Evaluation of the Adelaide Hills speed limit change from 100 km/h to 80 km/h

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Abstract

In January 2002 the speed limit was changed from 100 km/h to 80 km/h on 18 arterial roads in the Adelaide Hills area. An analysis has been conducted of the effect that these changes had on the number of casualty crashes and casualties occurring on these roads: the periods of five years before and five years after the changes have been compared. Different methods of evaluation were considered, some involving a control group and others not. Depending on which is chosen, the effect is between 3 per cent and 36 per cent reduction in casualty crashes, with 15 per cent (not statistically significant) being our preferred estimate.

Keywords

Speed limit, Crash reduction, Adelaide Hills, Before-and-after

Introduction

In January 2002 the speed limit on a number of roads in the Adelaide Hills was reduced from 100 km/h to 80 km/h. The change in speed limit came about as a result of a review of speed limits conducted by the Department for Transport, Energy and Infrastructure (DTEI), covering all DTEI roads in the Adelaide Hills, which in this paper means the local government areas of the Adelaide Hills Council and the District Council of Mount Barker. This paper reports casualty crash numbers before and after the reduction of speed limit on sections of DTEI roads in the Adelaide Hills. Comparisons are made with casualty crash numbers on the remaining roads in the Adelaide Hills, with roads in the surrounding council areas, and with trends in casualty crashes. The statistical significance (or lack of it) of the change in casualty crash numbers is also discussed.

The changes to speed limits, from 100 km/h to 80 km/h, occurred in the Adelaide Hills on 18 road sections of DTEI maintained roads. The lengths of these road sections range from less than a kilometre to almost 30 kilometres, with around half being less than 10 kilometres. Some of the longer sections pass through small towns which have existing 60 km/h or 50 km/h speed limits in place. The resulting total length of altered road sections is approximately 128 kilometres. The change in speed limit involved the installation of 100 new signs, some being repeaters. These signs were installed in January 2002. The new speed limit was effective and was subject to enforcement by the South Australia Police (SAPOL) as soon as the new signs were installed on each road.

All sealed DTEI roads with a speed limit of 100 km/h, lying in the Adelaide Hills Council and the District Council of Mount Barker were assessed. According to Woolley and Dyson [1], the speed limits were set based on traffic engineers' assessments of suitable speed limits, according to the characteristics of the roads and the speed zoning principles of the Australian Standards. The roads under consideration all had their speed limit notionally set at 80 km/h, with the original 100 km/h limit re-assigned only in cases where a set of predetermined criteria were met [2]. Through this process, the altered roads, where the speed limit was changed from 100 km/h to 80 km/h, were predominantly winding Adelaide Hills roads where a 100 km/h limit could not be justified; 40 per cent of the DTEI maintained 100 km/h road network in the Adelaide Hills was affected.

Methods

The changes in speed limit were made during January 2002. At the time of analysis, casualty crash data was available from 1981 to 2006. The time period of January 1997 until the end of December 2006 was chosen, allowing comparisons to be made between crash occurrences in the five years before the change and the five years that followed. The After period begins on the first of January 2002.

TARS database

The DTEI Traffic Accident Reporting System (TARS) database was the source of all crash and casualty data used in this analysis. The TARS database contains records of all casualty crashes that are reported to the Police in South Australia and is maintained by DTEI. Data is available from 1981 up to 2006 at the time the present analysis was conducted. The information in TARS includes the location of a crash, the severity of injuries sustained by occupants, the speed limit for the crash location as reported by people involved or the Police at the scene, and the date and time of day.

It is recognised that a routine crash dataset often has errors in it. Specifically, the location and speed limit of the crash site may have been incorrectly reported by the driver or other persons involved. If a person remembers seeing an 80 km/h sign somewhere, they may report the location as inside the section where the speed limit had been reduced, even if they had later left it and crashed where the default speed limit was 100 km/h. This may explain why the recorded speed limit in TARS has been found to be somewhat unreliable. In places where a change in speed limit has recently occurred the speed limit is often recorded as the prior value. These comments are based partly on evidence internal to TARS (i.e., inconsistent speed limits reported on the one stretch of road), and partly on cross-checks with in-depth at-scene crash investigations conducted by our colleagues in the Centre for Automotive Safety Research (CASR), University of Adelaide.

Crashes that involved at least one casualty were analysed, as these have the greatest economic and social cost. It is also likely that these crashes are more fully and accurately reported as it is a legal requirement for drivers to report a casualty crash. The categories of casualty and thus casualty crash severity in TARS are doctor treated and hospital treated (minor injury), admitted to hospital (serious injury) and fatal. These severity categories are abbreviated in results tables later as doctor, treated, admitted and fatal. The severity of a casualty crash is determined by the severity of the most severely injured person. Hence in the case of a crash where a person was treated at hospital and another admitted to hospital, the crash severity would be recorded as admitted to hospital.

Roads where there was a speed limit reduction

In order to evaluate the crash occurrence on the altered roads, a list of the roads where the speed limit had been altered was supplied by DTEI, with the sections of road identified by running distances (chainages) and some brief descriptions. To identify all of the crashes that occurred within the altered road sections, the road sections were located on maps. Then, using TARS, three lists were compiled, identifying each possible crash location within the altered road sections by using the three ways used in TARS to describe crash locations; at the intersection of two roads, at a section on a road between two other roads or by a particular running distance on a road. Data for the altered roads was selected from the database using the three lists of descriptions of altered roads, the time periods of 1997 to 2001 (before the change) and 2002 to 2006 (after), and recorded speed limits of 80, 100 and 110 km/h. As mentioned above, recorded speed limits in TARS are somewhat unreliable, so speed limits of 80, 100 and 110 km/h were selected for both before and after the change. By mapping crashes according to their recorded speed limit separately for the periods before and after the change, we could check the accuracy of this method. An advantage of using speed limit as a condition for selecting crashes is that where there were small town centres within the altered sections which had speed limits set at 60 km/h or 50 km/h, they would also be correctly excluded.

Alternative assumptions about an appropriate comparison

Having extracted the data for the altered roads, a decision is needed about the method of comparing the Before period with the After period. Does the change in crashes have meaning by itself, or should it be compared with the change in a control group? Furthermore, what assumption should be made about the trend in crashes, and what is the most appropriate control group?

Methods without a control group. The simplest method is not to have a control group: compare the five annual numbers before the change with the five annual numbers after. In the results section below, an eight per cent reduction will be reported (not statistically significant). However, to attribute this to the speed limit change would assume there is no general trend in the number of crashes. If there were reason to think that crashes were increasing by one per cent annually, for example, the After period would be expected to have five per cent more crashes than the Before period. Consequently, having found an eight per cent reduction in the number, the speed limit change would be considered to have reduced crashes by 13 per cent. This shows that a decision is needed about how to handle the possible trend.

- The first option is to assume the trend is zero. It might be said that five years is quite a short period, and it is reasonable to ignore any trend over this length of time.
- Alternatively, the trend might be estimated from the data: that is, a line is fitted having the same slope before and after the speed limit reduction, but with a change of level at that time. This is an objective method, as both the trend and the change are estimated from the data, without extraneous assumptions. However, using this method the estimated annual increase is about six per cent. The view of the present authors is that this is implausibly large: the population of the area was growing at only about 1.3 per cent annually in the period of this study [3].
- The rate of population growth provides us with another method. If the underlying trend in crashes is an increase of 1.3 per cent per year, the number should have increased by seven per cent in five years, and thus we can attribute a 15 per cent reduction (i.e., 8 + 7) to the speed limit reduction. (Rounding to whole numbers means that occasionally in this paper figures are slightly different from what might be expected.) Also, the state-wide trend in casualty crashes on roads with a speed limit of between 80 km/h and 110 km/h, for the After period, has been an increase of two per cent per year, again appreciably less than six per cent.

Methods with a control group. In principle, having a control group would overcome the necessity of making an assumption about the trend. If lengths of road had been randomly assigned to treatment and control groups, comparison would be straightforward, and if the control group were large, the estimate of the change would be an accurate one. In practice, there was no random assignment, and it seems unlikely that an appropriate control group will be large. Consequently, it will be difficult to choose a control group, and there will be appreciable random error resulting from its limited size. In this study, two alternative control groups are used.

- Control group A refers to roads which lie in the same area as where the changes occurred, within the Adelaide Hills Council and District Council of Mount Barker local government areas, but which were not altered, the speed limit remaining as 100 km/h.
- Control group B refers to 100 km/h and 80 km/h roads in five council areas surrounding the Adelaide Hills: the Barossa Council, the Mid Murray Council, the Rural City of Murray Bridge, the Alexandrina Council and the City of Onkaparinga. This area is geographically close to the Adelaide Hills, and the number of crashes is appreciably larger than in Control group A.

A disadvantage of principle in using a control group is that conceivably an effect of the speed limit reduction may not be confined to the sections of road that were altered: a lower speed limit on one section of road may lead to lower speeds, and fewer crashes, on adjoining unaltered sections of road.

Conclusions about the method. All the above methods are considered defensible. The range of results obtained will give an idea of how much uncertainty stems from choice of method. The preference of the present authors is to assume that crashes would have increased at the same rate as population. The other methods have disadvantages as follows.

- Beyond the general point that (mostly gradual) changes are happening all the time to roads, vehicles, behaviour, legislation, etc., the specific case against assuming no trend at all in the casualty crash numbers is that there has been considerable population growth in the Mount Barker area.
- The case against estimating the trend from the data is that this turns out to be an increase in crashes of about six per cent per year. This is implausibly large - implausible, that is, in comparison with trends at other times and in other places. (That result could not have been foreseen. What could have been foreseen is that the estimation of this extra quantity could mean that the estimation of the effect of speed limit change is very imprecise.)
- The case against using Control group A is that it is small, and random error is consequently introduced. Further, reduced speeds on altered roads might have spread on to control roads.

- The case against using Control group B is that some systematic error could potentially be introduced in the data processing. One issue of concern is that there were local government reorganisations. These were allowed for in selecting crashes from the database, but allowance could not be made for any accompanying changes in the accuracy of reporting crash location.

The above considerations do not utterly rule out any of the methods, but are sufficiently cogent that the present authors consider it preferable to assume crashes would have increased at the same rate as population. (Population, after all, is a commonly-used divisor to standardise crash or casualty numbers.) An alternative perspective is that instead of attempting to determine which method is best, one could simply direct attention to the simple comparison of number of crashes before with number of crashes after, with the intention that this answer be descriptive, without attributing any difference to the change of speed limit.

General criticisms. (1) It is uncertain exactly why the Adelaide Hills geographical area (Adelaide Hills Council and Mount Barker Council) was chosen for a speed limit change. Suppose that an increasing number of road crashes (about 10 per cent per year in the period 1997-2001) was one of the reasons. Very possibly, at least part of that trend is simply random variation. If so, the estimated trend is greater than the true value. Thus it may be that the same mechanism - a trend that, by chance, is more steeply increasing than the true trend - that leads to an area being chosen for the introduction of a road safety measure also leads to an over-estimation of the effect. (2) More likely, the area was chosen because of the likely acceptability of an 80 km/h speed limit on the winding roads. This would not bias the results in the same sense as just discussed, but it would mean that their relevance elsewhere would be reduced. (3) Some infrastructure work (such as shoulder sealing, guard rail installation, or road widening) was carried out on the altered and the control roads during the period considered. There is likely to have been roughly as much of this after the speed limit reduction as before, and as much in the control areas as on the altered roads, but it cannot entirely be excluded as a factor affecting the comparisons of crash numbers.

Statistical methods

The relevant statistical methods are well known, but three comments are worth making.

Extra year-to-year variability. Year-to-year variation in crash numbers tends to be rather larger than would be the case were crashes random events with numbers following what is termed the Poisson distribution. This is reasonably well-known in road accident studies [4] (but the reasons for it are not well understood). It is true of the present dataset (see the results section below). Consequently, it is more difficult to establish statistical significance than it would otherwise be.

Statistical analysis with a control group. In order to conduct a statistical test, we need to take account of the year-to-year variability. A simple method is to calculate the ratio of crashes on the altered roads to crashes on the control roads for each year separately. A standard method (such as the t-test) can then be used to test whether the five Before ratios have the same mean as the five After ratios.

Comment on statistical inference. It is desirable to not only determine the size of any effect on crashes, but also to establish whether it was statistically significant. If a reduction were found to be statistically significant, we would be fairly confident that the reduction did not occur due to chance alone. However (looking ahead again), the change is not statistically significant. Thus the possibility that the change was a random event remains credible - i.e., the random year-to-year variation in crash numbers is sufficiently great that it cannot confidently be said that they are really different in the After period compared with what they were in the Before period. It should be remembered, however, that being consistent with a zero difference is not the same as really being zero. Even though the results are not significant, the difference could still be real.

Results

The numbers of casualty crashes and casualties before and after the change are first given, followed by comparisons with the trends in the crash occurrence and their implications. Then comparisons with two different control groups are made.

The altered road network

Casualty crashes that occurred on the altered roads were identified for the years 1997 to 2006. The Before period covers the years 1997 to 2001 and the After period covers the years 2002 to 2006. Table 1 shows the number of casualty crashes for each severity of casualty that occurred in each five year time period, before and after the change in speed limit, for the roads where the speed limit was altered. Table 2 shows the number of casualties that occurred in each time period. In these and later tables, the severity category abbreviations of Doctor, Treated, Admitted and Fatal represent the categories as used in TARS: doctor treated, treated at hospital, admitted to hospital and fatal.

In Table 1 and Table 2 it can be seen that the reduction in casualty crashes and casualties amounted to about eight per cent fewer crashes and five per cent fewer casualties. These are the figures for the observed crash occurrence on the roads where the speed limit reduction occurred. In these and all tables in this paper a negative value in the '% Change' column indicates a reduction in crashes or casualties. Expanding the data to show the casualty crash and casualty numbers for each of the ten years, it may be seen (Tables 3 and 4) that there was much variation year to year. Because of this, it is no surprise that the reduction is not statistically significant: the standard error of the estimate of an eight per cent reduction in casualty crashes is about ten per cent.

Table 1: Casualty crash numbers for roads where the speed limit was altered from 100 km/h to 80 km/h (altered road network)

Severity	Before	After	Difference	% Change	Difference/year
Doctor	70	38	-32	-45.71	-6.4
Treated	149	170	21	14.09	4.2
Admitted	84	72	-12	-14.29	-2.4
Fatal	7	6	-1	-14.29	-0.2
Total	310	286	-24	-7.74	-4.8

Table 2: Casualty numbers for roads where the speed limit was altered from 100 km/h to 80 km/h (altered road network)

Severity	Before	After	Difference	% Change	Difference/year
Doctor	79	55	-24	-30.38	-4.8
Treated	213	233	20	9.39	4.0
Admitted	104	88	-16	-15.38	-3.2
Fatal	7	6	-1	-14.29	-0.2
Total	403	382	-21	-5.21	-4.2

Table 3: Casualty crash numbers for the altered road network for 1997 to 2006

Severity	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Doctor	10	14	18	18	10	8	6	11	4	9
Treated	24	20	35	35	35	31	39	38	23	39
Admitted	15	14	10	24	21	12	18	12	18	12
Fatal	1	1	0	1	4	0	2	2	0	2
Total	50	49	63	78	70	51	65	63	45	62

Table 4: Casualty numbers for the altered road network for 1997 to 2006

Severity	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Doctor	10	16	19	21	13	12	11	18	4	10
Treated	38	29	43	51	52	43	61	47	34	48
Admitted	20	14	11	33	26	12	19	17	21	19
Fatal	1	1	0	1	4	0	2	2	0	2
Total	69	60	73	106	95	67	93	84	59	79

Implications of alternative assumptions

There were fewer crashes in the After period compared with the Before period, by eight per cent. As discussed previously, there may be general trends over time in the number of crashes. There are a number of alternative assumptions that might be made about this.

- Assume no general trend over time. The estimated effect of the speed limit change is then eight per cent. As stated earlier, the estimated standard error is ten per cent.
- Estimate the trend from the annual numbers of crashes (Table 3). That is, fit a straight line that has a change in level from 2001 to 2002, but has the same slope in 1997-2001 as in 2002-2006. It turns out that the trend is an increase of about six per cent per year, and the estimated reduction in crashes from 2001 to 2002 is 36 per cent. (The estimated standard error is 21 per cent, and the reduction is not statistically significant.)
- Assume the trend over time is the same as the trend of population. That is an increase of 1.3 per cent per year in the region considered [3]. This accumulates to an increase in population of seven per cent over five years. Assuming that the trend in crashes if the speed limit reduction had not been made would be the same as the population trend, the reduction in crashes after the change of speed limit is estimated to be 15 per cent. The estimate of standard error applicable if zero trend is assumed, ten per cent, will be a reasonable estimate here, too.

The second method has the attraction of relying solely on the crash data, not on some separate assumption. However, the present authors consider the estimated annual increase of six per cent to be implausibly large. Additionally, it is not statistically significantly different from zero.

It was mentioned earlier that year-to-year variation in crash numbers is greater than would be the case if the Poisson distribution were a valid assumption. In the present dataset, for example, the numbers of crashes on the altered roads averaged 62.0 and 57.2 in 1997-2001 and 2002-2006, and the standard deviations would thus be expected to be 7.9 and 7.6, but in fact were greater (12.6 and 8.7).

Use of Control group A

Control group A, as described in the methods section, refers to group of roads in the same area as where the changes occurred, but where the speed limit was not changed.

Table 5 shows the number of casualty crashes for each severity of casualty that occurred in the five year time periods before and after the change in speed limit. By chance, for Control group A, there were exactly the same number of total crashes in the After period as in the Before period. The percentage changes from Table 1 and Table 5 are compared in Table 6. The difference between the altered network and the control group percentage changes indicates the overall benefit of the speed limit reduction. There was a 7.7 per cent reduction in total casualty crashes on the roads where the speed limit was altered from 100 km/h to 80 km/h, and no change on the control roads. Hence the reduction attributable to the speed limit reduction is estimated to be eight per cent.

This reduction was not statistically significant. The test used was described in the methods section above: the ratio of crashes on the altered roads to crashes on the control roads was calculated for the two groups of five separate years, and then a t-test applied. It implies that associated with the estimate of an eight per cent crash reduction is a standard error of about 13 per cent.

Casualty numbers are given in Table 7, and an estimate of the reduction in casualties after the reduction in speed limit is given in the Difference column of Table 8: a four per cent reduction in the total number of casualties is attributed to the change in speed limit.

Table 5: Casualty crash numbers for 80, 100, 110 km/h roads in the Adelaide Hills, excluding the altered roads (Control group A)

Severity	Before	After	% Change
Doctor	131	137	4.58
Treated	303	319	5.28
Admitted	187	167	-10.70
Fatal	35	33	-5.71
Total	656	656	0.00

Table 6: Results of the comparison between crash numbers five years before and five years after the change, for the altered road network and the control group (percentage change)

Severity	Control roads	Altered roads	Difference
Doctor	4.58	-45.71	-50.29
Treated	5.28	14.09	8.81
Admitted	-10.70	-14.29	-3.59
Fatal	-5.71	-14.29	-8.58
Total	0.00	-7.74	-7.74

Table 7: Casualty numbers for each casualty severity for Control group A

Severity	Before	After	% Change
Doctor	176	170	-3.41
Treated	458	491	7.21
Admitted	247	205	-17.00
Fatal	38	39	2.63
Total	919	905	-1.52

Table 8: Results of the comparison between casualty numbers five years before and five years after the change, for the altered road network and the control group (percentage change)

Severity	Control roads	Altered roads	Difference
Doctor	-3.41	-30.38	-26.97
Treated	7.21	9.39	2.18
Admitted	-17.00	-15.38	1.62
Fatal	2.63	-14.29	-16.92
Total	-1.52	-5.21	-3.69

Use of Control group B

Control group B refers to crashes and casualties on (unaltered) 100 km/h and 80 km/h roads in council areas surrounding the Adelaide Hills. The results of this analysis are presented for Control group B in the same way as they were for Control group A.

The results for casualty crashes are shown in Table 9. The percentage changes from Table 2 and Table 9 are compared in Table 10. The difference between the altered network and the control group percentage changes indicates the overall benefit of the speed limit reduction, when compared with this particular control group. Compared with the 7.7 per cent reduction in total casualty crashes on the roads where the speed limit was altered from 100 km/h to 80 km/h, there was a 4.4 per cent reduction in casualty crash numbers on the control roads. By comparing these values, the reduction attributed to the change in speed limit is three per cent.

This reduction was not statistically significant. The result of the test conducted implies that the three per cent estimated crash reduction has a standard error of about 10 per cent.

Table 9: Casualty crash numbers for Control group B

Severity	Before	After	% Change
Doctor	304	231	-24.01
Treated	870	877	0.80
Admitted	464	447	-3.66
Fatal	88	95	7.95
Total	1726	1650	-4.40

Table 10: Results of the comparison between crash numbers five years before and five years after the change, for the altered road network and the control group (percentage change)

Severity	Control roads	Altered roads	Difference
Doctor	-24.01	-45.71	-21.70
Treated	0.80	14.09	13.29
Admitted	-3.66	-14.29	-10.62
Fatal	7.95	-14.29	-22.24
Total	-4.40	-7.74	-3.34

Table 11: Casualty numbers for each casualty severity for Control group B

Severity	Before	After	% Change
Doctor	384	302	-21.35
Treated	1426	1364	-4.35
Admitted	661	596	-9.83
Fatal	101	107	5.94
Total	2572	2369	-7.89

Table 12: Results of the comparison between casualty numbers five years before and five years after the change, for the altered road network and the control group (percentage change)

Severity	Control roads	Altered roads	Difference
Doctor	-21.35	-30.38	-9.03
Treated	-4.35	9.39	13.74
Admitted	-9.83	-15.38	-5.55
Fatal	5.94	-14.29	-20.23
Total	-7.89	-5.21	2.68

The casualty numbers and calculations of the percentage change between the Before and After periods for the control group of roads is shown in Table 11. The percentage changes from Table 2 and Table 11 are compared in Table 12 to give estimates of the effect of the change on casualties. This method of calculation gives a three per cent increase in the total number of casualties attributed to the change in speed limit, after considering that there was an eight per cent decrease in the total number of casualties on the control roads.

Discussion

The speed limit on a set of roads in the Adelaide Hills was changed from 100 km/h to 80 km/h. The roads were selected as described in the Introduction, where conditions did not justify a speed limit of 100 km/h. The area also had a higher level of crashes and casualties than some others. Two strategies were used for comparing the number of crashes (or casualties) before and after the speed limit change: without a control group of roads, or using a control group.

The number of casualty crashes decreased by eight per cent when directly comparing the before and after period. As a pure description of what happened, this is of interest in itself. Concerning what resulted from the speed limit reduction, different assumptions lead to different results. Using the method of assuming a common trend in casualty crashes in both the Before and the After period, the effect of the speed limit change is estimated to have been as large as a 36 per cent reduction, as the trend in casualty crashes of an increase of six per cent per year accumulates to 29 per cent over five years. Using Control group B, the effect is estimated to have been as small as three per cent. These and the other estimates are summarised in Table 13. As mentioned earlier, quite apart from uncertainty arising from choice of method, random year-to-year variation in crash numbers means that the various estimates of the effect are not significantly different from zero.

As noted earlier, the present authors consider 15 per cent to be the most realistic figure for the crash reduction attributable to the speed limit change, derived by adding seven per cent (itself the population growth) to the eight per cent casualty crash reduction.

Table 13: Summary of the reductions in crashes estimated by different methods

Method	Estimated reduction
No control group, assumed trend of 0% p.a., total 0%	8%
No control group, assumed trend of 1.3% p.a. increase based on population growth, total 7%	15%
No control group, trend of 6% p.a. increase estimated from data, total 29%	36%
Control group A, no change found in After period, 0%	8%
Control group B, reduction of 4%	3%

In principle, comparison of before with after is simple. Yet five methods have been considered in this paper, each of which is justifiable. More still might have been used - e.g., include damage-only crashes, restrict to serious injury crashes, use other geographical areas for the control group, concentrate on casualties rather than crashes, utilise Control group B but also adjust for differences in population growth between that area and the altered roads area, and so on. This leads to some uncertainty as to which method provides the best estimate of the change in crashes after the change in speed limit.

- Part of the reason for uncertainty is random variation, which is inescapable because of the limited size of the area where the speed limit was changed. To reduce the random variation, it would have been necessary to include the Adelaide Hills area in a wider scheme of reducing speed limits on similar roads in other places (perhaps interstate and internationally) - and the elaborate organisation needed would be quite foreign to road safety research, more closely resembling medical research.
- A true experiment could have been performed. This would have involved making a list of road sections that were candidates for speed limit reduction, and then randomising them to either treatment or control groups. Randomisation ensures fairness. Moreover, a true experiment is typically carefully monitored and managed, and lengths of road subject to other changes could be excluded.

However, the present authors consider that true experiments have limitations of principle, as well as widely-acknowledged practical difficulties. Two examples are as follows.

- Inclusion of a small area in a large experiment would change the domain of validity of the results from the specific small area to the population of areas (similar to it) that were eligible for inclusion in the experiment.
- Suppose the results demonstrated an advantage for the treatment group, that could be seen on closer examination to stem from no change in crashes in the treatment group along with an inexplicable increase in the control group. A true experiment permits this to be brushed away on formal grounds: the decision was made when planning the study to compare one change with the other change. Yet it is arguable that the credibility of the advantage for the treatment group would be reduced, just as in the present study the credibility of using the data itself to estimate trend was reduced when the trend was estimated to be six per cent per year.

Both the advantages accompanying bigger sample sizes and true experiments, and difficulties in research that are not overcome by these strategies, are discussed by Hutchinson [5].

Conclusion

On the road sections where the speed limit was reduced from 100 km/h to 80 km/h, casualty crashes fell by eight per cent. Several methods have been considered for estimating the effect of the speed limit reduction - that is, the difference between what the number of casualty crashes was, and what it would have been in the absence of a speed limit reduction. The resulting estimates ranged between three per cent and 36 per cent. Further to this uncertainty concerning method, there is also much year-to-year variability in crash numbers. The figure for the crash reduction attributable to the speed limit change that is preferred by the present authors is the 15 per cent derived by adding seven per cent (itself the population growth) to the eight per cent casualty crash reduction. However, the reduction was not statistically significant.

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