Wire Rope Barrier Effectiveness on Victorian Roads

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ABSTRACT

Unsafe roadsides contribute to a significant number of crashes on Victorian roads. In the five years to 2009, well over half of all fatal and serious injury crashes in rural Victoria, nearly 5,000 crashes, resulted from vehicles running off the road or being involved in head-on crashes (VicRoads data, 2010). More importantly, around 60% of these involved hitting a roadside object. Wire rope barriers, or flexible barriers, are considered one of the most effective means of preventing such collisions based on international evaluations, but at the time of the study, no comprehensive evaluation had been undertaken on the effectiveness of this barrier in reducing such crashes on Victorian roads. An evaluation was completed by Monash University Accident Research Centre (MUARC) and included 100 km of wire rope barrier. Results indicate that the barriers are associated with significant reductions in the risk of both casualty and serious casualty crashes, of up to 87% on an individual route. This paper presents and discusses the results of the evaluation.

INTRODUCTION

Loss-of-control crashes represent a major source of serious road trauma. In the five years to 2009, well over half of all fatal and serious injury crashes in rural Victoria - accounting for nearly 5,000 crashes - were the result of vehicles running off the road or being involved in head-on crashes (VicRoads data, 2010). Of these, around 60% involved hitting a roadside object. This issue is not confined to Victoria or indeed Australia. Collisions with roadside objects were found to contribute to between 18 and 42% of fatal crashes in several EU countries: Great Britain: 18% of fatalities; Netherlands: 22% of fatalities, and Sweden: 25% of fatalities (ETSC paper, 1998). In the US, over 50% of fatal crashes were the result of vehicles running off the road (Slusher, 2011) and over 1,000 fatal crashes were associated with utility poles in 2002 alone. (NCHRP, 2004)

An increasingly common means of addressing this crash type is through the installation of wire rope barrier, referred to as “flexible barriers” for their ability to deflect and absorb much of the crash force. The barriers consist of highly-tensioned wire rope supported by steel posts. They are generally manufactured in two main forms: three to four wire ropes either placed parallel to the road surface; or with the two upper wire ropes parallel to the road surface and the lower two intertwined with each other. Wire rope barriers employ a dual mechanism to contain the errant vehicle and bring it to a halt, without imparting excessive force on to the vehicle and its occupants. The ropes deflect upon vehicle impact, absorbing much of the energy of the crash; the resultant residual energy posing reduced threat to the vehicle occupant. The posts, designed to collapse upon impact, allow the vehicle to be gradually decelerated to a standstill. There appears to be little potential for vehicle rebound due to the frangible posts and rope deflection that ensues during collision.

The presence of wire rope barriers on road networks is increasing rapidly. Wire rope barriers were initially introduced on Australian roads in the early 1990s, and well over 100 km were installed within Victoria in 2007, (VicRoads data, 2008). In 2009, the Victorian government announced $3.7 million funding for the trial of a centreline barrier along one of the major rural highways in Victoria. The Parliamentary Road Safety Committee of Victoria recommended that pending a successful outcome of this trial, the Minister for Roads and Ports "…ensures the installation of wire rope barriers as a low cost measure for improving the safety of Victoria's roads in the future" (Parliament Road Safety Committee of Victoria, 2010).

International evaluations of the effectiveness of these barriers have been highly promising. Evaluations in Europe and the US consistently indicate large reductions in injurious crashes associated with wire rope barrier use, with up to 70-90% reductions in serious casualty crashes for particular crash types (Hammond & Batiste, 2008.; NCHRP, 2003, Larsson, Candappa, & Corben, 2003). While it is likely that barrier effectiveness is largely independent of the road environment is it installed in, the applicability and relevance of these international findings to Australian roads were difficult to establish, with no comprehensive evaluation undertaken on the barrier effectiveness in an Australian environment at the time of the study.

This Victorian study was completed in 2009 to investigate how effectively wire rope barriers improve roadside safety in Australia. This paper presents and examines the results of the evaluation and examines estimated reduction in reported serious and fatal injury run-off-road crashes, after the installation of wire rope barriers on Victorian roads, as well as the overall effect on casualty crashes.

METHOD

The study comprised a quasi-experimental before and after study design, comparing crash frequency at each treated road section to that at untreated road sections of the same route (control sites) over the same time periods.

Subject road lengths were identified as sections of road lengths within 100km/h and 110 km/h speed zones that contained installed lengths of wire rope. Control sites were generally selected using postcodes or another section of the same road. Using VicRoads Road Crash Information System (RCIS) over the period January 1995 to October 2007 inclusive, crashes occurring within a 50 metre arc of a subject site were included for analysis. All crashes within the entire length were considered, irrespective of whether the crashes involved barriers. A total of 2,576 crashes were included in the study.

The evaluation examined the effect of the barriers on four crash categories: all crash types, targetted crashes only (head-on and off-path crashes), all crash injuries, and fatal and serious injury consequences only. A number of measures were taken to limit the possibility of regression-to-the-mean, including selecting a five-year time span of pre-treatment crash data and the maximum available after-treatment crash data; overlap was minimised between the before-data period and the data period from which the treated sites were selected.; and an analysis technique used successfully in other similar applications was used, (Brühning & Ernst, 1985; Newstead & Corben, 2001)

Reductions were established by comparing relative risk of a crash occurring before and after treatment when compared to control sites. Relative risk of one was used for the pre-treatment scenario.

RESULTS

Approximately 100 km of wire rope barrier installed on ten prominent routes in Victoria, Australia, were analysed in this study to estimate barrier effectiveness in reducing crash numbers and severity.

Of the ten routes, the study results contained two routes that produced significant findings, Hume Freeway and the Easter Freeway. Presentation of these results is restricted only to these two sites, with the intention of revisiting the evaluation when more data are available to produce more routes of significant results.

Table 1 and Table 2 present a summary of the lengths of wire rope on the respective routes as well as the percentage of barriers installed on the left, median and right sides of the roads. The Hume Freeway contained the longest total length of wire rope barrier and the Midland highway, the shortest. Around 60% of barrier has been installed on roadsides and 40% on medians.

Table 1-Lengths of wire rope barrier included in the analysis, by route

Routes	Metres
Monash Freeway	17685
Princes Highway	3343
Western Highway/Freeway	16167
Calder Highway	9031
Hume Highway	19923
Midland Highway	235
Gouburn Valley Highway	3815
Eastern Freeway	7106
Metropolitan Ring Road	5394
Western Ring Road	18972
Total	**101670**

Table 2 - Location of barrier within road cross section

Barrier Location	Metres
Total left	31441
Total median	40364
Total right	29863

Table 3 presents a summary of the key findings. These are explored in the following sections.

Table 3 - Estimated reductions in crash incidence associated with wire rope barrier

	Casualty Crashes		**Serious Casualty Crashes**	
	All Crashes	Targetted Crashes	All Crashes	Targetted Crashes
Overall	29%	44%	42%	56%
Hume Highway	77%	79%	77%	87%
Eastern Freeway	75%	86%	76%	83%

Effects of Barrier on All Casualty Crash Reductions

The study estimated an overall program relative risk of 0.71, or a reduction in all casualty crash occurrence associated with barrier use of 29% (*p*=0.0003) (Table 4). Similarly, a reduction of 77% (*p*=0.005) was estimated for the Hume Highway after wire rope barrier installation and 75% reduction in casualty crash risk (*p*<0.0001) for the Eastern Freeway.

Table 4 - Casualty crash reductions for all crash types

	Relative Risk	Lower 95% Confidence Limit	Upper 95% Confidence Limits	Statistical Significance
Overall	0.71	0.59	0.85	0.0003
Hume Highway	0.23	0.08	0.64	0.005
Eastern Freeway	0.25	0.15	0.41	<0.0001

Effects of barrier on Serious Casualty Crash Reduction

The relative risk of a fatal or serious casualty crash within the overall program was 0.58 (*p*=0.0005) (Table 5), the crash risk of a serious casualty crash reducing by 42%. Estimated risk of a fatal or serious casualty crash on the Hume Highway reduced by 77% (*p*=0.0165) and by 76% (*p*=0.0003) on the Eastern Freeway. Reduction proportions for serious casualty crashes were found to be very similar to that for reductions in all casualty crashes.

Table 5 - Serious casualty crash reductions for all crash types

	Relative Risk	Lower 95% Confidence Limit	Upper 95% Confidence Limits	Statistical Significance
Overall	0.58	0.43	0.79	0.0005
Hume Highway	0.23	0.07	0.76	0.0165
Eastern Freeway	0.24	0.11	0.53	0.0003

Effects of barrier on Targetted Casualty Crash Types

The study analysed the associated reductions when considering only the crashes expected to be addressed by the barrier, namely, run-off-road or head-on crashes. Relative risk for the overall program was estimated at 0.56 (*p*=0.0013) (Table 6), or a crash risk reduction of 44%. Considering each individual route, targetted crashes along the Hume Highway were expected to reduce by 79% (*p*=0.0322) and along the Eastern Freeway by 86% (*p*<0.0001).

Table 6 - Casualty crash reductions for targetted crash types

	Relative Risk	Lower 95% Confidence Limit	Upper 95% Confidence Limits	Statistical Significance
Overall	0.56	0.4	0.8	0.0013
Hume Highway	0.21	0.05	0.87	0.0322
Eastern Freeway	0.14	0.06	0.33	<0.0001

Effects of barrier on Serious Targetted Casualty Crash Types

Barriers are typically intended for run-off-road crashes where the crash outcome would otherwise be serious. It was hypothesised then that the greatest reduction obtained from barrier use would be for targetted, serious casualty crashes. The results supported the hypothesis, indicating that the relative risk in the overall program of a targeted, serious casualty crash was 0.44 (p=0.0023) (Table 7), or a 56% crash reduction. Estimated reductions on individual routes were 87% (Hume Highway, p=0.0484) and 83%, (Eastern Freeway, p=0.0023).

Table 7 - Serious casualty crash reductions for targetted crash types

	Relative Risk	Lower 95% Confidence Limit	Upper 95% Confidence Limits	Statistical Significance
Overall	0.44	0.26	0.75	0.0023
Hume Highway	0.13	0.02	0.99	0.0484
Eastern Freeway	0.17	0.06	0.53	0.0023

For a more practical application, these reductions were converted in to approximate lives saved as a result of barrier installation (Table 8). In terms of crash savings, an implied 270 casualty crashes and 98 serious casualty crashes are estimated to be saved on the Eastern Freeway alone over around a six and a half-year period; along the Hume Highway, an indicative 14 casualty crashes and ten serious casualty crashes are expected to be saved over a 21-month period. As symptomatic annual crash saving rates, around 42 casualty crashes on the Eastern Freeway and eight casualty crashes on the Hume Highway can be expected to be saved per year of treatment. With respect to serious casualty crashes, indicative serious casualty crash savings per year are 15 and six for the Eastern Freeway and the Hume Highway respectively. Of the targetted crashes, around over 100 casualty crashes and over 40 serious casualty crashes are estimated to be saved on the Eastern Freeway, and 8 casualty and 7 serious casualty crashes are estimated to be saved ion the Hume Freeway following wire rope barrier installation. Annually that equates to around 15 and 6 casualty, and serious casualty crashes on the Eastern Freeway, and around 5 and 4 casualty, and serious casualty crashes on the Hume Freeway.

Table 8 - Indicative crashes caved per year as a result of wire rope barrier

	Casualty Crashes							
	All Crash Types				**Targetted Crash Types**			
	After	**Reduction factor**	**Expected**	**Saved**	**After**	**Reduction factor**	**Expected**	**Saved**
Overall	501	29%	705	204	99	44%	176	77
Eastern Freeway	89	75%	359	270	18	86%	124	106
Hume Highway	4	77%	18	14	2	79%	10	8

	Serious Casualty Crashes							
	All Crash Types				**Targetted Crash Types**			
	After	**Reduction factor**	**Expected**	**Saved**	**After**	**Reduction factor**	**Expected**	**Saved**
Overall	166	42%	284	118	44	56%	99	55
Eastern Freeway	31	76%	129	98	9	83%	53	44
Hume Highway	3	77%	13	10	1	87%	8	7

DISCUSSION

Evaluation of the effectiveness of wire rope barrier on reducing the incidence and severity of police reported crashes on Victorian roads was undertaken using a quasi-experimental, before-and- after study design, analysing data between 1997-2007, inclusive. Results indicate that barriers are associated with significant reductions in the risk of both casualty and serious casualty crashes. When effect estimates are considered for the two individual routes that produced statistically significant results, the Eastern Freeway experienced estimated reductions of 75% in all casualty crashes, 76% in serious casualty crashes, 86% when including only targetted casualty crashes (off-road and head-on crashes), and 83% for serious casualty targetted crash types. The Hume Highway experienced very similar effects, with 77% for all casualty crashes, 77% for all serious casualty crashes, 79% for targetted casualty crashes, and 87% for targetted serious casualty crashes. Overall program findings suggest reductions of 29% in all casualty crashes, 44% in targetted casualty crashes, 42% in serious casualty crashes and 56% in targetted serious casualty crashes. In projected crash savings, up to 40, and eight targetted serious casualty crashes per year are estimated to be saved on the Eastern and Hume freeways respectively.

The study results are comparable with some of the overseas evaluations undertaken. Direct comparison is difficult due to variations in parameters from one study to another. For serious casualties (both fatal and serious injuries) for *all crash types,* evaluations in Sweden of a 2+1 wire rope barrier configuration[1] indicate savings of up to 76% of fatalities alone on an undivided road, and up to 90% on a freeway (Larsson et. al, 2003). A study in Alberta, Canada, of an 11 km long cable barrier installed on a median, produced preliminary results of 30 hits to the barrier over a ten-month period, none of which produced fatal injury consequences compared to a recent five-year period prior to barrier installation along the same section of road which produced seven fatal crashes, (McGregor, Hassan, & Lahey, 2008). Monitoring of cable barrier use in the US has found up to 100% reductions in fatal median crashes as a result of barrier installation, (Ray, 2008). Another preliminary study on the effect of cable median barrier use on crash numbers in Oklahoma, U.S., found that fatalities reduced from six to one, and injuries reduced from 77 to eight, post wire rope barrier installation (FHWA, 2008) – approximate reductions of between 80 and 90%.

In Australia, recent RTA figures indicate installations in 2004 of high tension wire barriers at Tabbimobile, NSW have resulted in 23 injuries and no fatalities on a stretch of Pacific Highway that was initially classified a BlackSpot. In the five years prior to the installation of the wire rope, there were 47 injuries and 11 fatalities. (ABC News website, 2011). Another comparison of crashes before and after installation of median barrier along two major highways in New South Wales, Australia, found a reduction of 51 fatalities and 147 fewer injuries (Soames, J, 2009). While this Victorian analysis does not distinguish between fatal and serious injury crashes, the study findings are still comparable in proportions, with over three out of four serious

[1] The 2+1 barrier system involves a road geometry that has one continuous lane in each direction and one centre lane alternating the permitted direction of travel at intervals of 1.5-2.5 km; flexible barrier is placed on the road pavement itself and physically separates the two directions of travel.

casualty crashes being reduced as a result of wire rope barrier implementation. Should only fatality crashes be considered, this figure is likely to be greater.

Comparing median crossover crash rates (per million vehicle miles travelled) in the State of Washington before and after wire rope barrier installation indicated a reduction in fatal crash rates of nearly 80% (Ray, 2007).

These study results compare well with the current study findings and consistently indicate the great potential of wire rope barriers to alleviate the heavy social and economic burden that results from run-off-road crashes.

Many of the individual routes in the current study analysed did not produce statistically significant findings. Statistical reliability is influenced not only by treatment effect, but also by adequate barrier length and crash data quantities as well as adequate after-periods. As barrier installation in Victoria has only gradually increased, long lengths of barrier along one route installed early enough to provide lengthy after-periods, are not common. Additionally, barriers may not always have been introduced as a result of crash history, so although a long length of barrier exists, there may have been insufficient crashes before and after to produce any statistically reliable estimates. Similarly, barriers may not always have been placed in long continuous stretches; instead they have often been installed in short, intermittent stretches. This not only reduces the potential for effective barrier protection, given the degree of randomness associated with loss-of-control crashes, and so the increased likelihood of errant vehicles slipping in between intermittent barrier lengths. It also limits the number of crashes that are appropriate to be included within the analysis. Despite these factors, two routes produced adequate data to result in statistically reliable findings.

CONCLUSION

An evaluation of the lengths of wire rope barrier installed on Victorian roads was completed. The barriers were shown to significantly reduce the incidence of all crashes, and run-off-road and head-on crashes, with estimated reductions on individual routes ranging between 75% and 87%. These results are consistent with overseas findings. Further analysis should be undertaken when more data become available to increase the likelihood of results being significant.

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