LAND transport safety AUTHORITY

Overall Results

of Crash Reduction Study Safety Improvements

March 2003

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 2366 monitoring sites where all recommended works had been completed, with data from reported injury crashes up to 31 August 2002, and uses this 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 were associated with the crash reduction study programme[1].

- All sites: **34%**

- Intersection sites: 41%
- Non-intersection sites: 57%
- Routes: 26%

- Open road sites: 41%
- Urban sites: 29%

- Fatal crashes: 50%
- Serious injury crashes: 38%
- Minor injury crashes: 33%

This reduction in injury crashes corresponds to an estimated saving in social cost of approximately $3.0 billion[2].

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	34%
Social cost saving	$3.0 billion
Sites in monitoring system	4169
Completed sites used in analysis	2366

1. Introduction

The Crash Reduction Study Programme (then referred to as the Joint Crash Investigation 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 (then the Land Transport Division, Ministry of Transport), 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, 4169 crash reduction monitoring sites have been entered into the monitoring system. Of these, 2177 (52%) are intersection sites, 621 (15%) are non-intersection sites, 1343 (32%) are routes and 28 are areas. 1783 sites (43%) are on State Highways and 2385 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 (site implementation status 1 or 6);

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 58% (2421) of the crash reduction monitoring sites, including 66% of State Highway sites and 52% of local road sites. 2366 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 H'way	Total
Unknown/ new sites	52	27	80
Fully implemented	1235	1171	2406
Not fully implemented	910	427	1397
No actions will be implemented	49	20	69
Works done not as part of joint study	130	72	202
Fully implemented, some dates unknown	9	6	15
Total	2385	1783	4169

Included in the *Unknown/ new sites* category is one new site whose location was not specified.

Table 3. Sites with recommended works still to be implemented *(site implementation status = 2)*

Full years since works recommended	Road classification: Local road	State H'way	All sites
under 3 years	149	82	231
3-4 years	159	89	248
5-6 years	164	131	295
7-8 years	186	84	270
9-10 years	149	57	84
11-13 years	99	34	133
14+ years	4	10	14
Total	910	487	1397

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. These results are based on injury crash data up to and including 31 August 2002. 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 5.5 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

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

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

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

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 ± t (0.025, n) * $V^{½}$

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 34%, after allowing for underlying crash trends in each site's local area. This represents a saving in social cost of approximately $3.0 billion (June 2002 prices).

9.1 Site type

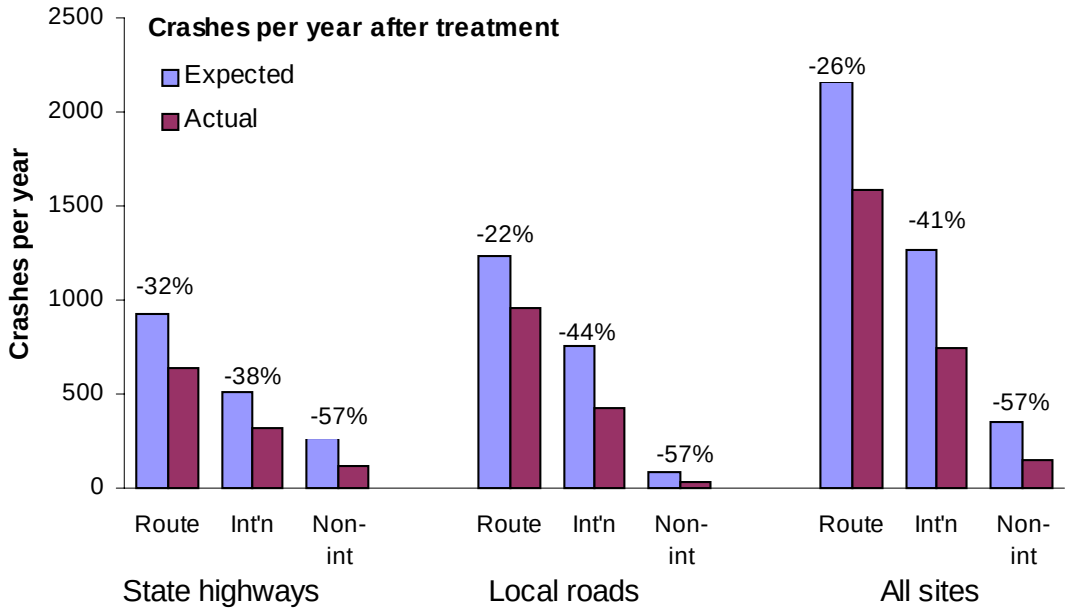
A 41% reduction in injury crashes was achieved at open road sites. A somewhat lower reduction of 29% was achieved at sites in urban areas. Crashes in urban areas are less likely to involve injury than open road crashes, due to the lower speeds involved. Non-injury crashes are not examined here due to changes in reporting rates over time, but it is to be expected that reduction in non-injury crashes form a substantial part of crash savings in urban areas.

Substantial reductions in injury crashes were achieved at all site types (route, intersection and non-intersection), with the greatest reduction (57%) at non-intersection sites.

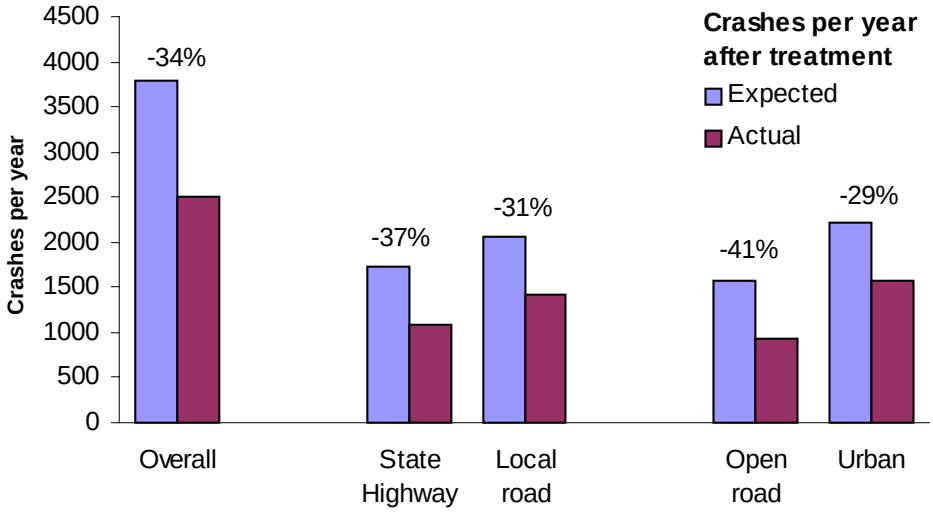
Fig 1 and Table 4 show the change in crash rate and the percentage reduction in crashes for various types of sites.

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

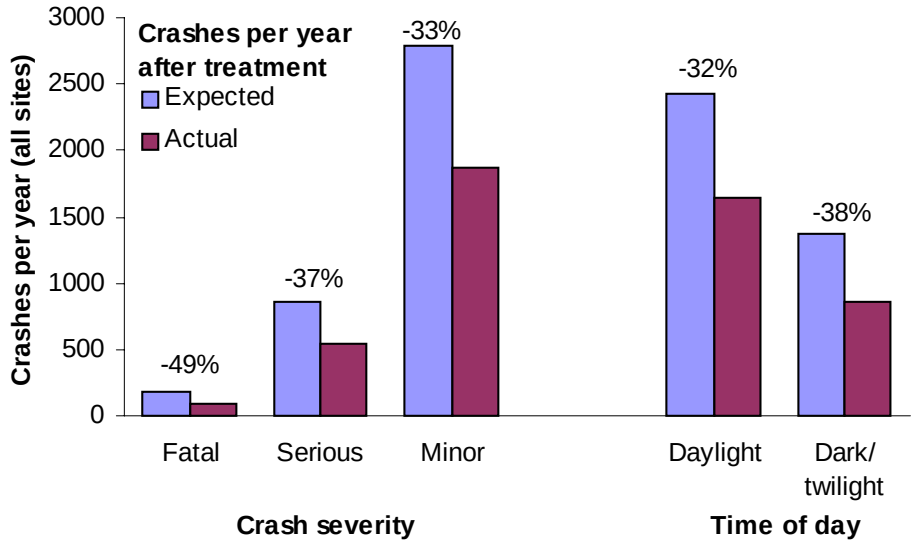


9.2 Crash type

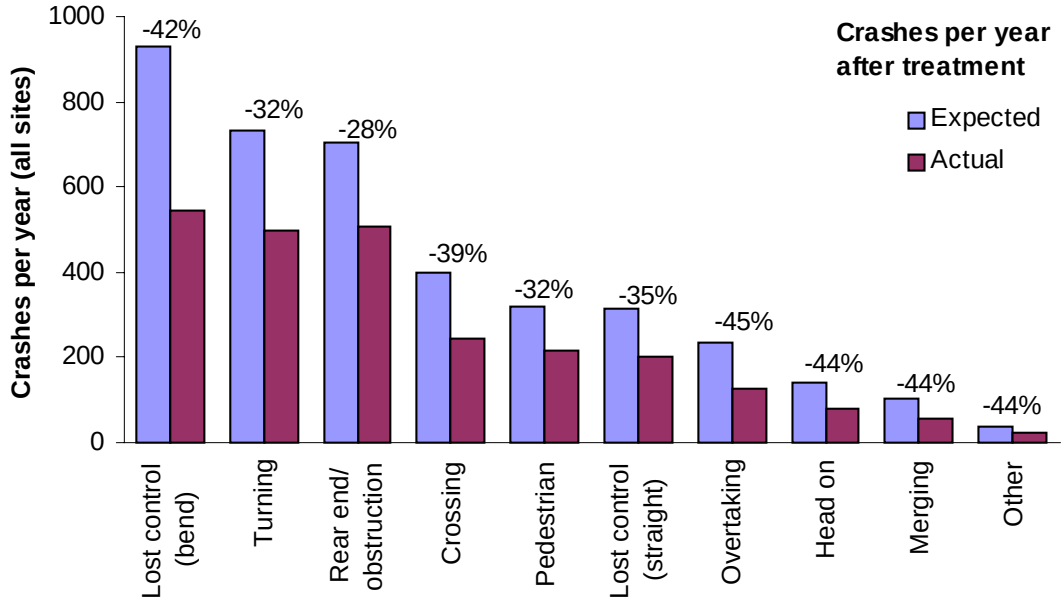
Substantial reductions in injury crashes were observed at all levels of crash severity and for most movement types. Fig 2 and Table 5 show the reduction in various types of crashes experienced at treated sites.

Fig 2: Crash reductions by crash type

a) Crash severity and night/day



b) Movement group



9.3 Reduction in severity of injury crashes

Some interventions are designed primarily to lessen the severity of crashes, rather than contributing to crash avoidance. 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 7% after site treatment, resulting in an estimated social cost saving of $220 million over and above the saving achieved from the overall reduction in injury crashes.

9.4 Total social cost saving

Table 3 below shows the total estimated saving in social cost at treated sites, after controlling for external trends in injury crashes. All social costs are given in June 2002 prices.

The reduction in open road injury crashes contributed a social cost saving of $1.98 billion. A saving of $770 million was contributed by the reduction in injury crashes at urban sites. Severity migration from *fatal and serious* to *minor* injury crashes resulted in a further social cost saving of $220 million.

It is expected that some injury crashes will have been avoided altogether, while others have been reduced to non-injury crashes. Table 3 shows the total estimated social cost savings under the two extreme assumptions, (i) that all injury crashes were avoided altogether and (ii) the conservative assumption that all injury crashes were reduced to non-injury crashes.

Table 3: Estimated social cost savings

	Social cost saving, $million (June 2002 prices)
Assumption 1: all injury crashes avoided	
Open road crashes	1980
Urban crashes	770
Decreased severity of injury crashes (from fatal or serious to minor)	220
Total social cost saving (assumption 1)	2970
Assumption 2: all injury crashes reduced to non-injury crashes	
Open road crashes	1970
Urban crashes	760
Decreased severity of injury crashes (from fatal or serious to minor)	220
Total social cost saving (assumption 2)	2960

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

	Number of sites	Expected annual crashes after treatment	Actual annual crashes after treatment	% reduction in injury crashes[1]	95% conf interval for % reduction
All sites	2366	3796	2501	34	(33, 35)
Road type					
State highways	1150	1723	1080	37	(35, 40)
Local roads	1216	2072	1420	31	(30, 33)
Speed limit area					
Open road (80-100 km/h)	942	1578	930	41	(39, 43)
Open road (State h'ways only)	730	1187	638	42	(40, 45)
Urban roads (up to 70 km/h)	1423	2220	1569	29	(27, 32)
Site type					
Route	789	2156	1590	26	(24, 29)
Intersection	1197	1270	745	41	(39, 43)
Non-intersection	380	352	151	57	(54, 61)

Table 5. Crash reductions by crash type

	Crashes in study period (sample size)	Expected annual crashes after treatment	Actual annual crashes after treatment	% reduction in injury crashes[1]	95% conf interval for % reduction
Light conditions					
Daylight	12553	2421	1642	32	(31, 34)
Dark/ twilight	8200	1368	852	38	(36, 40)
Movement group					
Overtaking	1298	233	128	45	(41, 49)
Head on	1033	143	81	44	(40, 48)
Lost control (bend)	4294	931	543	42	(38, 45)
Lost control (straight)	1563	314	204	35	(32, 39)
Rear end/ obstruction	3846	702	507	28	(24, 31)
Crossing	2287	400	245	39	(34, 43)
Merging	443	101	57	44	(36, 51)
Turning	4106	733	497	32	(28, 36)
Pedestrian	1779	321	218	32	(28, 37)
Other	135	38	22	44	(26, 61)
Crash severity					
Fatal	1051	183	94	49	(45, 53)
Serious	6106	863	540	37	(35, 40)
Minor	13627	2791	1867	33	(31, 35)

9.5 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 annual crashes after treatment	Actual annual crashes after treatment	% reduction in injury crashes[1]	95% conf interval for % reduction
Northland/ Auckland	722	1611	1092	32	(29, 35)
Waikato/ Bay of Plenty	449	705	418	41	(38, 44)
Gisborne/ Hawke's Bay	157	247	164	34	(28, 40)
Taranaki/ Manawatu/ Wanganui	242	296	177	40	(32, 49)
Wellington/ Nelson/ Marlborough/ Kaikoura	427	661	468	29	(25, 33)
Canterbury/ West Coast	203	198	134	33	(27, 39)
Otago/ Southland	166	140	89	37	(29, 44)
National total	2366	3796	2501	34	(33, 35)

10. References

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

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