Investigation of risk reduction for various safety treatments in different environments

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ABSTRACT

ARRB Group are involved in an extensive range of research aimed at identifying the level of risk for different road stereotypes, and at the reduction in this risk resulting from changes in design standards and from remedial treatments. This Austroads funded research is designed to aid policy makers and practitioners in assessing risk and prioritising treatment on their roads.

This paper will present results from one part of the research program that explores the crash reduction benefit from various engineering based treatments. Twenty-one measures were assessed, and crash reduction values derived for different road environments. This work is based on extensive reviews of the literature, and as well as assessing the crash benefit expected from various treatments, methodological issues in deriving these values are also discussed.

INTRODUCTION

This project forms part of an ongoing Austroads strategic research program to improve the understanding of the relationship between crash risk and road elements. The objectives of this part of the research were to:

1. Improve the knowledge of relative risk associated with various engineering issues (e.g. delineation, lane widths, roadside hazards) in different environments (e.g. urban, urban fringe, rural, regional town)
2. Provide more objective analysis methods for use by road authorities in assessing relative risk.

The tasks for this part of the project were to prioritise various road safety engineering issues (referred to hereafter as ‘issues’) for fuller assessment of safety benefits. This prioritisation was based on discussions with Australasian jurisdictions (Australian State Road Authorities, and Transit and the Land Transport Safety Authority in New Zealand) and on the degree of existing information on these issues. Once priority issues were identified, literature reviews were undertaken on each issue to identify the associated crash reduction figures, and to identify gaps in knowledge.

For each issue, a relative risk was derived from crash reduction figures. For example, if there is a crash reduction of 3.9% from advisory sign installation, the risk of not installing advisory signs in a location where they are required would be 1.04 (100/96.1). As the crash reduction figure increases the relative risk of not providing the treatment increases.

METHOD

A list of issues was developed based on the priorities indicated by State Road Authorities and New Zealand agencies during earlier stages of this project. The list of issues selected as priorities appear in Table 1.

Table 1 – List of priority issues for further investigation

Issue	
Accesses	Median crossovers
Clear zone - general	Off road delineation - guide posts
Clear zone - length hazard	Overtaking
Clear zone - point hazard	Pavement markings - centreline
Intersection - advanced warning	Pavement markings - edgeline
Intersection - intersection road types	Pedestrian/cyclist
Intersection - red light camera	Signs - advisory
Intersection - right turn phase/lane	Signs - regulatory
Intersection - signal timing	Street lighting
Intersection - signal visibility	Traffic Calming
Intersection - control beacons	

A literature review was then undertaken on each issue by consulting the ARRB Australian Transport Index (ATRI) database (1999 to 2004/05). The search began from 1999 as previous literature reviews had been completed on each of these issues to 1998. In some cases, earlier relevant research was detected that had not been included in the earlier review, and so this was also included.

In addition to Australian and New Zealand research reports, ATRI holds a large number of international research reports. The Transport Research Information Service (TRIS) and International Transport Research Documentation (ITRD) databases were also searched if little information was found on ATRI, although studies relevant to the Australian and New Zealand context were the highest priority.

Each new literature review was given a rating to determine the robustness of the study methodology. The purpose was to select a degree of confidence in the overall level of risk reduction suggested by the literature. The rating is from 1 to 5 as shown in Table 2 below. This rating system was developed by Peter Cairney and Kelly Imberger of ARRB. Similar rating scales have been developed in other fields of study, including the Maryland Scientific Methods Scale developed by Sherman (see Farrington et al., 2002) in the area of crime prevention research. The Maryland scale is a simpler one as it includes no measure of statistical analysis used. The other main contrast is that it includes random assignment as the highest standard of research. Given the lack of such research in road engineering evaluation research, this has not been included in the road engineering study rating system (although if the scale is applied to other types of interventions, this should be considered).

Table 2 – Study rating system

Study type	Descriptive statistics only	Simple statistical analysis	Complex statistical analysis
Simple study - no controls no traffic volume	1	1	(not likely)
Study without control group but traffic volume	2	2	(not likely)
Study using comparison group/all crashes etc. to control for general crash trends	3	4	5
Study controlling for general crash trends and the regression-to-the-mean effect, generally using controls based on similar sites	3	4	5
Study using matched comparison group, based on crash rates controlling for general trends and regression-to-the-mean	3	4	5

Procedure for devising/renewing relative risk models

A procedure for devising or renewing relative risks was developed, and included the following steps:

1. Identify the issue of interest.

2. Review literature, especially that relating to the crash reductions for the issue.

3. Note the contexts of each research study, including type of environment (e.g. high speed rural roads, urban arterials, local streets), whether the crash reductions reported related to ALL vehicles on the road (all crashes) or just an isolated movement such as head-on crashes, and the country in which the research was conducted.

4. Rate the study based on the method developed by Cairney & Imberger (see Table 2).

5. Adjust for all crashes (e.g. if a treatment decreased head-on crashes by 20% on a certain road, and head-on crashes are reported as 40% of the crash type on the particular road type then calculate the impact on all crashes).
6. Summarise the above information for all research on an issue in a table.

Once all of the information on an issue was summarised, attempts were made to provide a single crash reduction/increase figure for each issue in different environments. In many cases this was a difficult task, as there was a large amount of variation in the reductions provided in the research. To assist in this task, a greater weighting was applied to studies that had a better methodology according to the Cairney & Imberger rating scale. The highest study rating studies were used as the starting point. Where reduction/increase figures were similar (within 15%), a simple average was taken of the studies. Where differences were greater, the research was reassessed to determine if the

reductions related to different environments. If no difference was identified, a judgement was made based on the personal experience of the researchers/engineers.

The review involved at least two researchers (and for more complex cases, more were used), one who had experience in crash reduction for engineering treatments, and one with evaluation research and statistics experience .

For each relative risk, an assessment of confidence in the figures was produced based on the certainty of the data it was based on. A scale of one to three was used, with one meaning there is little confidence, two there is some confidence, and three there is high confidence.

In all cases, the relative risks derived were clearly documented and peer reviewed (initially by other ARRB staff and then externally).

RESULTS

The relative risks for each of the issues under investigation appear in Appendix 1. The numbers of studies are listed for each issue, along with the confidence in each model based on a rating of 1 to 3 (with 1 indicating little confidence, 2 indicating some confidence, and 3 indicating high confidence).

Gaps in knowledge

A number of issues did not have sufficient associated research (literature review material) or the research was not considered of suitable quality and thus they are considered to pose gaps in knowledge. In addition, specific items for research for each issue are highlighted where these have been identified.

- accesses, including research on two lane versus four lane environments. In urban areas, four lane roads were found to have a lower crash reduction with every access added, but in rural areas, this trend is reversed. Research is needed to determine why this occurs. Also, research is required on the effect of a median, and how land use type impacts on the effect of the median. Different types of turning movements occur in commercial versus residential areas, and so how the presence of a median affects risk in these different environments needs to be determined

- clear zones, including research on the impact of kerbs, shrubs, trees, embankments, posts, rollover (<4:1 fill), wall transverse and cliffs on clear zones

- cyclists, including research required into most cycling treatments and associated crash reductions. Literature that is older than the current literature review and that of the previous review should also be investigated

- intersection - advanced warning flashers/signs, including an estimate of the effectiveness of advance warning flashing lights for intersections

- intersection road types including further work on whether different crash types show different relative risks when sorted according to intersecting road volumes

- intersection - right turn lane, including the effect of partial and fully controlled right turn lanes

- intersection - signal timing, including research specific to particular timing modifications such as a project on increasing/decreasing the all-red time at an intersection, increasing/decreasing yellow phases etc.

- intersection - signal visibility, including 'see thru effects' and some aspects of the signal being less visible e.g. green light less visible than red light

- median crossovers, particularly research relevant to the Australian and New Zealand context

- off road delineation - guide posts, with research required on the effectiveness of guide posts on curves versus on straights (there is conflicting evidence in this area)

- pavement markings - centreline, for example a review of delineation on straight and curved road sections in the Australian and NZ context

- pavement markings - edgeline, including a review of delineation on straight and curved road sections in the Australian and NZ context

- pedestrians research on marked versus unmarked crossings, zebra crossings, concrete medians, roundabouts and pedestrian lighting

- signs, as there is little research on the effects of many types of signs. Research could be conducted on most warning sign types (e.g. fog, road narrows, animals etc.)

- street lighting, including further research on the difference between rural and urban lighting

- traffic calming, as despite overseas research, there is little research on the effects of many types of calming in the Australasian context.

CONCLUSION AND RECOMMENDATIONS

Based on an extensive review of the relevant literature, relative risk models have been developed or updated for 20 issues. However, due to lack of robust research evidence, for the majority of models only a medium level of confidence in these models has been applied. Only one model, intersection – red light camera, had a high level of confidence where there was strong evidence from the literature. Six models have 'little confidence' for one or more relative risks due to a lack of research evidence, or poor research methodology where evidence does exist.

It is recommended that further research to address the gaps in knowledge (as discussed on the previous page) be pursued. Such research will provide a higher level of confidence in relative risk models, which is particularly important for those models where there is little confidence. Additional research will be able to provide greater detail (through provision of relative risks) on some issues, including the level of risk in different road environments, allowing additional relative risk models to be developed.

In most cases this research will not be available from the existing literature (as this has been explored extensively in this study), but rather experimentation, or analysis from existing data sources will be required.

In addition to the 20 issues reviewed as part of this study, there are a number of other topics that should be considered in future research. It is recommended that those issues not assessed during this current research project be added to the list of potential topics for consideration and prioritisation.

Ideally information on the change in crash costs associated with a treatment should be collected as well as changes in crash numbers, as this would reflect the change in severity of crashes. In some cases, crash numbers may remain relatively stable following a treatment indicating only a marginal benefit, but the overall severity of crashes may be reduced significantly. This change in severity needs to be reflected when summarising treatment benefits, and therefore it is recommended that where possible information on crash costs be collected.

Finally, a lack of robust research has been highlighted in this study. Where research has been conducted, this is often of low quality and of limited use by practitioners. Some form of training or guidance may be required with respect to the evaluation of road safety treatments.

References

Farrington, D.P., Gottfredson, D.C., Sherman, L.W. & Welsh, B.C. (2002). The Maryland Scientific Methods Scale. In L.W.Sherman, D.P.Farrington, B.C.Welsh & D.L.MacKenzie (Eds.). *Evidence-based Crime Prevention.* London and New York: Routledge.

Appendix 1 – Relative risks for issues reviewed

Issue	Relative risk
Accesses	Open Road 4 lane 1+(0.02*residential/km+0.10*commercial/km+0.20*minor junctions)*({0.45 if median-solid or >3m}, 1 if no median) Open Road 2 lane 1+(0.01*residential/km+0.05*commercial/km+0.20*minor junctions)*({0.45 if median-solid or >3m}, 1 if no median) Built up 4 lane 1+(0.01*residential/km+0.08*commercial/km+0.05*minor junctions)*({0.45 if median-solid or >3m}, 1 if no median) Built up 2 lane 1+(0.02*residential/km+0.10*commercial/km+0.20*minor junctions)*({0.45 if median-solid or >3m}, 1 if no median) *Number of studies = 8. Confidence = 2.*
Clear zones	None at this point in time. Research continues on this issue, and will be combined with current results to provide clear zone adjustments.
Intersection – advance warning	Appropriate advance warning of the intersection 1.00 No advance warning of the intersection 1.07 *Number of studies = 5. Confidence = 2.*
Intersection – intersection road types	Where one of the intersecting roads is a local street 1.00 Where a primary arterial and collector road intersect 1.75 Primary arterial and secondary arterial intersect 2.25 Where all intersecting roads are primary arterials 3.00 *Number of studies = 4. Confidence = 2.*
Intersection – red light camera	Fully operational red light camera (on one leg) 1.00 No red light camera 1.06 *Number of studies = 4 (including one extensive ARRB review). Confidence = 3.*
Intersection – right turn phase/lane	Appropriate dedicated right turn phase and lane 1.00 Partial right turn phase and lane 1.11 No right turn phase or lane 1.30 *Number of studies = 14. Confidence = 2.*
Intersection – signal timing	Appropriate signal timing 1.00 Very poor signal timing 1.11 *Number of studies = 7. Confidence = 2.*
Intersection – signal visibility	Appropriate road or signal visibility 1.00 Very poor road or signal visibility 1.47 *Number of studies = 3. Confidence = 2.*
Intersection control beacons	Intersection control beacons present at intersection for required environment 1.00 Intersection control beacons absent at intersection for required environment 1.41 *Number of studies = 5. Confidence = 2.*
Midblock median crossovers	No median opening exists 1.00 Uni-directional median crossover exists 1.48 Bi-directional median crossover exists 2.14 *Number of studies = 4. Confidence = 2.*
Off road delineation – guide posts	A road with appropriate guideposts 1.00 A road with no guideposts at night 1.39 *Number of studies = 8. Confidence = 2.*

Overtaking	Provision of passing opportunities	1.00
	No provision of passing lane where required	1.30
	Number of studies = 16. Confidence = 2.	
Pavement markings - centreline	Centre line present in good condition	1.00
	No centre line present	1.43
	Number of studies = 5. Confidence = 1.	
Pavement markings - edgeline	Edge line present in good condition	1.00
	No edge line present	1.24
	Number of studies = 13. Confidence = 1.	
Signs - advisory	Advisory speed sign	1.00
	No advisory speed sign	1.33
	Warning sign – curve	1.00
	No warning sign – curve	1.33
	Chevron warning sign	1.00
	No chevron warning sign	1.43
	Bridge related warning sign	1.00
	No bridge related warning sign	1.43
	Guidance sign	1.00
	No guidance sign	1.18
	Variable message sign	1.00
	No variable message sign	1.18
	Vehicle activated sign	1.00
	No vehicle activated sign	1.52
	Number of studies = 13 (combined literature review with signs – regulatory). Confidence = 1 (except for variable message sign and vehicle activated sign = 2)	
Signs - regulatory	Signs – regulatory (midblock):	
	Required mid-block regulatory signs are missing	1.33
	Number of studies = 13 (combined literature review with signs – advisory). Confidence = 1.	
Street Lighting	*Intersections.*	
	Provision of appropriate lighting	1.00
	Provision of sub-standard/very poor lighting	1.67
	No lighting	2.00
	Midblocks.	
	Provision of appropriate lighting	1.00
	Provision of sub-standard/very poor lighting	1.43
	No lighting	1.67
	Rural.	
	Provision of lighting	1.00
	No lighting all sites	1.43
	No lighting at intersections	1.67
	Urban.	
	Provision of lighting	1.00
	No lighting all sites	1.43
	No lighting at intersections	1.25
	(Note – above refers to night time crashes only)	
	Number of studies = 15. Confidence = 1-2.	

Traffic calming

The layout is well suited to road use	1.00
The layout is highly inappropriate for road use	1.23

Number of studies = 11. Confidence = 2.

Ped/cyclist issues

Cycling issues

	Off-road Facility	On-road cycle lane	Wide curb side lane	No facility
No cyclists	1.000	1.000	1.000	1.000
Low	1.000	1.004	1.005	1.006
Low but regular	1.000	1.009	1.009	1.011
Medium regular	1.000	1.014	1.014	1.017
High regular	1.000	1.018	1.018	1.022
Very high	1.000	1.023	1.023	1.028

Number of studies = 8. Confidence = 1

Pedestrian issues

Provision of pedestrian overpass	1.0
No pedestrian overpass	1.1
Provision of pedestrian signals	1.00
No pedestrian signals	1.54
Provision of correct traffic signal interval timing	1.00
Traffic signal interval timing incorrect	1.04
Provision of school pedestrian crossing	1.00
No school pedestrian crossing	1.27
Provision of pedestrian refuge	1.00
No pedestrian refuge	1.04
Provision of concrete median to replace zebra crossing	1.00
No replacement of zebra crossing	2.00
Provision of concrete median	1.00
No concrete median	1.06
Provision of pedestrian fencing	1.00
No pedestrian fencing	1.30
Provision of wombat crossing	1.00
No wombat crossing	1.01
Provision of roundabout	1.00
No roundabout	1.08
Provision of pedestrian lighting	1.00
No pedestrian lighting	1.06
Provision of traffic calming	1.00
No traffic calming	1.01
Provision of barnes dance to replace standard signals	1.00
Standard signals	1.04

Number of studies = 23. Confidence = 2 (except for concrete median to replace zebra crossing, barnes walk 3; concrete median, roundabout, pedestrian lighting 1)