Overall Results

of Crash Reduction Study Safety Improvements

October 2004

Executive Summary

The Land Transport Safety Authority, Transit New Zealand and Local Authorities are partners in the Crash Reduction Study Programme in New Zealand. The original programme was established in 1985 to identify sites for treatment based on the crash history at each site, and recommend low cost engineering treatments aimed at reducing those crashes. A monitoring system has been developed progressively since 1989 to gather crash data on treated sites.

While specific crash types are targeted, an overall reduction in all crashes can be expected as a result of implementing the recommended works. This analysis matches site details from 2487 monitoring sites where all recommended works had been completed, with data from reported injury crashes to the 31 December 2003 or a maximum of six years following treatment. The matched data are used to estimate the overall crash reduction.

It is recognised that not all crash reductions at the sites can be attributed to the low cost treatments implemented. However, it is reasonable to assume that those treatments have had some effect. Efforts have been made to remove the effect of more generalised changes in crash patterns occurring across the local area.

The following reductions in injury crashes at crash reduction sites were associated with the crash reduction study programme[1].

- All sites: **35%**

- Intersection sites: 42%
- Non-intersection sites: 60%
- Routes: 27%

- Open road sites: 43%
- Urban sites: 30%

- Fatal crashes: 49%
- Serious injury crashes: 38%
- Minor injury crashes: 33%

This reduction in injury crashes corresponds to an estimated annual saving in social cost of approximately $200 million[2] over the last decade.

1. Quoted reductions do not take regression to the mean into account. See section 8 for discussion.
2. All social costs are in June 2002 prices.

Table 1: Injury crash reduction and cost savings at treated sites

Percentage reduction in crashes at sites	35%
Mean annual social cost saving 1994-2003	$200 million
Total social cost saving 1986-2003	$3.3 billion
Sites in monitoring system	4294
Completed sites used in analysis	2487

1. Introduction

The Crash Reduction Study Programme was set up in 1985 to undertake a continuous programme of systematic investigation of all roads in New Zealand. Since 1989 the Land Transport Safety Authority has progressively developed a monitoring system to gather data on sites investigated under the programme. This analysis uses data on the Crash Reduction Study Monitoring System database, now part of the LTSA's Crash Analysis System, to evaluate the overall crash reduction benefits associated with the programme.

2. Monitoring site data

The monitoring system consists of site information and data on works which are implemented at the site. These data are matched to crash data at each site for a selected time period. To date, 4294 crash reduction monitoring sites have been entered into the monitoring system. Of these, 2273 (53%) are intersection sites, 666 (16%) are non-intersection sites, 1325 (31%) are routes and 30 are areas. 1848 sites (43%) are on State Highways and 2446 are on local roads.

This study examines sites which meet the following criteria

a) all works have been completed and at least some implementation dates are known;

b) the site is a route, intersection or non-intersection site;

c) the number of injury crashes in the study ("before") period is known and

d) study begin and end dates are known.

3. Implementation status

Only fully implemented sites, that is those where all the recommended works are complete, are used in this analysis. Sites where work is still to be completed, or at which the recommended works will not be implemented, have been excluded.

At the time of this report all works have been completed at 60% (2560) of the crash reduction monitoring sites, including 67% of State Highway sites and 54% of local road sites. 2487 sites met the criteria listed in section 2 for inclusion in this study.

Table 2. Site implementation status by road classification

Implementation status	Local road	State Highway	Total
Unknown/ new sites	57	11	68
Fully implemented	1328	1212	2540
Not fully implemented	936	523	1459
No actions will be implemented	39	27	66
Works done not as part of joint study	80	72	152
Fully implemented, some dates unknown	6	3	9
Total	2446	1848	4294

Table 3. Sites with recommended works still to be implemented

Full years since works recommended	Road classification		
	Local road	State Highway	All sites
under 3 years	211	120	331
3-4 years	162	59	221
5-6 years	148	113	261
7-8 years	152	103	255
9-10 years	127	72	199
11-13 years	122	36	158
14+ years	14	20	34
Total	936	523	1459

4. Crash data

The crash data used in this analysis are from the LTSA's Crash Analysis System, which includes all crashes reported to the LTSA by NZ Police. The crash reductions at each site were based on injury crashes occurring up to six years after site treatment, or to the end of 2003, whichever came first. In a small number of cases a shorter “after” period was used, eg where the site was changed by other works or traffic flow changes.

Non-injury crashes have lower and more variable reporting rates than injury crashes, and were not used in this analysis.

The average study period before improvement was 5.2 years, and the average post-implementation study period was 5.6 years.

Changes in crash patterns were examined for different site and crash types. Crash types of interest selected for analysis were light conditions (daylight or dark), crash movement type and crash severity. Three levels of crash severity are defined based on the most severe injury to any person involved. A fatal crash is one in which one or more people died as a result of the crash, within 30 days. A crash is defined as serious if any person had injuries requiring hospitalisation, and minor if only less severe injuries were apparent. Selected crash types were examined across all sites.

5. Control Method

Underlying crash trends within each local area and speed limit zone (urban or open road) have been taken into account when calculating reductions at the monitored sites.

Each site was assigned a comparison group of injury crashes in the same local area and urban or open road speed limit category. Where crash numbers permitted controls were drawn from the same Local Authority; in areas with low crash numbers crashes were aggregated across the Local Government Region or in some cases a slightly wider area (see note 1). Only crashes occurring outside designated monitoring sites were included in the comparison group.

Note 1: Some adaptations to the scheme were necessary. Gisborne plus Hawkes Bay was used as the comparison region for Gisborne. Christchurch and the remainder of Canterbury were treated as separate regions; West Coast plus non-metropolitan Canterbury was used as the comparison region for West Coast urban crashes. Waikato region was used as the comparison region for Franklin District.

6. Analysis method

The number of injury crashes at each site was adjusted for underlying crash trends in the local area, to give an estimated number of injury crashes expected if the improvements had had no effect. The resulting expected number of injury crashes at a site or group of sites was calculated as follows

$$CrashesExpected = BeforeCrashes \times \frac{ControlAfter}{ControlBefore}$$

where

CrashesExpected is the expected number of injury crashes at the site in the 'after' period (ie the period of monitoring after all treatments were implemented), assuming the treatment had no effect;

BeforeCrashes is the actual number of injury crashes at the site in the (usually five-year) period before treatment;

ControlBefore and *ControlAfter* are the actual number of injury crashes in the control area during the site's 'before' and 'after' periods respectively.

Actual and expected numbers of 'after' injury crashes were summed across the chosen group of sites and the totals compared to give the crash reduction result as

$$\%Reduction = \left(\frac{CrashesExpected - AfterCrashes}{CrashesExpected}\right) \times 100$$

7. Regression to the mean

When, as in the Crash Reduction Programme, sites are selected for treatment on the basis of high crash counts, there is likely to be some reduction in crashes in subsequent years even if no works were carried out. This is due to a statistical phenomenon which is referred to as 'regression to the mean'.

The controls described above have been applied to account for underlying crash trends in the local area, but the reductions quoted have not been corrected for possible regression to the mean. Methods for doing this are under investigation. When regression to the mean is taken into account, crash reductions attributable to the programme may be smaller than the changes quoted here.

8. Confidence Intervals

Confidence intervals for the estimates have been computed using the random groups method (Särndal et al, 1992). This is essentially a simulation technique for estimating variance. In the method used here, the sample of sites under consideration (which might be all sites, urban sites, and so forth) was randomly split into two groups. The estimate of interest (in this case, percentage reduction in crashes) was computed for each group. The variance for this iteration (V_i) was calculated by comparing the estimate for group1 with that for group2, according to the formula described in Särndal. This process was then repeated a large number of times and the sample variance V was estimated as the median of the V_i. A 95% confidence interval for the percentage reduction was then calculated as:

$$\%\ reduction \pm t(0.025, n) * V^{1/2}$$

where n is the number of iterations used.

9. Injury Crash Reductions

Overall, there was an estimated reduction in injury crashes at the treated sites of 35%, after allowing for underlying crash trends in each site's local area. This represents a saving in social cost of approximately $3.3 billion (June 2002 prices), over the life of the programme.

9.1 Site type

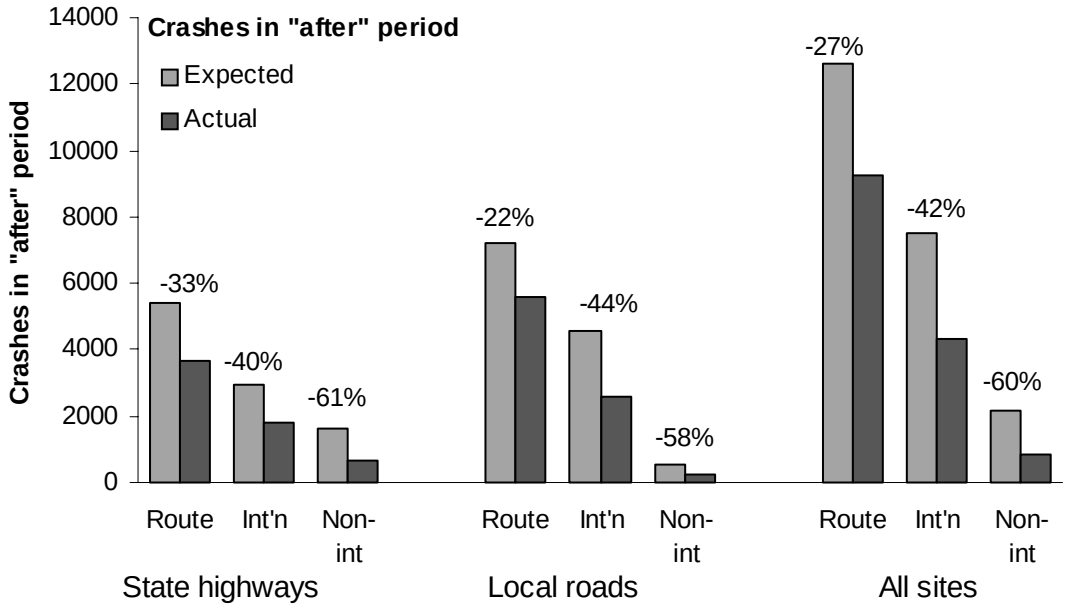
A 42% reduction in injury crashes was achieved at open road sites. (“Open road” sites are sites with posted speed limit of 80km/h or more). A somewhat lower reduction of 30% was achieved at sites in urban areas (areas with speed limit of 70km/h or less). Crashes in urban areas are less likely to involve injury than open road crashes, due to the lower speeds involved. Non-injury crashes are not examined here due to changes in reporting rates over time, but it is to be expected that a substantial reduction in non-injury crashes would also be achieved in urban areas.

Substantial reductions in injury crashes were achieved at all site types (route, intersection and non-intersection), with the greatest reduction (60%) at non-intersection sites.

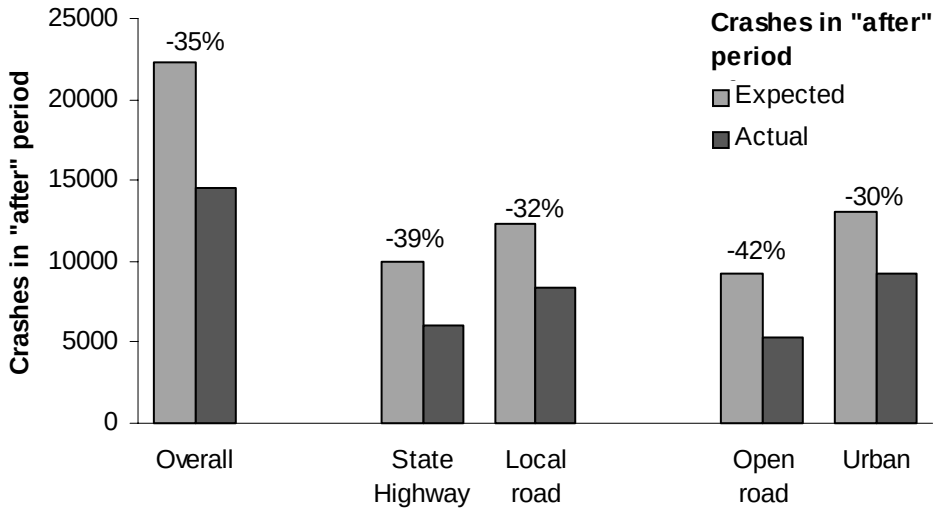
Fig 1 and Table 4 show the change in crash rate and the percentage reduction in crashes for various types of sites.

Fig 1: Comparison of crash reductions by site type

a) Injury crash reduction by site type and road type



b) Crash reductions by road type and speed limit area

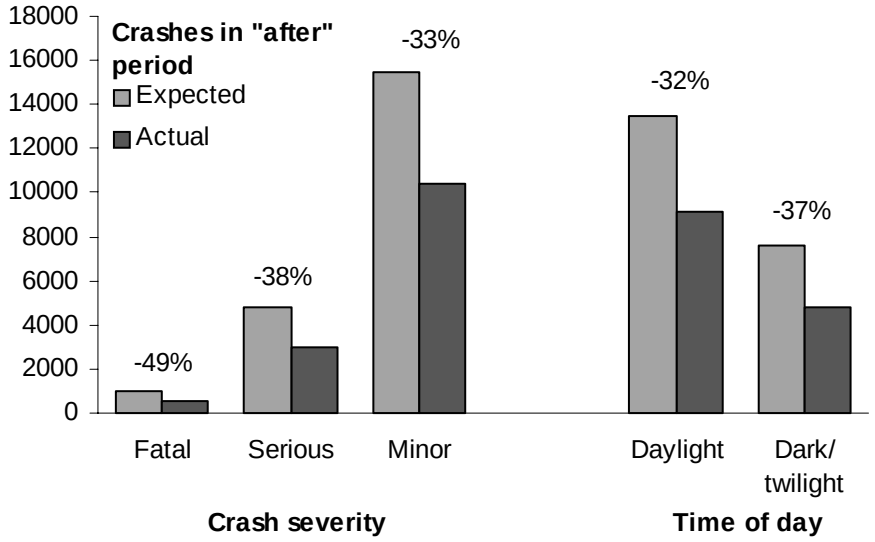


9.2 Crash type

Substantial reductions in injury crashes were observed at all levels of crash severity and for most movement types. Fig 2 and Table 5 show the reduction in various types of crashes experienced at treated sites.

Fig 2: Crash reductions by crash type

a) Crash severity and night/day



b) Movement group

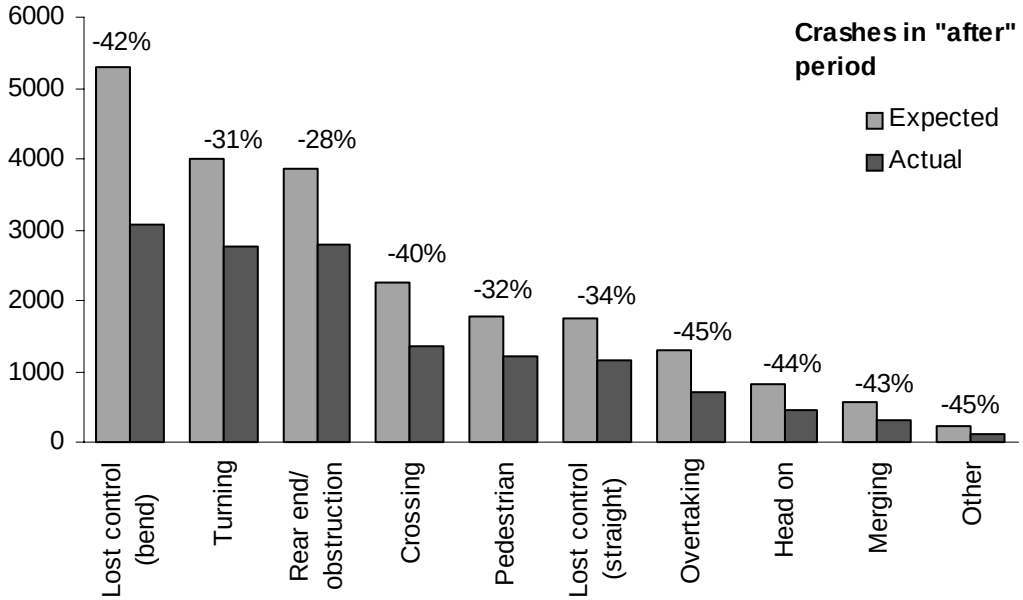


Table 4. Crash reductions at sites overall and by site type

	Number of sites	Expected crashes in "after" period	Actual crashes in "after" period	% reduction in injury crashes[1]	95% conf interval for % reduction
All sites	2487	22273	14475	35	(33.7, 36.3)
Road type					
State highways	1188	10000	6084	39	(36.2, 42.1)
Local roads	1299	12272	8391	32	(29.7, 33.6)
Speed limit area					
Open road (80-100 km/h)	1000	9176	5282	42	(39.7, 45.2)
Open road (State h'ways only)	764	6827	3817	44	(41.3, 46.9)
Urban roads (up to 70 km/h)	1485	13096	9193	30	(28.2, 31.4)
Site type					
Route	821	12627	9276	27	(24.4, 28.7)
Intersection	1246	7503	4340	42	(39.5, 44.8)
Non-intersection	420	2142	859	60	(56.6, 63.2)

Table 5. Crash reductions by crash type

	Crashes in study period (sample size)	Expected crashes in "after" period	Actual crashes in "after" period	% reduction in injury crashes[1]	95% conf interval for % reduction
Light conditions					
Daylight	13079	13497	9155	32	(30.4, 34.0)
Dark/ twilight	8523	7597	4756	37	(35.0, 37.8)
Movement group					
Overtaking	1363	1304	717	45	(41.2, 48.9)
Head on	1081	805	453	44	(39.6, 47.8)
Lost control (bend)	4613	5291	3065	42	(38.8, 45.3)
Lost control (straight)	1597	1741	1146	34	(30.4, 38.0)
Rear end/ obstruction	3938	3870	2798	28	(24.3, 31.1)
Crossing	2347	2241	1356	40	(34.7, 44.3)
Merging	455	549	314	43	(35.6, 50.1)
Turning	4239	4006	2764	31	(27.3, 34.7)
Pedestrian	1789	1789	1218	32	(27.9, 35.9)
Other	142	220	121	45	(24.6, 65.6)
Crash severity					
Fatal	1098	1038	533	49	(45.1, 52.1)
Serious	6338	4816	3010	38	(35.5, 39.5)
Minor	14201	15483	10409	33	(31.2, 34.3)

9.3 Regional crash reductions

Overall reductions in reported injury crashes at treated crash reduction sites can be estimated for the LTSA regions, which are normally comprised of two Local Government regions (see table 6 below). Further breakdown within these regions is not possible, as site numbers are too small to permit calculation of meaningful results.

The reduction in each region depends among other things on the mix of site types available for treatment. Nationally, for example, higher crash reductions were recorded at intersection and non-intersection sites than on routes; similarly, the overall reduction was higher at open road sites than at urban sites.

Table 6: Overall injury crash reduction by LTSA region

	Number of sites	Expected crashes in "after" period	Actual crashes in "after" period	% reduction in injury crashes[1]	95% conf interval for % reduction
Northland/ Auckland	787	8508	5697	33	(29.7, 36.3)
Waikato/ Bay of Plenty	489	4124	2364	43	(39.6, 45.8)
Gisborne/ Hawke's Bay	157	1560	1046	33	(26.9, 39.1)
Taranaki/ Manawatu/ Wanganui	243	1939	1154	41	(36.3, 44.7)
Wellington/ Nelson/ Marlborough/ Kaikoura	427	4213	2986	29	(25.1, 33.1)
Canterbury/ West Coast	218	1101	720	35	(29.2, 40.0)
Otago/ Southland	166	827	508	39	(30.9, 46.2)
National total	2487	22272	14475	35	(33.5, 36.5)

9.4 Reduction in severity of injury crashes

Some interventions are designed primarily to lessen the severity of crashes rather than to prevent crashes happening. These include installation of physical barriers such as median barriers and guardrails. An indication of the reduction in crash severity achieved (within injury crashes) is given by the ratio of fatal and serious injury crashes to minor injury crashes.

The ratio of fatal and serious crashes to minor crashes decreased by 8% after site treatment, resulting in an estimated social cost saving of $248 million over and above the saving achieved from the overall reduction in injury crashes.

[1] Percentage reduction includes adjustment for underlying crash trends, as described in section 5.

10. Total social cost saving

The social cost savings associated with the programme were estimated using the average social cost per reported urban or rural crash developed by the LTSA's Economic Analysis and Evaluation section. These social cost estimates are based on willingness to pay measures. The average social cost per reported crash is higher on the open road than in urban areas, as the increased open road speeds lead to higher severity crashes, so open road and urban crashes were treated separately.

The social cost saving is based on estimated crash savings multiplied by the average social cost of an urban or rural crash, in June 2002 prices.

Table 7: Estimated social cost savings associated with the programme

Total social cost saving associated with the programme 1986-2003	$ 3300 million
Mean annual saving associated with sites active in last ten calendar years (1994-2003)	$ 203 million per annum

- These social cost estimates take into account crashes occurring during the 'after' monitoring period only. There may be additional benefits from years after the monitoring period has finished. In this respect, these estimates are conservative.
- These estimates assume that the crash savings were constant over the 'after' monitoring period. This is likely to be a reasonable assumption in most cases, but it is possible that the effect of some interventions may have decreased over the (typically five-year) 'after' period.
- These estimates assume that all injury crashes were avoided. A previous report (*Overall results of crash reduction study safety improvements, March 2003*) found a 0.5% decrease in the estimated social cost saving under the assumption that all injury crashes were reduced to non-injury crashes.

11. Benefit cost estimation

Benefit cost estimates were made for sites for which actual or estimated costs of improvement were recorded in the monitoring system. The actual cost of implementation was available for 64% of completed sites. An estimated cost was available for a further 31% of completed sites. The remaining sites were not used in benefit cost calculations.

Average annual crash reductions at sites with known costs were estimated using the method described in section 6 above. Only crash reductions during the 'after' period were included. (This gives a conservative estimate of the BC). A discount rate of 10% per annum was applied to the resulting social cost estimates for the duration of the 'after' period, usually 5 years. Social costs were calculated in June 2002 prices.

The actual (or estimated) costs of implementation were adjusted for inflation to 2002 prices using the Consumer Price Index (Statistics NZ). Sites were then grouped into four broad cost bands as shown in Table 8.

Table 8 shows the resulting benefit cost estimates for each group of sites by site cost and open road or urban site location.

Table 8: Benefit cost ratio for sites with known or estimated costs, by total cost of site works

Total cost of site improvements[1]	*Number of sites*	**Benefit: cost ratio**		
		Open road sites (80-100 km/h)	Urban sites (70km/h or less)	All sites with known cost
$20,000 or less	*1671*	306	70	161
$20,001 to $75,000	*458*	55	12	28
$75,001 to $150,000	*129*	22	8	14
Over $150,000	*85*	5	3	4
All sites with known cost	*2343*	37	17	28

Note1: Actual cost where available; otherwise estimated cost. Costs have been adjusted for inflation to 2002 prices.

12. References

Särndal, C-E., Swensson, B., Wretman, J. (1992) Model assisted survey sampling. Springer series in Statistics, Spring-Verlag, New York.