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Methodologies used for economic appraisals of road safety educational or informational campaign programs in NSW

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Abstract

Transport for NSW (TfNSW) runs an annual road safety campaign program to reduce road fatalities and injuries. The NSW Government requires an economic appraisal for any public informational campaign with a cost of $1m or above. The main challenge facing the economic appraisal of road safety campaign is to establish the theoretical and empirical relationships between the campaign and road crash reduction to quantify economic benefit. In practice, such relationships are difficult to establish as the road safety outcome can be linked to many factors including road engineering measures, police enforcement, safer vehicle standards and driver behaviours. Existing literature provides abundant references on how road engineering measures affect road safety outcomes but the research on the effect of educational campaign is scarce.

From 2012 to 2016, TfNSW has undertaken the economic appraisal of 39 individual campaigns covering speeding, speed camera, drink driving, drug driving, driver fatigue, seat belt, children restraint, school zones, mobile phone distraction whilst driving, bicycle safety, bus safety, motorcycle safety, driveway safety and driver courtesy. Dependent on data availability, approaches including partially controlled before and after analysis, the Total Audience Rating Point (TARP) and meta-analysis have been used. We have also developed some theoretical rules for the attribution of crash reductions to road safety educational campaign in the presence of other factors such as police enforcement and road engineering measures. This paper summarises the models describing the relationships between educational campaign and driver behavioural change; the initial campaign effect and subsequent decay profile and ultimately campaign's impact on road safety outcome. The paper aims to contribute to transport research by outlining practical methodologies to estimate the economic benefits of road safety campaigns.

1. Introduction

Each year in NSW, road crashes cause over 300 fatalities, 20,000 injuries and significant property damage. To reduce road casualties, road safety measures have been implemented by providing safer roads through road engineering, safer vehicle standards, educational campaigns and police enforcement. TfNSW runs an annual road safety campaign program (described in Appendix 1) covering driver behavioural issues of drink-driving, speeding, fatigue, drug-driving etc.

An economic appraisal is required for any public educational campaign with a budget of $1m or more. The key challenge of the economic appraisals is to establish the causal relationship of the campaign, driver behaviour change and better road safety outcome. This is particular difficult as the road safety improvement is likely to be attributable to a range of factors including road engineering measures, safer car standards, police enforcement and educational campaigns. This paper focuses on road safety educational campaigns, their effects on driver behaviour changes, road crash reduction and economic benefits of road safety campaigns.

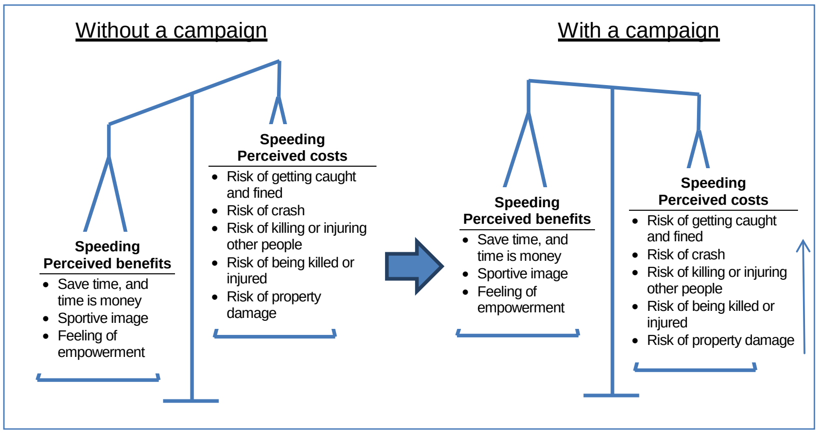
2. Advertising campaign and driver behaviour changes

A media plan is prepared before an economic appraisal is conducted. The media plan covers information on the campaign objectives, key messages, targeted audience, dates and duration of the campaign, recommended budget by month and media type. The most often used media include TV, cinema, radio, outdoor (bus backs, bus stop shelters, taxi backs), in-venue media (displays in hotels, clubs and university campus), digital (Youtube, Google, Facebook etc), Cultural and Linguistic Diversity (CALD) and Indigenous channels. The media plan is usually designed by a marketing expert guided by marketing theories and tracking surveys of previous campaigns of drivers' recall and recognition of advertisement messages, testimonials and intended driving behaviours.

Road safety communication campaigns attempt to inform, persuade, or motivate people to change their beliefs and/or behaviour in order to improve road safety as a whole or in a specific, well-defined target group. An informational / educational campaign aims to change driver behaviour through persuasion and deterrence. For example, for drink-driving, the campaign attempts to persuade drivers that the drinking will lower their cognitive ability, lead to a higher likelihood of getting involved in a crash and a higher degree of severity. The campaign will also have deterrence effect by indicating drink drivers are highly likely to be caught by police, with severe penalty, loss of licence and a possibility of permanent disability or even being killed[1].

Behavioural intentions are based on a weighted set of beliefs about the consequences of behaving in a particular way. Figure 1 illustrates how a speeding campaign can change driver behaviour. Before the campaign, drivers perceive that the benefits of speeding outweigh the potential costs. The benefits could be derived from "saving time", "sportive image" or "feeling of empowered". Counteracting with the perceived benefits are factors such as the likelihood of "getting caught and fined" and "getting involved in crashes leading to car damage, injury or even being killed". The campaign mainly works on the perceived cost side by persuading and deterring drivers that risk of being caught is high, and closing information gap for drivers that the speeding means more accident and higher severity if an accident does happen. With the reinforced messages, drivers are expected to perceive higher costs that hopefully would overweigh the perceived benefits. It is expected that the intended behavioural change will lead to actual behavioural change.

Figure 1: How a speeding campaign can change driver behaviour?

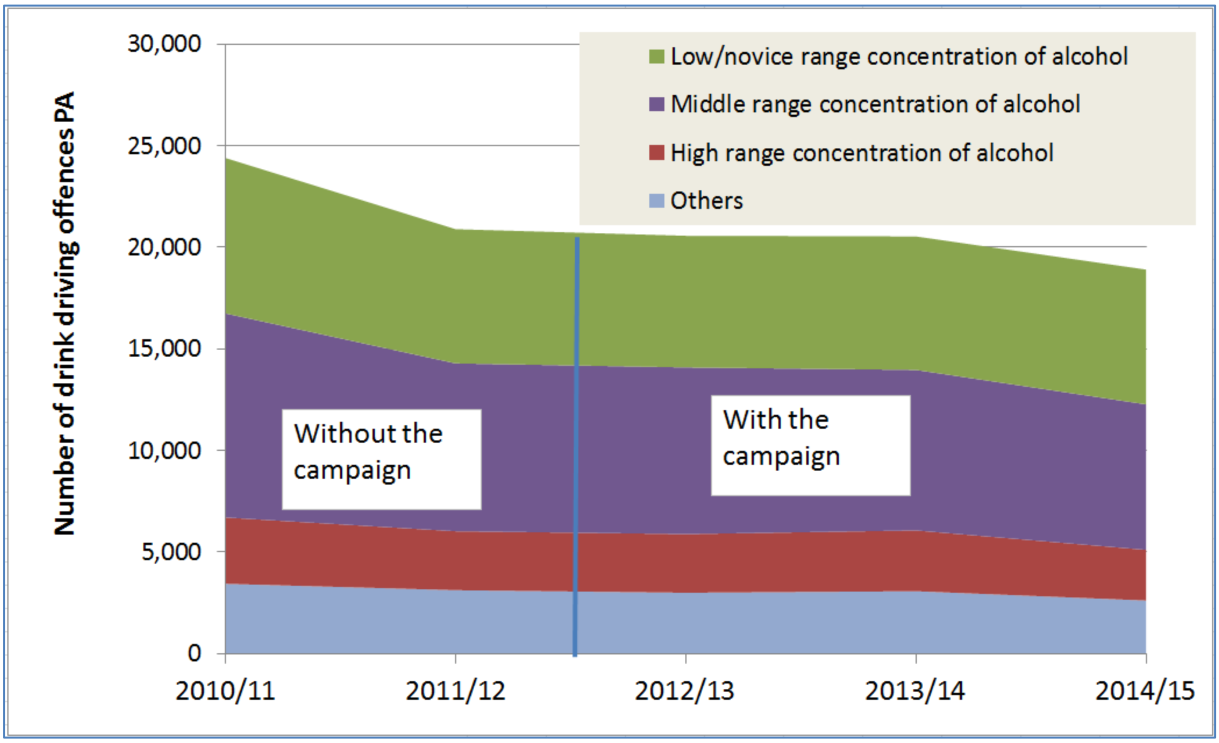


[1] The Government discourages drink-driving but did not discourage seeking a pleasurable activity such as a Friday afternoon drinking. One reviewer considers that the downside is that drink driving campaign may discourage people from undertaking a pleasurable activity. This has economic costs and wider economic loss to the hospitality trade. This is outside the transport appraisal framework i.e. only transport related costs and benefits are assessed.

3. Measuring the behaviour change

The hypothesis is that a road safety campaign would result in behavioural change. The available data for testing this hypothesis is driver offence / infringement statistics. Figure 2 gives time series data on drink driving offences over the five year period 2010/11 to 2014/15. There were drink-driving campaigns in 2012/13, 2013/14 and 2014/15 in NSW, but there were no campaigns in 2010/11 and 2011/12. Drink driving offences in NSW between 2010/11 to 2014/15 declined. It appears there were reductions in drink driving offences, indicating driver behavioural changes due to the campaign. However, the number of drink driving offences is also linked to Random Breath Tests (RBT). More RBT tests generally mean more offences caught. On the other hand, more tests give a clearer deterrence message that drink driving will be caught, which could result in fewer offences. Thus, it is difficult to specifically attribute the reduction in drink driving offences between the campaign and the RBT.

Figure 2: Number of drink driving offences in NSW by year by with and without campaign



Note: Others include supervising a driver under influence of alcohol / drug, supervising a driver with or above the low range concentration of alcohol, attempt to drive under the influence of alcohol / drug, attempt to drive with or above the low range concentration of alcohol, driver consumes alcohol while driving and wilfully alter the concentration of alcohol. Blood Alcohol Concentration (BAC) level (grams of alcohol per 100 millilitres of blood): High range = 0.15 or above; Mid-range = 0.08 – 0.15; Low range = 0.05 -0.08. Novice range = Over zero. Special range = 0.02 for special category drivers.

While drink-driving offences declined, speed offences increased. Over the 3 year period 2011/12 to 2014/15, police issued offences increased by 5% (1.7% per annum) as can be seen from Table 1. The increase appears to be broadly in line with traffic growth. By contrast, speed camera caught offences increased by 23% (7.7% per annum) which can be partially explained by an increase in red light speed cameras (increased by 55% over 3 years) and mobile speed camera operation hours (increased by 653% over 3 years), which were slightly offset by a 5% reduction of fixed speed cameras.

Table 1: Speed offences from 2010/11 to 2014/15

	2011/12	2012/13	2013/14	2014/15	% increase over 4 years (2011/12 - 2014/15)
Number of speed offences					
Speed offences: police issued	231,841	240,059	246,168	243,380	5%
Speed offences: speed camera	351,727	379,353	393,271	431,889	23%
Total speed offences	583,568	619,412	639,439	675,269	16%
Number of speed cameras / operation hours					
Fixed speed cameras	139	133	132	132	-5%
Red light speed cameras	106	106	144	164	55%
Mobile speed camera operation hours	11,160	11,160	11,160	84,000	653%
Point to point speed cameras	24	19	21	24	0%

Fitting the data to the regression model, it was found that:

$$\textit{Total speed offences} = 495{,}662 + 0.86 * \textit{No. of speed offences caught per camera} + 79.64 * \textit{Mobile speed camera operating hours} \quad (1)$$

However, it is worth noting that there were speeding campaigns over three years. Thus, we cannot draw a clear conclusion on the relationship between the speed campaign, speed camera and driver speeding behaviour. The offence data thus is not very helpful in identifying the campaign resulted behavioural changes. In seeking reliable data, analysts and practitioners advocate post completion reviews to collect data on how the campaign messages reached their targeted audience and planned versus actual behaviour change. Post completion reviews can be costly and unfortunately have rarely been undertaken.

4. Measuring fatality, injury and crash reductions

Section 3 indicates that the attitudinal and behavioural changes are difficult to measure. In many cases the enforcement data is only available information for investigating the behavioural changes. Even if a behavioural change is observed, it is still difficult to attribute them to a campaign, let alone to put a dollar value of it. Thus, more effort has been made for estimating the reductions of fatalities, injuries and crashes, and in doing that, various statistical techniques have been used.

4.1. Randomised control trial (RCT)

The Randomised Control Trial (RCT) has been used to analyse the crash reduction attributable to a campaign. The RCT is a statistical technique often used in medical experiments whereby eligible people are randomly allocated to one group that receives the ‘treatment’ and one group does not receiving the treatment (i.e., the control or placebo group). The effects of the treatment can then be scientifically measured by comparing the treatment group to the control group. A control group cannot typically be found for road safety campaigns. (An inter-state control group might be possible however the extraction of road crash data from different jurisdictions can be challenging). Thus, the estimated effects would require some adjustments for uncontrollable factors such as the size of campaign target group, campaign spending, changes of road safety engineering and vehicle safety standards over time. Two types of datasets, “with and without campaign” and “before and after campaign” have been used for estimating crash reductions.

4.1.1. With and without campaign

Road crash statistics during the campaign period and during a “controlled period” are collected and analysed. Usually, the controlled period is selected so that all other driving conditions are similar and the only difference is the presence of the campaign. Table 2 shows the summarised data on drink driving with and without campaigns. The drink driving campaign took place in 2012/13, 2013/14 and 2014/15, and the common campaign period was from 19 August to 2 February (137 days). During the common campaign period, road crashes where alcohol was one of contributing factors had resulted in 26 fatalities and 499 injuries on the average for three years.

For the same period from 2007/08 to 2011/12, road crashes that alcohol was one of contributing factors killed 39.4 persons and injured 613.4 persons on the average for five years. The casualty reduction is estimated at 33% for fatalities and 19% for injuries.

Table 2: Fatality data with and without drink driving campaigns

Without the campaign					
Year and “without campaign” comparison period	2007/08	2008/09	2009/10	2010/11	2011/12
	19 Aug - 2 Feb				
Fatality	39	47	48	32	31
Injury	692	673	618	572	512
Total casualty	731	720	666	604	543
With the campaign					
Year and “with campaign” period	2012/13	2013/14	2014/15		
	19 Aug - 2 Feb				
Fatality	35	20	24		
Injury	534	542	421		
Total casualty	569	562	445		
Casualty reduction					
	Without campaign, 5 year average	With campaign, 3 year average	Reduction	Estimated reduction rate	
Fatality	39	26	13	33%	
Injury	613	499	114	19%	
Total casualty	653	525	128	20%	

Source: Crashlink data base, NSW

One may be tempted to claim that these reductions were due to the drink driving campaign, but this was hardly the case. Other road safety initiatives including road safety blackspot program and road safety audit program probably played a role. Road conditions may have improved that provide a greater allowance for human driving errors. Vehicle safety also improved with air bags that reduce the likelihood of fatality or serious injury. On the other hand, as population and subsequent travel increases, there would be a natural crash increase, assuming drink driving behaviour remains unchanged. However, in a three-year period, road condition improvement and population growth would unlikely make significant contribution to the road fatality reduction. In addition, road fatalities are random thus accident rates may simply vary from year to year.

Thus, the calculated casualty reduction is entangled with other factors – better roads, safer vehicle, possible increase or decrease of police enforcement between years, natural travel increase and variation of weather conditions between years. While these factors are likely observable, authorities rarely keep detailed records, meaning that it is difficult to build all these factors into a model. Section 6 discusses methods of allocating the total crash reduction to influencing factors.

4.1.2. Before and after data

Road casualty reduction is also estimated from observed data immediately before the campaign, during the campaign and immediately after the campaign. The before campaign period is selected in a way that potential influencing factors can be controlled. The controlled before and after the campaign periods are specified so that the only difference between the two periods is the campaign itself. Certain factors, for example, additional police enforcement or presence of other related educational campaigns can be controlled, by removing these and any halo effect days from the before (or after) campaign observation period. Other factors which can affect the likelihood of crash occurrence, for example, traffic variability and weather condition, are more difficult to control as it is difficult to attribute a crash to these factors. A fully randomised controlled trial is therefore almost impossible for a road safety campaign.

Table 3 presents an example to demonstrate how crash reduction is forecast for a proposed 3 month driver fatigue campaign. Similar campaigns have been undertaken for past 5 years, with the observed fatality and injury before and after the campaign. The before and after campaign periods are selected to control other influencing elements as much as possible. Thus, days selected for each campaign are different. Standardised casualty reductions for 3 month period are 1.08 fatalities and 39.47 injuries. This is considered as fully controlled data thus can be used to forecast the casualty reduction for a proposed new campaign of similar target group and media intensity.

Table 3: Observed fatigue related casualty reduction before and during driver fatigue campaign in 5 year campaigns

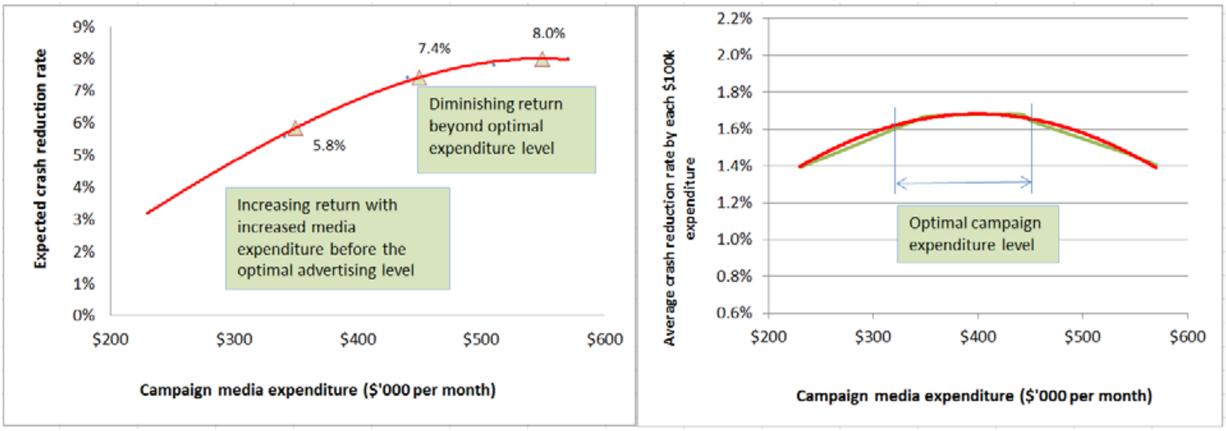
	Fatalities per Day			Injuries per Day			Total Casualties			Observation Days	
Period	Before	After	Change	Before	After	Change	Before	After	Change	Before	After
2010/11	0.20	0.11	-0.09	5.4	4.8	-0.66	5.6	4.9	-0.75	70	91
2011/12	0.23	0.23	0.00	6.0	5.6	-0.41	6.2	5.8	-0.42	56	70
2012/13	0.14	0.17	0.02	4.8	5.1	0.29	4.9	5.2	0.32	91	133
2013/14	0.09	0.13	0.04	5.8	4.9	-0.87	5.9	5.0	-0.83	65	115
2014/15	0.14	0.12	-0.02	4.8	4.2	-0.64	4.9	4.3	-0.66	51	94
Total	0.16	0.15	-0.01	5.3	4.9	-0.44	5.5	5.0	-0.45	333	503
Expected reduction in 90 days			-1.08			-39.47			-40.56		

Source: Road crash data extracted from NSW Crashlink database

4.1.3. Expenditure and diminishing return adjustment

The estimated crash reduction is subject to adjustment for the cost of the media campaign. As an example, the budget for three campaigns is shown in Figure 3. Based on this, it is possible to forecast the likely effectiveness of a proposed campaign for a particular budget. The relevant economic concept is “diminishing returns”. Figure 3 plots the crash reduction rates with media expenditure. As can be seen, returns first increase then peak at the optimal investment level. After the optimal level, the marginal returns decrease with increased media expenditure. For this particular type of the campaign, the optimal level of campaign is estimated between $350k and $450k per month, at which the expected crash reduction is between 1.5% and 1.6% per $100k expenditure. If there are sufficient observations based on past campaigns, such a curve can be drawn that can be used for adjusting the potential reduction estimated from “with and without data” or “before and after data”.

Figure 3: Diminishing return adjustment



Data source: Estimated crash reduction rate from motorcycle risk management campaigns in NSW

4.2. Total Audience Rating Point (TARP) model

Neither “with and without data” nor “before and after data” would be available in the following situations:

- A new campaign. For example, if a pedestrian safety campaign is planned for the first time in a jurisdiction, no controlled data would be available.
- A repeated campaign but a suitable controlled period cannot be identified due to a co-existing campaign, police operations or other reasons which means it is not possible to identify a controlled period.

For these situations, techniques of the Total Audience Rating Point (TARP) and meta-analysis have been used for estimating casualty / crash reductions. The TARP model is based on an equation established by Monash University Accident Research Centre (Cameron & Newstead, 1996) which describes the relationship between media campaign expenditure and expected crash reduction:

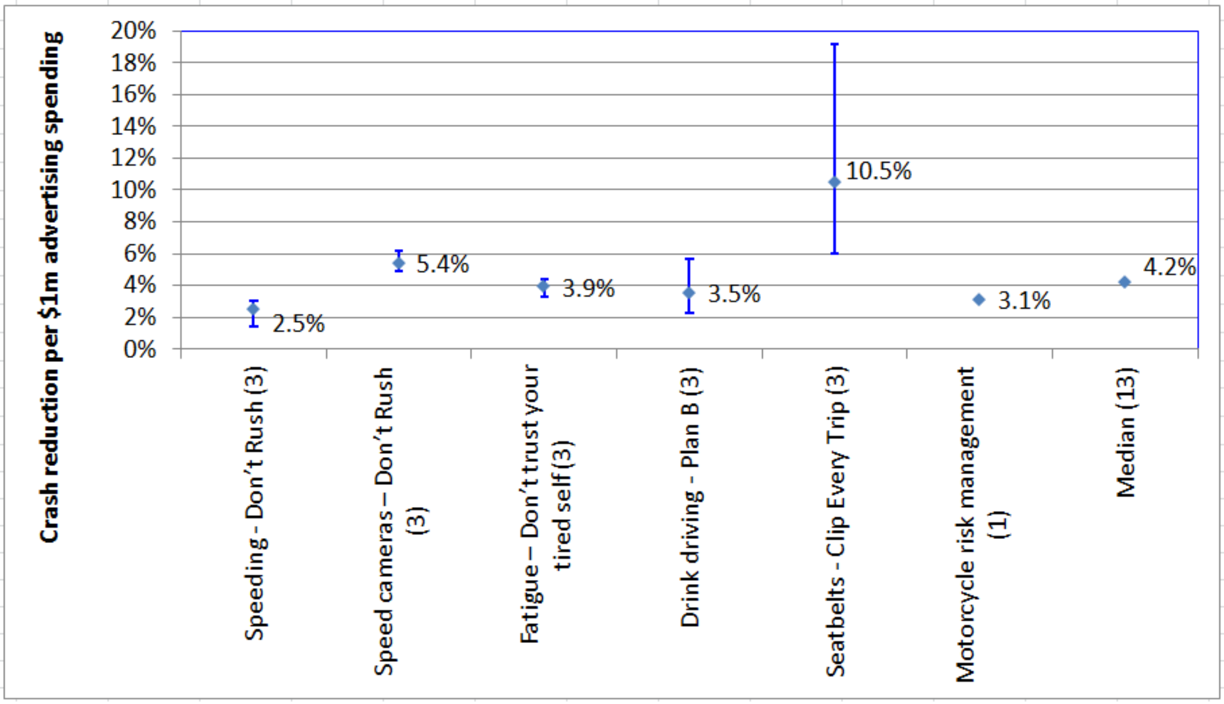
$$Casualty\ Crashes\ with\ Advertising\ Campaign = Existing\ Casualty\ Crashes \times TARP^{-0.0077} \quad (2)$$

In equation (2), existing casualty crashes can be obtained from road crash statistics. The exponential power (-0.0077) is the factor (calculated by regression) used to measure the effects of advertising campaigns. TARPs can be calculated if an advertising campaign budget is known. In December 2002, one unit of TARP could be achieved by a campaign expenditure of $493, which would be equivalent to $891 in June 2016 by using Australian CPI escalation. For a worked example, supposing vehicle and pedestrian crashes cause 2,000 injuries per annum, and a campaign with a budget of $1m is proposed. The proposed budget can purchase 1,122 units of TARP. Using the above equation, it is estimated that 105 injuries can be avoided due to the campaign (a 5% reduction). The advantage of TARP models is that they require less input data. However, the parameter is now quite old and should ideally be re-estimated.

4.3. Meta-Analysis

A literature review was undertaken to identify the estimated crash reduction of similar campaigns in other jurisdictions. The estimated rates were then applied to NSW data, with adjustments made according to factors such as campaign budget, size of target audience and total vehicle kilometres travelled. If there are no similar campaigns identified in other jurisdictions, a median crash reduction rate per million dollars of campaign expense based on previous campaigns was used and applied to the new campaign. Figure 4 shows, based on 13 campaigns, each million dollars spending produced a crash reduction of 4.2%.

Figure 4: Meta-analysis on crash reduction per $1m advertising spending



Note: Number in bracket indicates number of studies. Ranges in the chart shows the maximum and minimum reduction observed

5. Advertising effect and decay

Literature indicates that there are four phases of awareness and decay associated with informational and educational campaigns, shown in Figure 5.

1. **Ramp up:** The maximal awareness is reached in the first week. There is a trigger threshold of exposure to the advertising before most people are fully aware of the message. To achieve the trigger threshold, there is usually a high intensity in advertising at the outset of the campaign.

2. **Maximal awareness**

   (a) Maximal awareness is maintained during the campaign. NSW road safety campaign runs from 1 week to whole year, 52 weeks. For 14 campaigns running for 2016/17, the average campaign period is 27 weeks.

   (b) Halo effect means that the maximal awareness is maintained for some time after the campaign is stopped. It was found that following six days of enforcement, the duration of the time-halo for radar and marked police car was of the order of ten days (Cameron et al. 2003, p.2). This effect is confirmed by tracking surveys undertaken post campaigns (speeding, speed camera, drink driving, fatigue and mobile phone distraction). It was found that drivers' recognition of the campaign is maintained at the

96% level after the campaign was completed. Besides the time-halo, there is also distance-halo. Stationary enforcement, such as a visible marked police car, has a direct and local effect on traffic speed. This effect has been found to exist for a few kilometres around the enforcement site. Many speeding drivers reduced their speed two kilometres before reaching the enforcement site, and for four to six kilometres past the enforcement site. The typical halo effect is assumed to last two weeks for economic appraisal purposes.

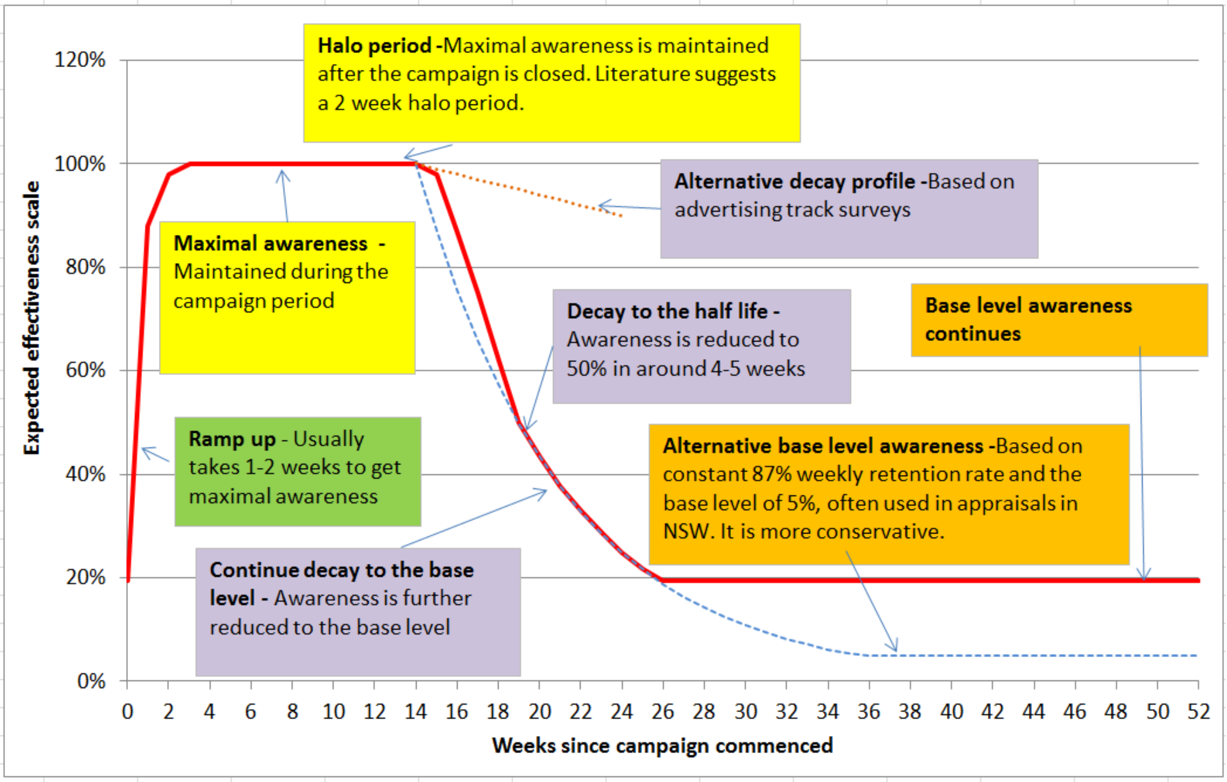
3. **Decays**

   (a) **Decay to half-life**: The awareness is reduced to 50% of the maximum and which is referred to as 'decay to the half-life'. A number of studies found that a half-life of 5 weeks is common (Broadbent 1979; Broadbent 1990, Cameron et al. 1993).

   (b) **Decay to the base level:** The base level is the lower limit of the campaign effect after the advertisement ceases. The base level estimated for Melbourne and rural Victoria ranges from 0% to 31.2%, with a mean of 19.79% and median of 19.5% (Delaney 2004, p. 47)[2]

4. **Continue on the base level**: The base level effect is assumed to continue till the next campaign resumes.

Figure 5: Advertisement awareness model



Two alternative decay profiles are shown in Figure 5. The first alternative is a decay profile based on tracking survey after the campaigns. The likely decay rates have been analysed using campaign tracking surveys on 5 campaigns (Don't Rush, Speed Cameras, Plan B, Don't Trust Your Tired Self and Mobile Distraction) undertaken in 2014/15. Table 4 shows the rates of driver recognition of the campaigns in the campaign month, the following month and the next month. The estimated monthly retention rate is 95% or a decay factor of just 5%. This high retention rate means that the campaign effect lasts much longer which leads to more

[2] In comparison, TfNSW uses a base level of 5% which is very conservative.

crash reduction. If used in economic appraisal, it tends to assign more crash reduction benefit compared to sharper decay rates (i.e. red and dotted blue lines in Figure 5).

Table 4: Driver recall/recognition of the 2014/15 campaigns: tracking survey result

Campaign	Campaign month end	% of drivers recognised the campaign in the sample			Weight by media spend
		Campaign month	Campaign month +1	Campaign month +2	
Don't Rush	Jul-14	72	72	72	27%
Speed Cameras	Nov-14	56	57	51	19%
Plan B	Sep-14	47	44	40	24%
Don't Trust Your Tired Self	Sep-14	64	58	54	18%
Mobile distraction	Sep-14	43	37	32	12%
Average weighted with media spend		58	56	52	100%
Estimated retention rate		**100%**	**95%**	**90%**	
Estimated decay rate			**5%**	**10%**	

Note: The tracking survey results are available for 3 months only.

The second alternative is a faster decay rate based on a constant weekly retention rate of 87% as estimated by Cameron and Newstead (1996). It represents the proportion of the target audience retaining awareness of the message in the next period, and then the same proportion of them in the next period, and so on. The faster decay means that the advertising effect lasts a shorter period which will generate a lower benefit.

6. Attributing factors

Crash reduction estimated from "with and without data", "before and after data" or TARP can be confounded with other factors notably police enforcement, road engineering and vehicle safety. Three methods have been used to untangle these effects.

6.1. Campaign and police enforcement

Delaney et al. (2004, p. 47) have developed a regression model from Victoria road safety campaign and enforcement data (Equation 2), where the awareness is a function of base level and the estimated 'Adstock value' for emotive campaign and enforcement activities. Adstock, the abbreviation of advertisement stock coined by Broadbent (1979), describes the prolonged and lagged effect of advertising on consumer purchase behaviour. It represents a certain level of publicity, which can be achieved by mass media campaign or police enforcement. To achieve one unit of Adstock, certain investment is needed. The budget for mass media campaigns include media cost, fixed costs for advertisement concept research, production and development and a mark-up factor to reflect the costs of supporting publicity. The cost to achieve 100 units of Adstock was estimated at $6,300 in December 1992 dollars (Cameron et al., 1993, p. 26), or equivalent to $11,384 in June 2016 dollars. The awareness is then estimated in Equation (2) and the coefficients presented in Table 5.

$$Awareness = \alpha + \beta 1 * (Adstock\ for\ Campaign / 100) + \beta 2 * (Adstock\ for\ Enforcement / 100) \quad (2)$$

Table 5: Regression model to allocate the effects of the campaign and enforcement

Theme	Region	Regression coefficients		
		Base level (α)	Campaign (β1)	Enforcement (β2)
Drink driving	Melbourne	26.5	4.26	3.99
	Rural	31.2	3.78	3.23
Speeding	Melbourne	26.7	4.26	2.93
	Rural	22.2	4.10	4.62
Average		**26.7**	**4.10**	**3.69**

Source: Adapted from Delaney et al. 2004

If a road safety program has a budget of $1m each for the media campaign and the enforcement, it can achieve a total of 17,560 units of Adstock, 8,780 units each for the campaign and the enforcement. Based on the regression model (2), the awareness will increase by 710 units, and among it, 51% attributable to the campaign, 45% to the enforcement and remaining 4% to other unobservable factors.

6.2. Road safety programs with key factors of enforcement, campaign and road engineering

Road crash reduction is a result of all road safety programs including police enforcement, publicity campaign and road engineering. Newstead et al. (1998) modelled Victoria's serious casualty crashes from 1990 to 1998, estimated the crash reductions and attributed modelled reductions to the following main factors:

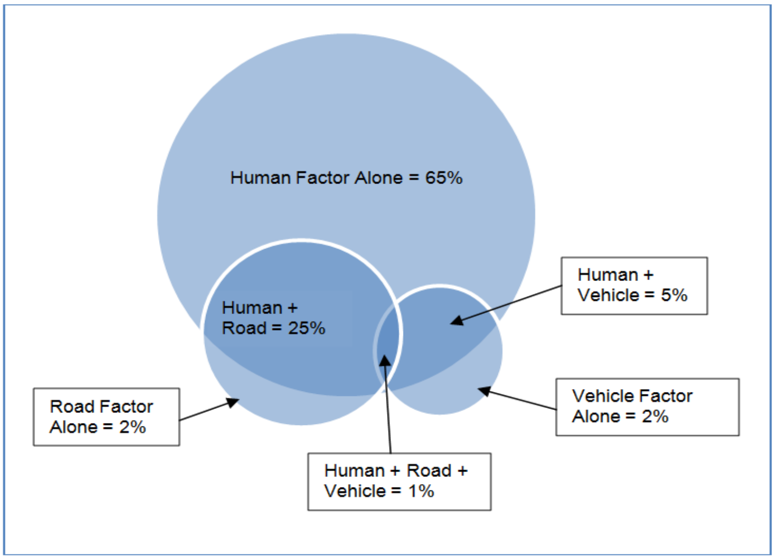
- **Speed camera operations**: Principally due to Traffic Infringement Notices (TINs), the serious casualties reduced by 10% - 11% each year.
- **Speed and concentration campaigns**: Reduced casualty crashes by 5% to 7% a year.
- **Random Breath Test (RBT) and drink driving campaign**: Reduced the casualty crashes by 9% to 10% a year.
- **Accident black spot treatment**: Reduced casualty crashes by 2% to 6% a year.
- **Economic activities**: There was economic downturn in Victoria in the period and the increased unemployment rate. It was estimated that the reduced economic activities contributed to a reduction in serious casualties by 3% to 16% a year.
- **Reduced alcohol sales**: Alcohol sales almost halved from 1984 to 1996 in Victoria (Newstead et al. 1998, p. 9), which contributed to a reduction in serious casualties by 3% to 10% a year.

Excluding the effects of the downturn trend in economic activities and alcohol sales observed for the modelled period, the serious casualty crash reductions can be broadly attributed to three main factors: police enforcement (33%), campaigns (36%) and road engineering (31%) (see Appendix 2 for details). It is worth noting that the proportions are based on road safety programs in Victoria from 1990 to 1996. The components of road safety programs in other jurisdictions and other time periods could be very different thus the attribution should be treated with caution.

6.3. Use the road crash contributors

Contributing factors to road crashes can be broadly categorised into 3 factors: human, road and vehicle. A road crash may be a result of one or more of these three factors as shown in the Venn Chart in Figure 6. Systematically, Haddon (1980) developed a matrix of events that considered driver, road and vehicle and how each of these contributed to a crash with respect to three ‘time phases’ defined as pre-crash, in-crash and post-crash. Measures for the pre-crash phase focus on reducing the frequency of crash occurrence while those for the in-crash and post-crash phases put most effort in alleviating the severity of injury either through driver/passenger protection or well-being of crash victims. Road users, the road, vehicle and their interactions are contributors to road crashes. The causes of road accidents drawn from the “Handbook of Road Technology” by Lay (1990) and Lay (2009) are given as percentages in Figure 6.

Figure 6: Causes of road accidents



Source: Based on Lay (1990) and Lay (2009) Handbook of Road Technology

Road crash reductions depend on investments in engineering measures (to make roads safer), vehicle fleet improvements and driver behaviour changes which can be attributed to campaigns and enforcement. Driver behaviour is the most important factor accounting for 65% as a sole factor in road crashes and for 96% of accidents in combination with other factors. It is also important to recognise that reductions in crashes can be attributed to improvements in road engineering (e.g. Black Spot program, installation of median guardrail, traffic calming measures) as well as vehicle technology (e.g. speed limiter, air bag and anti-lock brake). Vehicle improvements may make a bigger impact on crash statistics than previously due to prevalence of equipment such as ABS brakes, reversing cameras in the fleet relative to 20 years ago. Broadly, road crashes can be attributed to human factors (80%), road engineering (15%) and vehicle (5%) using the above model.

6.4. Crash reduction attribution factors

The selection of a particular allocation method will depend on data. If the reduction is caused by enforcement and campaign only, probably the most accurate method is to proportion the effect by the equivalent Adstock (or the estimated cost for enforcement and campaign components). If the equivalent Adstock cannot be estimated, 50% each could be used. The second method is based on all road safety programs in a jurisdiction over a longer time period. Effect of road engineering tends to be permanent but those from enforcement and campaign are more likely to be short-lived. If a long term (3-5 years) historical time series crash data is used, it is likely that the estimated crash reduction is jointly affected by road engineering, enforcement, campaign and vehicle safety standards. The reduction can be broadly allocated to enforcement, campaign and road engineering, one third each. If we look at the crash contribution factors, human factor accounts for 80% of crashes, while road and vehicle account for 15% and 5% respectively. Crash contribution factor method is suitable for a short period (1-3 years) with and without data. If the before and after data (with a time span less than 1 year) is used, it is considered that road engineering and vehicle safety standard is controlled (i.e. there is no significant change over one-year period). The attribution factor adjustment is unnecessary.

Table 6: Main attributable factors for road crash reductions

	Campaign only	Campaign and enforcement only	Crash contribution factors	All road safety programs
Enforcement		Proportion of Adstock for enforcement	80%	33%
Campaign	100%	Proportion of Adstock for enforcement		36%
Road engineering and vehicle safety			20%	31%
Total	100%	100%	100%	100%
Applicability	Before and after data with 1 year period in that road engineering and vehicle safety feature are assumed remain unchanged	Before and after data with 1 year period, both campaign and police enforcement was in place	With and without data in a mid-term (1-3 year) that the crash reduction is caused by enforcement, campaign and road engineering	With and without data in a long-term (4+ year) that the crash reduction is caused by enforcement, campaign and road engineering

7. Convert the crash reduction to economic benefit

The fatality and injury reduction forms the main benefits of road safety advertisement campaign. Fatality and injury cost values were estimated based on the Willingness-To-Pay (WTP) approach. The estimated values are presented in Table 7. The WTP approach assesses the risks of a fatality, serious injury and minor injury and the amount that the community is willing to pay to avoid those risks.

Table 7: Economic parameters for estimating reduction benefits ($2016)

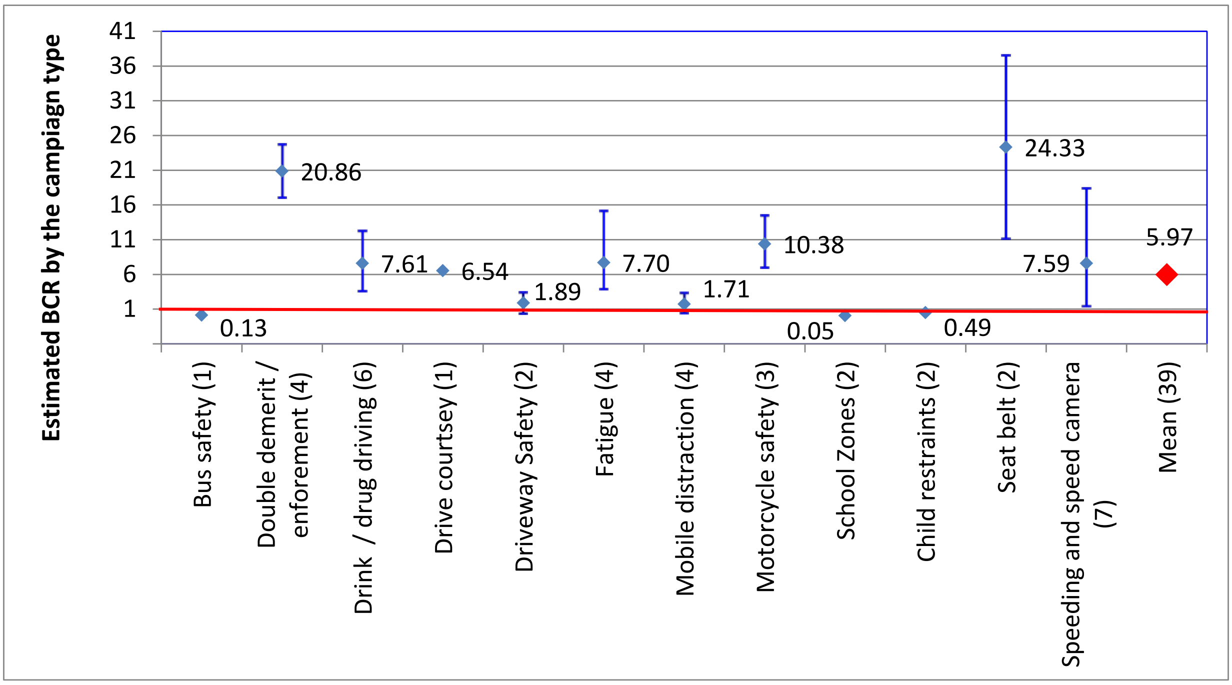
Crash type	WTP Values ($/crash
Fatality	$7,272,032
Serious injury (injury requiring hospitalisation)	$466,010
Moderate and minor injury	$72,804
Property damage only	$9,743

Source: Transport for NSW Economic Appraisal Guidelines, 2016 update

The second benefit of the campaign is the improved traffic flow. As the number of road crashes in road network is reduced, the traffic flow improves. Travel time savings from the reduced traffic delay can be estimated from traffic volume, road capacity, presence of a diverting route and crash type. Overall, road safety campaigns generates economic benefits mainly from reduced fatal crashes (65%), injury and property damage crashes (33%) and traffic flow improvement (2%). The traffic improvement benefit is minor.

The estimated Benefit Cost Ratio (BCR) extracted from 39 campaign appraisals is presented in Figure 7. The mean BCR is 5.97, indicating general good economic return for road safety campaigns. Some campaigns (school zones, bus safety and child restraints) may have a BCR less than 1. Decision on these campaigns is more about the community perception (absolute safety for children). The range of BCR for some campaigns (e.g., seat belt) is wide indicating a large variation of serious casualty reduction between different campaign years.

Figure 7: BCRs of road safety campaigns



Note: Number in bracket indicates number of studies. Ranges in the chart shows the maximal and minimal reduction observed

8. Concluding remarks

Road safety campaign attempts to change road users' behaviour by persuasion and deterrence. It informs users that certain behaviours involve a higher risk of road crash, injury and fatality. Illegal behaviour would be caught by police and the penalty is heavy. In most cases, offence or infringement data represents the only available source for measuring behavioural changes. However, the number of offences tends to be correlated with police enforcement (e.g. road site RBT) and physical infrastructure (e.g. number of speed cameras) and it is often difficult to separate the effects from various factors.

Economic appraisal of road safety campaign requires estimating the casualty or crash reductions purely attributable to the campaign itself. Partially controlled "with and without campaign" data or "before and after campaign" data have been used to estimate the reduction. Both datasets tend to overstate the effect of the campaign due to the presence of confounding effects of road safety engineering, vehicle safety standards and police enforcement. Adstock based regressions, allocation of the effect to all road safety programs and contributing factor adjustment have been used for singling out the pure effect of the campaign.

The impact of a campaign decays over time. The advertisement awareness model has been used to represent the ramp-up, maximal awareness, halo period, decay to the half-life and decay to the base level. Studies found a half-life decay of 4-5 weeks representing a weekly retention rate of 87% or a decay rate of 13%. The base level effect is around 19.5% of maximal effect.

The selection of an appropriate method for an individual campaign is dependent on data availability and quality and the nature of the campaign. Ideally, a controlled before and after analysis should be selected, as it gives the most accurate measure of the campaign effect.

This study and associated economic appraisals highlight the further research areas for evaluating road safety educational campaigns. Firstly, the existing evaluation techniques tend to measure the "behavioural change intention". For instance, for a speeding campaign, drivers are surveyed before the campaign with a question: "*Thinking about when you are driving on public roads in the previous 4 weeks, how often have you driven up to 10km/h more than the speed limit?*" After the campaign, drivers are surveyed with a similar question: "*Thinking about when you are driving on public roads in the next 4 weeks, how often will you drive up to 10km/h more than the speed limit*?" The behavioural intentions can be estimated from the responses before and after campaigns. It is generally believed that the behavioural intention correlates to the actual behavioural change but there is lack of research on the extent of the correlation. Secondly, an important research area is to value the behavioural change. To put a dollar value for the campaign benefit, the current framework has to estimate the reduction in fatality and injury due to the campaign. These are no direct methods of putting a dollar cost on an unsafe or unlawful behaviour such as holding a mobile while driving, driving after a drink or speeding. Finally, often the economic appraisal has to rely on outdated models such as TARP which was estimated in 1996. It would be useful for updating these models.

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Appendix 1: Road safety informational / educational campaigns

Campaign	Theme	Key message
Plan B	Drink Driving	If you are drinking, don't drive. You need an alternative option (Plan B) to get home.
Double Demerits	Enforcement	Reminds drivers and riders that during double demerit periods the consequences for breaking the road rules are more severe which encourage safer driving behaviour.
You're In Our Sights	Enforcement	Support police operations targeting speeding, drink driving and non-use of seatbelts.
Don't Trust Your Tired Self	Fatigue	The campaign highlights the consequences of driver fatigue, and encourages drivers to assess how tired they are and manage their fatigue both before they drive as well as during driving.
Ride To Live	Motorcycle risk management	Encourage motorcyclists to make good decisions by highlighting the risks motorcyclists face on the road and ways to manage it. It also focuses on car drivers to look out for motorcyclists.
They're Counting On You	Restraints	Encourages the correct use of child car seats / child restraints and awareness that some child car seats are not fitted correctly.
Clip Every Trip	Restraints	To reinforce and remind all drivers and passengers in rural areas to use seatbelts at all times no matter the duration of trip or how well they know local roads.
Don't Rush - Speeding	Speed	Reduce the speed related road trauma by highlighting the consequences of speeding and to motivate drivers to change their behaviour towards speeding.
Don't Rush - Speed Cameras	Speed	Campaign highlights the impact of speeding on the community and the benefits of speed cameras in reducing speed related road trauma.
School Zones	Speed	Reminds drivers and riders when school zone times apply, highlighting the need to stick to the speed limit and reduce speeding in school zones.
Get Your Hand Off It	Mobile Distraction	Highlights the road safety risks of holding and using a mobile, and that there is no excuse for this behaviour.
Driveway Safety	Driveway risk management	Raise awareness about the need for safety in residential driveways and educate parents and carers about preventative measures that can be routinely undertaken.
Drug Driving	Drug Driving	Deter illicit drug users from driving after taking drugs by changing perceptions of the likelihood of being caught by Police.
Bus Safety	Bus safety risk management	Raise awareness of bus safety regarding interactions between buses and other groups such as motorists, cyclists, bus passengers and pedestrians.

Source: Centre for Road Safety website, http://roadsafety.transport.nsw.gov.au/clampaigns/index.html

Appendix 2: Estimated reductions in serious casualty crashes attributable to major factors from Victoria road safety programs 1990-1996

	1990	1991	1992	1993	1994	1995	1996	% Contribution
Actual serious casualty crashes	6,219	5,371	5,111	5,192	5,184	5,286	5,196	
Expected serious casualty crashes	8,371	8,585	8,770	9,099	9,345	9,480	9,572	
Reduction in serious casualty crashes	25.7%	37.4%	41.7%	42.9%	44.5%	44.2%	45.7%	
Reduction attributable to economic activities and alcohol sales	0.6%	7.6%	10.8%	9.9%	11.0%	10.5%	12.5%	
Reduction attributable to road safety programs	25.1%	29.8%	30.9%	33.0%	33.5%	33.7%	33.2%	
Contribution breakdown for road safety programs								
Traffic Infringement Notices (TINs)	9.6%	10.9%	11.1%	11.1%	11.2%	11.0%	11.2%	
Campaign: Speed and concentration	5.0%	7.0%	7.1%	6.7%	6.1%	6.5%	6.2%	
Random Breath Test (RBT) and drink driving campaign	8.9%	9.4%	9.5%	9.9%	10.0%	10.0%	10.2%	
Road engineering: Blackspot program	1.6%	2.5%	3.2%	5.3%	6.2%	6.2%	5.6%	
Main components *								
Police	9.3%	10.2%	10.3%	10.5%	10.6%	10.5%	10.7%	33%
Campaign	9.5%	11.7%	11.9%	11.7%	11.1%	11.5%	11.3%	36%
Road engineering	6.4%	8.0%	8.8%	10.9%	11.8%	11.7%	11.2%	31%

Source: Adapted from Newstead et al. (1998, p.17). * TINs are allocated to enforcement (50%) and road engineering (50%). RBT is also allocated by the 50% split.