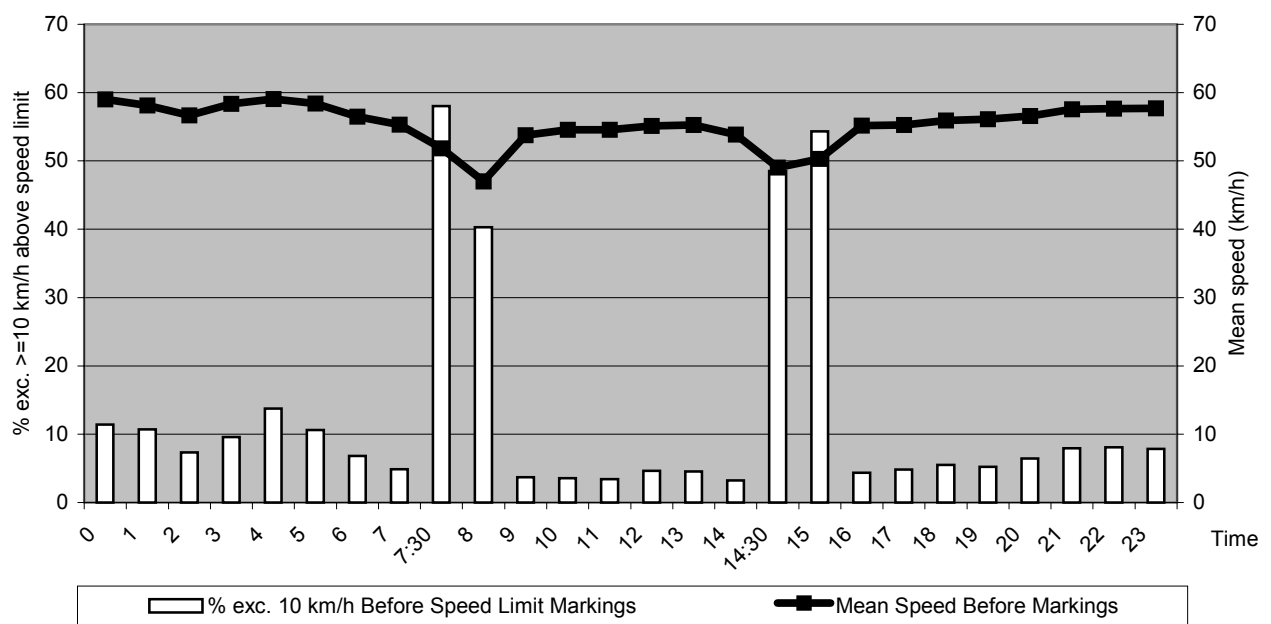
Speed Limit Period	Speed with Respect to the Speed Limit (km/h)						Total
	Under limit	+< 10	+10 - 15	+15 - 20	+20 - 30	+>=30	
Speed limit 40 km/h	6132	9921	5706	4820	4186	709	31474
	19.48*	31.52	18.13	15.31	13.3	2.25	
Speed limit 60 km/h	77202	27701	3512	1254	703	160	110532
	69.85	25.06	3.18	1.13	0.64	0.14	
Total	83334	37622	9218	6074	4889	869	142006

\* Percent of vehicles

The data indicates that during the 40 km/h speed limit periods more than 50 % of vehicles are travelling through the school zones at speeds of 10 or more km/h above the posted speed limit. The 60 km/h speed limit data suggests that drivers are less likely to travel at higher speeds during the school hours than other times of the day (see Figure 2). The compliance rate to 10 km/h above the speed limit during the school hours was estimated to 96.1% compared 94.2% at other times, i.e. during the school hours between 9.00 a.m. and 2.30 p.m., 3.9% of drivers exceed the speed limit of 60 km/h by 10 or more km/h above the limit compared to 5.8% at the period between 4.00 p.m. and 7.30 a.m.

In addition, drivers are less likely to comply with the speed limit of 40 km/h between 7.30 to 8.00 a.m. than between 8.00 to 9.00 a.m., or in the afternoon between 2.30 and 4.00 p.m., possibly due to less presence of school children early in the morning within the defined school zones.

**Figure 2. Percentage of vehicles exceeding 10 km/h above the speed limit and mean speeds by time of day before 40 km/h speed limit markings**



Although 40% of drivers travel 10 or more km/h between 8.00 and 9.00 a.m., the compliance rate for this period is significantly better than the other school time periods, 7.30 to 8.00 a.m. or 2.30 to 4.00 p.m.

### After Treatment (Painting of Speed Limits) Speed Data Analysis

A speed survey was undertaken for each of the sites in the sample at least one month after painting of the 40 km/h speed limit signs at the entry to the school zones. The vehicle speeds were recorded at the same points on the roads as in the survey conducted prior to the pavement markings. Analysis presented below is based on the time periods that corresponded to the periods for which data was available in the pre-treatment survey. The data collected during the non-overlapping periods were discarded. The total number of vehicle data satisfying the set criteria, such that vehicle speed was greater than 10 km/h and its headway was 4 or more seconds, was 148 362, of which 31015 were recorded during the 40 km/h periods and 117 347 during the 60 km/h period.

#### School Zones Periods After Speed Limit Markings

Comparison between morning and afternoon school zone time periods indicated that there was no significant difference in mean vehicle speeds between the two periods, 49.29 vs. 49.42 km/h ( $t = 1.04$ , d.f. = 31014,  $p < 0.297$ ). Similarly, 85<sup>th</sup> percentiles differed only by 0.4 km/h, 59.7 vs. 60.1 km/h. For the distributions of the speeds for the two periods refer to the Figure 1, above.

#### Comparison between 40 km/h and 60 km/h Periods After Speed Limit Markings

Driver speed behaviours measured in terms of travelling speeds collected after the 40 km/h pavement marking showed minimal differences when compared against the data taken before the markings. Mean speed during the school zone periods was 49.36 km/h compared to the mean of 55.83 km/h during the other 60 km/h time periods, a difference of over 6 km/h. Similar to the first survey, the after treatment survey indicated that 85<sup>th</sup> percentile of

vehicles speeds was approximately 4 km/h higher during the 60 km/h than during the 40 km/h school zone time periods, 59.9 vs. 64.4. Similar to the survey prior to the treatment, 5% of vehicles were found to exceed 10 or more km/h during the 60 km/h speed limit period compared to 49% during the school zone periods (see Table 3, below). Distribution of speeds by other speed groups after the treatment is similar to the distribution before the treatment.

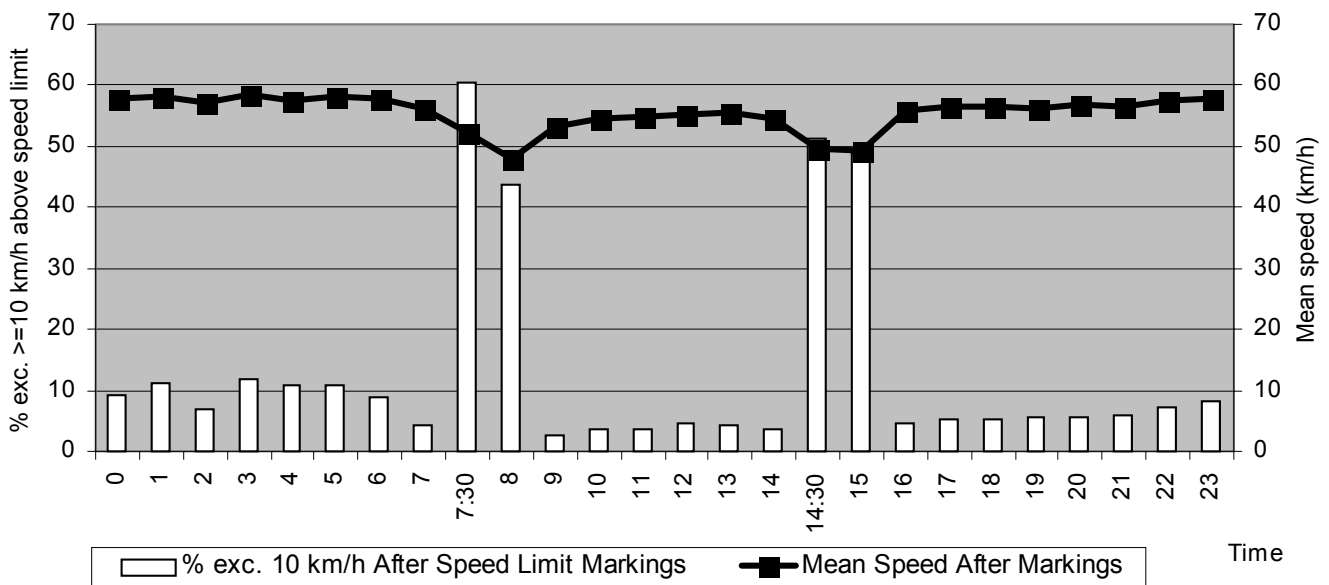
**Table 3. Speed compliance rates to the speed limits of 40 and 60 km/h within school zones after 40 km/h speed limit markings**

Speed Limit Period	Speed with Respect to Speed Limit (km/h)						Total
	Under Limit	+< 10	+10 - 15	+15 - 20	+20 - 30	+>=30	
Speed limit 40 km/h	5439	10336	5730	4827	4042	642	31016
	17.54*	33.32	18.47	15.56	13.03	2.07	
Speed limit 60 km/h	80244	31221	3646	1320	737	179	117347
	68.38	26.61	3.11	1.12	0.63	0.15	
Total	85683	41557	9376	6147	4779	821	148363

\* Percent of vehicles

Distribution of mean speeds and proportions of drivers exceeding speed limits by time of day after implementation of 40 km/h speed limit markings indicate no significant differences when compared to the distributions observed before the treatment (see Figure 4, below).

**Figure 3. Percentage of vehicles exceeding 10 km/h above the speed limit and mean speeds by time of day after 40 km/h speed limit markings**



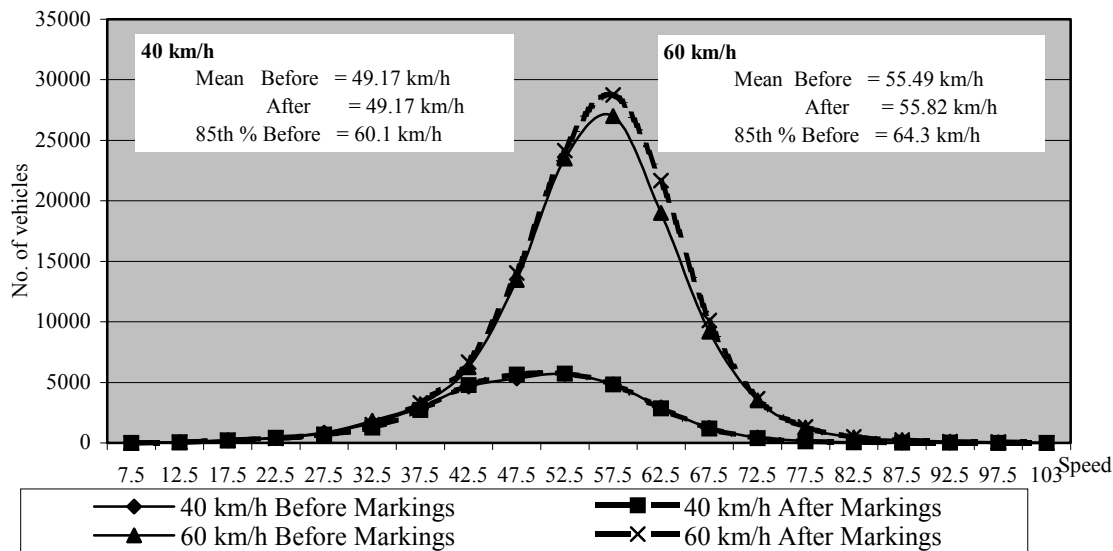
Mean vehicle speeds between 7:30 and 8:00 a.m. were approximately 4 km/h higher than in the period 8:00 to 9:00. Similarly, proportions of vehicles exceeding 10 or more km/h for the same periods were approximately the same as were found in the survey taken before the implementation of the speed markings, 60% and 43%, respectively.

The percentage of vehicles exceeding 10 or more km/h during the school hours, when 60 km/h speed limit applies, 9:00 a.m. to 2:30 p.m. was lower than during the other times, 4:00 p.m. to 7:30 a.m., 3.71 compared to 5.79 km/h.

**Comparison of Vehicle Speeds Before and After Speed Limit Markings**

Effects of speed limit markings were measured in terms of changes in speed indices derived from vehicle speeds during the 40 km/h school zone periods and other times when 60 km/h speed limit applied: mean speeds, 85<sup>th</sup> percentiles and proportions of drivers exceeding certain speeds. Distributions of the speeds measured before and after 40 km/h speed markings for the 40 km/h and 60 km/h periods are presented in Figure 4, below.

**Figure 4. Distributions of speeds before and after 40 km/h speed limit markings**



A two-way analysis of variance was performed to examine the differences between the two sets of speed data collected before and after speed limit markings. The two factors considered were speed limit (two levels: 40 km/h and 60 km/h) and survey (two levels: before treatment and after treatment). There were statistical differences in mean speeds between the two surveys ( $p < 0.0001$ ) and between the speed limits (as expected,  $p < 0.001$ ), see Table 4.

**Table 4. Analysis of variance – comparison between the surveys and speed limits**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2016018.76	672006.25	6968.05	<.0001
Error	290365	28003122.32	96.44		
Corrected Total	290368	30019141.08			
Survey	1	10554.90	10554.90	109.44	<.0001
Speed Limit	1	2005230.02	2005230.02	20792.30	<.0001
Survey x Speed Limit	1	233.84	233.84	2.42	0.1194
R-Square = 0.0672					

No significant interaction was observed between the survey and speed limits factors, indicating that any differences in mean speeds between the surveys were not significantly different between the speed limits of 40 km/h and 60 km/h.

The “after” speed survey showed statistically significant but negligible increase in overall vehicle mean speeds of 0.38 km/h, accounted for by increase 0.19 km/h during school zone periods and by increase of 0.34 km/h during other 60 km/h speed limit period. The marginal differences in mean speeds between the two surveys could well be associated with weather conditions, seasonal variations or speed measurement errors. Distribution of means by Speed Limit and Survey is presented in Table 5, below.

**Table 5. Distribution of means and 85<sup>th</sup> percentiles by survey and speed limit**

Sped Survey	Speed Limit (km/h)		Grand Mean	85th percentiles	
	40	60		40 km/h	60 km/h
Before Speed Limit Markings	49.17	55.49	54.09	60.1	64.3
After Speed Limit Markings	49.36	55.83	54.47	59.9	64.4
Grand Mean	49.26	55.66	54.29		

Comparisons between the morning and afternoon periods, and the surveys, before and after the speed limit markings, showed some unexplained anomalies in mean vehicle speeds. The “after” treatment survey indicated a decrease in the mean speed of 0.48 km/h during the afternoon period while there was an increase in the mean speed of 0.87 km/h during the morning period.

Analysis of proportions of vehicle speeds in various speed groups indicated no significant changes in driver speed behaviours after implementation of speed limit markings in any of the two speed limit categories, 40 km/h or 60 km/h periods. Percentage of drivers travelling 10 or more km/h through the zones remained the same (see Table 6).

**Table 6. Percentage of drivers exceeding the speed limits by 10 or more km/h**

Survey	Speed Limit	
	40 km/h	60 km/h
Before Speed Limit Markings	49.00	5.09
After Speed Limit Markings	49.14	5.01
p - value	0.720	0.382
X <sup>2</sup> (d.f. = 1)	0.128	0.762

Comparison of the 85<sup>th</sup> percentiles between the “before” and “after” speed surveys showed no significant differences in the 85<sup>th</sup> percentiles for neither of the speed limits, less than 0.2 km/h.

## CONCLUSIONS AND RECOMMENDATIONS

The speed measurement on 19 local roads surrounding 12 schools within the city of Belmont before and after 40 km/h speed limit markings suggests that:

1. Drivers, on average, travelled 6 km/h less during the 40 km/h speed limit operational periods than during the 60 km/h periods.
2. The 85<sup>th</sup> percentile during the 40 km/h period was 4 km/h less than during the 60 km/h speed limit period.
3. Driver speed compliance to the speed limit of 40 km/h was significantly less than the compliance to 60 km/h, 51% compared to 95%.
4. Comparison of the mean speeds before and after 40 km/h speed limit markings showed no significant change for both speed limit categories. Mean speeds for the operational speed limit periods of 40 km/h and 60 km/h remained the same, approximately 49.0 km/h and 55.5 km/h, respectively. Likewise, 85<sup>th</sup> vehicle speed percentiles after the treatment were not significantly different from the percentiles before implementation of the 40 km/h speed limits markings, for the 40 km/h and 60 km/h speed limit time periods the percentiles being approximately 60 km/h and 64 km/h, respectively.
5. No changes were observed in percentage of vehicles exceeding 10 or more km/h above the speed limits, neither in the 40 km/h nor 60 km/h speed limit time periods. Likewise, no significant differences were found in the proportion of vehicles travelling with the speed above 50 km/h and 70 km/h when the respective operational speed limits applied.

In summary, on the basis of this trial, it can be concluded that 40 km/h speed limit markings within the defined school zones on local Access Roads surrounding school sites have no significant effect on driver speed behaviours within the zones additional to the effects inflicted on drivers by the standard regulatory signs. One of the reasons for no change in driver behaviours may be explained by the hypothesis that the same or not significantly different population of drivers are traversing the school zones, such as parents dropping to or picking up children from school, or local household drivers, who are well accustomed to the school zones and who already had formed the “speed norms” such that no additional signage can influence their driving behaviours. If this hypothesis is true, as it seems to be the case based on this trial, it can be concluded that pavement 40 km/h speed limit markings would not significantly change driver speed behaviours within school zones located on similar roads surrounding other schools within the metropolitan area.

The findings of this study should not be generalized to apply to all school zones located on different types of roads, characterized by high volumes, different functionality or types of traffic. For example, it is possible that the 40 km/h speed limit markings may have quite different effect on driver speed behaviours within the school zones on arterial types of roads with a high volume of through traffic, or high operational speed roads, which provide opportunities for drivers to travel at high speeds, irrespective of posted speed limits applied to the roads containing the zones. It is suggested that similar trials should be conducted on these types of roads in order to assess effectiveness of the 40 km/h speed limit markings at locations that are not typical to the environments investigated in this study.

It is recommended that the findings of this study should not, in general, be used as an argument against the 40 km/h speed limit markings within the school zones, but as a case for justification in being more selective in considering the sites for the treatment.

Although the speed limit markings showed no effect on driver speed behaviours within the school zones, their presence might still have a beneficial effect in increasing driver alertness when travelling within such environments, not measured in this study.

Perceptual effects of the signs might act as stimuli for a greater caution exhibited by the drivers when approaching the zones, but not necessarily having positive effect on driver speeds who tend to drive according to some form of predetermining norms, based on a number of factors possibly associated with: road and traffic conditions, activity within the zones, past experiences related to level of enforcement, and other extraneous or subjective factors.

## **REFERENCES**

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