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MUARC'S SPEED ENFORCEMENT RESEARCH: PRINCIPLES LEARNT AND IMPLICATIONS FOR PRACTICE

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Abstract:

The effectiveness of speed enforcement programs in Victoria has been the subject of a significant volume of research conducted by the Monash University Accident Research Centre (MUARC). This report provides a coherent review of MUARC's speed enforcement research to date and highlights the enforcement principles established by the research. The report also examines the practical implications of the research for future enforcement operations.

The MUARC research reviewed in this report includes evaluations of the effectiveness of a range of enforcement technologies including mobile speed cameras, hand-held laser speed detection devices, mobile radar speed detectors and fixed speed cameras. The effectiveness of these technologies has been evaluated in terms of both the effect on casualty crash frequency and severity and in some instances the effect on driver behaviour. Principles and implications arising from this research relating to the timing, intensity and location of enforcement operations are provided where appropriate. In addition, the role of mass media publicity and driver perceptions of enforcement activities are examined in the context of future enforcement operations.

Key Words:
Enforcement, Speed

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Preface

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EXECUTIVE SUMMARY

The effectiveness of speed enforcement programs in Victoria has been the subject of a significant volume of research conducted by the Monash University Accident Research Centre (MUARC). This research has evaluated specific speed enforcement programs in terms of their effect on casualty crashes and in some instances their effect on driver behaviour. The role of mass media publicity supporting the speed enforcement operations has often figured in this research. More general research has also been conducted that examines driver perceptions of enforcement activities and the reported behaviour of specific groups of drivers.

This report provides a coherent review of speed enforcement research conducted by MUARC to date and practical measures that can be used in planning future enforcement operations.

GENERAL PRINCIPLES FOR SPEED ENFORCEMENT

All types of speed enforcement examined by MUARC have led to at least some positive impact on either casualty crash frequency, crash severity or driver behaviour. In most cases this effect has been significant. However, the effectiveness of the enforcement program may depend on the appropriateness of the speed enforcement device or scheduling method for the road type on which the program operates. The research suggests that the following conclusions are relevant in this context:

- Speed cameras are effective in reducing casualty crash frequency on arterial roads in metropolitan Melbourne and country towns and on highways in rural areas. These devices are also effective in reducing crash severity in Melbourne.
- Mobile radar devices are effective in reducing casualty crashes in rural areas on undivided roads in 100 km/h speed zones. Analysis of the effects of the mobile radar devices in outer metropolitan areas was inconclusive.
- Hand-held laser speed detection devices are effective in reducing casualty crash frequency, but not severity, on arterial roads in metropolitan Melbourne.
- The Random Road Watch program, which involves the allocation of overt enforcement resources in a random way with respect to time and space, is effective in reducing crashes of all severity levels in non-metropolitan areas. The effect of the program in metropolitan areas is unclear.

It is noted that the use of laser devices was intended to alleviate problems associated with speed detection using hand-held radar devices on arterial roads. In addition, mobile radar devices were primarily intended for use on two-way, undivided, 100 km/h speed limit roads in rural areas where it is difficult to use speed cameras covertly. It is therefore evident that speed detection devices work best when used on the road type for which they were intended. This indicates the following principle:

Principle 1: The use of different types of speed enforcement devices should concentrate on the road type or geographical region for which their use is intended.

The second important general result relates to the duration of the impact of speed enforcement. The analysis of speed cameras and mobile radar devices has produced important results in this area.

It is important to note a number of key differences between these devices. First, the use of speed cameras in Victoria is largely covert and infringement notices issued as a result of speed camera operations are usually received one to two weeks after the offence occurs. In addition, speed cameras are able to detect large volumes of speeding motorists per enforcement hour. In contrast, an offender detected speeding by a mobile radar device is issued with an on-the-spot fine in a deliberately overt manner. Also, the volume of speeding motorists detected by mobile radar devices per enforcement hour is lower than that for speed cameras. Differences in the duration of the enforcement effects are also evident. Speed camera enforcement operations have been shown to impact on casualty crash frequency during the two weeks after the infringement notices are received. The exact duration of the effect is unclear. On the other hand, mobile radar enforcement was found to have the greatest effect during the four days immediately following the enforcement operations.

Differences in the duration of the enforcement effects are important issues to consider when planning future speed enforcement programs. However, it is unclear which of the differences between the two enforcement programs result in the different duration of the enforcement effects. It is therefore difficult to extend these findings to speed enforcement programs operating under different conditions.

Principle 2: The duration of the effect of overt speed enforcement programs resulting in visible issuance of on the spot fines issued at the time of the offence is likely to be more immediate but shorter than the effect generated by a delayed issuance of infringement notices resulting from covert operations which detect many offences per enforcement hour.

EFFECTS OF OVERT SPEED ENFORCEMENT

As with any form of enforcement program, the effectiveness of overt speed enforcement may be due to the effect of specific deterrence, general deterrence or some combination of the two. There appears to have been some conflict as to whether overt enforcement has a significant general deterrence effect. Given the extensive use of overt speed enforcement in Victoria, some discussion of this conflict is necessary.

First it is noted that the initial introduction of the speed camera program in Victoria involving the overt use of cameras had no overall impact on casualty crash frequency. In addition, some research indicated that no relationship between the amount of enforcement seen by drivers and a driver's perceived risk of detection could be found. These results indicate that speed enforcement operations may not have a general deterrence effect.

On the other hand, more recent research relating to laser speed detection devices found that the use of these devices resulted in a significant decrease in casualty crashes. This supports the proposition that overt enforcement activity can have a significant impact on crashes and has a general deterrence effect that may be localised in space.

In addition, an evaluation of the New Zealand speed camera program found that the use of covert speed cameras to supplement overt cameras in signed areas generalised the effect of

the program beyond the speed camera sites. It is concluded that the use of visible symbols, such as signs warning of potential camera presence and marked enforcement vehicles, may help to remind drivers of the unseen threat of covert operations, thus increasing general deterrence.

These results suggest that the general effect of overt speed detection programs can be increased by expanding the geographical coverage of the enforcement sites. In terms of future enforcement operations this suggests the following principle:

Principle3: T*o maximise the general deterrence effect of overt enforcement programs, these programs should involve low to medium intensity speed enforcement at multiple sites on the road network.*

In addition to the localised, general deterrence effect of overt speed enforcement, it has been suggested that some forms of speed enforcement have a specific deterrence effect. This effect is primarily used in the speed camera program where the receipt of Traffic Infringement Notices (TINs) has been shown to impact on subsequent speeding behaviour, and consequently the number of casualty crashes occurring. Early research relating to the period from 1990 to 1993 showed that the receipt of TINs for speeding offences resulted in reductions in casualty crashes. However, similar analysis using data from 1994 to 1996 found evidence of reductions in crash severity but not casualty crash frequency as a result of the receipt of TINs.

The change in the effect of the receipt of TINs suggests that the specific deterrence effect of speed camera enforcement may have declined over time. This decline may be in part due to changes in the public's attitudes towards receiving TINs. The public may have become accustomed over time to receiving TINs and consequently may no longer adjust their driving behaviour. Alternatively, the magnitude of the penalties may not have been sufficient to deter speeding behaviour. Further research into this area is required to determine whether speed enforcement programs continue to have adequate specific deterrence effects.

MOBILE SPEED CAMERAS

1. The initial use of a small number of overtly operated speed cameras in Victoria could not be shown to reduce casualty crash frequency and its effect on speeds was limited to within 1-2 km of the enforcement site. This implies that the overt use of speed cameras is only effective in reducing speeds in the vicinity of the camera site and may produce small, localised casualty crash reductions, but has no general impact on casualty crash frequency.

2. Significant reductions in low alcohol hour[1] casualty crashes were experienced during the initial implementation phase of the new, covert speed camera program in 1990 when publicity was high but actual enforcement levels were relatively low. This suggests that, even with low enforcement levels, high profile media activity can establish and maintain a threat of detection in the short term.

[1] Low-alcohol hours are times of the week when alcohol related crashes are less likely to occur, whereas high-alcohol hours of the week are those periods when alcohol related crashes are more likely to occur.

3. Following the full implementation of the speed camera program, statistically significant reductions in low alcohol hour casualty crashes were found across arterial roads in Melbourne and country towns and on rural highways. This demonstrates that, the intense, covert use of speed cameras can lead to long term reductions in low alcohol hour casualty crashes across a number of road types when accompanied by high-profile publicity (i.e. a general effect much broader than any localised effects).

4. Initially, no casualty crash reduction effects were found within one kilometre of enforcement sites in the week following enforcement sessions. Localised reductions in high alcohol hour casualty crashes were experienced during the two weeks following the receipt of TINs. This indicates that, in addition to the general effect outlined above, the speed camera program has a localised effect on high alcohol hour casualty crashes corresponding to the two-week period after the receipt of TINs. The exact duration of this effect is unknown.

5. Later research identified additional casualty crash reductions within one kilometre of enforcement sites in the week following enforcement sessions. This demonstrated that the localised effect of the speed camera program was also linked to the enforcement presence although perhaps less strongly than the receipt of TINs. Recent changes to make camera operations more covert and unpredictable may have weakened this localised, additional effect.

6. From the research relating effects to the receipt of TINs emanating from camera-detected speeding offences, it can be concluded that specific deterrence, operating through the actual detection and punishment of offenders, works effectively to reduce high alcohol hour casualty crashes.

7. Links between reductions in casualty crashes and road safety advertising relating to speed and drink-driving enforcement operations have been established. Enforcement related advertising effectively magnifies the deterrent effects of enforcement operations.

8. During the period 1990-1993, both the TINs issued and publicity with speeding-related themes contributed to reductions in serious casualty crashes. This implies that, both specific deterrence (achieved through the issuing of TINs) and general deterrence (achieved through media advertising of speeding offences) are effective in reducing serious casualty crashes.

9. An economic analysis of speed camera operations in Melbourne during low alcohol hours indicates that effective speed enforcement programs are highly cost beneficial. The benefits were measured by the reduced social costs due to savings in road crashes and injuries, and the costs were those required to operate the speed camera program. Fine revenue was not included as a benefit (or a cost). The analysis indicated that the level of speed camera activity used up to 1998 could be increased with further economic benefits. The level of camera activity was increased by 50% during 2001/02, consistent with this finding.

HAND-HELD LASER SPEED DETECTION DEVICES

1. The laser speed detection program implemented during 1997 was successful in reducing casualty crashes on arterial roads in metropolitan Melbourne when conducted at low to medium intensity levels (sessions typically less than one hour, for up to 15 hours per site per year). Therefore, overt forms of speed detection can be effective in reducing casualty crashes when enforcement operates at low to medium intensity levels.

2. The effect of laser detection devices may be localised in space suggesting that overt forms of speed enforcement may have a general deterrence effect that is limited to the location at which enforcement activity is observed.

3. To expand the general effect of overt speed detection programs, a more extensive geographical coverage may be required.

4. It follows from points 1 to 3 that low to medium intensity speed enforcement at multiple sites on the arterial road network will have a greater effect on crashes than high intensity enforcement at fewer locations.

5. The casualty crash reduction effects identified were found to be statistically significant for arterial roads only. Current knowledge does not allow firm conclusions concerning the effectiveness of laser enforcement on non-arterial roads.

MOBILE RADAR SPEED DETECTORS IN MARKED AND UNMARKED CARS

1. The effect of mobile radar enforcement and associated publicity was found to be greatest during the four days immediately following the enforcement, with the effect diminishing between five and seven days after the enforcement presence. This suggests the existence of a four-day residual enforcement effect on casualty crashes.

2. Casualty crash reductions were found following speed enforcement operations involving either covert operations (unmarked cars) or a mix of overt and covert enforcement activity (marked and unmarked cars operating together).

3. No statistically significant effect on casualty crashes was found on the actual day of enforcement activity in rural Victoria. Therefore, it is not clear that mobile radar activity is effective in reducing casualty crashes in rural Victoria on the actual day of enforcement.

4. The most significant impact on casualty crashes occurred when high public awareness of media publicity accompanied radar enforcement. However, the effect was greater when high publicity awareness levels were specific to mobile radar enforcement as opposed to when the high publicity awareness levels related to general, speed-related road safety themes.

   Therefore, publicity relating to specific enforcement programs may be more effective in reducing casualty crashes when accompanying the enforcement than publicity relating to speeding generally.

5. The strongest effect on casualty crashes was found on the same day as enforcement when high levels of mobile radar publicity accompanied mobile radar enforcement operations involving both overt and covert activity.

FIXED SPEED CAMERAS ON CITYLINK

1. Fixed position, automated speed cameras located in the Domain tunnel have successfully reduced the average speed of motorists travelling in the tunnel and the proportion of vehicles exceeding speeds of 80, 90 and 110 km/h.

2. Reductions in the measures of effect described in point 1 can be expected to translate into reductions in crash risk and injury risk in the tunnel.

3. The fixed position speed cameras have had varied effects depending on the lane the vehicle is in, the day of the week and the time of day that the vehicle travels. In particular the cameras have:
    - Been more effective in reducing vehicle speeds in the left lane than in the right;
    - Been more effective in reducing vehicle speeds on weekends than during the week; and
    - Been most effective in reducing vehicle speeds on weekdays during the peak afternoon period.

    No time of day pattern is evident on the weekends.

ENFORCEMENT SCHEDULING: THE RANDOM ROAD WATCH (RRW) PROGRAM

1. The RRW program has been successful in producing statistically significant crash reductions at all severity levels in non-metropolitan Queensland. The effect of the program in metropolitan areas has been more difficult to assess.

2. The effect of the RRW program has increased over time for all crash types (except those involving fatalities, for which the effect was approximately constant).

3. From points 1 and 2 above it is concluded that, randomising the time and location of police road safety enforcement can have significant positive effects on the number of crashes reported and this effect has been shown to increase over time.

4. The positive effect of the RRW program on crashes of various severities in both rural and urban areas indicates that, such a program may be as effective on lower speed roads as on open highways.

5. The statistically significant association between program coverage and crash effects indicates that in operational terms, wide spread but perhaps less intense, randomised enforcement will result in greater crash effects than more intense but less diverse coverage. That is, the coverage of a randomised enforcement program is a key contributor to its effectiveness.

6. Analysis of similar programs in other jurisdictions suggests that the results experienced in Queensland could be reproduced elsewhere.

SPECIFIC GROUPS AT RISK

A number of specific groups have been identified as presenting particular road safety problems in regard to speeding. Having identified these groups it is then necessary to formulate enforcement programs or other measures that can be targeted towards these groups and have positive impacts on their behaviour and crash involvement.

The following groups of drivers may need to be the target of specific programs in future. First, it is noted that for two particular groups of drivers, enforcement may not be sufficient to alter their behaviour. It is also noted that there is some overlap between these two groups.

The first group is those classified as younger drivers. For this group, it was found that enforcement is unlikely to be the dominant determinant of behaviour. Therefore, enforcement alone is unlikely to be sufficient to address the behaviour of this group. This suggests the following principle:

Principle 4: Public education campaigns should play an important role in targeting younger drivers particularly when accompanied by a significant increase in speed enforcement activities during the evenings and late at night.

The focus of education campaigns should be on the particular biases of those young people involved in crashes including biases towards males, car owners, those who drive for social reasons at night and people with offence histories. In addition, advertising specific to the road conditions in which these drivers face difficulties would be useful.

The second group of drivers for whom enforcement is unlikely to affect behaviour is also likely to benefit from an education campaign. This group is comprised of those drivers under the age of 20 and those drivers between the ages of 20 and 29 who perceive their personal risk of detection as high but are nevertheless prone to speeding behaviour.

Three further groups were identified as possible targets of future enforcement initiatives. The first of these groups had a high recall level for road safety material presented on the radio. This group is more likely to be male, live in metropolitan areas, drive as part of their occupation and have higher levels of exposure to driving risk and enforcement.

Principle 5: Targeting of drivers who drive as part of their occupation and possess the other specific characteristics detailed above should involve radio advertising.

The second group identified has a low perceived risk of detection combined with a relatively high likelihood of alcohol consumption. Members of this group are more likely to be classified as young drivers, drive in built-up areas during the daytime and experience lower levels of exposure to enforcement activities.

The final group comprised mainly of 20-29 year olds, was predominantly male and believed that speed enforcement was overt and that detection could be avoided.

Principle 6: Targeted enforcement programs aimed at the identified groups of drivers who are either exposed to lower enforcement levels or believe that enforcement can be avoided must involve an increase in the actual detection of offences.

Given the characteristics of these two groups, increasing the actual level of offences detected amongst these groups should alter perceptions of the levels of enforcement and the risk of detection when speeding.

THRESHOLD LEVEL OF ENFORCEMENT AND DRIVER PERCEPTION OF OVERT AND COVERT ENFORCEMENT INITIATIVES

1. *Some research suggests that an increase in visible enforcement must achieve a threshold level for that increase to be effective in reducing casualty crash frequency*. The exact threshold required is unclear, but few studies have shown effects on crashes when visible enforcement is increased by a factor of less than three.

2. Later research of both manual and automatic enforcement techniques does not indicate a threshold with a smooth relationship between the amount of enforcement and the level of road safety.

3. Overt Police enforcement operations are likely to have a general deterrence effect. On the other hand, covert operations need to rely on high levels of detection to ensure that specific deterrence is effective.

4. Two groups of drivers have particularly negative speed-related attitudes and behaviours, which may need to be targeted in future speed enforcement initiatives.

5. The first risk group comprised mainly of 20-29 year olds was predominantly male, and believed that speed enforcement was overt and that detection could be avoided. Effects on this group could benefit from an increase in their actual risk of detection.

6. The second group of drivers perceived their personal risk of detection as high but were nevertheless prone to speeding. Both genders are represented in this group and they were predominantly comprised of drivers under 20 or between 20-29 years of age. Given that the second risk group already reports a high risk of detection, the attitudes and behaviours of this group may not be affected by enforcement activities alone.

SPEEDING AND YOUNG DRIVERS

1. Speed related crashes are more likely to involve younger drivers, particularly younger male drivers. This suggests that younger drivers present particular problems in relation to speeding, and should be a target for speed enforcement.

2. Younger drivers are over-represented in crashes occurring on sections of curved road especially in the evening in wet road conditions and late at night. This corresponds with low levels of speed enforcement during the evening and late at night.

3. Point 2 above suggests that, an increase in speed enforcement activities during the evenings and late at night may be necessary to have an impact on the incidence of crashes involving younger drivers.

4. No clear relationship between either exposure to enforcement or the perceived risk of detection and other speed-related attitudes has been found. This indicates that, future enforcement programs aimed at younger drivers need to do more than rely on high level of enforcement.

5. Point 4 above is supported by the fact that younger drivers who have previously been detected speeding continue to have unsafe attitudes towards speeding behaviour.

6. Previous MUARC research suggests that the following characteristics may be useful elements of future enforcement programs aimed at younger drivers:
    - A focus on personal (actual) risk of detection would be expected to have a greater effect on behaviour than a more general perceived risk of detection.
    - Public education programs accompanying increased enforcement could focus on those younger drivers more likely to be involved in crashes, including: males, people who drive for social reasons at night, and drivers with histories of offending.

GENERAL PRINCIPLES FOR SUPPORTING PUBLICITY

TAC road safety publicity aimed at increasing both awareness of specific enforcement programs and general public awareness of safety issues has been integral to the implementation of many speed enforcement programs in Victoria. Such publicity is generally run to increase the general deterrence effect associated with new or existing enforcement programs.

Results from the research relating to the effectiveness of publicity indicate a number of underlying themes:

1. Public education campaigns should play an important role in targeting younger drivers particularly when accompanied by a significant increase in speed enforcement activities during the evenings and late at night.

2. Targeting of drivers who drive as part of their occupation and possess the other specific characteristics (males living in metropolitan areas) should involve radio advertising.

3. Targeted enforcement programs aimed at the identified groups of drivers who are either exposed to lower enforcement levels or believe that enforcement can be avoided must involve an increase in the actual detection of offences.

4. The use of enforcement related advertising in future enforcement programs should increase the effectiveness of such programs and will contribute to the cost beneficial nature of those programs.

5. In the short-term, high profile publicity can be used as an effective interim measure to reduce crash frequency when enforcement levels are low.

First, in all instances examined, publicity supporting enforcement programs has apparently been effective in magnifying the effects of the enforcement program. These magnified effects have been evident over a range of road types. Also, the combined effect of speed

enforcement programs and publicity is highly cost beneficial. This leads to the following principle:

Principle 7: The use of enforcement-related advertising in future enforcement programs should increase the effectiveness of such programs and will contribute to the cost-beneficial nature of those programs.

It is noted that publicity supporting speed enforcement programs is more effective in reducing crashes when it is specific to the enforcement rather than when it encompasses more general speed-related themes.

High profile media activity has also been found to be effective in reducing casualty crashes even when enforcement levels are low.

Principle 8: In the short-term, high profile publicity can be used as an effective interim measure to reduce crash frequency when enforcement levels are low.

CONCLUSION

MUARC's evaluations of speed enforcement to date have shown that speed enforcement initiatives conducted in Victoria in recent years have successfully contributed to reductions in road trauma. However, the current study highlights a number of areas in which further research is required to more fully understand the mechanisms at work and the effectiveness of enforcement operations in a variety of environments. In particular, it would be valuable to consider the following issues in the context of future speed enforcement research:

- The interaction effect between publicity and enforcement operations
- The duration effect of enforcement in its variety of forms
- The use of fixed-location automatic surveillance techniques outside of a tunnel environment to determine the efficiency and effectiveness of the enforcement
- The influence of reduced speed offence threshold levels on speed behaviour and casualty crashes
- The relative effect of randomised scheduling of speed enforcement operations in Victoria compared with current practices

Further, there are a number of issues that have not been examined in detail that would add to current knowledge on speed enforcement. Specifically, issues relating to the issuance and processing of traffic offences within the administrative and judicial systems are relevant to the effectiveness of enforcement operations. The perception of these systems by road users may provide an understanding of some of the mechanisms behind effective operations.

Finally it is noted that the effect of speed enforcement initiatives may change over time and the outcomes of this review should be updated and supplemented by future research in this area.

1 INTRODUCTION

The effectiveness of speed enforcement programs in Victoria has been the subject of a significant volume of research conducted by the Monash University Accident Research Centre (MUARC). This research has evaluated specific speed enforcement programs in terms of their effect on casualty crashes and in some instances their effect on driver behaviour. The role of mass media publicity supporting the speed enforcement operations has often figured in this research. More general research has also been conducted that examines driver perceptions of enforcement activities and the reported behaviour of specific groups of drivers.

This report aims to extend the existing body of research by providing a coherent review of speed enforcement research conducted by MUARC to date. Further, this report aims to extract the relevant principles and implications from the research for use in the planning of future enforcement operations.

Before proceeding further, a discussion of the two primary mechanisms involved in generating the effects of speed enforcement is required. Speed enforcement, and traffic enforcement more generally, works to improve road safety through two key mechanisms: general deterrence and specific deterrence.

General deterrence is a process of influencing a potential traffic law offender, through his fear of detection and the consequences, to avoid offending. The threat of detection as perceived by the driver is the key issue. The perceived risk of detection may be higher than the actual risk. On the other hand, *specific deterrence* is a process of encouraging an apprehended offender, through his actual experience of detection and the consequences, to avoid re-offending. The magnitude of the penalty, especially that applying if subsequent offences are committed, is the key issue. Such offenders have actually experienced the threat of detection, so they know that the risk is real.

Speed enforcement programs aimed at invoking both of these mechanisms have been implemented in Victoria in the past and evaluations of these programs have involved an analysis of the mechanisms at work. Such analysis is critical to the planning of future enforcement programs and these issues will be addressed throughout this report.

Because speeding is a relatively "transient" offence, the effects may be localised or more generally spread, depending on how the threat of detection is perceived. Enforcement programs relying on the general deterrence mechanism commonly have general effects, but the two “general” concepts are different. Programs based on the specific deterrence mechanism can have both general and localised effects on crashes.

The following mechanisms are possible ways in which speed enforcement achieves its effects:

1. Receipt of speeding Traffic Infringement Notices (TINs) and associated demerit points (specific deterrence)
2. Receipt of multiple speeding TINs, demerit points and/or licence suspension (specific deterrence)
3. Knowledge of other drivers who have received speeding TINs (general deterrence)
4. Knowledge of actual speed enforcement operations (general deterrence)
5. Publicity about speed enforcement and the risks of speeding (general deterrence).

The type of enforcement program that can be implemented will be influenced by the type of technology available. In general, speed enforcement technology can be either fixed or mobile. Fixed devices, such as the safety cameras located in the Burnley and Domain tunnels in Victoria, are located permanently at one site. In contrast, technologies such as slant radar speed cameras are portable and tend to operate at one site for only a short period of time. This technology, along with others that can be moved from site to site, is referred to as mobile technology.

In some circumstances, the location of speed enforcement, whether fixed or mobile, may be chosen to affect a known problem of high crash risk or the risk of particularly severe crashes in a defined area. Such treatments are referred to as "black spot" treatments. Where the increased risk relates to a particular route or area the treatment can be spread across this black route or area. In general, black spot or black route programs are intended to have the greatest effect at the black spot site or along the black spot route and are rarely aimed at treating speed across the road network.

Zaidel (2002), in a comprehensive review of the impact of enforcement on crashes, has noted that most police traffic agencies plan their deployment according to a "black spot approach". Most experts advise the police to do this, as it appears consistent with good management principles. Zaidel notes that the approach is responsive to public concerns and can have, sometimes, immediate benefits at the specific locations. He suggests, however, that it is not necessarily a good guide for routine and sustained traffic enforcement aimed to raise compliance all over the network, at all times.

Given this background it is now possible to discuss previous MUARC studies relating to particular speed enforcement programs or studies of driver perceptions. Each of these will now be discussed in turn.

2 SPEED CAMERAS

2.1 IMPLEMENTATION

Speed cameras were first introduced in Victoria on a trial basis in 1985 and were aimed at detecting a large number of speeding vehicles per hour. The initial trial involved a small number of cameras operating with warning signs at high crash frequency sites. The effect of this operation was minimal. No statistically significant reductions in casualty crashes in the areas surrounding the camera sites were found. In addition, the effect on speed was limited to distances of approximately one to two kilometres from the camera sites (Portans, 1988).

Following the evaluation of the initial trial, a new program of speed camera enforcement was introduced in December 1989 that involved the use of covert speed cameras. At this time, strong public statements asserting that widespread use of numerous cameras would occur were made.

In April 1990, a high-profile publicity campaign was launched that related to speeding and the speed camera enforcement program. However, it was not until the Traffic Camera Office was established in June of the same year that the increasing number of cameras were used extensively. It is noted that the establishment of the Traffic Camera Office

corresponded with a rapid increase in the number of traffic infringement notices issued per month. The full complement of 54 new slant radar cameras came into operation in January 1991.

More recently, in November 1998, the operation of the speed camera program was outsourced to LMT Australia. At that time, the enforcement program involved the use of 54 speed cameras and aimed to achieve 4200 hours of enforcement per month. Since then, average monthly enforcement hours have increased to 6000. This increase occurred in three stages and involved cumulative increases of 600 enforcement hours per month commencing in August and December 2001 and February 2002.

2.2 OUTPUTS OF THE PROGRAM

During the period from mid 1990 to December 1993 the total number of traffic infringement notices (TINs) issued per month varied from 14,000 to 64,000. During the second half of 1990, an average of 16,100 TINs were issued each month. This increased to a monthly average of more than 40,000 TINs for each of the years between 1991 and 1993. It is noted that the increase in the monthly average number of TINs issued corresponds to the introduction of the complete set of 54 speed cameras in January 1991. Since that time, the monthly average number of TINs issued remained between 40,000 and 50,000, until January 2002 when the number rose to about 60,000 per month.

2.3 IMPACT OF THE PROGRAM

The impact of the speed camera enforcement program has been evaluated in terms of its effect on the number of casualty crashes during the period between December 1989 and December 1991 (Cameron et al., 1992)

From December 1989 to March 1990, there was a statistically significant 15% reduction in low alcohol hour[2] casualty crashes on arterial roads. This coincided with low levels of both speed camera enforcement and speed related publicity. During the period April 1990 to June 1990, when the publicity campaign was launched but prior to extensive enforcement operations, low alcohol hour casualty crashes were reduced by 34% on Melbourne arterial roads and 21% in country towns. Reductions in the severity of injuries sustained in these crashes were also found in Melbourne during this period.

Following the high levels of both publicity and enforcement experienced from July 1990, low alcohol hour casualty crashes were reduced on arterial roads in Melbourne, country towns and on rural highways by 32%, 23% and 14% respectively. The injury severity of these crashes was also found to have decreased, principally in Melbourne. The effect of the speed camera enforcement program on high alcohol hour crashes is less clear.

Further analysis of the period from July 1990 to December 1991 indicated that the speed enforcement program may have some localised effects (Rogerson et al., 1994). That is, the effect of speed enforcement may be restricted to the immediate area surrounding the enforcement sites. During the two weeks following the receipt of TINs by offending motorists, a statistically significant 10% reduction in *high* alcohol hour casualty crashes was experienced on arterial roads within one kilometre of the camera site. However, there was no reliable evidence of casualty crash reductions within one kilometre of the camera

[2] Low-alcohol hours are times of the week when alcohol related crashes are less likely to occur, whereas high-alcohol hours of the week are those periods when alcohol related crashes are more likely to occur.

site during the week immediately following a speed camera enforcement session. In addition, no localised reductions in *low* alcohol hour casualty crashes or the severity of crashes were found during this period.

The above results were updated in a more recent study examining the localised effects of the speed camera program during the period from July 1990 to December 1993 (Newstead et al. 1995). This study evaluated the localised effects of speed camera enforcement in rural towns and metropolitan Melbourne separately. In relation to rural towns, the speed camera program was found to have no statistically significant effect on casualty crashes following enforcement operations or the receipt of TINs. In contrast, statistically significant casualty crash reductions in metropolitan Melbourne were identified and linked to both camera operations and the receipt of TINs. The influence of TINs was evident during the three weeks following their receipt and was greatest on all roads during high alcohol hours. An 8.92% reduction in casualty crashes was experienced in high alcohol hours, on all roads, during the week following the receipt of TINs.

It is also worth noting the differences in the results of the two studies detailed above. First, the estimated effect of the receipt of TINs is slightly less in the 1995 study; 6.2% compared to 8.4%. Second, the effect of the receipt of TINs on casualty crashes on arterial roads was not evident in the 1995 study but was statistically significant in the 1994 study. Third, the 1995 study identified casualty crash reductions during the week immediately following the enforcement presence during both high and low alcohol hours. The earlier study found no such evidence of casualty crash reductions following the enforcement presence. There are a number of possible explanations for these changes. The additional two years of data included in the 1995 analysis may be affected by changes in the behaviour of motorists during this period. Drivers may have become more aware of speed camera sites and adjusted their driving behaviour at these sites. In turn, this may have resulted in the reduced crash risk observed at the sites. However, further study would be required to examine this possibility.

2.4 MECHANISMS OF THE PROGRAM

Efforts to determine the mechanisms that drive reductions in casualty crashes have also been made. Based on 1990-91 data, relationships between the level of low alcohol hour casualty crashes and the inputs of the enforcement program have been established. Casualty crash frequency was related to the number of speeding TINs issued (generally 2-3 weeks after the offence occurred) and publicity levels in the same month. Also, crash severity was related to camera operating hours and the number of speeding TINs issued (Cameron et al. 1992).

These results imply that actual detection of speeding drivers, as evidenced by the number of TINs issued, is a key driver of the frequency of casualty crashes. Supporting media publicity also acts as a crash reduction mechanism. Therefore, it can be concluded that both specific deterrence measures (the issuing of TINs) and general deterrence measures (media advertising) contribute to casualty crash reductions.

An update of this analysis using data from January 1994 to December 1996 produced some different results (Gelb et al. 2000). Casualty crash frequency was responsive to the TAC's speed and concentration related advertising but reductions in casualty crash frequency were no longer attributable to TIN issuance. In addition, the number of hours of enforcement no longer had a positive effect on crash severity. Crash severity was still affected by the

number of TINs issued. This suggests that there has been a change over time in the mechanisms behind the speed camera enforcement program.

Further evidence on the effect of advertising on road trauma was found in an evaluation of the effects of different monthly levels of TAC advertising (Cameron, 1995). Clear links between reductions in casualty crashes and road safety advertising relating to speed and drink-driving enforcement operations were identified. The impact of advertising not relating specifically to enforcement programs was less clear.

Another study examined the contribution of each of a number of factors, including publicity, to the reduction in serious casualty crashes (Newstead et al., 1995a). It was found that TINs issued as a result of speed camera operations contributed reductions in serious casualty crashes of 8-9% during the 1990-1993 period. In the same period, publicity relating to the themes of speed and concentration were found to have contributed reductions of 6-8%.

It is noted that the interactions between the enforcement and publicity have not been examined in detail. However, it has been suggested that there was a positive interaction between the two initiatives. That is, the contribution of speed camera enforcement to reductions in casualty crash frequency would not have been as great if the enforcement was not accompanied by advertising and vice versa. Also, the combined effect of the two initiatives may be greater than the sum of the individual components. A more accurate measure of the overall effect of the program may therefore be obtained by estimating the overall effect of the program rather than the individual effect of each of the program's components.

2.5 THE ECONOMIC VALUE OF THE PROGRAM

Given the change in the mechanisms behind the effective speed camera enforcement program mentioned above, an examination of the economic costs of the existing program was conducted by MUARC during 1999. The study aimed to evaluate whether the existing speed camera operations involving approximately 4000 hours of operation per month was best practice. This was done using a marginal cost/benefit analysis in terms of both hours of operation and TIN issuance. The benefits were measured by the reduced social costs due to savings in road crashes and injuries, and the costs were those to operate the speed camera enforcement system. Fine revenue was not included as a benefit (or a cost).

The economic analysis was limited to speed camera enforcement in Melbourne during low alcohol hours because most speed camera activities occur in Melbourne during these hours. In addition, crash data for low alcohol hours is less likely to include accidents associated with drink driving. Crash data from 1987 to 1998 was used along with data relating to the actual costs of running the speed camera program and the costs of casualty crashes to society in general.

The results presented below are drawn from the economic analysis based on TIN issuance. These results are likely to provide a better estimate than those based on hours of operation due to the greater variability of the TINs measure.

It has been determined that, in order to reduce the social costs associated with casualty crashes the number of TINs issued per month should fall within the range of 37,000 to 66,000. This corresponds to a range of 3,592 to 6,408 enforcement hours per month and an

optimal average investment per month of 5,146 enforcement hours. This would be expected to result in a reduction in monthly levels of low alcohol hour casualty crashes of 13%. Further, the marginal benefit cost ratio was determined to be 6.3. That is, by investing in an average of 5,146 operational hours per month the benefits obtained in reduced social costs per casualty crash would be 6.3 times the cost of investment.

These results are limited to benefits of speed camera enforcement under the program existing up to 1998. The results would change if any of the elements of the program such as camera technology or the operational principles underlying the timing and location of enforcement operations were to change. Any technological advance that would increase the number of speeders detected per hour of camera operation would also increase the benefit/cost ratio of the program. Further, if it became possible to issue the same number of TINs with fewer hours of enforcement, the cost of the program would decrease and the benefit/cost ratio would necessarily increase. If such changes did occur, the estimates provided above could be viewed as the lower bounds of an economic assessment of a redesigned speed camera program.

2.6 THE NEW ZEALAND EXPERIENCE: OVERT VS COVERT SPEED CAMERAS

The introduction of mobile speed cameras in New Zealand commenced in late 1993. The operation of the cameras was restricted to roads classified as 'speed camera areas' based on a record of speed related crashes. Entrances to these roads were clearly sign posted to ensure that motorists were aware of the potential presence of the speed cameras. Further, the majority of speed cameras were mounted on police cars and operators were prohibited from hiding the cameras. In urban areas, limited use was made of fixed position speed cameras mounted on poles; however, these were subject to the same signage requirements as the mobile camera operations. In total, 13 fixed and 31 mobile cameras have been operating in New Zealand since 1993. Prior to July 2000, the enforcement threshold was set at the 85^{th} percentile speed for each site as determined by speed surveys of that site. Financial penalties (but no demerit points) were imposed where vehicles were detected travelling at or above the enforcement threshold. However, since 1 July 2000 a flat 10 km/h enforcement threshold has been in operation.

An evaluation of the effect of the speed camera program described above, found that fatal and serious crashes on roads with speed limits of 70 km/h or less were reduced by an estimated 13% during low alcohol times of day (Mara et al., 1996). In speed camera areas, the reduction in fatal and serious low alcohol hour crashes was 23.3%. Less substantial reductions in all injury crashes were experienced in speed camera areas on roads with speed limits of 100 km/h. No effect on crashes was identified on these roads when non-speed camera areas were included in the analysis.

As detailed above the operation of mobile speed cameras in New Zealand is conducted in a highly visible manner. However, from mid-1997 to mid-2000 a trial of the covert use of speed cameras was conducted in one of the four police regions in New Zealand on roads with speed limits of 100 km/h. This involved adding to existing signage an indication to motorists that hidden cameras may operate in the speed camera areas. In addition to the extra signage, there were high levels of newspaper and radio publicity relating to the trial prior to its commencement. It is also noted that in the first year of operation there was a 26% increase in the operational hours of speed cameras in the trial region. In the second year of operation, the number of operational hours decreased by 13% from the first year

level. There were no changes in the operation of speed cameras during the trial period in other areas of New Zealand. In particular, on all roads in non-trial speed camera areas, speed camera operations remained overt. Further, on roads with speed limits of 70 km/h or less in the trial region, speed cameras were operated overtly.

An evaluation of the hidden camera trial in terms of vehicle speeds and reportable crashes demonstrated that during the first two years of the trial, improved road safety outcomes were experienced (Keall et al., 2002). First, average speed in the trial regions decreased by an estimated 1.3 km/h over the first two years of the trial. The speed below which 85 percent of vehicles travelled in the trial region fell by an estimated 4.3 km/h. In addition, reportable crashes in the trial region fell by 11% in comparison to reportable crashes in the control regions. Further, it was found that the number of casualties in the trial region fell by 19% in comparison to casualties in the control regions. The number of casualties per crash fell by 9% on open roads in the trial region compared to open roads in the control regions. It is noted that these results relate to reductions across the treated region and not only at camera sites. This indicates that the covert mobile operations were able to generalise the effect of the New Zealand program beyond the speed camera sites.

Despite the above results it is difficult to draw conclusions from this study on the relative effectiveness of overt and covert automated speed enforcement programs. During the trial period, enforcement levels in the trial region were higher than in the non-trial regions. Further, the number of penalties issued in relation to incidents in the trial areas increased four fold (Keall et al., 2002). Therefore, based on previously established relationships between speed enforcement and crashes (Cameron et al., 1995), it is not unexpected that improvements in road trauma would occur as the level of enforcement increases. Nevertheless, the authors point to three factors that they believe together support the conclusion that the introduction of covert speed cameras influenced the casualty crash reductions. First, the fall in the frequency of casualty crashes coincided with the introduction of the covert program. Second, mean and high percentile speeds fell significantly during the trial. Finally, the reduction in the number of casualties per crash also confirms that speeds fell during the trial period.

2.7 CONCLUSIONS AND RECOMMENDATIONS

1. The initial use of a small number of overtly operated speed cameras in Victoria could not be shown to reduce casualty crash frequency and its effect on speeds was limited to within 1-2 km of the enforcement site. This implies that, *the overt use of speed cameras in Victoria is only effective in reducing speeds in the vicinity of the camera site and may produce small, localised casualty crash reductions, but has no general impact on casualty crash frequency.*

2. Significant reductions in low alcohol hour casualty crashes were experienced during the initial implementation phase of the new, covert speed camera program when publicity was high but actual enforcement levels were relatively low. This suggests that, *even with low enforcement levels, high profile media activity can establish and maintain a threat of detection in the short term*.

3. Following the full implementation of the speed camera program, statistically significant reductions in low alcohol hour casualty crashes were found across arterial roads in Melbourne and country towns and on rural highways. This demonstrates

that, *the intense, covert use of speed cameras can lead to long term reductions in low alcohol hour casualty crashes across a number of road types when accompanied by high-profile publicity* (i.e. a general effect much broader than any localised effect).

4. Initially, no casualty crash reduction effects were found within one kilometre of enforcement sites in the week following enforcement sessions. Localised reductions in high alcohol hour casualty crashes were experienced during the two weeks following the receipt of TINs. This indicates that, in addition to the general effect outlined above, the speed camera program has a localised effect on high alcohol hour casualty crashes corresponding to the two-week period after the receipt of TINs. The exact duration of this effect is unknown.

5. Later research identified additional casualty crash reductions within one kilometre of enforcement sites in the week following enforcement sessions. This demonstrated that the localised effect of the speed camera program was also linked to the enforcement presence although perhaps less strongly than the receipt of TINs. Recent changes to make camera operations more covert and unpredictable may have weakened this localised, additional effect.

6. From all the research relating effects to the receipt of TINs emanating from camera-detected speeding offences, it can be concluded that specific deterrence, operating through the actual detection and punishment of offenders, works effectively to reduce high alcohol hour casualty crashes.

7. Clear links between reductions in casualty crashes and road safety advertising relating to speed and drink-driving enforcement operations have been established. *Enforcement related* a*dvertising effectively magnifies the deterrent effects of enforcement operations.*

8. During the period 1990-1993 both the TINs issued and publicity relating to the themes of speed and concentration contributed to reductions in serious casualty crashes. It is thought that some positive interaction between these two initiatives may exist. This implies that, *both specific deterrence (achieved through the issuing of TINs) and general deterrence (achieved through media advertising of speeding offences) are effective in reducing serious casualty crashes.*

9. An economic analysis of speed camera operations in Melbourne during low alcohol hours indicates that, *effective speed enforcement programs are highly cost beneficial.* In addition, *the level of speed camera activity used up to 1998 could be increased with further economic benefits.*

10. Covert operations increase uncertainty about the presence and location of the threat of detection, thus spreading the general deterrence effect over a broader area than overt operations. Covert mobile operations running concurrently with overt operations in New Zealand were able to generalise the effect of the New Zealand program beyond the speed camera sites.

11. The use of visible symbols, such as signs warning of potential camera presence and marked enforcement vehicles, may help to remind drivers of the unseen threat of covert operations, thus increasing general deterrence.

3 HAND-HELD LASER SPEED DETECTION DEVICES

3.1 IMPLEMENTATION

The use of laser speed detection devices was introduced in Victoria following some difficulties with the existing enforcement program involving radar detection devices. It was envisaged that the laser devices would be more effective than the radar devices in busy traffic areas such as arterial roads. Further, given the overt nature of the enforcement program, the objective was to increase the risk of detection rather than the number of speeding vehicles detected. The use of the laser devices commenced in metropolitan Melbourne in November 1996 and continued in all metropolitan Melbourne Police Districts during 1997.

3.2 OUTPUTS OF THE PROGRAM

The output of the laser speed enforcement program was compiled using data obtained from laser activity forms completed by Victoria Police during 1997 and returned to MUARC. The laser activity forms available to MUARC for inclusion in the analysis represent 97.8% of all enforcement sessions undertaken during 1997 compared with official Victoria Police statistics.

During 1997 there were 14,921 enforcement sessions or 15,026.65 hours of operation. These sessions resulted in a total of 49,693 speeding offenders being detected. The majority of the enforcement sessions commenced between the hours of 6am and 5:59pm and reached a peak between 7pm and 7:59pm. Also, the number of both speeding offenders detected and enforcement hours peaked on Sunday.

3.3 IMPACT OF THE PROGRAM

The research conducted on laser speed detection devices relates to three main areas: the overall effect of enforcement on crashes, the effect of different enforcement levels on crashes and the effect of enforcement activities on crashes on different road types. Each of these will now be discussed in turn.

The laser speed enforcement program has been found to have a positive overall impact on the number of casualty crashes occurring (Fitzharris et al. 1999). A statistically significant 8.28% reduction in all casualty crashes was found during 1997 in the areas where laser speed detection devices were used. In addition, the similar crash reductions found for the two categories of casualty crash suggest that the enforcement program affected the number of crashes rather than the severity of crashes.

In terms of the intensity level of enforcement, the laser speed enforcement program was apparently effective in reducing casualty crashes only for low and medium levels of enforcement. It is noted that, low enforcement is defined as up to three hours of enforcement activity at a given site during the year whereas medium intensity enforcement was defined as more than three but no more than fifteen hours of enforcement at a given site per year. Further, 70 percent of enforcement sessions were conducted for less than one hour and 23 percent of sessions were conducted for between one and two hours.

The final set of results relate to the type of road on which the enforcement activity was carried out. The three road types were defined as freeways, arterial roads and other roads.

The laser enforcement program led to a statistically significant 8.23% reduction in all casualty crashes on arterial roads only. The crash reductions on other types of roads were similar in magnitude but not statistically significant. However, the analysis for freeways and other roads was based on relatively few observations and may therefore have statistical power problems.

Finally, it is noted that the results presented in terms of the intensity level of enforcement and road type may have some interaction with each other. In 1997 enforcement intensity was highest on freeways and lower on arterial and other roads. Therefore, the analysis of the effect of laser speed enforcement as it relates to road type will be affected by the differing intensity levels of enforcement for each road type. Similarly, the analysis in respect of the intensity of enforcement will be affected by the road type on which the enforcement took place. Separating these effects has not been possible to date. However, given that the aim of using the laser devices was to provide more effective enforcement in busy traffic areas it was considered more appropriate to focus on the results as distinguished by road type, in particular the results for arterial roads.

3.4 CONCLUSIONS AND RECOMMENDATIONS

1. There is clear evidence that the laser speed detection program implemented during 1997 was successful in reducing casualty crashes on arterial roads in metropolitan Melbourne when conducted at low to medium intensity levels (sessions typically less than one hour, for up to 15 hours per site per year). Therefore, overt forms of speed detection can be effective in reducing casualty crashes when enforcement operates at low to medium intensity levels.

2. The effect of laser detection devices may be localised in space suggesting that *overt forms of speed enforcement may have a general deterrence effect that is limited to the location at which enforcement activity is observed*. On average, enforcement sites were 2 kilometres in length.

3. *To expand the general effect of overt speed detection programs, a more extensive geographical coverage may be required*.

4. It follows from points 1 to 3 that *low to medium intensity speed enforcement (defined as up to 15 enforcement hours per site per year) at multiple sites on the arterial road network will have a greater effect on casualty crashes than high intensity enforcement at fewer locations.*

5. The casualty crash reduction effects identified were found to be statistically significant for arterial roads only. *Current knowledge does not allow firm conclusions concerning the effectiveness of laser enforcement on non-arterial roads.* Further research into this area is therefore warranted.

4 MOBILE RADAR SPEED DETECTORS

4.1 IMPLEMENTATION

In 1995, the Transport Accident Commission (TAC) purchased 30 new mobile radar units which came into operation on 29 June 1995. The units are also known as moving mode

radar. These units were in addition to the existing 18 that had been in operation for approximately 10 months. A further 25 mobile radar units were then purchased in 1996 and became operational in late June of the same year. This brought the total number of operational units to 73. In addition, a television advertisement pertaining to the mobile radar enforcement program was launched in November 1996 by the TAC.

These mobile radar devices were used primarily in rural areas on two-way, undivided, 100 km/h speed limit roads. The units are mounted on a police car's driver door window and are operated while the police car is travelling in the opposite direction to on-coming, near-parallel traffic. The beam of the radar device is capable of reaching a car up to one kilometre away, and assessing its speed. If the speed is found to be excessive the police car can intercept the speeding vehicle when it arrives and issue an on the spot fine.

During this enforcement program all rural Police Districts in Victoria were issued with the mobile radar units. In addition, a number of Police Districts covering outer metropolitan areas operated the units. The devices were used on both marked and unmarked patrol vehicles. However, during the 1995/96 period, 81% of the operational hours were completed by marked patrol cars. This decreased slightly to 72% during the 1996/97 period. Further, 49% of the operational hours occurred between 7 a.m. and 3 p.m.

In November 1996 the TAC launched a television advertisement specific to the enforcement program. This advertisement was shown in both rural and metropolitan areas of Victoria. During the same period other advertisements relating to speeding generally were also shown in both rural and metropolitan areas.

4.2 OUTPUTS OF THE PROGRAM

For the period from July 1995 to June 1996, 48 mobile radar units were in operation for a total of approximately 902 hours per week. That is, a total of 47,136 hours of operation were achieved over the 12-month period. This number increased to 904 hours per week during the July 1996 to June 1997 period when the number of devices in operation increased to 73. This indicates, that the total number of operational hours achieved did not differ significantly despite the increased number of units in operation. However, the rate of detection of speeding offences did change as the number of units increased. In the period when 48 units were in operation the average monthly rate of detection was 0.68 offences an hour. As the number of mobile radar units increased to 73, the average monthly detection rate increased to 0.83 offences an hour.

The detection rate also varied between marked and unmarked patrol vehicles. In the 1995/96 period marked patrol cars detected an average of 0.73 offences per hour. In contrast, unmarked patrol cars detected only an average of 0.47 offences per hour. The overall detection rates increased during the 1996/97 period and the difference between detection rates for marked and unmarked vehicles declined dramatically. During this period, the radar devices detected 0.82 and 0.86 offences per hour on average for marked and unmarked vehicles respectively.

The offence rates per hour did not vary greatly with the time of day during which the radar units operated. However, community awareness of the publicity concerning the enforcement program and general speed related advertising varied considerably over time.

4.3 OUTCOMES OF THE PROGRAM

The enforcement program and associated publicity was evaluated in terms of its effect on casualty crashes on undivided roads in 100 km/h speed zones in Victoria (Diamantopoulou et al 1998).

The preliminary analysis found no change in the number of casualty crashes in outer metropolitan regions where the mobile radar devices were used. Therefore, the following results relate to casualty crashes in rural Victoria only.

The analysis determined that the enforcement program had a positive effect on casualty crashes in rural Victoria for a period of approximately four days following the enforcement. The effect of the program diminished after this period. In addition, the effect of the program varied with the level of public awareness of the two advertising campaigns.

The most noticeable effect on casualty crashes occurred when there were high levels of awareness of the specific mobile radar publicity. This corresponded to the period of November 1996 to June 1997. During this period a 28% net reduction in casualty crashes was observed one to four days after the enforcement was present. However, this reduction was only marginally statistically significant. The net reduction found for casualty crashes occurring on the same day as the enforcement was not statistically significant. Further, when there was low public awareness of the specific mobile radar advertising no evidence of casualty crash reductions was found.

Similarly, during the period July 1996 to June 1997 there were weeks of high-level awareness of general speed-related publicity (including mobile radar publicity) and the strongest effect on casualty crashes was found during the four days after the enforcement was present. However, the effect was not as strong as that experienced when the publicity was specific to mobile radar activity. In fact, the 11% reduction in casualty crashes that occurred during this period was found not to be statistically significant.

The results for the combined period from July 1995 to June 1997 also indicate that the strongest effect occurred when awareness of the general speed-related enforcement was high. However, the 8% reduction in casualty crashes detected was found not to be statistically significant. A comparison with high awareness levels of specific mobile radar publicity over the full two-year period cannot be made given that this type of publicity was only introduced in November 1996.

Finally, the results detailed above should be considered as somewhat conservative given a number of technical decisions that were made relating to the evaluation (Diamantopoulou et al., 1998).

4.4 COMPARISON OF OVERT AND COVERT MOBILE RADAR OPERATIONS

In addition to the above analysis, the effect of mobile radar devices on road trauma in rural Victoria has been examined in terms of the type of enforcement operation (Diamantopoulou and Cameron 2001). That is, the effect of covert (unmarked car), overt (marked car) and mixed (marked and unmarked cars in same traffic region) mobile radar operations has been examined to identify any differences between the outcomes of

different types of enforcement activity. It is noted that the analysis assumes a four-day residual enforcement effect based on the findings of Diamantopoulou et al. (1998) discussed in section 4.3.

This analysis was conducted using crash data from July 1995 to June 1997 which was divided into two periods. These periods were July 1995 to June 1996 and July 1996 to June 1997 and corresponded with the use of 48 and 73 mobile radar devices respectively. Analysis was also conducted on the two periods combined when up to 73 mobile radar device were in operation.

A net 20.7% reduction in crashes occurring one to four days after a *covert* enforcement presence was identified during the period from July 1995 to June 1996. The presence of *overt* enforcement also had a positive effect on casualty crashes occurring one to four days after enforcement however, the effect was less pronounced.

During the period from July 1996 to June 1997, the largest reductions in casualty crashes occurred following mobile radar enforcement operations involving *both* marked and unmarked police cars. This effect was greatest on the day on which the enforcement activity took place (40.2% reduction).

The results of the combined period in which up to 73 mobile radar devices were in operation found that the most significant reductions in casualty crashes occurring one to four days after enforcement resulted from covert mobile radar enforcement. However, a mix of overt and covert enforcement was also found to be effective in reducing casualty crashes during this period.

It is noted that the casualty crash reductions presented above are not statistically significant. Nevertheless the results are indicative of the likely relationships between overt, covert and mixed mobile radar enforcement and casualty crashes in rural Victoria.

Further to the above analysis the interaction between mobile radar enforcement and supporting publicity was examined as part of the same study. As noted in section 4.3, the introduction of mobile radar publicity began in November 1996. Therefore, the following results are restricted to the period from July 1996 to June 1997. The strongest casualty crash reductions occurred on the same day as enforcement operations involving both overt and covert activity when high levels of mobile radar publicity awareness accompanied this type of enforcement. Non-statistically significant casualty crash reductions were found when high levels of mobile radar publicity awareness accompanied enforcement operations involving overt or covert operations only.

4.5 CONCLUSIONS AND RECOMMENDATIONS

1. Preliminary results do not provide evidence of reductions in casualty crash frequency in outer metropolitan regions due to the use of mobile radar devices. However, this may be due to insufficient data to detect any real crash frequency changes.

2. *In rural Victoria the number of mobile radar units available did not significantly affect the number of hours of operation achieved*. This may be a result of constraints on the number of man-hours available to police for enforcement operations.

3. The rate of detection of offences per hour did not vary significantly with the time of day during which the radar units operated.

4. The effect of the enforcement and associated publicity was found to be greatest during the four days immediately following the enforcement, with the effect diminishing between five and seven days after the enforcement presence. *This suggests the existence of a four-day residual enforcement effect on casualty crashes.*

5. *Casualty crash reductions were found following speed enforcement operations involving either covert enforcement activity (unmarked cars) or both overt and covert enforcement activity (marked and unmarked cars operating together).*

6. No statistically significant effect on casualty crashes was found on the actual day of enforcement activity in rural Victoria. Therefore, *it is not clear that mobile radar activity is effective in reducing casualty crashes in rural Victoria on the actual day of enforcement.*

7. The most significant impact on casualty crashes occurred when high public awareness of media publicity accompanied radar enforcement. However, the effect was greater when high publicity awareness levels were specific to mobile radar enforcement as opposed to when the high publicity awareness levels related to general, speed-related road safety themes.

   Therefore, *publicity relating to specific enforcement programs may be more effective in reducing casualty crashes when accompanying the enforcement than publicity relating to speeding generally.*

8. The strongest effect on casualty crashes was found on the same day as enforcement when high levels of mobile radar publicity accompanied mobile radar enforcement operations involving both overt and covert activity (marked and unmarked cars).

5 FIXED SPEED CAMERAS ON CITY LINK

5.1 BACKGROUND

The commencement of the CityLink project in the late 1990s created a new set of speed enforcement issues that needed to be addressed. The project involved the creation of two new, multi-lane, one-way tunnels of 1.6 and 3.5 kilometres in length. The use of existing enforcement measures in these tunnels was not practical given limited roadside space and high traffic volumes and speeds. To ensure that speed enforcement activity could take place, fixed-position speed cameras were placed in the tunnels and operated on a full-time basis.

The first of the two tunnels, the Domain Tunnel, was opened to traffic in April 2000 and a speed limit of 60 km/h was in operation for about 1 month. The speed limit was then increased to 80 km/h on 3 May 2000. Enforcement operations commenced in mid September and were accompanied by two rounds of advertising relating to the fixed-position speed cameras in the Domain tunnel that commenced on 10 September and 26 September 2000.

5.2 RESULTS

The effectiveness of the fixed-position speed cameras was evaluated in terms of the impact on vehicle speeds in the tunnel (Diamantopoulou and Corben, 2001). Analysis of the effect on the enforcement was conducted with respect to each lane in the tunnel, the day of the week of travel and the hour of the day of travel.

The overall effect of the fixed-position speed cameras was to reduce the proportion of those drivers exceeding the speed limit and to reduce the average speed of vehicles in the tunnel. Average vehicle speeds fell from 75.05 km/h to 72.50 km/h. The proportion of drivers exceeding the 80 km/h speed limit fell by 66%. In addition, the proportion of drivers exceeding speeds of 90 and 110 km/h were also significantly reduced by 79% and 76% respectively.

A lane-by-lane analysis of the effects of the speed enforcement initiative suggests that the cameras were effective in reducing average vehicle speeds and the proportion of drivers exceeding speeds of 80, 90 and 110 km/h in all lanes of the tunnel. However, the effect was greater in the left lane than the right.

The day-by-day analysis also indicated that reductions in these measures of effect were experienced on both weekdays and weekends. In particular, average vehicle speeds were reduced by 2.9% during the week and 5.4% on weekends. Also, the proportion of drivers exceeding the speed limit was reduced by 65% during the week and 68% on weekends.

For the time of day analysis, it was found that the fixed-position speed cameras were effective in reducing both average vehicle speeds and the proportion of drivers exceeding speeds of 80, 90 and 110 km/h for most time periods on weekdays. The most significant reduction was experienced in the afternoon peak period. However, during the morning peak period no reductions in either average vehicle speeds or the proportion of vehicles exceeding 110 km/h were experienced. In addition, there was no reduction in the proportion of vehicles exceeding 110 km/h during the non-peak daytime period.

The cameras were also shown to be effective in reducing average vehicle speeds during all time periods on weekends. Reductions in the proportion of vehicles exceeding speeds of 80, 90 and 110 km/h were also found in all time periods. There was one exception relating to the proportion of vehicles exceeding 110 km/h during the nighttime period. However, this exception may be due to data insufficiency.

5.3 CONCLUSIONS AND RECOMMENDATIONS

1. *Fixed position, automated speed cameras located in the Domain tunnel have successfully reduced the average speed of motorists travelling in the tunnel and the proportion of vehicles exceeding speeds of 80, 90 and 110 km/h.*

2. *Reductions in the measures of effect described in point 1 can be expected to translate into reductions in crash risk and injury risk in the tunnel*.

3. The fixed position speed cameras have had varied effects depending on the lane the vehicle is in, the day of the week and the time of day that the vehicle travels. In particular the cameras have:
   - Been more effective in reducing vehicle speeds in the left lane than in the right;

- Been more effective in reducing vehicle speeds on weekends than during the week; and
- Been most effective in reducing vehicle speeds on weekdays during the peak afternoon period.

No time of day pattern is evident on the weekends.

6 ENFORCEMENT SCHEDULING: THE RANDOM ROAD WATCH PROGRAM

6.1 IMPLEMENTATION

The Random Road Watch program (RRW) of traffic policing was introduced to Queensland during December 1991 in the rural areas of the Southern Police Region. Since that time the program has been extended and it now operates throughout the state. The program aims to allocate enforcement resources in a random way so as to maximise road safety benefits. That is, the timing and location of visible road safety enforcement is randomised. The central aims of this approach are to decrease the ability of road users to predict the location and timing of enforcement activities and to enable the police to cover larger parts of road network than would be the case with conventional policing.

This approach is implemented by using the existing Police structure of regions and districts to select a number of road segments (approximately 40) that will be the subject of enforcement. These road segments are chosen to ensure that roads covering over 50 percent of all road crashes are included in the program. The next stage of implementation involves dividing each day into 2-hour segments for enforcement between 6am and 12 midnight. No enforcement takes place between midnight and 6am each day. A random selection of sites and times is then selected for enforcement activities. The number of hours per week required by each Division is tailored to match Police resources available within each Division.

It is noted that similar programs have been conducted in other jurisdictions and although the outcomes of these are not conclusive they indicate that reductions in crash frequency can be achieved by implementing randomly scheduled police enforcement.

6.2 OUTCOMES OF THE PROGRAM

The RRW program was evaluated in terms of the effect of its implementation on crash frequency over the period of December 1991 to July 1996 (Newstead and Cameron, 1999).

The analysis indicated that for all non-metropolitan areas of Queensland the RRW program resulted in statistically significant crash reductions at all severity levels. The crash reductions increased as the severity level of the crash increased. Examining crash reductions for rural and urban areas separately produced some interesting results. In rural areas, there was a statistically significant 34.3% reduction in fatal crashes but reductions in other crash categories were not statistically significant. On the other hand, urban areas experienced crash reductions for all categories except fatal crashes. However, the failure to identify statistically significant reductions in fatal crashes may be due to insufficient data.

In addition to the variations between metropolitan and rural areas, the outputs and crash effects of the program differed across Police regions. The relationship between the outputs of the program, such as the number of hours of enforcement, and the crash effects of the program in each region was investigated with the aim of determining the mechanisms that drive the program. Significant variations in the offences detected per crash treated and enforcement hours per crash treated were identified across regions. Treated crashes are defined as crashes in the year prior to the introduction of RRW on routes and in time bands enforced by RRW. It was found that the crash coverage of the program (i.e. the percentage of previous crashes in the region covered by the program) was positively related to both the total number of crashes saved and the percentage of crashes saved in the region. The analysis also indicated that total crashes saved and the percentage crash savings are positively related to offences detected and hours enforced, however, these associations were not statistically significant.

The effects of the program over time have also been analysed. The results show that the effect of the RRW program on all crash types except those involving fatalities has increased over time. The effect of the program on fatalities appears to be fairly consistent across the three years immediately following the implementation of the scheme.

Due to data insufficiency it proved difficult to produce conclusive results on the effect of the RRW program in the Metropolitan South Police region that forms part of metropolitan Brisbane. However, in general terms the overall effects in this region appear to be consistent with those experienced in the rest of Queensland. That is, reductions in overall crashes were experienced along with reductions within each year of the programs operation and within each of the crash severity crashes.

6.3 CONCLUSIONS AND RECOMMENDATIONS

1. The RRW program has been successful in producing statistically significant crash reductions at all severity levels in non-metropolitan Queensland. The effect of the program in metropolitan areas has been more difficult to assess.

2. The effect of the RRW program has increased over time for all crash types (except those involving fatalities, for which the effect was approximately constant).

3. From points 1 and 2 above it is concluded that, *randomising the time and location of police road safety enforcement can have significant positive effects on the number of crashes reported and this effect has been shown to increase over time.*

4. The positive effect of the RRW program on crashes of various severities in both rural and urban areas indicates that, *such a program may be as effective on lower speed roads as on open highways*.

5. The association between program coverage and crash effects indicates that in operational terms, widespread but perhaps less intense, randomised enforcement will result in greater crash effects than more intense but less diverse coverage. That is, *the coverage of a randomised enforcement program is a key contributor to its effectiveness*.

6. *Analysis of similar programs in other jurisdictions suggests that the results experienced in Queensland could be reproduced elsewhere.*

7 THRESHOLD LEVEL OF ENFORCEMENT AND THE PERCEIVED RISK OF DETECTION

7.1 BACKGROUND

It is thought that there are minimum levels of increased enforcement that are likely to be perceived by road users, leading to an improvement in compliance and to a consequent reduction in road crashes or their severity. Previously, it had been suggested that there are marked thresholds with respect to the effect of police enforcement on crashes (Bjornskau and Elvik, 1992). A review of many evaluations of mainly manual enforcement operation found few studies demonstrating reductions in violation rates and crashes when the enforcement had been increased by a factor of less than three. Therefore, it was suggested that the amount of enforcement had to be increased by a factor of at least three to have a demonstrable effect.

A more recent review, of both manual and automatic enforcement techniques, does not support the existence of marked threshold effects (Elvik, 2001). The relationship between the amount of enforcement and the level of road safety appears to be quite smooth, with no sharp discontinuities. Elvik reviewed a large number of studies of the effects of varied levels of traffic enforcement on casualty crashes and concluded that the relationship is of the form shown in Figure 1 below.

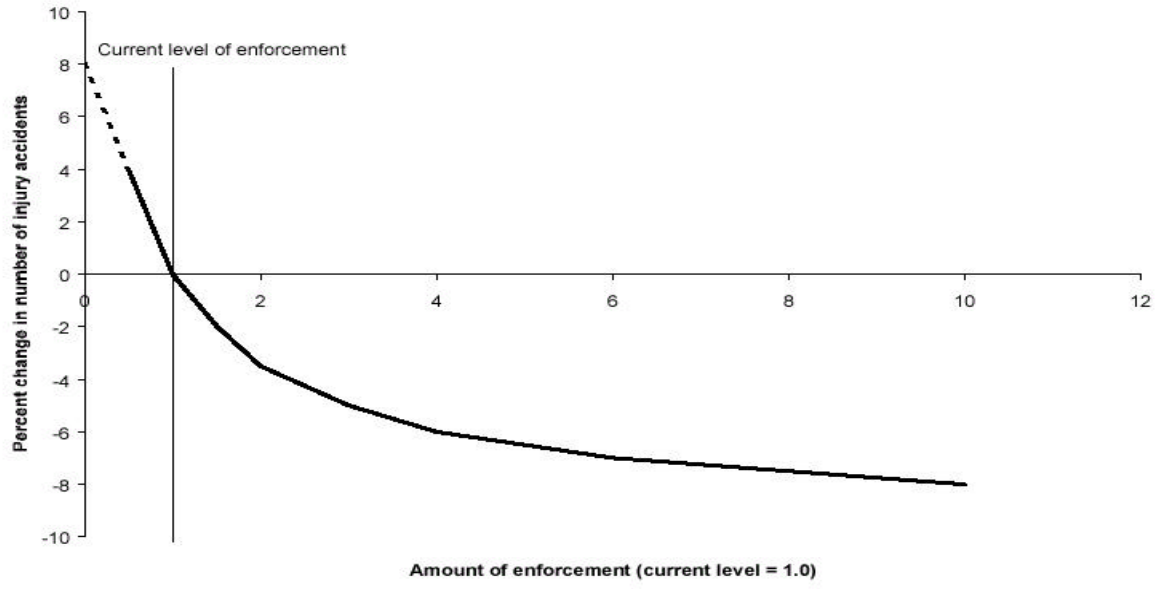

Figure 1: General relationship between traffic enforcement and crashes identified by Elvik (2001)

It is in this context that the mechanisms that translate enforcement into behavioural change were investigated (Harrison and Pronk 1998). Between 8 August 1997 and 18 September 1997 additional speed enforcement (over and above existing levels) was conducted in Police Districts D and Q. The exact level of the increase in enforcement is unknown

however it is believed that enforcement levels increased by between one-quarter and one-third of pre-existing levels. This enhanced enforcement coincided with TAC public educational campaigns targeting driving speed. In addition, enhanced enforcement of drink-driving offences took place during another period shortly after the enhanced speed enforcement.

Surveys of driver perceptions of enforcement were conducted over a four-month period in 1997 and the results presented below are restricted to speed enforcement where possible. Further, the results relate to driver perceptions of both overt and covert speed enforcement.

7.2 RESULTS

The results of the analysis indicate that the enhanced speed enforcement had no significant effect on driver's perceived risk of detection. Little change in enforcement activity was detected by drivers in Police Districts D and Q. Therefore, it is likely that the small increase in enforcement was not sufficient to increase driver's perceived risk of detection. The authors of this study also suggest that any small increases in enforcement detected may need to be experienced over a period longer than 6 weeks to have a significant effect on drivers.

Further results indicate that two groups of drivers in particular pose potential road safety problems with regard to speeding. The first of these groups represented only 8% of the sample. The respondents in this group were more likely to be male and live in metropolitan areas than other drivers. They were also more likely to drive as part of their occupation and have a higher level of exposure to driving risk and enforcement than other drivers. However, despite high levels of exposure to enforcement and a greater likelihood of previous detection for speeding and drink driving, this group reported only moderate perceptions of the risk of detection for speeding. Interestingly, respondents in this group were more likely than others to recall road safety advertising presented on the radio.

The second high-risk group comprised a significantly larger 31% of the sample. The respondents in this category were more likely to be young drivers (18-21 years) and drive in built-up areas during the daytime. These respondents had experienced lower levels of exposure to enforcement activity than other drivers and had relatively low perceptions of the risk of detection for speeding. In addition, these drivers were more likely to consume alcohol than other drivers. However, it is noted that this group was not significantly different to other groups in terms of actual enforcement experience or offence history.

7.3 CONCLUSIONS AND RECOMMENDATIONS

1. *Some research suggests that an increase in visible enforcement must achieve a threshold level for that increase to be effective in reducing casualty crash frequency.* The exact threshold required is unclear, but few studies have shown effects on crashes when visible enforcement is increased by a factor of less than three.

2. Later research of both manual and automatic enforcement techniques does not indicate a threshold with a smooth relationship between the amount of enforcement and the level of road safety.

3. *Two groups of respondents to the survey were found to pose particular road safety problems.* The first of these had a high recall level for road safety advertising

presented on the radio. This group is more likely to be male, live in metropolitan areas, drive as part of their occupation and have higher levels of exposure to driving risk and enforcement.

4. From point 2 above it is concluded that, *effective targeting of the first risk group identified should include radio advertising.*

5. *The second risk group identified poses a potential road safety risk because of the combination of a low perceived risk of detection and the relatively high likelihood of alcohol consumption.*

   Members of this group are more likely to be classified as young drivers, drive in built-up areas during the daytime, experience lower levels of exposure to enforcement activities, have relatively low perceptions of the risk of detection and consume alcohol more than other drivers.

6. From point 4 above it is concluded that, *effective targeting of the second risk group identified should include increasing the actual risk of detection.*

8 DRIVER PERCEPTIONS OF OVERT AND COVERT ENFORCEMENT INITIATIVES

8.1 BACKGROUND

Community perceptions of overt and covert aspects of enforcement, the risk of detection and speed-related skills, attitudes and behaviours are all relevant to the planning of enforcement activities. These perceptions have been explored in a MUARC study that involved a survey of 1000 drivers in metropolitan Melbourne in October 1999 (Senserrick 2000).

8.2 RESULTS

The attitudes of those involved in the survey indicate that an increase in both overt and covert enforcement programs could improve road safety outcomes. In particular, in terms of general speed enforcement, it was anticipated that overt programs would reduce speeds more effectively, although perhaps only in the vicinity of the enforcement sites. In terms of speed camera enforcement, it was anticipated that covert programs would detect more speeding drivers.

It has also been found that Police are perceived as detecting more speeding drivers when they conduct visible operations. In contrast to the results in section 2.2, this suggests that overt enforcement activities act as a general deterrent. On the other hand, when the visibility of Police vehicles is low, enforcement levels are perceived to be low. That is, low visibility operations may not be perceived as covert, but rather they are associated with low enforcement levels. Therefore, the general deterrent effect of covert operations is likely to be low if they rely solely on the visibility of operations to achieve this effect. Other mechanisms of general deterrence are possible, such as word-of-mouth communication about offences detected - a relevant mechanism in the case of Victoria's speed cameras.

Further, two groups of drivers in particular have been identified as having negative speed-related attitudes or behaviours. The first of these comprised mainly of 20-29 year olds, was predominantly male and believed that speed enforcement was overt and that detection could be avoided. This group reported both negative speed-related attitudes and behaviours.

The second group of drivers identified reported very negative speed-related behaviours. They perceived their personal risk of detection as high but were nevertheless prone to speeding behaviour. No bias towards males or females was detected in this group but the group was predominately comprised of drivers under 20 years of age or between the ages of 20 and 29.

8.3 CONCLUSIONS AND RECOMMENDATIONS

1. *Overt Police enforcement operations are likely to have a general deterrence effect. On the other hand, covert operations need to rely on high levels of detection to ensure that specific deterrence is effective.*

2. The negative attitudes and behaviours of the two risk groups identified may need to be targeted in future speed enforcement initiatives.

3. *The first risk group identified could benefit from an increase in their actual risk of detection.*

4. Given that the second risk group already reports a high risk of detection, *the attitudes and behaviours of this group may not be affected by enforcement activities alone.*

9 SPEEDING AND YOUNG DRIVERS

9.1 BACKGROUND

Young, novice drivers are subject to a range of factors that increase their crash risk when compared to other groups in the community. Previous research has indicated that younger drivers are more likely to drive at excessive speeds than older drivers and are also more likely to be involved in speed-related crashes. Evidence that younger drivers are more likely to engage in objectively risky behaviour has also been found. In addition, the driving motivation for a young person may not be purely transport related and these non-transport related motivations may increase the crash risk of younger drivers. The social and psychological factors influencing younger drivers may also result in greater exposure to nighttime driving where conditions are more difficult. Finally, younger drivers may lack the cognitive process to cope with complex or unusual driving situations.

Given the specific issues relating to speeding and younger drivers, the effectiveness of existing speed enforcement programs in relation to younger drivers has been questioned.

A study involving crash data from the period 1995-96 identified some of the key characteristics associated with involvement in crashes. A survey of younger drivers was also completed in September 1997 to enable the investigation of the relationship between enforcement and speeding (Harrison et al., 1999).

It is noted that within this study younger drivers are defined as those drivers aged between 18 and 21 years.

9.2 RESULTS

The data analysis conducted as part of the study confirmed previous results relating to younger drivers and speeding. It is noted that out of control crashes were used as a surrogate for speed-related crashes and this is likely to cause some bias in the results. However, the results detailed below are still considered to apply *a priori* to speed-related crashes.

It was found that speed-related crashes were more likely to involve younger drivers and in particular male drivers were more likely to be involved than any other sex or age group. Also, speed-related crashes involving younger drivers were over-represented on curved road sections, especially in the evening in wet conditions and late at night. These types of crashes were more likely to occur in higher speed zones and males were more likely on average to crash in the evening and late at night than females.

Attitudes towards speeding and speed enforcement were also investigated through the survey of younger drivers. In general, the young drivers surveyed indicated that they could drive more safely at lower speeds than at higher speeds but believed themselves to be safe when driving within the speed limits set in Victoria. However, at higher speeds younger male drivers perceived themselves to be safer drivers than younger female drivers and were more comfortable exceeding the speed limit by 15 km/h than younger female drivers. This suggests that younger male drivers may be over-confident in their driving abilities and hold less safe driving attitudes. Similarly, younger drivers who had been caught speeding reported higher levels of perceived safety than those younger drivers who had not been caught speeding. This may indicate that drivers who exceed the speed limit more often and are therefore detected speeding more often, are over confident in their driving abilities and safety.

The effect of the speed limit on driver behaviour was also examined. The individuals surveyed reported that the speed limit affected their behaviour more when they were driving on residential streets than when driving on main roads. Participants were also more comfortable exceeding the speed limit on main roads than on residential streets despite the perceived risk of detection being greater on main roads. This may indicate a general perception amongst younger drivers that residential streets present more hazards than main roads and it is therefore safer to speed on main roads than it is on residential streets. However, it may also reflect a perception of younger drivers that exceeding the speed limit on residential streets where speed limits are relatively low represents a greater breach of the speed limit than exceeding the higher speed limit on main roads.

Despite the majority of speed enforcement activity occurring during the daytime, younger drivers reported feeling safer exceeding the speed limit during this time of day. This is likely due to the less difficult driving conditions present during the daytime. However, it does indicate that there is *not* a strong link between the perceived risk of detection, which is higher during the daytime, and the perceived safety of exceeding the speed limit.

Further analysis indicated that the effect of exposure to enforcement activity was also a significant determinant of the perceived risk of detection. However, the perceived level of enforcement and risk of detection were not substantially linked to other speed-related

attitudes. This implies that a range of factors other than speed enforcement may affect the behaviour of younger drivers and exposure to speed enforcement may not be the dominant determinant of behaviour.

9.3 CONCLUSIONS AND RECOMMENDATIONS

1. Speed related crashes are more likely to involve younger drivers, particularly younger male drivers. This suggests that *younger drivers present particular problems in relation to speeding, and should be a target for speed enforcement.*

2. Younger drivers are over-represented in crashes occurring on sections of curved road especially in the evening in wet road conditions and late at night. This corresponds with low levels of speed enforcement during the evening and late at night.

3. Point 2 above suggests that, *an increase in speed enforcement activities during the evenings and late at night may be necessary to have an impact on the incidence of crashes involving younger drivers.*

4. No clear relationship between either exposure to enforcement or the perceived risk of detection and other speed-related attitudes has been found. This indicates that, *future enforcement programs aimed at younger drivers need to do more than rely on high level of enforcement*.

5. Point 4 above is supported by the fact that younger drivers who have previously been detected speeding continue to have unsafe attitudes towards speeding behaviour.

6. Previous MUARC research suggests that the following characteristics may be useful elements of future enforcement programs aimed at younger drivers:
   - *A focus on personal (actual) risk of detection* would be expected to have a greater effect on behaviour than a more general perceived risk of detection.
   - Public education programs accompanying increased enforcement could focus on those younger drivers more likely to be involved in crashes including; males, people who drive for social reasons at night, and drivers with histories of offending.

10 GENERAL PRINCIPLES

Although each of the conclusions and recommendations made throughout this report relate to specific enforcement programs or studies of driver perceptions, some general themes can be identified. In particular, significant conclusions about the general deterrence effect of overt enforcement, significant risk groups and the effect of publicity on road trauma can be made. Further, these conclusions can be translated into principles for use in the planning of future enforcement operations.

10.1 GENERAL RESULTS

Prior to discussing the principles arising from the areas identified above, it is useful to make some more general comments about principles of speed enforcement.

First, it is noted that all types of speed enforcement examined by MUARC have led to at least some positive impact on either casualty crash frequency, crash severity or driver behaviour. In most cases this effect has been significant. However, the effectiveness of the enforcement program may depend on the appropriateness of the speed enforcement device or scheduling method for the road type on which the program operates. The research suggests that the following conclusions are relevant in this context:

- Speed cameras are effective in reducing casualty crash frequency on arterial roads in metropolitan Melbourne and country towns and on highways in rural areas. These devices are also effective in reducing crash severity in Melbourne.
- Mobile radar devices are effective in reducing casualty crashes in rural areas on undivided roads in 100 km/h speed zones. Analysis of the effects of mobile radar devices in outer metropolitan areas was inconclusive.
- Hand-held laser speed detection devices are effective in reducing casualty crash frequency, but not severity, on arterial roads in metropolitan Melbourne.
- The RRW program is effective in reducing crashes of all severity levels in non-metropolitan areas. The effect of the program in metropolitan areas is unclear.

It is noted that the use of laser devices was intended to alleviate problems associated with speed detection using hand-held radar devices on arterial roads. In addition, mobile radar devices were primarily intended for use on two-way, undivided, 100 km/h speed limit roads in rural areas where it is difficult to use speed cameras covertly. It is therefore evident that speed detection devices work best when used on the road type for which they were intended. This indicates the following principle:

Principle 1: The use of different types of speed enforcement devices should concentrate on the road type or geographical region for which their use is intended.

The second important general result relates to the duration of the impact of speed enforcement. The analysis of speed cameras and mobile radar devices has produced important results in this area.

It is important to note a number of key differences between these devices. First, the use of speed cameras in Victoria is largely covert and infringement notices issued as a result of speed camera operations are usually received one to two weeks after the offence occurs. In addition, speed cameras are able to detect large volumes of speeding motorists per enforcement hour. In contrast, an offender detected speeding by a mobile radar device is issued with an on-the-spot fine in a deliberately overt manner. Also, the volume of speeding motorists detected by mobile radar devices per enforcement hour is lower than that for speed cameras. Differences in the duration of the enforcement effects are also evident. Speed camera enforcement operations have been shown to impact on casualty crash frequency during the two weeks after the infringement notices are received. The exact duration of the effect is unclear. On the other hand, mobile radar enforcement was found to have the greatest effect during the four days immediately following the enforcement operations.

Differences in the duration of the enforcement effects are important issues to consider when planning future speed enforcement programs. However, it is unclear which of the differences between the two enforcement programs result in the different duration of the enforcement effects. It is therefore difficult to extend these findings to speed enforcement programs operating under different conditions.

Principle 2: The duration of the effect of overt speed enforcement programs resulting in visible issuance of on the spot fines issued at the time of the offence is likely to be more immediate but shorter than the effect generated by a delayed issuance of infringement notices resulting from covert operations which detect many offences per enforcement hour.

10.2 EFFECTS OF OVERT SPEED ENFORCEMENT

As with any form of enforcement program, the effectiveness of overt speed enforcement may be due to the effect of specific deterrence, general deterrence or some combination of the two. There appears to have been some conflict as to whether overt enforcement has a significant general deterrence effect. Given the extensive use of overt speed enforcement in Victoria, some discussion of this conflict is necessary.

First it is noted that the initial introduction of the speed camera program in Victoria involving the overt use of cameras had no overall impact on casualty crash frequency. In addition, some research indicated that no relationship between the amount of enforcement seen by drivers and a driver's perceived risk of detection could be found. These results indicate that speed enforcement operations may not have a general deterrence effect.

On the other hand, more recent research relating to laser speed detection devices found that the use of these devices resulted in a significant decrease in casualty crashes. This supports the proposition that overt enforcement activity can have a significant impact on casualty crashes and has a general deterrence effect that may be localised in space.

This has a number of implications for future enforcement programs. First, given the available evidence it appears that the latter results and explanation are reasonable. Therefore, the general effect of overt speed detection programs can be increased by expanding the geographical coverage of the enforcement sites. In terms of future enforcement operations this suggests the following principle:

Principle3: T*o maximise the general deterrence effect of overt enforcement programs, these programs should involve low to medium intensity speed enforcement at multiple sites on the road network.*

In addition to the localised, general deterrence effect of overt speed enforcement, it has been suggested that some forms of speed enforcement have a specific deterrence effect. This effect is primarily used in the speed camera program where the receipt of TINs and has been shown to impact on subsequent speeding behaviour, and consequently on the number of casualty crashes occurring. Early research relating to the period from 1990 to 1993 showed that the receipt of TINs for speeding offences resulted in reductions in casualty crashes. However, similar analysis using data from 1994 to 1996 found evidence of reductions in crash severity but not crash frequency as a result of the receipt of TINs.

The change in the effect of the receipt of TINs suggests that the specific deterrence effect of speed camera enforcement may have declined over time. This decline may be in part due to changes in the public's attitudes towards receiving TINs. The public may have become accustomed over time to receiving TINs and consequently may no longer adjust their driving behaviour. Alternatively, the magnitude of the penalties may not have been sufficient to deter speeding behaviour. Further research into this area is required to

determine whether speed enforcement programs continue to have adequate specific deterrence effects.

10.3 SPECIFIC GROUPS AT RISK

A number of specific groups have been identified as presenting particular road safety problems in regard to speeding. Having identified these groups it is then necessary to formulate enforcement programs or other measures that can be targeted towards these groups and have positive impacts on their behaviour and crash involvement.

The following groups of drivers may need to be the target of specific programs in future. First, it is noted that for two particular groups of drivers, enforcement may not be sufficient to alter their behaviour. It is also noted that there is some overlap between these two groups.

The first group is those classified as younger drivers. For this group, it was found that enforcement is unlikely to be the dominant determinant of behaviour. Therefore, enforcement alone is unlikely to be sufficient to address the behaviour of this group. This suggests the following principle:

Principle 4: Public education campaigns should play an important role in targeting younger drivers particularly when accompanied by a significant increase in speed enforcement activities during the evenings and late at night.

The focus of education campaigns should be on the particular biases of those young people involved in crashes including biases towards males, car owners, those who drive for social reasons at night and people with offence histories. In addition, advertising specific to the road conditions in which these drivers face difficulties would be useful.

The second group of drivers for whom enforcement is unlikely to affect behaviour is also likely to benefit from an education campaign. This group is comprised of those drivers under the age of 20 and those drivers between the ages of 20 and 29 who perceive their personal risk of detection as high but are nevertheless prone to speeding behaviour.

Three further groups were identified as possible targets of future enforcement initiatives. The first of these groups had a high recall level for road safety material presented on the radio. This group is more likely to be male, live in metropolitan areas, drive as part of their occupation and have higher levels of exposure to driving risk and enforcement.

Principle 5: Targeting of drivers who drive as part of their occupation and possess the other specific characteristics detailed above should involve radio advertising.

The second group identified has a low perceived risk of detection combined with a relatively high likelihood of alcohol consumption. Members of this group are more likely to be classified as young drivers, drive in built-up areas during the daytime and experience lower levels of exposure to enforcement activities.

The final group comprised mainly of 20-29 year olds, was predominantly male and believed that speed enforcement was overt and that detection could be avoided.

Principle 6: Targeted enforcement programs aimed at the identified groups of drivers who are either exposed to lower enforcement levels or believe that enforcement can be avoided must involve an increase in the actual detection of offences.

Given the characteristics of these two groups, increasing the actual level of offences detected amongst these groups should alter perceptions of the levels of enforcement and the risk of detection when speeding.

10.4 TAC ROAD SAFETY PUBLICITY

TAC road safety publicity aimed at increasing both awareness of specific enforcement programs and general public awareness of safety issues has been integral to the implementation of many speed enforcement programs in Victoria. Such publicity is generally run to increase the general deterrence effect associated with new or existing enforcement programs.

The results from the studies discussed above indicate a number of underlying themes. First, in all instances examined, publicity supporting enforcement programs has apparently been effective in magnifying the effects of the enforcement program. These magnified effects have been evident over a range of road types. Also, the combined effect of speed enforcement programs and publicity is highly cost beneficial. This leads to the following principle:

Principle 7: The use of enforcement-related advertising in future enforcement programs should increase the effectiveness of such programs and will contribute to the cost-beneficial nature of those programs.

It is noted that publicity supporting speed enforcement programs is more effective in reducing crashes when it is specific to the enforcement rather than when it encompasses more general speed-related themes.

High profile media activity has also been found to be effective in reducing casualty crashes even when enforcement levels are low.

Principle 8: In the short-term, high profile publicity can be used as an effective interim measure to reduce crash frequency when enforcement levels are low.

11 CONCLUSION

MUARC's evaluations of speed enforcement to date have shown that speed enforcement initiatives conducted in Victoria in recent years have successfully contributed to reductions in road trauma. However, the current study highlights a number of areas in which further research is required to more fully understand the mechanisms at work and the effectiveness of enforcement operations in a variety of environments. In particular, it would be valuable to consider the following issues in the context of future speed enforcement research:

- The interaction effect between publicity and enforcement operations
- The duration effect of enforcement in its variety of forms
- The use of fixed-location automatic surveillance techniques outside of a tunnel environment to determine the efficiency and effectiveness of the enforcement

- The influence of reduced speed offence threshold levels on speed behaviour and casualty crashes
- The relative effect of randomised scheduling of speed enforcement operations in Victoria compared with current practices

Further, there are a number of issues that have not been examined in detail that would add to current knowledge on speed enforcement. Specifically, issues relating to the issuing and processing of traffic offences within the administrative and judicial systems are relevant to the effectiveness of enforcement operations. The perception of these systems by road users may provide an understanding of some of the mechanisms behind effective operations.

Finally it is noted that the effect of speed enforcement initiatives may change over time and the outcomes of this review should be updated and supplemented by future research in this area.

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