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Reduction of speed limit from 110 km/h to 100 km/h on certain roads in South Australia: a follow up evaluation

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ABSTRACT

In July 2003, the speed limit on approximately 1,100 km of rural arterial roads in South Australia was reduced from 110 km/h to 100 km/h. A previous CASR study found that the speed limit change was associated with a 1.9 km/h reduction in average speed and a 19.7 per cent reduction in casualty crashes. However, the reduction in casualty crashes was not statistically significant; potentially due to the limited quantity of crash data available at the time. This report details a follow up investigation using more crash data (10 years before and after the speed limit change) and longer term speed data (up to 11 years after the speed limit change). The number of crashes on the subject roads since the speed limit was lowered was found to be 27.4 per cent lower than would have been expected if the subject roads had just followed the control road (roads that remained at 110 km/h) reductions. This reduction was found to be statistically significant with 95% confidence limits of +/- 12.4%. The number of people injured was also found to have fallen by a similar amount resulting in a rough, dollar equivalent, estimate of $6.7 million per year in economic savings. The limited long term speed data suggests that speeds, and particularly high speeds, have continued to fall on the subject roads in the 10 years since the speed limit was lowered. While the methodological design of this study was not ideal: the size of the effect, the consistency of the various elements, and agreement with other research provides rather convincing evidence that the lowered speed limits were effective in reducing casualty crashes and injuries by a large amount.

KEYWORDS

Speed limit, Rural area, Arterial road, Accident rate, Data analysis

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Summary

In July 2003, the speed limit on approximately 1,100 km of rural arterial roads (73 road sections) in South Australia was reduced from 110 km/h to 100 km/h. A previous CASR report investigated the change in casualty crashes on these road segments, as well as on control road segments where the speed limit remained at 110 km/h, using data from two years before and two years after the speed limit reduction. The investigation found that the speed limit change was associated with a 1.9 km/h reduction in average speed and a 19.7 per cent reduction in casualty crashes. A 19.0 per cent reduction in casualties was also identified, which was calculated as an injury cost saving to the South Australian community of $9 million per year. However, these results were not statistically significant; potentially due to the limited quantity of crash data available.

This report details a follow up investigation of the effect of the speed limit reductions on the identified road segments. Casualty crash data on the subject road segments from ten years before and ten years after the speed limit reduction were analysed. New control road segments, where the speed limit has not been changed from 110 km/h during the longer analysis period, were also selected and analysed. Long term trends in speeds were analysed by examining two long term speed sites located on the changed roads.

The average number of crashes on both the subject roads and the control roads declined over time. However, the decline was greater on the subject roads. The number of crashes on the subject roads in the after period was 27.4 per cent lower than would have been expected if the subject roads had just followed the control road reductions. This reduction was found to be statistically significant with 95% confidence limits of +/- 12.4%.

The number of people injured was also found to have fallen by a similar amount resulting in a rough, dollar equivalent, estimate of $6.7 million per year in economic savings.

The limited long term speed data suggests that speeds, and particularly high speeds, have continued to fall on the subject roads in the 10 years since the speed limit was lowered.

While the methodological design of this study was not ideal: the size of the effect, the consistency of the various elements and agreement with other research provides rather convincing evidence that the lowered speed limits were effective in reducing casualty crashes and injuries by a large amount.

Contents

1 Introduction

In July 2003, the speed limit on approximately 1,100 km of rural arterial roads (73 road sections) in South Australia was reduced from 110 km/h to 100 km/h. A previous CASR report (Long et al., 2006) investigated the change in casualty crashes on these road segments, as well as on 8,671 km of road segments where the speed limit remained at 110 km/h (for use as control data), using data from two years before and two years after the speed limit reduction. The investigation found that the speed limit change was associated with a 1.9 km/h reduction in average speed and a 19.7 per cent reduction in casualty crashes. A 19.0 per cent reduction in casualties was also identified, which was calculated as an injury cost saving to the South Australian community of $9 million per year. However, these results were not statistically significant; potentially due to the limited quantity of crash data available.

This report details a follow up investigation of the effect of the speed limit reductions on the identified road segments. Casualty crash data on the subject road segments from ten years before and ten years after the speed limit reduction were analysed. New control road segments, where the speed limit has not been changed from 110 km/h during the longer analysis period, were also selected and analysed. Long term trends in speeds were analysed by examining two long term speed sites located on the changed roads.

Also included in this report is a brief review of other studies that have examined changes in crashes associated with changes in speed limits and a discussion of the potential issues with the methodology in the present study.

2 Literature review

This literature review seeks to identify studies that have investigated how crashes are affected after speed limit changes, especially within Australia. The review focusses on the effects of changes to high speed roads, but there is also a significant amount of literature on the effects of changes to lower speed limits that reveal findings similar to those presented below (e.g. Kloeden et al., 2007).

2.1 Predicting changes in crash risk

Travelling speed contributes to crash risk and a lower travelling speed is associated with a reduced risk of crashing (Aarts & van Schagen, 2006). A method of quantifying the change in crash risk resulting from a given change in travelling speed was suggested by Nilsson (1981). This method was referred to as the Power Model as the change in crash risk was estimated as the change in travelling speed raised to a certain power (see Equation 2.1). Based on speed surveys and crash data collected in Sweden, Nilsson (1981) suggested that all crashes, casualty crashes, and fatal crashes would be changed in accordance with the Power Model raised to the 2nd, 3rd, and 4th power respectively.

$$\frac{crashes\ after}{crashes\ before} = \left(\frac{speed\ after}{speed\ before}\right)^{x}$$

Equation 2.1
The “Power Model”, where a different exponent, or power, (x) is used for various types of crash

However, Nilsson (1981) noted that these Power Model exponents were only generally applicable, in that they were monotonically increasing and based on a single set of data from mainly rural roads in Sweden. Another limitation of the Power Model is that it does not account for factors beyond crash severity such as traffic environment or speed limit. Indeed, Cameron & Elvik (2010) found that for urban roads the exponents above significantly overestimated crash reductions.

A refinement of the Power Model exponents, to address the above limitations, was produced by Elvik et al. (2004) and Elvik (2009) who conducted meta-analyses of several studies that investigated how crashes were changed as a result of a change in vehicle travelling speed. Studies using data from several countries and from both urban and rural road environments were included in the meta-analyses. As such, exponents that allow the Power Model to more accurately predict the effect that a change in travelling speed will have on crash risk were identified. Additionally, disaggregation of the crash data allowed Power Model exponents applicable to various levels of crash severity (property damage, all casualty, slight, serious, fatal) as well as different traffic environments (urban or rural) to be calculated.

Studies of the relationship between travelling speed and crash risk in Australia have shown results comparable to those predicted by the Power Model (Kloeden et al., 2001; Kloeden et al., 2002).

Reductions in speed limits are intended to improve road safety by decreasing travelling speed and thus reducing the risk of crashes occurring and the severity of crashes that do occur. While travelling speeds would naively be expected to decrease by the same amount as a speed limit decrease, this has been shown to be incorrect (Nilsson, 1981; Elvik et al., 2004; Kloeden et al., 2007). The meta-analysis by Elvik et al. (2004) found that mean travelling speed typically decreases by only about 2.5 km/h for every 10 km/h reduction in the speed limit. Beyond this initial decrease, mean travelling speed appears to continue to decline slowly over time (Kloeden et al., 2007).

Any reduction in mean travelling speed that is achieved would be expected to lead to a corresponding reduction in crash and injury risk. The Power Model, described above, could be used to calculate an expected crash reduction for the speed limit reduction being investigated in this report (110 km/h to 100 km/h). However, it has been noted that the Power Model may not accurately predict the effects of travelling speed reductions where the initial speed was high (Elvik, 2009; Elvik, 2013).

In order to overcome this limitation, a re-parameterisation of the Power Model was suggested by Elvik (2013). Rather than model crash risk changes across the entire range of travelling speeds with a single power function, this new model utilises an exponential function for each 10 km/h band of initial travelling speed. Using this model to investigate the effect of a reduction in mean travelling speed from 105 km/h to 95 km/h predicts a 32.1 per cent reduction in casualty crash risk.

2.2 Measuring changes in crash risk

A previous report by CASR (Long et al., 2006) investigated the effects of reducing the speed limit from 110 km/h to 100 km/h on approximately 1,100 km of rural road in South Australia. Analysis of travel speed at six sites, in locations where the speed limit was changed, showed a 2 km/h reduction in average speed. Crash data was also analysed through a comparison of casualty crashes from two years before the speed limit change and two years after the change. This analysis revealed a 20 per cent reduction in casualty crashes and a 19 per cent reduction in casualties, which was calculated to have resulted in economic savings of $9 million per year. However, these results were not statistically significant.

Following on from the favourable findings by Long et al. (2006), it was reported by Dua et al. (2013) that speed limit reductions from 110 km/h to 100 km/h were made on a further 864 km of South Australian rural roads in 2011. Analysis of the public education campaign associated with the new speed limit reductions was conducted through a survey of 579 South Australian drivers. It was found that 67 per cent of the drivers were aware of the speed limit changes and 58 per cent believed that the changes would reduce the injury severity of a crash. A comparison of the number of casualty crashes in the year following the speed limit change to the average number of casualty crashes in the five years prior to the change was conducted. However, this comparison was rather rudimentary (in that it only used a single year of data after the limit change and did not make use of control data or account for trends) and the finding of a 13 per cent reduction in casualty crashes should be interpreted as indicative only. Note, that the road segments investigated by Dua et al. (2013), which had their speed limit reduced from 110 km/h to 100 km/h in 2011, are not part of the analysis described in the Sections below.

Other research from Australia on the effects of reducing the speed limit from 110 km/h to 100 km/h has shown similar results. In 1987 the speed limit on the Victorian freeway network was increased from 100 km/h to 110 km/h. Then in 1989 the 110 km/h speed limit was removed and a 100 km/h limit was reintroduced. Sliogeris (1992) investigated the effect that these speed limit changes had on the rate of casualty crashes. It was found that casualty crashes increased by 25 per cent following the speed limit increase and decreased by 19 per cent following the subsequent speed limit decrease.

An investigation into the effects of a speed limit reduction from 110 km/h to 100 km/h on the Great Western Highway in rural NSW was conducted by Bhatnagar et al. (2010). A reduction in mean travelling speeds, from above 102 km/h to less than 98 km/h, was accompanied by a reduction in casualty crashes of 27 per cent. The analysis did not make use of control sites.

Cameron (2009) conducted a theoretical investigation into the economic cost/benefits of lowering speed limits on Tasmanian high speed roads. Evidence for a positive economic outcome (which included a predicted reduction in crashes and injuries) as a result of reducing speed limits from 110 km/h to 100 km/h on National Highways was identified.

International research has also produced evidence that a reduction in the speed limit on high speed roads will result in a corresponding reduction in crash frequency. An investigation by De Pauw et al. (2014) into the effect of reducing speed limits from 90 km/h to 70 km/h on Flemish highways found a statistically significant decrease of 33 per cent in the number of crashes involving serious injuries or fatalities.

Similarly, Jaarsma et al. (2011), who looked at the effect of the reduction of the speed limit from 80 km/h to 60 km/h on minor rural roads in the Netherlands, found a statistically significant decrease of 24 per cent in casualty crashes. It should be noted that the speed limit change was also complemented by infrastructure upgrades such as edge marking, speed humps, and raised platforms at intersections.

In Israel, Friedman et al. (2007) investigated the crash rate consequence after the speed limit was increased from 90 km/h to 100 km/h on 115 km of major interurban highways in November 1993. To control for exposure changes over the analysis period, which was three years before and three years after the speed limit change, the monthly proportion of serious and fatal casualties that were fatal was considered. A statistically significant increase of 2.5 per month in the proportion of fatal casualties was identified.

In the United States there have been several instances of speed limits being increased on high speed rural roads. A major trigger of such action was the 1995 repeal of the national maximum speed limit, which allowed each state to set their own speed limits for rural Interstate routes. As a result of the repeal many states increased the rural Interstate speed limit from 65 mph (105 km/h) to 70 mph (113 km/h) or 75 mph (121 km/h).

Farmer et al. (1999) investigated how the frequency of fatalities was affected in 24 states where the speed limit on rural Interstates was increased. Fatalities on rural Interstates in seven states that did not change the speed limit were used as a control. An increase in fatalities of 15 per cent was found, rising to 17 per cent if changes in mileage were taken into account.

A similar situation in the state of Iowa, which increased the speed limit on most rural Interstates from 65 mph to 70 mph in 2005, was investigated by Souleyrette and Cook (2010). A statistically significant increase of 25 per cent in total crashes was found. Increases of 52 per cent in night time fatal crashes and 25 per cent in serious cross median crashes were also identified but were not statistically significant.

2.3 Summary

There is good evidence that a reduction in crash risk will occur as a result of a reduction in travelling speeds brought about by a lowered speed limit. In the case of a speed limit reduction from 110 km/h to 100 km/h, the reduction in casualty crashes would be expected to be in the order of 20 to 30 per cent.

3 Identifying crashes on subject and control road segments

The investigation presented here consists of a before and after analysis of casualty crashes on the road segments where the speed limit was reduced from 110 km/h to 100 km/h. The before period spans 10 years, from July 1993 to June 2003. The after period also spans 10 years, from July 2003 (during which the speed limit was reduced) to July 2013.

Because of the considerable length of the analysis period, control road segments (where the speed limit remained at 110 km/h) were used to account for background changes in casualty crash numbers.

3.1 Defining subject and control road segments

As in the previous report (Long et al., 2006), the South Australian Department of Planning, Transport and Infrastructure (DPTI) provided a list of the 73 road segments (on 48 unique roads) where the speed limit was reduced from 110 km/h to 100 km/h in July 2003. Another list consisting of the 328 road segments (on 151 unique roads) where the speed limit remained at 110 km/h through the analysis period of July 1993 to June 2013 was also provided by DPTI. These two lists defined the subject road segments and control road segments analysed in this study.

For logistical purposes all major South Australian roads have an associated road code. Each coded road also has an associated start and end point such that a specific location along the road can be identified via a 'run distance', which is the travel distance from the start point to the point of interest. Each of the subject and control road segments is defined by a start and end run distance along a particular road (specified by the corresponding code).

3.2 Characteristics of subject and control road segments

It should be noted that the application of speed limit reductions to the subject road segments was not random and the control road segments were not matched characteristically (e.g. by traffic volume or level of infrastructure) in any way to the subject road segments.

The geographic location of the subject road and control road segments can be seen in Figure 3.1. The majority of the subject road segments are located on the Yorke Peninsula or within a few hundred kilometres of Adelaide. Conversely, the control road segments are located relatively far away from Adelaide and comprise several major arterial rural highways. Given that the majority of South Australia's population is located in and around Adelaide, the subject road segments are likely to experience greater traffic flows compared to the control road segments. Similarly, because of their remote location, there are likely to be differences in the safety infrastructure of the control road segments compared to the subject road segments.

The potential effect that these study deficiencies may have upon the results are discussed in Section 7.2. While these potential effects cannot be ignored, it is unlikely that the differences in the characteristics of the subject and control road segments would be sufficient to explain the crash reductions reported in Section 4.

3.3 Locating crashes in South Australia

Details of all police reported crashes that occur in South Australia are reviewed by DPTI and entered into the Traffic Accident Reporting System (TARS) database. Within the TARS database, crashes are located[1] using road codes and run distances in three ways. The first is used to locate crashes that occur at major intersections by noting the codes of the two intersecting roads. Crashes that occur between intersections (or intersections with minor roads that do not have an associated road code) can be located by providing a single road code and run distance. A crash can also be located at an unknown point between two intersections by providing the three road codes. The first code indicates the road on which the crash occurred and the remaining two codes indicates the bounding intersections.

In more recent times additional effort has been put into accurately locating crashes, and the practice of using three roads has been considerably reduced. Since the subject road and control road segments are defined between intersections this change in location method should not have any affect on the results.

3.4 Identifying crashes on subject and control road segments

Data on all casualty crashes that occurred between July 1993 and June 2013 were extracted from the TARS database. Each crash was then categorised as occurring on a subject road segment, a control road segment, both a subject road segment and a control road segment, or neither type of road segment (in which case they were removed from the analysis).

Crashes that were located with a single road and run distance were categorised relatively simply; checking for a match to a road on either the subject road or control road lists, and then investigating whether the run distance was situated between the start and end point of the corresponding segment.

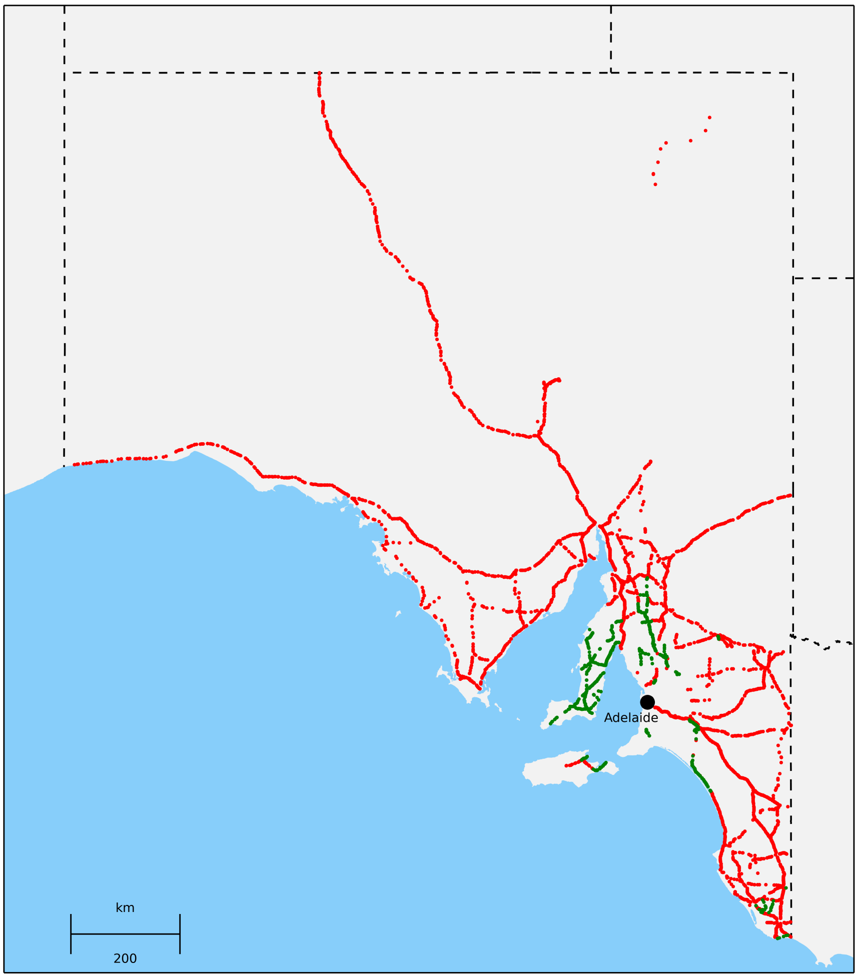
For crashes located with two or three road codes, the categorisation process was more complex. First, those crashes that occurred on a subject or control road were identified. This was achieved by checking for a match to either of the intersecting roads for crashes located with two road codes, or to the main road for crashes located with three road codes. Next, a manual check was conducted to establish whether the intersecting road or both bounding roads were situated between the start and end point of the subject or control road segment.

Using these methods, there were 935 crashes identified on subject road segments and 4,884 crashes identified on control road segments. There were 105 crashes categorised as occurring on both a subject road segment and a control road segment. Since these crashes were unable to be definitively categorised they were removed from the analysis. Note that the removal of these crashes means that the number of crashes on the subject road segments identified in this report will be lower that the number identified in Long et al. (2006).

Figure 3.1 shows the location of all the identified crashes on both the subject and control road segments. These data points were mapped using the GPS coordinates associated with each crash.

[1] Crashes are also located with GPS coordinates. However, the facilities to match GPS coordinates to the specified road segments were not available.

Figure 3.1
Location of crashes on subject road segments (green dots) and on control road segments (red dots) between July 1993 and July 2013



4 Estimating the reduction in number of casualty crashes

Because the speed limit on the subject road segments was reduced in July 2003, the data analysis is conducted using financial years (i.e. beginning July of one year and ending June of the following year).

The casualty crashes identified in each financial year on the subject road segments and the control road segments is shown in Table 4.1. The table presents the number of crashes split into the before and after periods and disaggregated by crash severity. The total number of casualty crashes (of all severities) on the subject road and control road segments per financial year is also shown in Figure 4.1.

The average number of crashes on both the subject road segments and the control road segments declined from the before to the after period. This reduction in the average number of crashes was apparent for all severity categories apart from crashes that resulted in injuries that required hospital treatment on control road segments, which showed a slight increase from the before to the after period.

In Table 4.2, the ratio of casualty crashes on subject road segments to casualty crashes on control road segments in each financial year is shown. The results are again presented disaggregated by before/after period and by crash severity. The ratio of the total number of casualty crashes per financial year is shown in Figure 4.2.

The ratio results reveal that the decline in the number of crashes from the before period to the after period was greater on the subject road segments compared to the control road segments. This is evidenced by the reduction in the average ratio from 0.2197 in the before period to 0.1595 in the after period. That is, the number of crashes on the subject road segments in the after period was lower than would have been expected if the subject road segments had just followed the control road segment reductions. This greater reduction on subject road segments was found for all crash severity categories. When looking at Figure 4.2, the step drop in the ratio of crash frequency from the before period to the after period can be seen clearly.

The amount by which crashes were reduced on the subject road segments compared to the control road segments was investigated further. Table 4.3 shows the average before and after ratio for each severity category, along with the percentage ratio change which represents the additional crash reduction on the subject road segments beyond those found on the control road segments. An independent sample t-test was applied to the crash ratios in each financial year to determine the upper and lower 95% confidence limits of the change in crash ratio between the before and after periods.

The results from Table 4.3 reveal a 27.4 per cent reduction in all casualty crashes on subject road segments beyond that of the control road segments. The associated bounds of ± 12.4 per cent indicate that this reduction in crashes is highly statistically significant ($p < 0.0001$). The reductions in crashes that resulted in an admission to hospital or treatment at hospital were also statistically significant. However, the confidence intervals were too wide to determine whether there were greater reductions for crashes of a higher severity category.

Looking again at Figure 4.2 it appears that there is a greater reduction in the ratio during the final three financial years of the after period. This may be indicative of a downward trend which would mean the 27 per cent reduction in crashes identified here is an underestimate of a long term effect and an overestimate of the short term effect.

The reductions found for each of the severity categories are used in Table 4.4 to estimate that over 140 crashes were prevented as a result of the reduction of the speed limit from 110 km/h to 100 km/h on the subject road segments.

Table 4.1
Number of casualty crashes on the subject and control road segments per financial year (1993/94 to 2012/13) by crash severity

Period	Financial year	Subject					Control				
		Doctor	Treated	Admitted	Fatal	Total	Doctor	Treated	Admitted	Fatal	Total
Before (110 km/h speed limit on subject roads)	1993/94	5	23	23	4	55	18	96	112	27	253
	1994/95	6	23	23	3	55	21	123	88	14	246
	1995/96	4	27	36	4	71	18	105	123	36	282
	1996/97	8	19	19	3	49	18	104	115	20	257
	1997/98	3	23	18	3	47	14	99	102	19	234
	1998/99	7	26	19	4	56	12	111	107	23	253
	1999/00	4	32	17	3	56	14	113	119	15	261
	2000/01	4	23	13	7	47	14	105	107	13	239
	2001/02	4	29	23	6	62	18	116	86	19	239
	2002/03	4	26	27	8	65	14	121	131	29	295
	Total	49	251	218	45	563	161	1093	1090	215	2559
	Average	4.9	25.1	21.8	4.5	56.3	16.1	109.3	109.0	21.5	255.9
After (100 km/h speed limit on subject roads)	2003/04	3	24	16	8	51	18	111	110	17	256
	2004/05	1	20	14	1	36	12	119	96	24	251
	2005/06	4	17	16	4	41	8	90	98	23	219
	2006/07	1	26	16	1	44	7	124	93	4	228
	2007/08	5	16	12	3	36	9	118	86	13	226
	2008/09	5	30	13	0	48	13	94	110	16	233
	2009/10	2	25	8	2	37	14	124	89	25	252
	2010/11	3	15	8	1	27	10	124	86	18	238
	2011/12	2	9	12	2	25	5	112	75	13	205
	2012/13	0	11	13	3	27	16	124	60	17	217
	Total	26	193	128	25	372	112	1140	903	170	2325
	Average	2.6	19.3	12.8	2.5	37.2	11.2	114.0	90.3	17.0	232.5

Figure 4.1
Number of casualty crashes on subject road and control road segments per financial year (1993/94 – 2012/13)

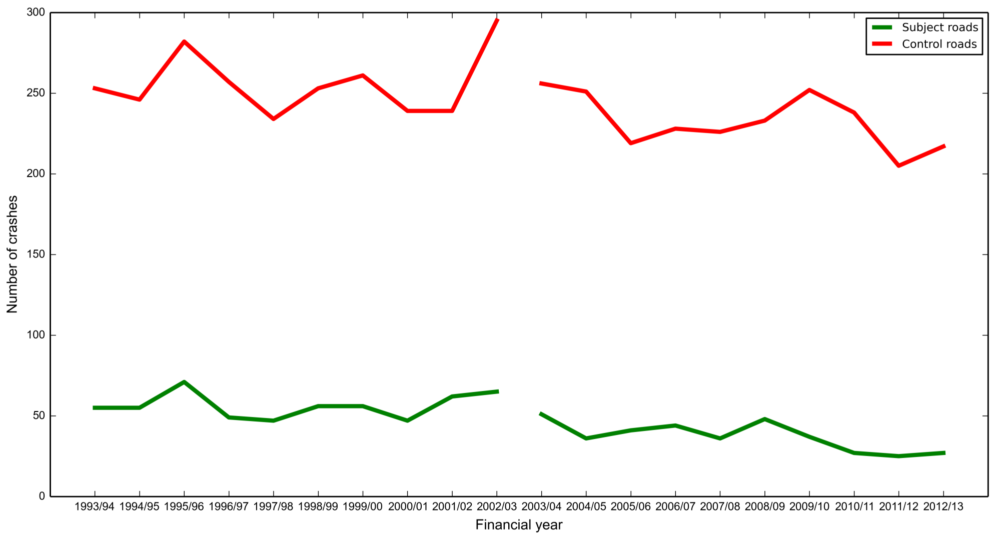


Table 4.2
Ratio of crashes on subject road segments to crashes on control road segments per financial year (1993/94 – 2012/13) by crash severity

Period	Financial year	Doctor	Treated	Admitted	Fatal	Total
Before (110 km/h speed limit on subject roads)	1993/94	0.2778	0.2396	0.2054	0.1481	0.2174
	1994/95	0.2857	0.1870	0.2614	0.2143	0.2236
	1995/96	0.2222	0.2571	0.2927	0.1111	0.2518
	1996/97	0.4444	0.1827	0.1652	0.1500	0.1907
	1997/98	0.2143	0.2323	0.1765	0.1579	0.2009
	1998/99	0.5833	0.2342	0.1776	0.1739	0.2213
	1999/00	0.2857	0.2832	0.1429	0.2000	0.2146
	2000/01	0.2857	0.2190	0.1215	0.5385	0.1967
	2001/02	0.2222	0.2500	0.2674	0.3158	0.2594
	2002/03	0.2857	0.2149	0.2061	0.2759	0.2203
	Average	0.3107	0.2300	0.2017	0.2285	0.2197
After (100 km/h speed limit on subject roads)	2003/04	0.1667	0.2162	0.1455	0.4706	0.1992
	2004/05	0.0833	0.1681	0.1458	0.0417	0.1434
	2005/06	0.5000	0.1889	0.1633	0.1739	0.1872
	2006/07	0.1429	0.2097	0.1720	0.2500	0.1930
	2007/08	0.5556	0.1356	0.1395	0.2308	0.1593
	2008/09	0.3846	0.3191	0.1182	0.0000	0.2060
	2009/10	0.1429	0.2016	0.0899	0.0800	0.1468
	2010/11	0.3000	0.1210	0.0930	0.0556	0.1134
	2011/12	0.4000	0.0804	0.1600	0.1538	0.1220
	2012/13	0.0000	0.0887	0.2167	0.1765	0.1244
	Average	0.2676	0.1729	0.1444	0.1633	0.1595

Figure 4.2
Ratio of crashes on subject road segments to crashes on control road segments per financial year (1993/94 – 2012/13)

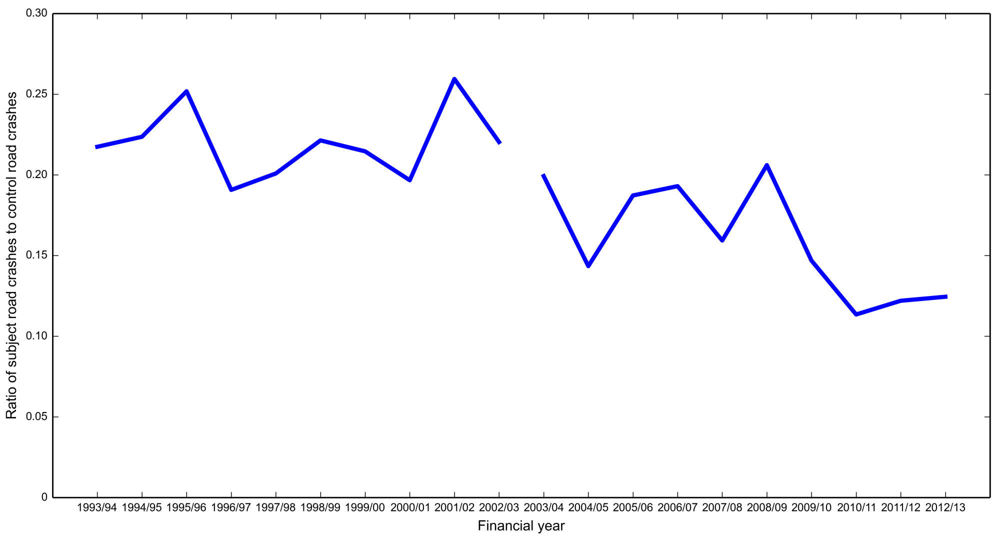


Table 4.3
Change in the ratio of crashes between the before and after period by crash severity

Crash severity	Average ratio (before)	Average ratio (after)	% ratio change	Upper confidence limit	Lower confidence limit
Fatal	0.2285	0.1633	-28.56	25.24	-82.35
Admitted to hospital	0.2017	0.1444	-28.40	-6.01	-50.78
Treated at hospital	0.2300	0.1729	-24.82	-2.45	-47.19
Treated by doctor	0.3107	0.2676	-13.88	33.23	-60.99
Any severities	0.2197	0.1595	-27.40	-39.82	-14.97

Table 4.4
Estimated number of crashes prevented in the after period by crash severity

Casualty severity	% crashes avoided	Number in after period	Number avoided
Fatal	28.56	25	9.99
Admitted to hospital	28.40	128	50.77
Treated at hospital	24.82	193	63.71
Treated by doctor	13.88	26	4.19
Any severities	27.40	372	140.37

5 Estimating the reduction in casualties and the resulting dollar equivalent savings

The number and severity of casualties that resulted from the crashes that occurred on the subject and control road segments in each financial year are shown in Table 5.1. There were 1,481 casualties on the subject road segments and 7,541 casualties on the control road segments.

Table 5.1
Number of casualties on the subject and control road segments by financial year and injury severity

Period	Financial year	Subject					Control				
		Doctor	Treated	Admitted	Fatal	Total	Doctor	Treated	Admitted	Fatal	Total
Before (110 km/h speed limit on subject roads)	1993/94	6	40	37	5	88	21	181	171	35	408
	1994/95	13	38	31	4	86	27	219	135	21	402
	1995/96	6	52	47	6	111	24	209	184	40	457
	1996/97	14	30	25	3	72	24	150	164	21	359
	1997/98	3	46	28	5	82	21	172	160	28	381
	1998/99	9	43	29	5	86	19	220	175	27	441
	1999/00	4	60	26	3	93	23	200	167	15	405
	2000/01	5	31	24	9	69	16	185	159	15	375
	2001/02	4	56	46	8	114	24	203	116	21	364
	2002/03	5	42	40	8	95	18	202	199	31	450
	Total	69	438	333	56	896	217	1,941	1,630	254	4042
	Average	6.9	43.8	33.3	5.6	89.6	21.7	194.1	163.0	25.4	404.2
After (100 km/h speed limit on subject roads)	2003/04	3	45	28	9	85	25	186	153	18	382
	2004/05	1	38	16	1	56	14	205	140	33	392
	2005/06	6	40	27	7	80	9	186	158	29	382
	2006/07	3	35	21	1	60	11	201	134	4	350
	2007/08	7	33	18	4	62	12	196	123	15	346
	2008/09	9	41	14	0	64	19	163	149	20	351
	2009/10	3	44	10	2	59	19	192	121	29	361
	2010/11	4	24	12	1	41	16	181	114	22	333
	2011/12	2	16	14	3	35	7	180	99	16	302
	2012/13	3	18	19	3	43	21	183	75	21	300
	Total	41	334	179	31	585	153	1,873	1,266	207	3499
	Average	4.1	33.4	17.9	3.1	58.5	15.3	187.3	126.6	20.7	349.9

Table 5.2 shows, for each severity category, the average ratio of casualties on subject road segments to casualties on control road segments in both the before and after periods. The percentage change in the ratio from the before period to the after period is then calculated along with 95% confidence intervals (calculated from an independent sample t-test).

Table 5.2
Change in the ratio of casualties between the before and after period by casualty severity

Casualty severity	Average ratio (before)	Average ratio (after)	% ratio change	Upper confidence limit	Lower confidence limit
Fatal	0.2429	0.1733	-28.65	28.46	-85.75
Admitted to hospital	0.2099	0.1448	-31.01	-2.44	-59.59
Treated at hospital	0.2258	0.1785	-20.92	0.65	-42.48
Treated by doctor	0.3148	0.3024	-3.93	49.68	-57.54
Any injury	0.2221	0.1654	-25.56	-10.55	-40.57

This ratio change percentage is then used to determine the reduction in casualties (for each severity category) that coincides with the change in the speed limit on the subject road segments (Table 5.3).

Table 5.3
Estimated number of casualties prevented in the after period by casualty severity

Casualty severity	% casualties avoided	Number in after period	Number avoided
Fatal	28.65	31	12.45
Admitted to hospital	31.01	179	80.48
Treated at hospital	20.91	334	88.33
Treated by doctor	3.93	41	1.68
Any injury	25.56	585	200.84

The dollar equivalent costs of a single casualty of each severity category were obtained (BITRE, 2009). These costs were quoted in 2006 dollars and so were converted to 2013 dollars using a CPI inflation calculator (ABS, 2014).

In Table 5.4, the reduction in the number of casualties in each severity category has been multiplied by the costs to calculate the dollar equivalent savings associated with the speed limit change on the subject road segments.

Table 5.4
Dollar equivalent savings attributed to the reductions in casualties resulting from speed limit changes

Casualty severity	Estimated reduction in casualties	Cost per casualty (2013 dollars)	Dollar equivalent savings over 10 years	Dollar equivalent savings per year
Fatal	12.45	$3,215,260	$40,018,020	$4,001,802
Admitted to hospital	80.48	$320,132	$25,762,748	$2,576,275
Treated at hospital	88.33	$17,743	$1,567,220	$156,722
Treated by doctor	1.68	$12,038	$20,175	$2,017
Total			$67,368,163	$6,736,816

The total estimated savings due to the lowered speed limits is $6.7 million per year or $67 million in the 10 years since they were introduced.

Note that there is considerable uncertainty about the number of casualties of a particular severity that were prevented, particularly for fatal injuries, which are the most expensive individually. Therefore, the total savings should only be taken as an indicative measure that has a high degree of uncertainty.

6 Speed changes

The previous study (Long et al., 2006) analysed six sites that had speed measurements on the changed roads before and after the change and found a combined 1.9 km/h average speed reduction after the speed limit reduction.

The current study attempted to identify sites, where the speed limit was lowered, that had speed measurements taken before the change and for a long period after the change so that long term trends could be examined.

Two of the original sites were later made into permanent year round speed measurement sites and so extensive speed data is available for those sites. These sites were located on the Yorke Highway in Port Clinton and the Spencer Highway in Urania.

For each of these permanent sites, obviously anomalous days (in terms of traffic volume or speeds) and partially measured days were removed and speed statistics were calculated for each one week contiguous block of data that remained. For Site 6262 - Port Clinton, traffic volumes and speed measurements were found to have a strong seasonal effect which tended to mask any changes. Since the 110 km/h speed limit measurements were taken in mid to late January 2003, only measurements taken in mid to late January in subsequent years for Site 6262 are presented.

The Figures below show the changes in speed measurements over time for each of the two sites. The red solid dots are before the speed limit was changed and the open blue dots are after.

The trends apparent in Figures 6.1-6.12 are:

- A slight upward trend in traffic volume
- A general downward trend in mean speed
- A large downward trend in 85th percentile speed
- A general downward trend in the percentage of vehicles above 100 km/h
- A large downward trend in the percentage of vehicles above 110 km/h
- A large downward trend in the percentage of vehicles above 120 km/h

The reductions in the high speed measurements (85th percentile and per cent above 110 and 120 km/h) appear to be particularly large in the first two years after the speed limit was lowered.

As can be seen in the Figures, there is considerable week to week random variation in speed measurements. Individual sites can also be subject to variations from changes elsewhere in the nearby road network. So any conclusions drawn from only two sites have to be tentative at best.

Given this, it appears that speeds (and particularly high speeds) may have fallen rapidly during the first two years after the speed limit was lowered and have continued to decline since then. While tentative, this is entirely consistent with the observed changes in casualty crashes over the same time period.

Figure 6.1
Site 540 - Urania
Weekly traffic counts

Figure 6.2
Site 6262 - Port Clinton
Weekly traffic counts

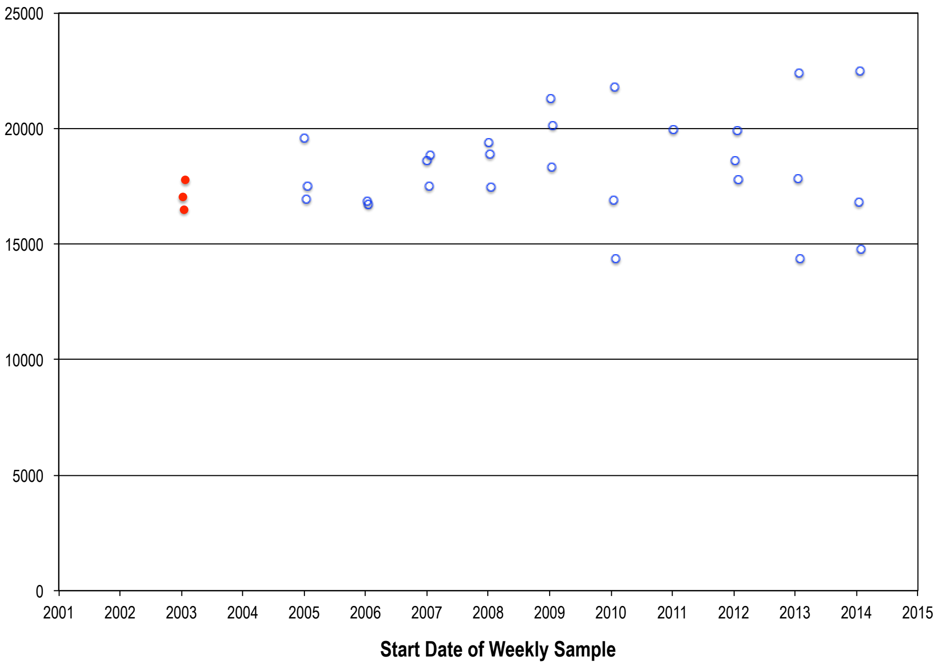


Figure 6.3
Site 540 - Urania
Mean speed (km/h)

Figure 6.4
Site 6262 - Port Clinton
Mean speed (km/h)

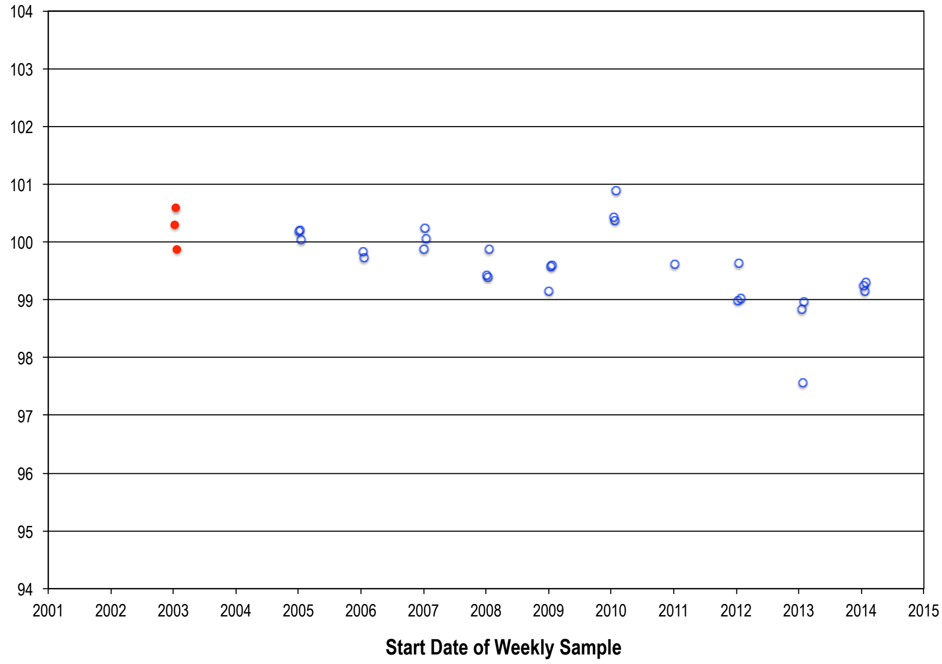


Figure 6.5
Site 540 - Urania
85th percentile speed (km/h)

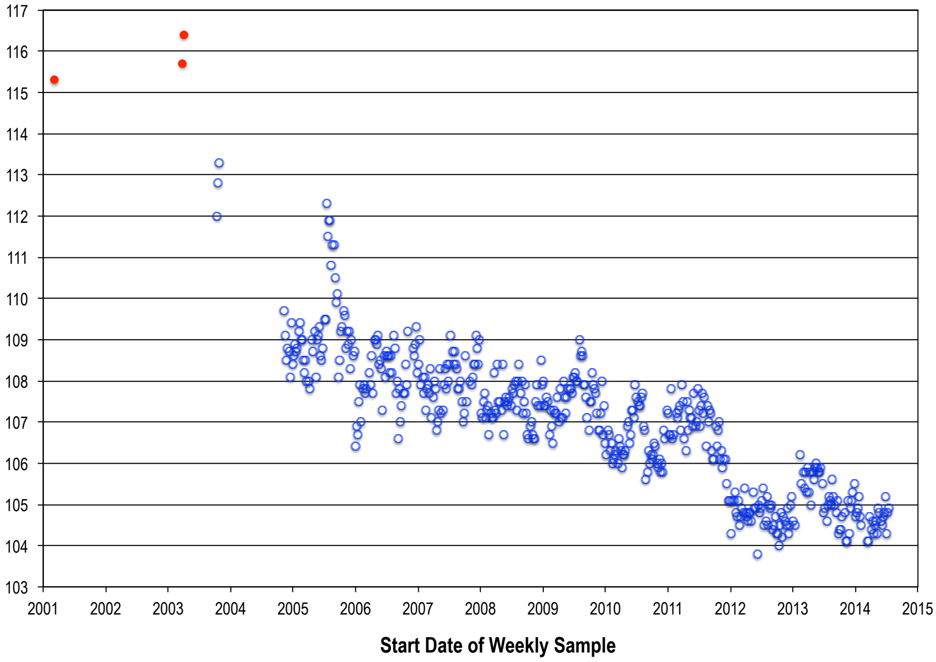


Figure 6.6
Site 6262 - Port Clinton
85th percentile speed (km/h)

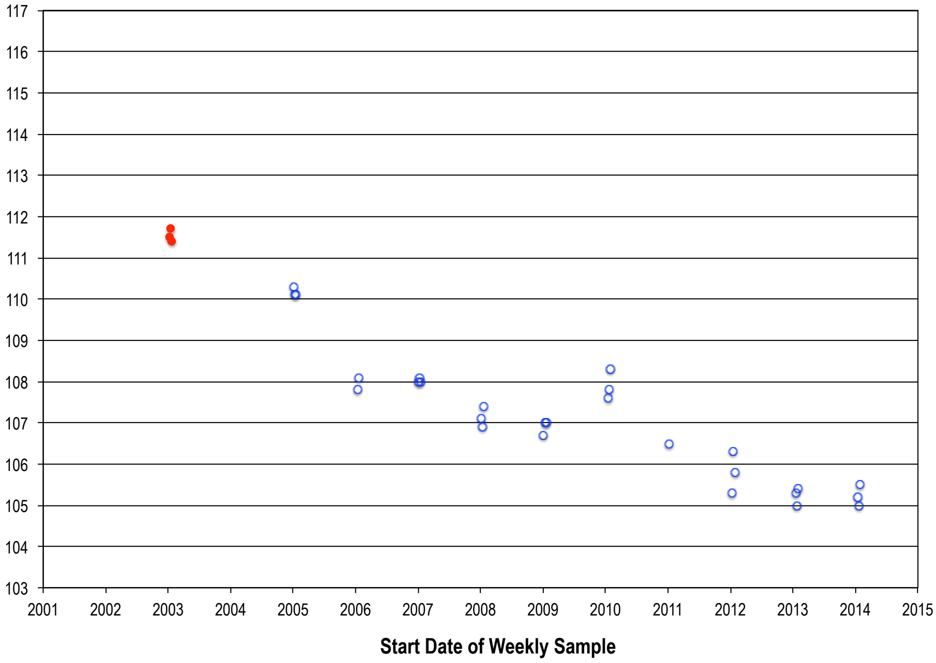


Figure 6.7
Site 540 - Urania
Percentage of vehicles above 100 km/h

Figure 6.8
Site 6262 - Port Clinton
Percentage of vehicles above 100 km/h

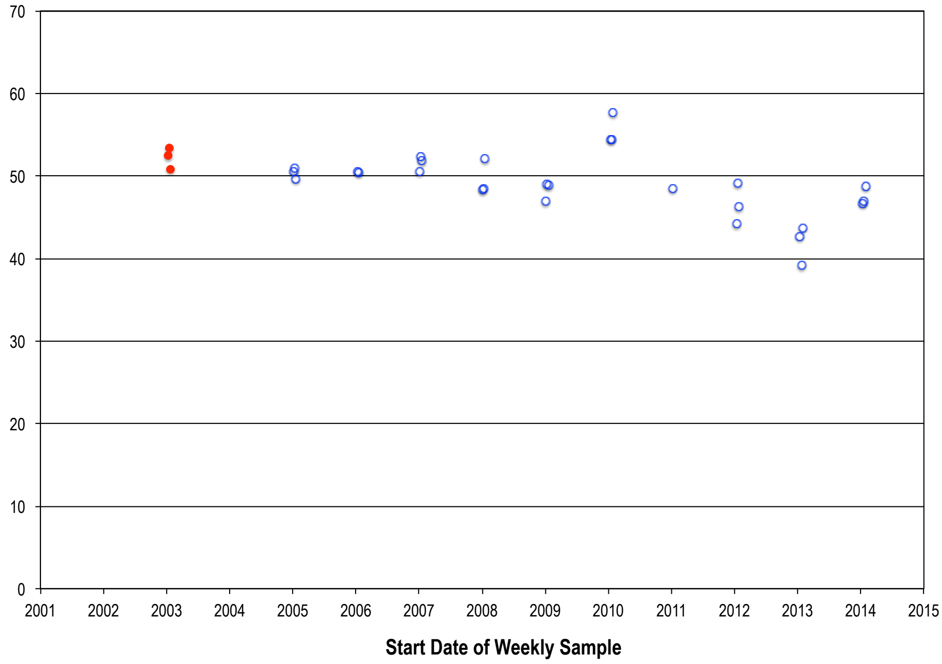


Figure 6.9
Site 540 - Urania
Percentage of vehicles above 110 km/h

Figure 6.10
Site 6262 - Port Clinton
Percentage of vehicles above 110 km/h

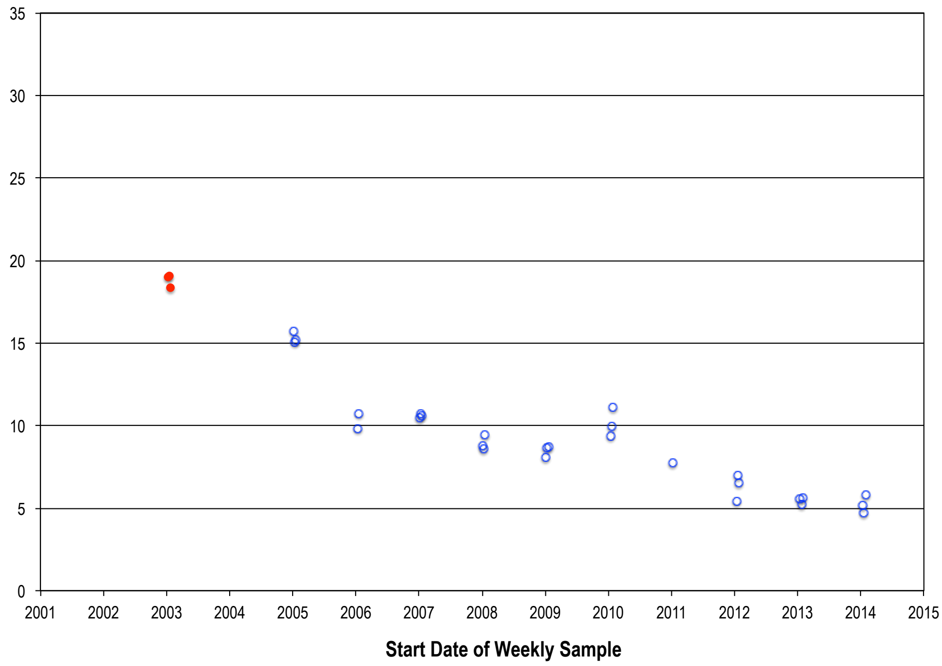


Figure 6.11

Site 540 - Urania

Percentage of vehicles above 120 km/h

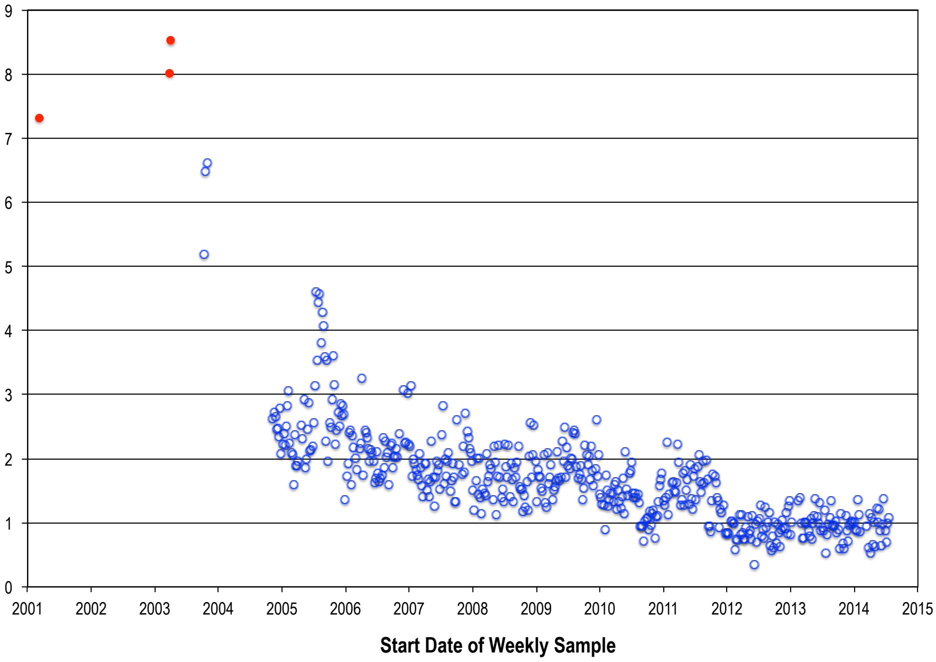
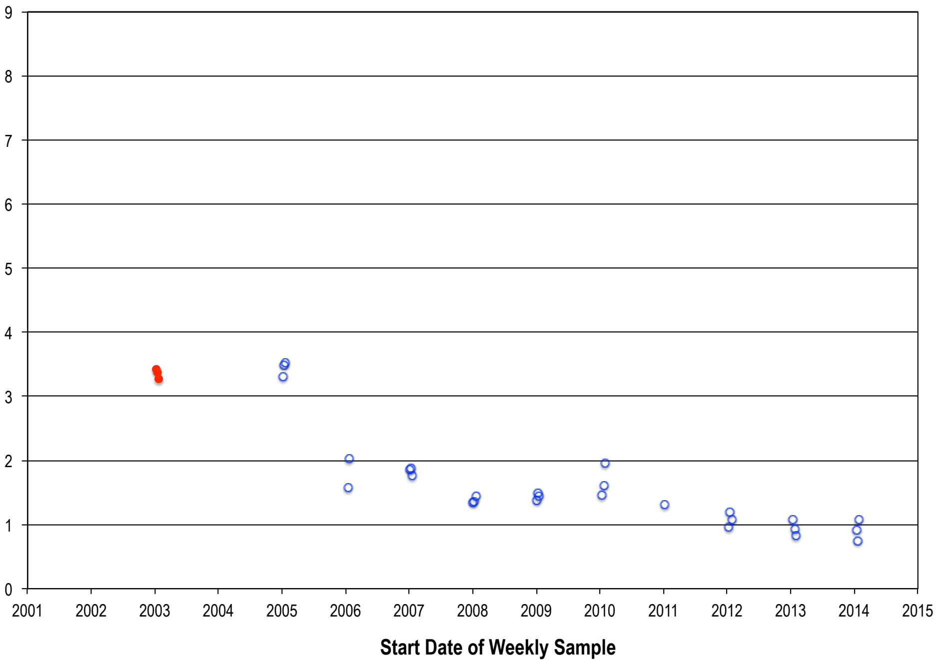


Figure 6.12

Site 6262 - Port Clinton

Percentage of vehicles above 120 km/h



7 Discussion

7.1 Overview

The number of crashes on the roads with speed limits lowered from 110 km/h to 100 km/h was found to be 27.4 per cent lower than would have been expected if these roads had just followed the control road reductions. The result was highly statistically significant, with the 95 per cent confidence interval being plus or minus 12.4 per cent.

The large size of this effect and relatively narrow confidence interval provides convincing evidence that the lower speed limits were highly effective in reducing casualty crashes with estimated crash injury cost savings estimated at $6.7 million per year or $67 million in the 10 years since they were introduced.

There are also some indications that speeds and crashes continued to decline for many years after the drop in speed limit. This suggests that current benefits may be even greater than the average of the past 10 years. However, there is insufficient data to state this with certainty.

7.2 Methodological limitations

This study was not based on a randomised case control design where potential sites are randomly allocated into treatment or control groups to avoid selection and other biases. Therefore, there are other possible explanations for the results seen in this study. These need to be carefully considered when interpreting the results.

Regression to the mean on subject roads

The subject roads may have been selected, in part, because of their high crash rates. Part of this high crash rate could have been random variation in the high direction shortly before treatment that would not recur subsequently. This phenomenon is often referred to as regression to the mean and would lead to an apparent reduction that is not related to the treatment effect.

Such an effect is unlikely to be large given the relatively consistent crash numbers on the subject roads over the 10 years before the speed limit was lowered (see Table 4.1 and Figure 4.1). It appears that the treatment roads were chosen more on their characteristics than on their recent crash rate.

Comparability of control roads

In order to account for other safety factors over the course of the study (such as better vehicles and general road improvements) a control group of roads was used. This consisted of all roads that remained at 110 km/h. However, this group of roads is not directly comparable to the subject roads. The control roads included major highways and multilane roads throughout the State whereas the subject roads were generally narrow two lane roads close to Adelaide (see Figure 3.1).

If there were differential effects on the two road types that coincided with the speed limit change on the subject roads, then an apparent effect could be produced that is not representative of the actual effect of the speed limit change.

Such effects cannot be ruled out but the ones that could conceivably have lowered crashes on the subject roads or increased crashes on control roads (which would lead to the observed change) are considered below.

Other effects that could have lowered crashes on the subject roads after the speed limit change:

- Lower traffic volumes - reduced traffic volumes on the subject roads could explain why there are fewer casualty crashes - unlikely as the available data (Figures 6.1 and 6.2) suggest traffic volumes are consistently slowly increasing
- Infrastructure changes that reduce risk - hazard reduction and road improvements may be reducing risk of casualty crashes on the subject roads - considered unlikely but may be a contributor
- Change in traffic type to less risky types - a reduction in the number of motorcycles and bicycles would lead to fewer casualty crashes - considered unlikely to have changed greatly
- Increased enforcement - greater enforcement could be reducing the number of casualty crashes - unlikely as enforcement is always generally low on rural roads

Other effects that could have increased crashes on the control roads after the speed limit change:

- Higher traffic volumes - higher traffic volumes on the control roads could result in more crashes on those roads - unlikely as there seems to be a consistent small increase in traffic on all roads over time
- Infrastructure changes that increase risk - something about the road infrastructure may be changing in such a way as to increase risk - unlikely as most infrastructure changes are considered beneficial to safety (overtaking lanes may be an exception as they allows higher average traffic speeds)
- Change in traffic type to more risky types - an increase in the number of motorcycles or bicycles would lead to more casualty crashes - considered unlikely to have changed greatly
- Decreased enforcement - less enforcement could lead to an increase in the number of casualty crashes - unlikely as enforcement is always generally low on rural roads

There is not an obvious mechanism for the size of the results seen apart from the change in speed limit. So while it is still possible that the results are an artefact of the roads analysed, it seems unlikely.

7.3 Conclusion

While the present study is not definitive, the results together form a consistent picture:

- A distinct drop in casualty crashes is apparent on the subject road segments after the speed limit was lowered
- There is a long-term trend of a reduction in crashes on the control road segments that remained at 110 km/h
- Making allowance for this by calculating the ratio of crashes on the subject road segments to crashes on control road segments, an extra reduction on the subject road segments is detected
- There is some indication that casualty crashes continued to fall further in the 10 years after the speed limit was lowered
- The subject road segments differed from the control road segments, but no likely confounding effects could be identified
- These results are consistent with other research on speed, speed limits and casualty crashes
- Speeds measured at two sites on the subject road segments fell shortly after the limit was lowered

- These speeds (and particularly high speeds) remained low and appeared to fall further in the 10 years after the speed limit was lowered

While the study has some methodological limitations, the size of the effect and the consistency of the various elements provides rather convincing evidence that the lowered speed limits were effective in reducing casualty crashes and injuries by a large amount.

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References

Aarts, L., & Van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention*, 38(2), 215-224.

Australian Bureau of Statistics [ABS] (2014). *Consumer Price Index Inflation Calculator*. Retrieved October 10th, 2014, from [http://www.abs.gov.au/websitedbs/d3310114.nsf/home/consumer+price+index+inflation+calculator].

Bhatnagar, Y., Saffron, D., deros, M., & Graham, A. (2010). *Changes to speed limits and crash outcome – Great Western Highway case study*. Australasian Road Safety Research, Policing and Education Conference, Canberra, Australian Capital Territory, 31 August – 3 September 2010.

Bureau of Infrastructure, Transport and Regional Economics [BITRE] (2009). *Road crash costs in Australia 2006* (Report 118). Canberra: BITRE.

Cameron, M. (2009). *Economic evaluation of the introduction of lower rural defaults and national highway speed limits in Tasmania*. Melbourne: Monash University Accident Research Centre.

Cameron, M. H., & Elvik, R. (2010). Nilsson's Power Model connecting speed and road trauma: Applicability by road type and alternative models for urban roads. *Accident Analysis & Prevention*, 42(6), 1908-1915.

De Pauw, E., Daniels, S., Thierie, M., & Brijs, T. (2014). Safety effects of reducing the speed limit from 90 km/h to 70 km/h. *Accident Analysis and Prevention*, 62, 426-431.

Dua, A., Anderson, C., Cartwright, F., & Holmes, J. (2013). *The NOW 100 speed limit changes in South Australia*. Australasian College of Road Safety Conference, Adelaide, Australia, 6-8 November 2013.

Elvik, R, Christensen, P. & Amundsen, A. (2004). *Speed and road accidents – An evaluation of the Power Model* (Report 740/2004). Oslo: Institute of Transport Economics.

Elvik, R. (2009). *The Power Model of the relationship between speed and road safety – Update and new analysis* (Report 1034/2009). Oslo: Institute of Transport Economics.

Farmer, C., Retting, R., & Lund, A. (1999). Changes in motor vehicle occupant fatalities after repeal of the national maximum speed limit. *Accident Analysis and Prevention*, 31, 537-543.

Friedman, L. S., Barach, P., & Richter, E. D. (2007). Raised speed limits, case fatality and road deaths: a six year follow-up using ARIMA models. *Injury Prevention*, 13(3), 156-161.

Jaarsma, R., Louwerse, R., Dijkstra, A., de Vries, J & Spaas, J-P. (2011). Making minor rural road networks safer: The effects of 60 km/h zones. *Accident Analysis and Prevention*, 43, 1508-1515.

Kloeden, C. N., Ponte, G., & McLean, A. J. (2001). *Travelling speed and the risk of crash involvement on rural roads* (CR204). Canberra: Australian Transport Safety Bureau.

Kloeden, C. N., McLean, A. J., & Glonek, G. (2002). *Reanalysis of travelling speed and the risk of crash involvement in Adelaide South Australia* (CR207). Canberra: Australian Transport Safety Bureau.

Kloeden, C. N., Woolley, J. E., & McLean, A. J. (2007). *A follow-up evaluation of the 50km/h default urban speed limit in South Australia*. Road Safety Research, Education and Policing Conference, Melbourne, Australia, 17-19 October 2007.

Long, A. D., Kloeden, C. N., Hutchinson, T. P., & McLean, A. J. (2006). *Reduction of speed limit from 110km/h to 100km/h on certain roads in South Australia: A preliminary evaluation* (CASR024). Adelaide: Centre for Automotive Safety Research.

Nilsson, G. (1981). *Effects of speed limits on traffic accidents in Sweden*. In: Proceedings, International symposium on the effects of speed limits on traffic crashes and fuel consumption, Dublin. OECD, Paris.

Sliogeris, J. (1992). *110 kilometre per hour speed limit – evaluation of road safety effects* (GR 92-8). Melbourne: Vic Roads.

Souleyrette, R., & Cook, D. (2010). *Evaluation of Iowa's 70 mph speed limit – 4 years later* (InTrans Project 06-247). Ames: Iowa State University Institute for Transportation.