LAND transportsafety AUTHORITY

ROAD LIGHTING IMPROVEMENTS

December 1997

EXECUTIVE SUMMARY

The safety benefits of road lighting have been evaluated using the data available in the Land Transport Safety Authority (LTSA) crash investigation monitoring system database.

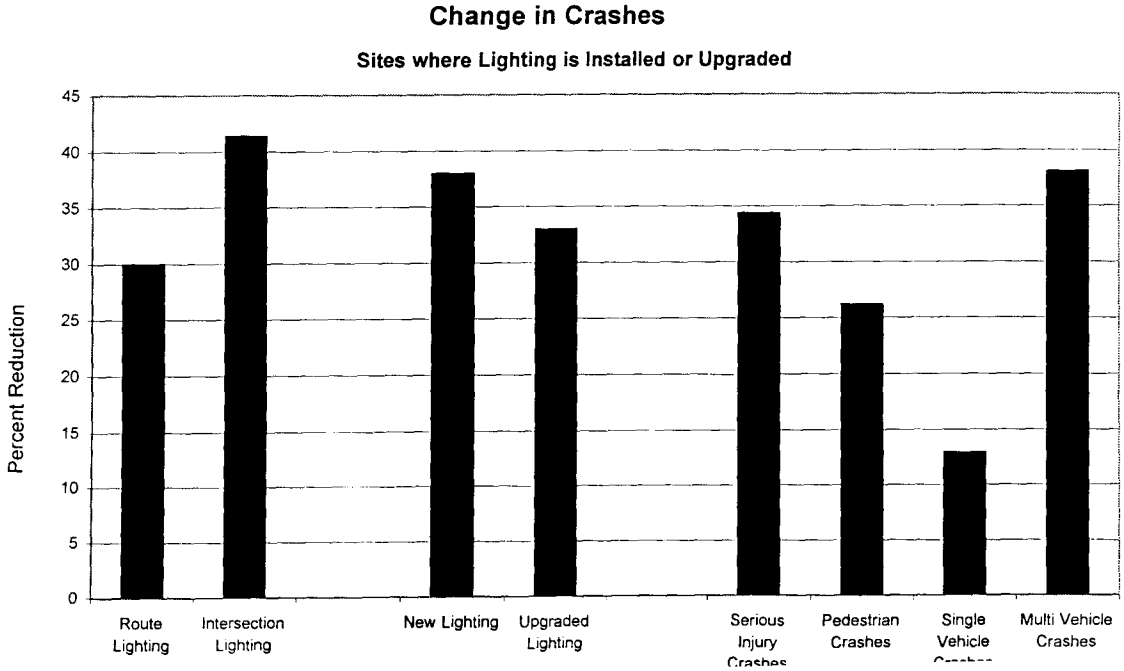
There were 231 sites in the crash investigation monitoring system database where road lighting had been improved. Analysis of these sites revealed night time crash reductions in the range of 30% to 40%.

This report examines the effects of road lighting and looks at the question of value for money in terms of the safety dollar. In N.Z. approximately $34m dollars per year is being invested in road lighting. Around $4m of this is spent on improvements or upgrades.

Minimum traffic flows and crash densities are required to justify road lighting to produce an economical cost benefit result.

Key Findings:

- At the selected sites, road lighting installations reduced night time crashes overall by 33%. At intersections the reduction was 41% and on routes 30%.
- Crash reductions to serious and fatal crashes due to road lighting was 34%.
- New lighting installations showed only a slightly higher crash saving than upgraded installations - 38% verses 33%.
- Single vehicle crashes showed only a minimal (non significant) improvement when lighting was installed (13%).
- The major road safety benefits of improved lighting appear to be in vehicle versus vehicle and vehicle versus pedestrian crashes.



BACKGROUND

In 1985, the government approved a programme of systematic crash investigation. The Land Transport Safety Authority (formerly the Ministry of Transport, Land Transport Division) developed a crash investigation monitoring system in 1989, which contains data on sites which have had works implemented as part of the joint crash investigation programme.

The systematic introduction of crash investigation teams and benefit cost procedures included recommendations for road lighting schemes. Localised concentrations of night time crashes were identified by the crash investigation teams and upgraded road lighting was often proposed as the appropriate crash countermeasure. The crash investigation monitoring system database provides for detailed records to be maintained, which allow ongoing Before and After evaluations of their crash reducing performance. These studies form the basis of crash analysis.

SITE SELECTION

As at July 1995 the database contained comprehensive data on some 1500 sites * where roading improvements have been made as a direct result of an crash investigation study. At 231 of these sites new or improved lighting was installed either at an intersection or along a route.

Typically road lighting has been installed or upgraded on the basis of a combination of traffic volume, road hierarchy, and social amenity. Many upgrades were and still are simple replacements of old low pressure sodium luminaire with new, modern light fittings (high pressure sodium fittings.)

* Analysis is based on complete crash and site data up to and including June 1995.

METHOD

To isolate the effect that road lighting has had on crash occurrence it is first necessary to eliminate the effect of two confounding variables:

1. Other Countermeasures

At the sites in the crash investigation studies, road lighting was usually installed along with other countermeasures. For example there could well be improvements to the signs, markings or traffic control system made at the same time as a lighting upgrade. Not all of the crash reduction that occurred at a site could therefore be attributable to road lighting.

The fact that lighting is mainly effective at night whereas the other countermeasures are usually effective both day and night provides the mechanism to isolate the effect of road lighting. Only the additional night time savings over daytime savings were attributed to road lighting.

This is reflected in the "r" ratio given by;

Percentage crash reduction = $(1 - r) \times 100\%$

where

$r = (a \times b) / (c \times d)$

and

a is the number of night crashes after
b is the number of day crashes before
c is the number of day crashes after
d is the number of night crashes before

2. Crash Trends

There is a need to isolate from the results any national trends in night time crash occurrence that are not due to road lighting. In particular national and local efforts to reduce drinking and driving will have a greater effect at night (when most of the drink driving is done) than during the day. The national trend in night crashes has been downward (see figure 1) and while some of this can be attributed to improvements to road lighting a significant portion of it will be due to changes in social habits of motorists.

The control group chosen was crashes at all intersection and route sites in the crash investigation monitoring system database where no night time countermeasures were installed, ie excluding all sites with new Road Lighting or Retro-reflective Pavement Markers installed. The night to day crash trend at these sites was taken to represent behaviour of the lighting sites had lighting not been installed.

To include the control, the "r" factor was modified to;

$$r = r_l \times 1/r_c \times 100\%$$

where

r_c = the "r" factor for the control sites
r_l = the "r" factor for sites with road lighting

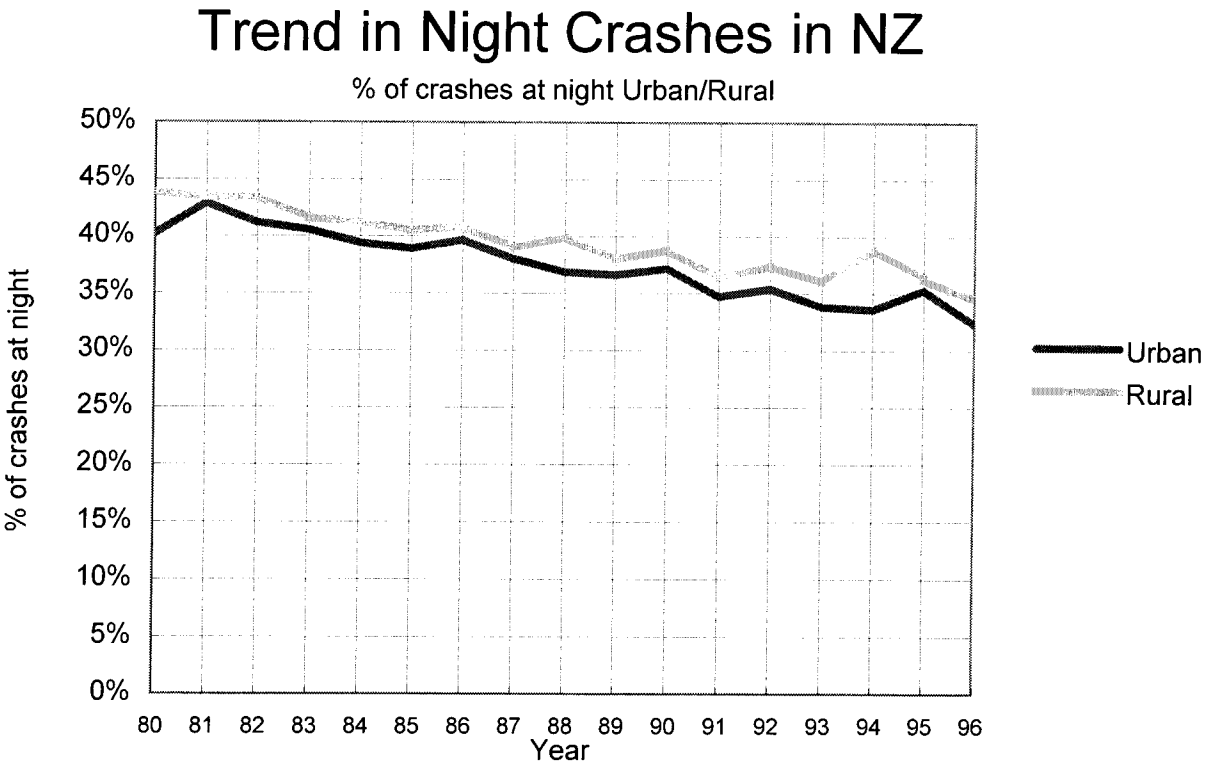


Figure 1: Percentage of Crashes at Night in N.Z. from 1980 to 1996

ANALYSIS

Table 1 below shows the basic statistics of both the lighting and the control group of sites. The control sites showed a 9.7% reduction in the night to day crash ratio while the sites where lighting was installed showed a 40.1% reduction.

	Sites with Road Lighting		Control Sites	
	BEFORE	AFTER	BEFORE	AFTER
No. of Day Crashes	1553	793	7366	3208
No. of Night Crashes	1351	413	4350	1711
No of Sites	231	231	1094	1094
Average Period	5.1 yrs	3.6 yrs	5.2 yrs	3.8 yrs
"r" factor		0.598		0.903

Table 1: Number of crashes at sites with road lighting and at the control sites.

After accounting for the changes to the control group the net reduction in night-time crashes where road lighting was installed was:

r_c = 0.903 (10%)
r_l = 0.598 (40%)
r(overall) = 1 - (0.598 / 0.903)

Overall Crash Saving = 33.7 % * * indicates statistical significance

The data was of sufficient size to permit limited disaggregation. Table 2 below shows a similar analysis as above but applied to routes and intersections, new and upgraded installations, crashes involving serious injury, pedestrians, and crashes involving single and multiple vehicles.

Group	No of sites	"r_l" value (no control)	"r" value (with control)	Night Crash Reduction
Route Lighting	89	0.632	0.700	30.0% *
Intersection Lighting	142	0.529	0.586	41.4% *
New Lighting	64	0.559	0.619	38.0% *
Upgraded Lighting	153	0.605	0.670	33.0% *
Serious Injury Crashes	208	0.592	0.656	34.4% *
Pedestrian Crashes	99	0.666	0.738	26.2%
Single Vehicle Crashes	158	0.786	0.871	12.9%
Multi vehicle Crashes	231	0.560	0.619	38.1% *

* indicates statistical significance at 5% level using 2x2 Chi Square test

Table 2: Crash Reductions due to Road Lighting

RESULTS

- At the selected sites, road lighting installations reduced night-time crashes overall by 33%. At intersections the reduction was 41% and on routes 30%.

- Crashes at night tend to have a higher injury severity than crashes during the day. The crash reductions to serious and fatal crash due to road lighting (34%) was similar to the overall, all injuries reduction (33%)

- New lighting installations showed a slightly higher crash saving than upgraded installations (38% verses 33%). Since upgraded installations produce crash reductions very similar to new installations, the effectiveness of some of the old installations is questioned. In many cases it may be appropriate to consider their contribution to road safety as "approaching zero"

- Single vehicle accidents showed only a minimal (non significant) improvement when lighting was installed (13%).

BENEFIT COST

While good road lighting is obviously beneficial it cannot be justified on all roads. A knowledge of what the likely benefit cost ratios are can assist traffic engineers in deciding which road lighting projects are worth investigating.

Tables 3 and 4 provide an indication of the minimum traffic volume and the minimum crash density required to justify road lighting (1995 costs and benefits) on the basis of:

- Transfund NZ Project Evaluation Manual crash costs
- a 30% saving in night crashes from improved street lighting
- an average urban night time crash rate of 20 acc/100 million vehicle kilometres travelled
- an lighting design at the most basic level, ie V4 (NZS1158) or Intermediate (NZD6701)
- equipment and energy costs that are typical of the Wellington Region

The three options I, II and III listed in tables 3 and 4 represent the amount of lighting hardware that is already available to the designer on-street. Clearly the more hardware that is available the lower the cost of the installation and the more that can be justified for a given benefit cost ratio.

Cut off Benefit / Cost Ratio	OPTION I Cabling + Poles + Luminaires Required	OPTION II Poles + Luminaires Required	OPTION III Arms + Luminaires Required
1	2,900	1,400	1,100
2	5,800	2,800	2,200
3	8,700	4,200	3,300
4	11,600	5,600	4,400
5	14,500	7,000	5,500
6	17,400	8,400	6,600
7	20,300	9,800	7,700
8	23,200	11,200	8,800
9	26,100	12,600	9,900
10	29,000	14,000	11,000

Table 3: Minimum Traffic volume (A.A.D.T.) required to justify intermediate level road lighting under varying cost/benefit criteria.

Cut off Benefit / Cost Ratio	OPTION I Cabling+ Poles + Luminaires Required	OPTION II Poles + Luminaires Required	OPTION III Arms + Luminaires Required
1	0.2	0.1	0.1
2	0.4	0.2	0.2
3	0.6	0.3	0.2
4	0.9	0.4	0.3
5	1.1	0.5	0.4
6	1.3	0.6	0.5
7	1.5	0.7	0.6
8	1.7	0.8	0.6
9	1.9	0.9	0.7
10	2.1	1.1	0.8

Table 4: Minimum number of Night crashes per km per year to justify intermediate route road lighting under varying Benefit /Cost criteria.

CONCLUSIONS

- Data from the crash investigation monitoring system database showed a 33% overall crash saving where lighting was installed.
- Crashes involving multi vehicle collisions (38%), serious injuries (34%) or intersection lighting (41%) showed the greatest reductions.
- An economic cost/benefit model developed for road lighting suggests that where poles and cables already exist a benefit cost at the current cut off value of 4 can be achieved on roads carrying at least 4,400 vpd or with an average of 0.3 night time injury accidents per kilometre, per year..
- The results above are in general agreement with that found in the international literature.