Post 50 km/h Implementation Driver Speed Compliance Western Australian Experience in Perth Metropolitan Area

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Biography
Brian joined Main Roads in 1966 and since 1980 Brian has been involved in the Traffic and Safety areas of Main Roads and was appointed as Road Safety Manager in 1999. Brian is a member of a number of state committees, and Road Safety Taskforces, and on the Executive Board for the Injury Control Council of WA. Brian currently chairs the State Task Forces for Speed and Vulnerable Road Users, and Railway Crossing Protection.

Abstract
Western Australia introduced a default 50 km/h general urban speed limit on built-up roads state-wide in December 2001. The model chosen for 50km/h speed limit in Western Australia was to change the default general urban speed limit of 60km/h for built-up areas to 50 km/h by regulation in the Road Traffic Code. This model resulted in the erection of very few actual 50 km/h speed signs.

This study is restricted to the Perth Metropolitan Area where initially 135 sites were surveyed as a baseline study prior to the introduction of the 50 km/h speed limit. 115 of these speed surveys were on roads that were blanketed to the speed limit of 50km/h, and the remainder on roads that preserved to old speed limit of 60 km/h.

This paper provides a quantitative analysis on the results of three speed surveys conducted to measure driver speeds on local roads, one in November 2000 before the introduction of the blanket 50 km/h speed limit in December 2001, and 6 month and 12 month subsequent surveys in June 2002 and November 2002.

Reductions in speed behaviour were assessed in terms of 85th speed percentile, mean speed, and proportion of drivers travelling below 60 km/h on both roads that became 50km/h and roads that remained at 60 km/h.

For roads that became 50 km/h, six months and twelve months after implementation the 85th speed percentile was reduced by 2.6 km/h and 2.0 km/h, respectively. Similarly, for roads that became 50 km/h the mean speed was reduced by 1.87 km/h six months after implementation, and by 1.33 km/h twelve months after implementation.

For roads that remained and were signed at 60 km/h some but not as high reductions in the 85th speed percentile and mean speed were recorded.

The most significant finding resulting from the reduction in speed limit from 50 to 60 km/h on local roads is associated with the change in driving behaviour. There was a decrease of 6.91% of drivers travelling above 60 km/h, 29.30% to 22.38 %, equating to a 24% reduction in percentage of drivers travelling in speeds in excess of 60 km/h.

1. INTRODUCTION

The introduction of the 50km/h speed limit legislation in Western Australia followed an exemption from the Australian Road Rules where all roads on a state-wide basis within built-up areas would be blanketed to the speed limit of 50 km/h unless otherwise signed. Under

regulation 297 (1) of the WA Road Traffic Code 2000, Main Roads WA has the responsibility to erect traffic signs state-wide, and in the case of most regulatory signs including speed limit signs, Main Roads has retained this responsibility in house. Prior to December 2000 all local roads and state roads were 60 km/h, unless signed otherwise. Roads that retained the previous speed limit of 60 km/h were signed by the date of implementation of the 50 km/h speed limit, 1 December 2001. Most of the higher functionality order roads such as Distributor A, Distributor B and Primary Roads preserved the speed limit of 60 km/h and were signed accordingly. The introduction of the blanket 50 km/h speed limit in urban areas, generally applied to all Access Roads and Local Distributor roads classified according to the functional road hierarchy (MRWA, 1999) agreed upon by individual Local Government Authorities.

In Western Australia, Main Roads WA took the responsibility for speed evaluation of the program by measuring changes in drivers' speed behaviours over time, before and after the legislation had taken effect. Ultimately effects of changes in drivers' speed behaviours subsequent to the introduction of the 50 km/h speed limit will also be assessed against changes in number and severity of crashes.

The main objectives of the speed surveys were:

(1) To collect speed data prior to, 6, 12 and 24 months after implementation of the 50 km/h speed limit
(2) To monitor driver compliance on signed (60 km/h) and unsigned (50 km/h) roads.

2. METHOD

2.1 Survey design

The Perth metropolitan area road network covers a vast area of 5366 km^2 managed by thirty metropolitan LGAs. It was assumed that there were no differences in distribution of proportions of drivers between the LGAs. Factors like traffic exposure and driver population within the LGAs were estimated on the basis of population size using the Australian Bureau of Statistics Statistical Local Areas of the 1996 census. Statistical Local Area population size was used in determining number of survey roads per locality. Subsequently, the number of survey roads by 37 Statistical Local Areas were merged by LGA, where required, into the final sets of survey sites distributed over the 30 Local Authorities in the Perth metropolitan area based on AUSTROADS Functional Classification System. Where possible, a proportional number of road types were chosen within each of the Local Government Authorities with each represented with at least one road.

2.2 Sample Size

Previous research studies involving surveys of the size of 50000 vehicles have been proved to be sensitive in detecting changes in the 95^{th} percentile speed as small as 2 km/h between two consecutive years (Cameron & Vulcan, 1998). The survey was designed such that the minimum sample size by each of the principal strata (road type and speed limits, 50 km/h and 60 km/h) was not less than 50000 vehicles.

A sample of speeds taken on 60 km/h locations in the metropolitan area suggested that the minimum sample size of 1000 vehicles was required to detect changes of 1 km/h in the mean speed. A pilot survey indicated that the minimum sample sizes required to detect the change in 95^{th} percentile of 1 km/h with 99% confidence level and error of 1 km/h, assuming speed variances of two surveys were the same, would be approximately 2N, where N was estimated at 2000 vehicles.

The surveys were confined to the four types of local roads and traffic environments, namely, District Distributor A, District Distributor B, Local Distributor and Access Road. A sample of

approximately 140 sites was considered sufficient in size to provide reliable representativeness of driver speed behaviours. The number of surveyed sites by LGA varied between 1 and 18 with some LGAs represented by all four road types. Care was taken to achieve the most feasible representation of driver speed behaviours over all strata. In the baseline survey, of the proposed 141 roads/road links, 138 were surveyed.

2.3 Speed Survey Site Selection Methodology

Selection of a physical location on a road is based on the following five criteria:

a) Pre-implementation speed limit of 60 km/h
b) A "free" flowing traffic
c) Equipment installed at the mid-point of a section defined by two intersecting roads.
d) No installations within a "school zone".
e) Road features such as bridges, culverts, railway level crossings, and floodways were avoided.

2.4 Other Survey Characteristics and Criteria

The data collection took place during expected stable weather periods, namely, between October and beginning of December, May and June. Data collected on rainy days was excluded. An anticipated data collection period per site was 3-4 days. In order to control for the differences between days of the week, the surveys were arranged in such a way that each day of the week would be approximately equally represented in the sample. Vehicle data collected in excess of the multiples of 24 hours was discarded to control for differences in time of day.

2.5 The Six-month Survey

An attempt was made to collect speed data on each location in the baseline sample over the similar days of the week, with the maximum overlap of days and hours. Two sites that were included in the baseline, 2000, survey were excluded in the second, June 2002, survey. Out of the 138 baseline roads, 115 changed to the speed limit of 50 km/h, while 23 roads remained as signed with a 60 km/h speed limit.

2.6 The Twelve-month Survey

The twelve-month survey was conducted in November/December 2002. The sample consisted of 124 roads that were surveyed in the earlier surveys, represented by 11 Distributor A roads, 12 Distributor B roads, 36 Local Distributor roads and 65 Access roads, of which 103 were in the 50 km/h group and 21 in the 60 km/h group.

3. RESULTS AND DISCUSSION

Speed indices were compared between the pre-50 km/h speed limit legislation surveys and the post-50 km/h speed limit legislation surveys for both roads where the speed limit was changed from the default speed limit of 60 km/h to the new default speed limit of 50 km/h, and roads which preserved and were signed at 60 km/h.

The speed indices, as measures of driver speed behaviours, in the surveys were: mean speeds, average 85th percentiles, and proportions of motor vehicles below/above certain speeds for both 50 and 60 km/h speed limit roads.
The baseline speed survey recorded 1.65 million vehicles of which 1.27 million were considered to have travelled with "free" speeds i.e. headway was four or more seconds (Standards Australia, 1999). Vehicles with lower headway values were excluded from the

analysis. The subsequent two surveys, six and twelve months after the introduction of 50 km/h speed limit 1.77 and 1.46 million vehicles, respectively, of which 1.26 and 1.02 million travelled with the headway greater or equal to 4 seconds.

Assuming that each driver of a vehicle passed a survey spot twice a day over the spot survey period of 3 to 4 days, and if compensation is made for those drivers who make multiple trips by those drivers who make single trips, then one can estimate that approximately 130 000 to 160 000 different driver speed behaviours were recorded in each of the surveys. More conservatively if it was assumed that, on average, each driver traversed the same path four times a day, then the number of different driver speed behaviours recorded would be estimated at 65 000 to 80000. One can therefore infer that the sample consisted of between 65 000 and 160 000 drivers, representing approximately 9 to 18 percent of the metropolitan drivers.

Comparisons between the vehicle speed distributions for each of the speed limit sample of roads suggest no significant changes in shapes of the distributions between the three surveys. As expected, characteristics of the distributions are similar to most of vehicle speed distributions, being symmetrical and leptokurtic, having high kurtosis values. Speed variance on 60 km/h roads remained fairly constant over the time with no practically significant differences observed between the surveys, however, for 50 km/h roads speed variance was smaller after than before the introduction of the speed limit, representing some indication of changes in driver speed behaviours applying speeds closer to the mean speeds of the distributions. Speed variances on 60 km/h were significantly less than the variances on 50 km/h roads in all surveys, indicating a “smoother” traffic movement on the higher speed roads than on the lower speed roads. These differences in speed variances may be related to the differences in road characteristics, the 50 km/h roads having lower functional road characteristics, mainly shorter Access roads or Local Distributor roads, than the 60 km/h roads which are longer and wider or multilane District Distributor roads.

Speed distribution parameter estimates were compared for both, 50 km/h and 60 km/h roads. Initial two-way analysis of variance, speed limit by survey, showed a significant interaction ($F = 32.11$, d.f. = 2, $p < 0.0001$) between the two factors, indicating that the mean speeds between the surveys varied across the two speed limit roads. The differences between the survey means for the two speed limit roads were further examined using one-way analysis of variance. The differences between the speed indices are discussed in the sections below.

3.1 Analysis of Speeds on 50 km/h roads

The baseline survey speed indices were compared against the six and twelve months after speed indices. The number of “free speed” travelling vehicles recorded during the surveys ranged from 636 000 in November 2002 to 850 000 in November 2000.

Mean Speeds and 85th Percentiles

A comparison of the mean speeds suggests that there were significant differences in mean speeds between the three surveys ($F = 6337.1$, d.f. = 2, $p < 0.001$). Mean speed in the baseline survey was 54.15 km/h, significantly higher than in the other two surveys, 52.29 km/h in June 2002 and 52.87 km/h in November 2002 (see Table 1), corresponding to mean speed reductions of 1.87 km/h (95% C.I.: 1.91, 1.82) and 1.29 km/h (95% C.I.: 1.33, 1.24) respectively, with an increase in mean speed of 0.58 km/h (95% C.I.: 0.54, 0.63) between June 2002 and November 2002.

Time of Survey	Speed Limit Changed to 50 km/h							
	Yes				No			
	N	Mean	s.d.	85th %	N	Mean	s.d.	85th %
Nov 2000	850157	54.15	11.34	64.4	417924	61.17	9.14	69.0
Jun 2002	778581	52.29	10.49	61.8	478887	59.29	8.95	66.8
Nov 2002	636475	52.87	10.55	62.4	381318	60.07	9.21	67.8
Differences								
Jun 2002 vs Nov 2000*		-1.87		-2.6		-1.88		-2.2
Nov 2002 vs Jun 2002*		0.58		0.6		0.79		1.0
Nov 2002 vs Nov 2000*		-1.29		-2.0		-1.09		-1.2

* for all indices $p < 0.05$

Table 1. Descriptive statistics by survey and speed limit metropolitan area

Similarly, comparisons of vehicle speeds between the surveys indicate that both, the six-month and twelve-month, surveys had significantly smaller 85thpercentiles than the baseline survey of 2.6 km/h and 2.0 km/h respectively when compared to the baseline survey. Similar to the increase in mean speed from June to November 2002, the 85th percentile was increased by 0.6 km/h.

Analysis of Speed Group Proportions

A more detailed examination of vehicle speeds by survey revealed that after the introduction of the 50 km/h speed limit a number of drivers changed their driving behaviours in that some proportions of the drivers tend to travel with slower speeds than previously accustom to. The data suggests that in the post-50 km/h implementation period there was a significant shift in number of drivers from travelling with speeds greater than 60 km/h to speeds less than 60 km/h (see Table 2, below).

Time of Survey	Vehicle Speed						
	<= 50	50 - 60	60 - 70	70 - 80	80 - 90	>= 90	Total
Nov 2000	265676	335356	202283	39083	5592	2167	850157
(A)	31.25	39.45	23.79	4.6	0.66	0.25	
Jun 2002	294008	326900	132410	20717	3167	1379	778581
(B)	37.76	41.99	17.01	2.66	0.41	0.18	
Nov 2002	222856	270998	119544	18988	2935	1154	636475
(C)	35.01	42.58	18.78	2.98	0.46	0.18	
Total	782540	933254	454237	78788	11694	4700	2265213
% Diff. B - A	*6.51*	*2.54*	*-6.78*	*-1.94*	*-0.25*	*-0.07*	
% Diff. C - B	*-2.75*	*0.59*	*1.77*	*0.32*	*0.05*	*0.00*	
% Diff. C - A	*3.76*	*3.13*	*-5.01*	*-1.62*	*-0.2*	*-0.07*	
Chi Square =21837, d.f. = 10, $p < 0.0001$							

Table 2. Distribution of vehicle speeds on 50 km/h roads within the metropolitan area before and after the introduction of the speed limit (headway >= 4 sec)

It was shown that number of drivers travelling above 60 km/h in November 2002 was significantly reduced by approximately 7% (from 29.3 % to 22.4%, $\chi^2 = 8917$, d.f. = 1, $p < 0.0001$), when compared to the number of drivers travelling with the same speed prior to the introduction of the default speed limit, which equates to 24% reduction in the number of drivers travelling with speeds higher than 60 km/h. Overall compliance to the speed limit in November to 2002 was 35%, as expected, significantly less than the compliance observed on the 60 km/h roads (47%).

3.2 Analysis of Speeds on 60 km/h Roads

An analysis of speed data representing driver speed behaviours on the roads that remained with the speed limit of 60 km/h is presented below. Like 50 km/h roads, an analysis of speed data obtained from the surveys on 60 km/h roads showed similar pattern in differences between the surveys in mean speeds and 85th percentiles indices.

Mean Speeds and 85th Percentiles
The data suggests that drivers on 60 km/h roads that were signed at 60 km/h tended to on average, travel slower after the introduction of the default speed limit of 50 km/h than it was the case prior to its introduction. Mean speeds in June 2002 and November 2002 were reduced by 1.88 (95% C.I.: 1.93, 1.83) and 1.09km/h (95% C.I.: 1.14, 1.04), respectively. Similarly, 85th percentiles were significantly less on signed 60 km/h roads after than before the introduction of the 50 km/h speed limit ranging between 2.2 km/h in June 2002 to 1.2 km/h in November 2002 (ref Table 1, above).

Assuming that all factors that could have affected drivers' speed behaviours remained the same over the period between the baseline and the twelve-month surveys, the observed speed indices, measured in terms of average speeds and 85th percentiles, suggest that the change in the default speed limit on Local roads had relatively small effects on driver speed behaviours on both speed limit roads, 50 km/h and 60 km/h roads. In absence of adequate control samples one can hypothesise that the observed reduction in mean speeds and 85th percentiles on 60 km/h roads are likely to be associated either with 60 km/h signage, or carry-over effects from the behaviours on the 50 km/h roads to these roads.

Analysis of speed group proportions
An analysis of speed data collected on 60 km/h roads that were signed after the introduction of the default speed limit suggests similar pattern in changes in driver speed behaviours to those observed for the 50 km/h roads (see Table 3).

Time of	Vehicle Speed						
Survey	<= 50	50 - 60	60 - 70	70 - 80	80 - 90	>= 90	Total
Nov 2000	35224	139122	190401	45782	6025	1370	417924
(A)	8.43	33.29	45.56	10.95	1.44	0.33	
Jun 2002	54516	194133	191832	32868	4294	1244	478887
(B)	11.38	40.54	40.06	6.86	0.9	0.26	
Nov 2002	40379	138462	164188	32597	4504	1188	381318
(C)	10.59	36.31	43.06	8.55	1.18	0.31	
Total	130119	471717	546421	111247	14823	3802	1278129
% Diff. B - A	*2.95*	*7.25*	*-5.5*	*-4.09*	*-0.54*	*-0.07*	
% Diff. C - B	*-0.79*	*-4.23*	*3.00*	*1.69*	*0.28*	*0.05*	
% Diff. C - A	*2.16*	*3.02*	*-2.5*	*-2.4*	*-0.26*	*-0.02*	
Chi Square = 11744, d.f. = 10, p <.0001							

Table 3. Distribution of vehicle speeds on 60 km/h roads within metropolitan area before and after the introduction of the default 50 km/h speed limit on local roads (headway >= 4 sec.)

In June 2002, the 60 km/h roads experienced 10% reduction in number of drivers travelling above 60 km/h, which was significantly larger than the proportion of 5% recorded in the November 2002 survey. The observed increase in number of drivers travelling above 60 km/h in November 2002 could well be associated with driver adjustment to the new system of speed limits on local roads and experiences in distinguishing between acceptable speed behaviours on the two types of roads. The twice as large reduction in the proportions of drivers travelling above 60 km/h in June 2002 survey compared to the November 2002 survey was more likely to be associated with adaptation to the two speed limits types of Local roads rather than with the real effect of transferable 50 km/h speed limit effect or

signage of these roads. Nevertheless, the reduction of 5% in the number of drivers travelling above 60 km/h on these roads, as recorded in November 2002, is significant (χ^2 = 2172, d.f. = 1, $p < 0.0001$) considering the time period after the speed limit changes took place. This reduction in the driver speeds increased compliance to the speed limit from 41.72% in 2000 to 46.90% in November 2002.

Since no extensive publicity or campaign had been conducted, and no significant changes in enforcement on the local roads had been implemented between the two surveys, it is quite likely that driver speed behaviours had stabilized and are likely to remain as such in the future.

4. CONCLUSIONS

The analysis of the speed data collected during the three surveys, one before the introduction of 50 km/h in Nov 2000 and two after the introduction of the speed limit, one in June 2002 and Nov 2002 suggests that drivers have somewhat changed their speed behaviours on the Local roads network in the metropolitan area. The changes in driver speed behaviours as measured in terms of mean speeds, 85th percentiles and proportions of drivers in various speed groups can be summarised as follows:

50 km/h Roads

1. Six months after 85th speed percentile reduced by 2.6 km/h (from 64.4 to 61.8 km/h).
2. 12 months after 85th speed percentile reduced by 2.0 km/h (from 64.4 to 62.4 km/h).
3. Six months after mean speed reduced by 1.87 km/h.
4. 12 months after mean speed reduced by 1.29 km/h.
5. Twelve months after the introduction of 50 km/h, the number of drivers travelling above 60 km/h was reduced by 7%, which equates to a reduction of 24% in the number of drivers that used to travel with the speed above 60 km/h.

60 km/h Roads (Roads that remained with the speed limit of 60 km/h but signed):

1. Six months after, 85th speed percentile reduced by 2.2 km/h (69.0km/h to 66.8km/h).
2. 12 months after, 85th speed percentile reduced by 1.2 km/h (69.0km/h to 67.8km/h).
3. Six months after, mean speed reduced by 1.88 km/h (61.17km/h to 59.29km/h).
4. 12 months after mean speed reduced by 1.09 km/h (61.17km/h to 60.07 km/h).
5. Speed limit compliance rate on the 60 km/h roads has been increased by 5.18%, from 41.72% in 2000 to 46.90% Nov 2002.

Although relatively small, the reductions in mean speeds and 85th percentiles on the 60 km/h roads in the metropolitan area might be associated with either transferable effects from behaviours on 50 km/h roads or existence of speed limit signs.

The observed differences between the two post-50 km/h implementation surveys, June 2002 and Nov 2002, could be associated with publicity and 50k campaigns, which were stronger during the first six months after the speed limit was introduced. It is highly unlikely that the observed differences between the two surveys could be explained by seasonal variation related to weather conditions since both surveys were conducted on fine days. On the other hand the small increase in the speed indices recorded in November 2002 could possible be associated with seasonal variations in driver speed behaviours related to proximity of Christmas period. One can hypothesis that the true overall driver speed behaviours measured in terms of mean speeds, 85th percentiles and proportions of drivers travelling with various speeds would be somewhere between the range represented by the two sets of indices. Since very little publicity or driver awareness campaigns have been conducted over recent times, it is quite reasonable that future driver speed behaviours will be similar to the behaviours estimated in the June 2002 and November 2002 surveys.

The most significant outcome resulting from the reduction in the speed limit from 50 to 60 km/h on Local roads seems to be associated with a change in driving behaviours where the proportion of drivers on 50 km/h roads driving above 60 km/h decreased by 24%, compared to the decrease of 9% on the 60 km/h roads. Although, for practical reasons, no control samples could have been used in the study for neither of the speed limit road types, the observed small differences in the measured speed indices between the unsigned 50 km/h and signed 60 km/h roads may be associated with different driver speed behaviours on each of the roads after the introduction of the 50 km/h speed limit due to the reduction of the default 50 km/h speed limit and signing of the remaining 60 km/h roads, respectively.

Since speed is associated with probability in crash occurrence and its severity, one would expect that the reduction especially in number of drivers travelling with higher speeds, above 60 km/h, would result in a lesser number of crashes and less severity of the crashes if all other road safety factors remained the same. The study to examine the change in crashes since the introduction of the default 50 km/h general urban speed limit on built-up roads state-wide in December 2001 was not complete at the time of writing this paper.

In conclusion, since the study showed that changes in speed indices for both types of roads were similar after the introduction of the default speed limit it may be debatable whether the introduction of the default speed limit had a significant effect on driver speed behaviours on the 50 km/h roads, or the 60 km/h when compared to other higher speed roads at the network level. However, further recommended studies based on speed surveys to be arranged on the same roads twelve months after the introduction of the 50 km/h speed limit and other general speed surveys at the network level, incorporating all speed limit roads surveyed before and after the introduction of the speed limit, may clarify anomalies in the differences between the before and after surveys on Local roads and differences between the two road types.

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