**Department of Civil Engineering**

# The Sustainability of Towards Zero Strategy: Examining Speeding, Enforcement Measures and Road Users' Attitudes

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**of**
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# DECLARATION

To the best of my knowledge and belief that this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: …………….

Date: …………….

# DEDICATION

To My Beloved Family

# ABSTRACT

Worldwide, speeding is considered to be a major factor contributing to road crashes. Many key Australian organisations have identified speeding as an ongoing concern. However, many states in Australia, including Western Australia, have come a long way in reducing crashes and are now working towards the goal of getting drivers to slow down and comply with speed limits. This ambition is behind the 'Towards Zero' strategy that authorities in WA have embraced. Safe speeds are one of the cornerstones of that road safety strategy. The Safe Speeds initiative has the potential to save 3200 people from being killed or seriously injured over the 12 year life of the strategy. Lower speed limits may help to realise this aim. Many countries in the world are embracing lower speed limits in urban areas, including Perth in WA. Lower speed can play a vital role in the future of road safety in Australia due to the significant rewards towards sustainable benefit that can bring to safer urban cities.

Although the 40km/h school zone speed limit has been in use for many years and research progress made during the last decade, there are still significant gaps in knowledge on drivers' speeding behaviours, enforcement and road users' attitudes within the 40km/h zones. This gap needs to be addressed by extending the knowledge of these factors, which in turn can be applied to other roads if the 'Towards Zero' strategy is to progress in terms of two the main pillars: 'Safe Speed' and 'Safe Road Use'.

There are 1072 public and private schools with a 40km/h school zone across WA. Therefore it is vital to study these school zones in terms of safety and reflect upon whether these zones can be used in other areas such as shopping strips and many commercial and industrial roads. In line with the above, authorities have recently decided to use new electronic 40km/h signs in one shopping centre and have used standard signs elsewhere, the study has find an important case study to examine the two roads. Moreover the effectiveness of 40km/hr, as a low speed limit may need to be investigated compared to other speed limits such as 60km/h, which is a very common speed limit around Perth commercial roads. This approach would also fill a gap in the current knowledge.

This research targets all aspects of the use of electronic signs displaying the 40km/h speed limit. The objectives of this study were to generate extensive knowledge of speeding behaviours taking place in areas where electronic 40km/h school zone signs are in use and then compare this to speeding behaviours and crashes taking place in non-school zones . In addition to compare the incidence of crashes and the speeding behaviour in the 40km/h non-school zones on the basis of two different engineering measures, i.e. the electronic signs verses the standard signs. Further is to identify the age group of the drivers who constitute the highest risk in terms of pedestrian crashes and speeding in the 40km/h school and non-school zones. Including the modelling of the speeding behaviour of drivers before and after the installation of the 40km/h speed limit within the non-school zones. Provide evidence for the contribution of the 40km/h electronic signs to reducing the incidence and severity of crashes and/or speeding enforcement in comparison to 60km/h roads with standard signs. Furth more it is to examine behavioural attitudes toward the 40km/h limit and reveal the different social, technical and delay concerns. Finally is to reveal the roader attitudes of Perth road users toward the strategic speed enforcement initiatives by converting all Australian Auditor-General Reports into questionnaires.
These above objectives have been successfully achieved in this PhD study.

First, the electronic 40km/h school zone signs made a positive contribution, as the pedestrian crash rate for younger school pedestrians 2–16 years old was lower than for other age groups, with the sharpest negative trend. Speeding behaviour also seemed to be lower within the school zones than within non-school zones. Chi-square analysis revealed that roads within non-school zones showed higher levels of speeding compared to the school zones based on ‘on-the-spot’ detection, where there was an association between speeding levels and the environment (school or non-school zones). There is much evidence to suggest that, within non-school zones, the electronic signs are may be delivering the desired result, in terms of improving speeding behaviour and reducing crashes.

Second, in terms of reducing crashes and speeding, the research found that within the non-school zones, the electronic signs are outperforming the standard 40km/h signs with standard road markings. Different lane widths may also contribute to speeding behaviour, as every time the drivers showed a tendency to speed once they had left the narrow width sections and entered the wider lanes.

Third, results demonstrated the significant effect of ‘on-the-spot’ detection upon risk-taking by young drivers under three different speed limits (40, 50 and 60km/h) and across all age groups, In addition, regardless of detection types (‘roadside’ or ‘on-the-spot’), younger drivers appear to be taking more risks on roads with higher speed limits. On-the-spot detection showed that younger drivers are frequently detected speeding with higher speeding levels away from the speed limits compared to the ‘roadside’ detection method, which was unable to detect the higher speeding levels that are much away from the limit. Analysis revealed an association between male drivers and higher speeding levels that are much away from the limit.

Fourth, the modelled speeding data showed that drivers slowed down after the installation of the flashing electronic 40km/h signs. The time of the day was also found to be significant in the model around non-school zones, where more TINs (Traffic Infringement Notices) recorded in the afternoons than in the mornings. These results support the usefulness of such signs in reducing speeding within non-school zones. They could be a promising tool for use elsewhere, such as around busy shopping centres inside busy municipal roads.

Fifth, the study found that the rate of TINs/hr around 40km/h roads was higher than on 60km/h roads, but also showed, importantly, that crashes were less frequent and less severe on the 40km/h roads than on the 60km/h roads. From a sustainability viewpoint, it is more appropriate to recommend a strategy that results in more TINs and less severe crashes than otherwise. Moreover, across all the speed limit zones in Perth, 38% of road crashes occur in 60km/h zones, while less than 2% occur in 40km/h zones.. It was found that targeting more speeders on the spot for excessive speeding in 60km/h zones is vital. The study concludes that increasing the number of roads with a 40km/h speed limit will contribute to the development of a road user culture that meets the fundamental aims of the Towards Zero strategy. This means the more the roads with 40km/h available, it would become a practice for road users initially which can become a culture that will contribute to the fundamentals aim of Towards Zero Strategy. The 40km/h variable signs will be used where and when there are pedestrian-vehicle conflicts, and not necessarily in roads that have less pedestrians In addition, the study found it was crucial to increase the number of hours of the on-the-spot speed enforcement in roads with a limit of 60km/h. Therefore, if roads are converted to 40km/h zones, these hours of detection will monitor the 40km/h rather than the 60km/h speed limit, which would increase the level of slower speed awareness, another aim of the Towards Zero strategy under the pillar of safe road use. Therefore, for the benefit of the community, politicians and the public may need to support such socio-political decisions as converting some of the risky 60km/h limit roads into 40km/h zones where appropriate.

Sixth, in terms of attitudes toward the use of electronic 40km/h speed limit signs along the shopping strip (a non-school zone), the study found that the mean rate responses for the day zone delay concerns reached 74%, whereas acceptance of the night zone preference reached 64%. This shows that drivers are willing for authorities to apply the 40km/h limit only at night-time when roads are quiet. Multi variance analysis of variance analysis (MANOVA) showed a statistically significant difference for drivers obeying the 40km/h limit sign, and the Australian group were the most concerned about implementing the 40km/hr limit during the day due to delay concerns. They recorded the highest mean rate response of concern at 77%. The European group did not believe that delays were caused by the 40km/h speed limit, but rather by traffic signals. A statistical difference was also found between male and female drivers, with male drivers' believing that 40km/h during the day is too slow a speed limit. Importantly, the 18–29 year age group was the most concerned about the 40km/h day zone implementation compared to other age groups. Surprisingly, they also recorded the lowest mean response rate of all age groups for the implementation of a 40km/h night zone limit. Their attitude was against the implementation of the 40km/h limit all together, preferring to leave the 60km/h speed limit unchanged.

Seventh, drivers from non-industrial environments were more likely to approve the idea of speed awareness courses than drivers from industrial areas. Out of the five visual initiatives, there was a high level of approval for the presence of more police on the road for safer speed behaviour. Similarly, cameras at locations with crash history would increase public confidence and this also received a high level of approval by road users.

Based on approval levels, drivers indicated that authorities need to select the right locations in order to reduce the incidence of crashes. This means that it is better to get the location right at the start rather than removing the speeding camera at a later stage. Most interestingly, road users showed little approval for publishing camera locations. In terms of non-visual initiatives such as those that deal with policymaking, tougher demerit rules to deter speeding drivers were seen as important. This high percentage of demerit rules could be more common matter to all states in Australia and it is a appearing to be of most priority similar to LOA (Level Of Approval) regarding the presence of police on the road. Hence, tougher demerit rules and greater police presence may be considered a priority for the authorities. In the case of tougher demerits for repeat offenders, most comments suggested that tougher demerits would remove dangerous drivers from the road system resulting in an overall decrease in dangerous drivers with the removal of repeat offenders. Similarly, police presence would focus on the same target by deterring drivers from speeding.

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# LIST OF PUBLICATIONS

## Chapter in a Book

**Zuhair Ebrahim and Hamid Nikraz.** Harm minimisation in a school zone: a strategy for sustaining pedestrian safety. *Urban Street Design & Planning,* edited by Professor A. Pratelli, University of Pisa, Italy. PP 65-72, WIT Press **2014,** UK. ISBN978-1-84564847-3

## Journal Papers published

1. **Zuhair Ebrahim and Hamid Nikraz**. Examining attitudes towards safe speed to protect pedestrians. *International Journal of Transportation Science and Technology* **2012,** 4: 319-333.

2. **Zuhair Ebrahim and Hamid Nikraz**. Management of Speeding Comparing two Applied Engineering Measures, *International Journal of Management and Production Engineering Review* **2013**, 4: 1-5.

3. **Zuhair Ebrahim and Hamid Nikraz.** A concern about young drivers in Perth. To appear in the *International Journal of Sustainability Development and Planning* **2015**.

4. **Zuhair Ebrahim and Hamid Nikraz**. Multivariate statistical analysis of speed camera system in Australia. To appear in the *International Journal of Transportation Science and Technology* **2014**.

5. **Zuhair Ebrahim and Hamid Nikraz**. A multivariate model on speeding in urban road. To appear in the *International Journal of Safety and Security Engineering* **2014**.

## Conference Papers Presented

1. **Zuhair Ebrahim and Hamid Nikraz**. Towards protecting pedestrians as road users. *International Seminar on National Road Development Strategies & Road Safety on Improved Highways*, **2011**, 14-16th March, New Delhi, India.

2. **Zuhair Ebrahim and Hamid Nikraz**. Strategic plan to enforce changes in speeding behaviour Australian vs. Indian perspective, *6th International Road Federation Conference: Road Safety in India - Action Plan*, **2011**, pp165-171, 3-5th October, New Delhi, India.

3. **Zuhair Ebrahim and Hamid Nikraz.** Examining attitudes Towards safe speed to protect pedestrians, 1st *Forum of Traffic Safety* **2011**, 12-14th December, Dammam, and KSA.

4. **Zuhair Ebrahim and Hamid Nikraz.** Targeting speeders on Perth roads. *1st National Conference on Intermodal Transportation: Problems, Practices, and Policies* **2012**, 11-12th October, Hampton University Virginia, USA.

5. **Zuhair Ebrahim and Hamid Nikraz.** Harm minimisation in a school zone: A strategy for sustaining pedestrian safety: *18th International Conference on Urban Transport* **2012**, 14-16th May, Coruña, Spain.

6. **Zuhair Ebrahim and Hamid Nikraz.** Safe speed on urban roads. The 12 PRI World Congress, **2012,** 6th - 9th June, Marrakech Morocco.

7. **Zuhair Ebrahim and Hamid Nikraz.** Before -After studies to reduce the gap between road users and authorities, *19th International Conference on Urban Transport* **2013**, 29-31st May, Kos, Greece.

8. **Zuhair Ebrahim and Hamid Nikraz.** Safe speed on urban roads. 16th Road Safety on Four Continents Conference, Accepted but not presented. **2013,** 15th -17th May. Beijing, China.

9. **Zuhair Ebrahim and Hamid Nikraz.** Gap reduction on a range of sustainable initiatives on speed camera system in Australia, *2nd Forum of Traffic Safety:* **2013**, 4-6th December, Dammam, Kingdom of Saudi Arabia.

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# CHAPTER 1 INTRODUCTION

## 1.1 Background

Road injuries are a pressing global concern. About 1.24 million people die each year as a result of road crashes (World Health Organization, 2013). They predicts that without action, road crashes will result in the deaths of around 1.9 million people annually by 2020. One of the most important pillars of the UN road safety plan for the next ten years is enforcing a change in risky behaviour to move towards safer road use (United Nations General Assembly, 2011). One persistent concern arising from this human behavioural calamity is speeding. It is not only an issue in developed countries such as the USA, Europe and Australia, but continues to be a cause of alarm in many countries in Asia, Africa and the Middle East. Researchers around the world have emphasised one common goal and that is to reduce vehicle driving speed (U.S. Department of Transportation, 1999; Oxley, Diamantopoulou and Corben, 2001; Preusser et al., 2002; Mohan, 2010). Researchers also agree that in order to ensure that drivers comply with the new reduced speed limit, enforcement measures are an essential complementary component.

In Australia, the lowering of speed limits has been the responsibilities of road authorities. For instance, a review of international speed limits (comparing Australia to other OECD countries) found that Australia's limits were higher than those found elsewhere, including in Europe and North America (Austroads, 2005). Austroads (2005) recommended that in order to further reduce road injury rates, more must be done to lower speed limits which are considered to be a critical component in achieving this outcome. This Austroads report also revealed that EU countries have utilised harm minimisation principles as the basis for setting speed limits.

In Western Australia (WA), the government has initiated the ambitious 'Towards Zero' road safety strategy 2008-2020, aiming to minimise all type of road fatalities and focusing on two important cornerstones ‘safe speeds’ and ‘safe road use’. The WA (West Australian) Government wanted to aim that speed limits and travel speeds are appropriate for the safety of the road infrastructure. They have also introduced a 40km/h limit around school zones and recently around one shopping centre in order to minimise crashes by requiring drivers to slow down. Authorities have decided to use new flashing electronic 40km/h signs in some areas and standard signs elsewhere, the effectiveness of which will be investigated in this study.

The success of the new 40km/h speed limit requires safe driving behaviours and the right attitudes. Since attitudes are the result of behaviours, this study will investigate both. Authorities were found to measure speed of the travelling vehicles using the 85% percentile on the new limit, but there are still gaps in the knowledge about the relationship between the 40km/h speeding rates and the incidents and severity of crashes. Such knowledge is important for determining how much benefit can be gained from the implementation of the 40km/h speed limit. It is known to authorities that there is a high incidence of pedestrian crashes resulting in serious injuries on roads with a 60km/h speed limit. Some busy roads with pedestrians may need to be converted to a lower limit such as the 40 km/h limit. This can be done by identifying the nature of different suburbs, be they commercial, residential or industrial, and investigating them with respect to speeding, crashes and speeding enforcement levels.

Another area needing further investigation is the attitude towards speeding in 40km/h zones. A speed of 40km/h may be considered slow by many drivers. This needs to be investigated in terms of social, technical and stress-related delays. The study also includes a survey on Australia’s speed enforcement, based solely on the Auditor-General’s reports on speed cameras and enforcement in seven Australian states. This sort of survey has never been done before, nor this sort of data collected. It will expand the understanding of attitudes on those areas and will also include an educational component including awareness courses for repeat speeding offenders in the abovementioned commercial, residential and industrial areas.

## 1.2 Scope and Objectives

The study aims to provide an understanding of the 40km/h speed limit, which would then add to the knowledge of the 60km/h limit. The main objectives of this research project are to:

1. Generate extensive knowledge on the speeding behaviours relating to use of the electronic 40km/h school zone signs, and then compare that to the non-school zones in terms of speeding behaviours and crashes.
2. Compare the incidence of crashes and the speeding behaviour occurring in non-school 40km/h zones on the basis of two engineering measures, i.e. electronic versus standard signs.
3. Identify the age group of the drivers who are at the greatest risk in terms of pedestrian crashes and speeding in 40km/h school and non-school zones.
4. Model the speeding behaviour of drivers before and after the implementation of a 40km/h speed limit within non-school zones.
5. Provide evidence of the contribution made by the electronic 40km/h signs to reducing the incidence and severity of crashes and/or enforcing speed limit in comparison to 60km/h roads with standard signs. This evidence may guide policymakers to further target the reduction of pedestrian KSI (Killed or Seriously Injured) in 60km/h zones by implementing a lower speed limit such as 40km/h, as well as using the electronic signs.
6. Examine behavioural attitudes towards the 40km/h limit and reveal the different social, technical and delay concerns.
7. Reveal the broader attitudes of Perth road users towards the strategic speed enforcement initiatives by converting all of the Australian Auditor-General Reports into questionnaires for use as a survey.

## 1.3 Thesis Outline

There are a total of nine chapters in this thesis (including this chapter). The large number of chapters was chosen for ease of reading. The thesis structure is shown in Figure 1-1, and details are as follows:

Chapter 1: Introduces the background and objectives of the research.

Chapter 2: Reviews the speeding-related literature to date and identifies existing research gaps on speeding enforcement in 40km/h zones.

Chapter 3: Summarises the methodology employed to achieve the research objectives and explains the analytical and statistical techniques used.

Chapter 4: Investigates the effect of speeding-reduction measures in two 40km/h environments (school and non-school zones). It includes a case study on the age group most likely to pose a risk to pedestrians on 40km/h roads.

Chapter 5: Investigates the effect of two different speeding intervention measures in 40km/h zones along two of the busiest shopping strips in Perth.

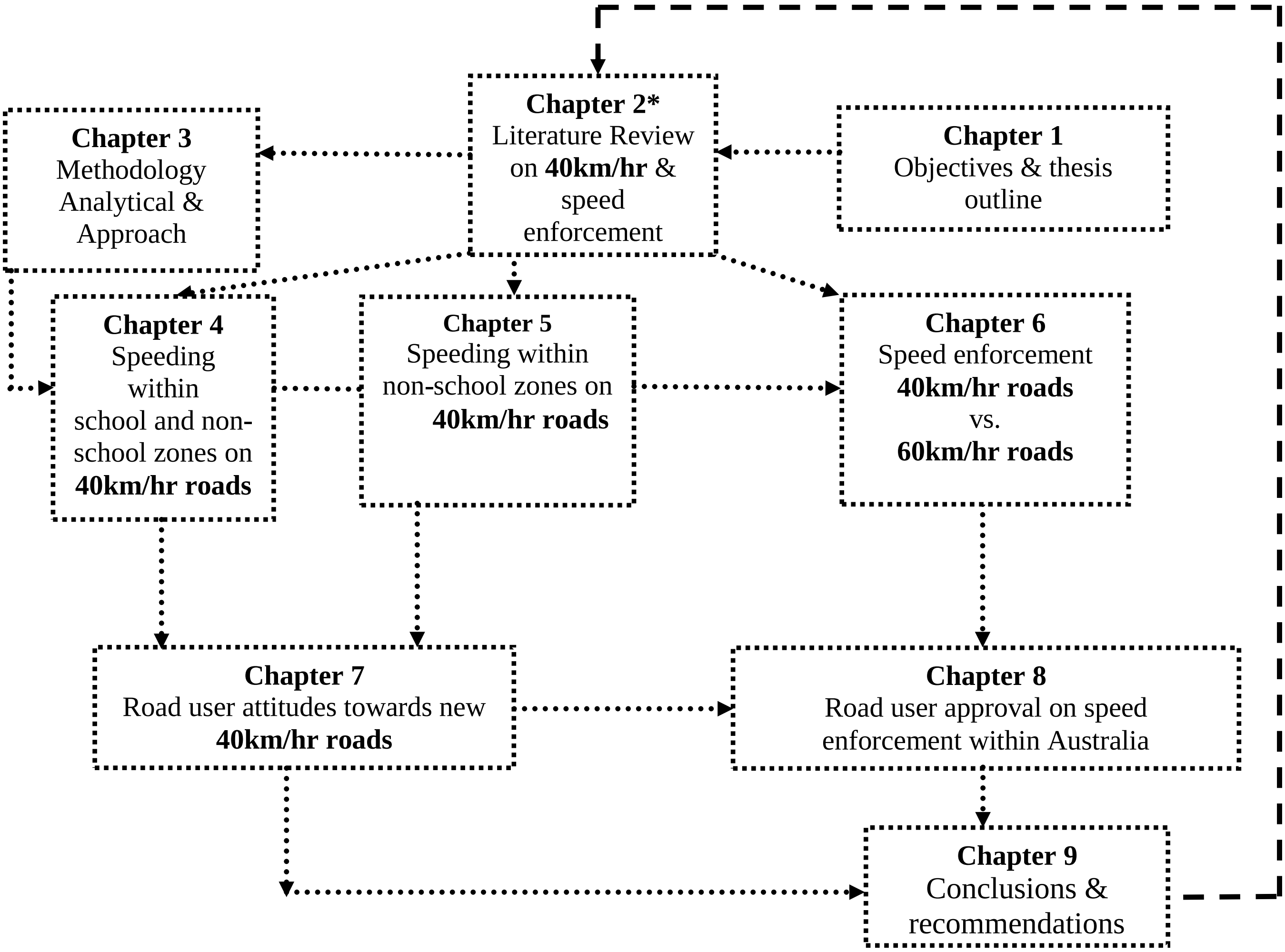
Chapter 6: Compares the effect of speed enforcement on the incidence of crashes, on both 40km/h and 60km/h roads.

Chapter 7: Examines evidence on road user attitudes towards the 40km/h speed limit, and explores these attitudes.

Chapter 8: Investigates the approval of road users towards speed enforcement measures used in Australia.

Chapter 9: Concludes the study and makes recommendations for future work.

* Each chapter will have **Bold** & *Italic* texts at each section where appropriate to highlight important findings.




* Each chapter will have **Bold** & *Italic* texts at each section where appropriate to highlight the important findings.

Figure 1-1: A schematic diagram of the research examining the sustainability of the 'Towards Zero' speed enforcement measures

# CHAPTER 2 LITERATURE REVIEW

## 2.1 Introduction

This research attempts to collect the literature relevant to the 40km/h speed limit investigated in this study. The use of this speed limit in Perth is important as it may contribute to harm minimisation by reducing pedestrian crashes if adopted in the busy areas of Perth instead of the current 60km/h limit. Although the 40km/h limit has been used in Australia, Europe, Canada and the USA, there has been little research on the subject. A search found that, despite almost a decade of research, there are still significant gaps in the knowledge regarding driver speeding behaviours, enforcement and road user attitudes regarding 40km/h zones.

The literature review will be based on two major zones, including the 40km/h zones around primary and secondary schools, and the 40km/h non-school zones around commercial areas, such as shopping centres and shopping strips. Both will be discussed in Chapters 4 and 5. The review will also investigate 60km/h zones as the study will focus on the use of this speed limit on urban busy roads, to be discussed in Chapter 6. Therefore literature review will investigate six major sections based on the above zones (see Figure 2-1).

The first includes the type of signs and the appropriate design selected and the other three are dealing with safety behavioural components surrounding the signs environments in terms of speeding, enforcement and pedestrian road crashes. It will also include the 60km/hr speed limit roads. The purpose of this is to compare such safety behavioural aspect in those higher speed limits. The remaining two deal with attitudes at two levels; the first being attitudes towards speeding within 40km/h and the second being attitudes on speeding enforcement within the Australian jurisdiction. It is believed that these are the most important elements against which the 40km/h electronic signs can be tested in terms of their usefulness. The review will be divided up into literature on:

2.2 Design of 40km/h traffic signs design.
2.3 Speeding.
2.4 Speeding enforcement.
2.5 Pedestrian road crashes.
2.6 Speeding attitudes (See Chapter 7)
2.7 Speed enforcement from Australian Auditor-General reports (See Chapter 8)

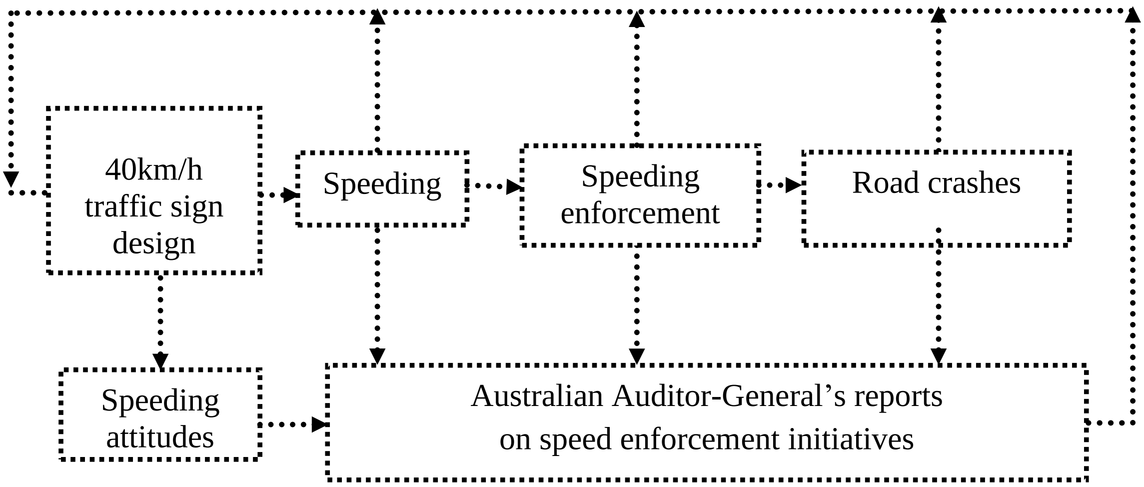



Figure 2-1: Systematic literature search on road user speeding, speed enforcement, crashes and attitudes

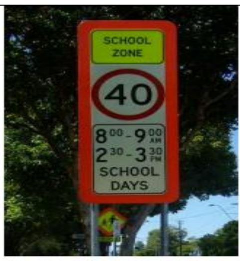
## 2.2 40km/h Traffic Sign Design

This topic is discussed in two sub-sections dealing with school zones and non-school zones.

### 2.2.1 Ideal Traffic Sign Designs for School Zones (40km/h)

In a bid to conduct regular audits of school zones to identify key safety issues, authorities have recently conducted a major survey of school zone signs. It found that two-thirds of the school zone signs investigated throughout south-eastern New South Wales and the ACT (Australian Capital Territory) have not been upgraded to the Australian standard, which uses a fluorescent yellow-green colour. The remaining third were hard to see because they were obscured by trees or other roadside clutter (NRMA, 2013).

The literature search also revealed that many studies in recent years have attempted to find the best solution for the school zone engineering measures, such as line markings, fluorescent signs or flashing signs, solar powered signs etc. For instance, an early study in Atlanta found that school zone signage appeared to have no influence on driver behaviour at the sites studied (Young and Dixon, 2003). In Queensland, Australia, a recent study by Singh (2011) tested four types of school zone signs which had been installed to determine whether any particular type of sign was more effective than the others (see Figure 2-2). It was found that the enhanced school zone sign was the most effective. An enhanced sign consists of a standard school zone sign incorporating a flashing red annulus and twin alternate flashing yellow lights mounted above the ‘school zone’ plate. The lights flash during the operation of a school zone. According to the Department of Transport and Main Roads (2012), these signs will be installed at approximately 330 school zones, covering 300 schools over the next four years starting from 2013. Authorities believe that these signs will draw motorists’ attention to the operation of the school zones. Foley (2012) reported that some schools in Queensland were split-campus schools which places students at a higher road safety risk due to having to travel between campuses. Authorities have therefore decided to enforce all-day school zones in these instances.




Static school zone speed limit sign (also installed in advance of signs shown below)


Enhanced School zone speed limit sign (flashing light school zone sign)


Variable speed limit sign (installed in conjunction with static school zone sign)


Vehicle activated “SLOW DOWN” speed limit sign (installed in conjunction with static school zone sign)

Figure 2-2: The four school zone signs trialled in Queensland

For the state of New South Wales, a study by Roper et al. (2006) investigated four types of signs (see Figure 2-3). The static 'Slow Down' signs were the only ones found to be associated with increases in speed. Flashing lights placed on regulatory 40km/h school speed zone signs were found to be the most effective in reducing vehicle speeds, while the use of flashing lights on advisory signs proved ineffective in reducing vehicle speeds.


Figure 2-3: The four school zone signs trialled in New South Wales

For Perth, a study by Radalj (2002) found that 40km/h speed limit markings on the road had no significant effect on driver speeding behaviour, whereas another study showed that flashing lights had a positive influence on driver speeding behaviour in school zones (Radalj and Gibson, 2004). Similarly, a study by Brewer and Fitzpatrick (2012) in Garland, Texas found that 80% compliance was reached when flashing beacons were used.

This study will not focus on flashing lights, but rather will focus on the electronic signs which are now used around many school zones in Western Australia (see Figure 2-4). This will be compared with similar signs around non-school zones.


Figure 2-4: School zone signs in Perth. Western Australia

***Overall the research found that the addition of flashing lights to signs yielded positive results, by capturing drivers' attention. This may result in more effective speed reduction than the standard static signs.***

### 2.2.2 Ideal Traffic Sign Design for Non-School Zones (40km/h)

The literature search revealed that 40km/h zones were not restricted to school zones, but could also be beneficial for other locations where pedestrian traffic is considered high. For instance, Melbourne’s busiest shopping strips use electronic variable speed signs and advance warning signs. Following a trial of these 40km/h signs, they are gradually being introduced to more shopping strip zones (Vic Roads, 2012; Wright, 2012). An electronic solar flashing sign has been used in certain shopping strips in the Melbourne CBD, Figure 2-5. The electronic signs will also be tested along commercial roads in Perth, Western Australia in terms of non-school zone. Like the Melbourne signs, the Perth signs are electronic variable signs, but without the advance warning signs used on Melbourne roads.


Figure 2-5: Electronic solar signs used for shopping centres in Victoria (left) and a sign used for the study in Western Australia (right)

Similarly, authorities in Toronto are adopting a 40km/h limit for areas with high pedestrian movement, and 30km/h for most residential streets (Moran, 2012). In addition to that, the European Parliament is currently calling for speed limits on residential roads and single-lane roads without cycle tracks to be reduced to 30km/h throughout the European community in the interests of road safety. That would equate to 20mph in the UK and the move has been welcomed by the campaign group '20's Plenty for Us', which lobbies for that limit to be put in place (MacMichael, 2012). In fact 20mph (32km/h) speed limits have already been introduced in a number of cities in Britain including Bristol and Liverpool.

In WA, the 40km/h electronic signs are used and are currently being trialled using 85% speed and by collecting crash data. This study will attempt to collect both speeding enforcement and crash data to evaluate the electronic sign since it is the first time the 40km/h electronic flashing solar signs will be used along one of Perth's busy shopping strips. Another shopping strip with a 40km/h limit was furnished only with standard signs and standard road markings; the study will compare this with the road with the electronic signs. The primary motivation for introducing this speed reduction program in both roads was to reduce the incidence of serious crashes mostly benefiting the more vulnerable users of local area road networks such as pedestrians, children and bicyclists. The comparison will also highlight any advantage of the electronic signs over the standard static signs.

***Two roads with a 40km/h speed limit but different signage systems will be investigated. Electronic variable signs will be compared with the standard signs in terms of speeding enforcement and incidence of crashes.***

## 2.3 Speeding

### 2.3.1 Speeding within 40km/h School Zones

A detailed report on NSW school zones by the Auditor-General (2010: p. 45), covering the years between 1998 and 2008 and involving school-aged pedestrians between five and 16 years of age, found that this group represented the greatest reduction in crashes over the ten year period, greater than for overall road casualties and all pedestrian casualties.. However, the report also found that, despite the use of school zone signs with flashing lights and fixed speed cameras, motorists continued to exceed the 40km/h speed limit in school zones.

The RTA (Road Traffic Authority) of NSW school zone speed survey report showed that for only two of the 12 schools surveyed were vehicle speeds close to the speed limit. In the same report. A survey of 11 Sydney schools in 2005 found that only half of the motorists were obeying the 40km/h speed limit during school zone hours. The report stated clearly that the presence of a 40km/h zone contributes to the reduction in pedestrian crashes. This indicated that the result of harm minimisation is effective in a 40km/h speed limit, but it is not doing the same for speeding behaviours, as it continued to be of concern.

The literature search revealed that a number of states around Australia have reported speeding concerns within school zones. For instance, the number of traffic infringement notices (TINs) issued within school zones in Queensland has steadily increased over the past few years, with 12,335 in 2009, almost 15,976 in 2010, and 8822 in the first six months of 2011 (Queensland Government, 2011 (cited in Abdul Hanan, King and Lewis, 2013)). In addition, evidence from Ipswich in Queensland found that 27% to 30% of drivers exceeded 45km/h in the morning and afternoon periods when the school zones were in operation (Yarrow, 2006 (cited in Abdul Hanan, King and Lewis, 2013)).

The case was quite similar for New South Wales, where a study by Ellison, Greaves and Daniels (2011) found that speeding remains very common in school zones, where 23% of the distance driven in school zones is above the posted speed limit of 40km/h. But they agreed that speeding is still a concern for pedestrians.

***The above information reveals that although the incidence of crashes involving school children has decreased, speeding is still a persistent problem despite the attention given to the matter in the literature.***

***There was no literature available on non-school 40km/h zones, so this study will investigate them along with the 40km/h school zones in Chapter 4 and will also discuss them in Chapter 5, Case Study Two in the non- school zones environment.***

### 2.3.2 Speeding within Zones other than 40km/h

Speeding of vehicles has become a global concern. According to the European Conference of Ministers of Transport (OECD, 2006: p. 13) there has been an increasing demand, particularly in urban areas, for strategies to reduce vehicle speed and the adverse impact of road crashes. Road crashes are a high priority for any traffic authority.

The Western Australian Office of Road Safety reports that there is a far greater problem in Perth, involving thousands of 'good' drivers who take frequent smaller risks such as low-level speeding (O'Leary, 2011). It adds that going 5km/h over the limit will double the risk of a crash.

A study on the 50km/h limit by Radalj and Sultana (2009), found that about 18.2% of Perth drivers were estimated to be travelling at 10km/h or more above the speed limit in 2008. A recent analysis of speed limits in Western Australia by Radalj and Sultana (2012) suggested that the poorest compliance to the speed limit was observed on 60km/h roads. However, they also noted that compliance was increasing, ranging from 48% in 2000 to 68% in 2011.

The above literature search has dealt with speeding mechanisms other than enforcement, i.e. monitoring and calculating 85$^{th}$ percentile speed, etc. This study will compare the hourly rate of speed enforcement measures using data in the form of TINs obtained from the West Australia Police. The speeding enforcement measures are discussed in details in Chapters 4 and 5 and 6.

The literature search found that studies have generally adopted covert vs. overt speeding detection (Cameron, 2009; Cameron and Delaney, 2006; Cameron et al., 2003a; Cameron et al., 2003b). This is unlike 'on-the-spot' data; on-the-spot detection is what occurs on site when the infringement is delivered immediately to speeding drivers. Covert detection is not necessarily on the spot. It can make use of hidden or non-flashing cameras. It appears that 'on-the-spot' detection shows police presence in a more positive light and highlights the effectiveness of their role. For the first time, this study analyses data for ‘on-the-spot’ vs. ‘roadside’ detection, instead of for the covert vs. overt types of speeding detection used previously.

Research has revealed that the purpose of covert cameras is to increase the likelihood of detecting speeding drivers. According to Harrison (2001), this shift towards covert cameras has removed one positive reinforcer for speeding at the enforcement sites.

Others like Scruby (2011) have reported a decline in measured travel speeds on many parts of the road network and not just at camera sites. There is also the influence of the psychological ‘halo effect’ on those caught speeding, which lasts for a period of time and is effective around the location concerned. South (1998) argues that the threat of being detected speeding is stronger than the punishment, although the punishment is still considered vital for changing behaviours and is likely to be most psychologically effective when delivered with the shortest possible delay.

***This means that on-the-spot fines would be quite effective, according to South (1998), and will therefore be used for the speeding analysis in this study.***

## 2.4 Speed Enforcement

This study taken into account two types of speeding drivers. There are drivers who obey the speed limit but for some reason do not see the signs or are confused about of the timing of the school zone, and there are those who know about the speed limit and the school zone time, and choose to speed anyway. The purpose of enforcement is to ensure that drivers do not exceed the posted speed limits. To achieve this, the deterrence theory (DT) introduced by Homel (1988) was adopted. Although DT deals with drink driving behaviour, it was found acceptable amongst Australian road safety practitioners for addressing speeding behaviour, and considers speeding as a deliberate offence. Details of enforcement approaches by Australian authorities were discussed in Ebrahim and Nikraz (2011b).

Belin et al. (2010) have compared the Australian and Swedish approaches. The belief in Sweden seems to be that drivers speed due to lack of information, and therefore may need more social support and information, whereas the Australian approach indicates that the higher the perceived level of enforcement, the higher the perceived risk of being detected. In Australia, speeding drivers are considered to be offenders, and are not considered to be ignorant of the law or lacking in information, Ebrahim and Nikraz (2011).

The strategy of Australian policymakers focuses on specific and general deterrence in curbing speeding behaviour, using the most sophisticated fixed and mobile enforcement cameras. Cameron and Delaney (2006) have studied a comprehensive speed enforcement package in Perth, Western Australia, aimed at saving $186 million in social costs per annum.

The mission of the strategy is ‘anywhere, anytime’ and most importantly depriving the offenders of the positive consequences they thought they could gain from exceeding the speed limit. The aim of this strategic deterrence was to make drivers slow down. Authorities concentrated on two types of drivers: those who drove at excessive speed and those who engaged in low-level speeding including repeat offenders.

The introduction of covert cameras in Australia added a new dimension and acted as a negative reinforcer along with the overt camera program. The addition of the covert speed cameras made it more difficult to know the timing and the location of the speed cameras (Harrison, 2001). A study by Abdul Hanan, King and Lewis (2011) compared Australian 40km/h school zone fatalities to those in Malaysian school zones, and found that the Malaysian speed enforcement policy is far behind the Australian one, despite similar engineering measures used at the sites. The study findings attributed the lower incidence of pedestrian fatalities to the higher level of enforcement in Australia. In fact, according to several authors, speed enforcement has an effect on speed and on road fatalities (Bourne and Cooke, 1993; Harrison, 2001; Cameron, 2009; Elvik, 2009; 2011).

In terms of measuring the effect of the enforcement dose and the response in terms of lower injury reduction, most studies investigate general effects and no 40km/h was found. Instead, a study by Elvik (2001) reported that the percentage change in the number of injury accidents started to drop as the dosage of enforcement was increased. Higher intensities generally result in greater effects. However, it concludes that the maximum increase in effectiveness was reached when the enforcement intensity was doubled or tripled. The incidence of crashes will keep decreasing until the curve reaches a diminishing return or decay.

Other relationships between incidence of crashes and number of TINs were explored by (Cameron et al. 2003a; Cameron et al.  2003 cited in Cameron and Delaney 2006). The enforcement data was collected using (covert mobile speed cameras), and showed that changes in incidents of crashes were inversely associated with number of TINs, starting with a sharp fall indicating the effectiveness of the number of the TINs in the previous month has shown an effect on the change casualty crashes percentage in the following month. The study also showed that the effect started to flatten horizontally. The study does not talk about the diminishing returns as the previous study.

Cameron and Delaney (2006) also tested the number of hours of enforcement using (overt mobile speed cameras) and the effect on the rate of crashes, and their data revealed an inverse relation fitting a logarithmic function form with a high $R^2$ (0.88). It also showed that there has been a decrease in the general effect of the crash reduction when the number of camera hours increased. This was based on six data points

***The results of the above research indicate that when the number of hours of detection are increased and/or when the number of TINs (traffic infringement notices) is high, there is an inverse effect on the number of crashes. However, the benefit of reducing crashes can reach a diminishing return. It would be interesting to test the two speed limits to find out whether the data for these shows similar relationships.***

According to the literature, speed enforcement activities are best repeated frequently, at irregular intervals and with different intensities (OECD, 2006). From the Australian perspective, Cameron (2009) has indicated that speed enforcement requires intensive covert operation or randomised scheduling of overt mobile speed cameras. Despite the effect of enforcement on road crashes, there still seems to be limited success if the frequency of enforcement is not high enough. In other words, enforcement will continue to be needed in order to deter drivers from speeding, and to save lives and minimise harm to road users. For instance, as early as 1994, detailed research by Zaal (1994) for the Monash University Accident Research Centre in Victoria concluded that it has been difficult to reduce the level of speeding behaviour; the study recommended more reliance on legislation and enforcement campaigns. Fourteen years later, the European Transport Safety Council (ETSC) (2008) considered enforcement to be a difficult task since speeding remains the most widespread offence. In fact, a report by the OECD (2006) concluded that if the system is not perfect and drivers are not perfect, then enforcement will become an important option and an indispensable supporting measure.

A recent communication between the European Commission and the European Parliament recommended that the second key objective for the next decade is to increase enforcement of road rules. It added that enforcement remains a key factor in improving the conditions for a considerable reduction in the number of deaths and injuries, especially when it is intensively applied and widely publicised (EC, 2010).

***To conclude, enforcement was found to be a crucial and tangible element in monitoring, regulating and sustaining safe speed. Of particular interest are the relationship between TINs and the incidence of crashes, and between the hours of detection and the reduction in road crashes. Both relationships will be tested in this study within the 40km/h and the 60km/h speed limits.***

## 2.5 Pedestrian Road Crashes

### 2.5.1 Road Crashes within School Zones (40km/h)

A report by WHO (World Health Organization), found that, despite significant reductions in child pedestrian injury in many high-income countries, the prevention of such injury remains a problem, particularly among 5-14 year olds (Peden, Oyegbite and Ozanne-Smith, 2008). On a similar note, a detailed report on NSW school zones by the Auditor-General (2010: p. 45) involving school-age pedestrians between five and 16 years found that the largest reduction in crashes over the ten years between 1998 and 2008 was among school-age pedestrians. The reduction of the crashes around NSW schools has also been confirmed by Graham and Sparkes (2010).

The case for a lower number of fatalities around school zones is not the same in other countries. For instance, the Malaysian Royal Police (2010, cited in Abdul Hanan, King and Lewis, 2013) reported that during 2009 in Malaysia, which is considered a middle-income country, almost 13% of pedestrian fatalities (i.e., a total of 605 pedestrian fatalities) were child pedestrians.

***Therefore it is concluded that pedestrian crashes involving young children have decreased in Australia, but are still of concern to other nations.***

### 2.5.2 Pedestrian Road Crashes other than 40km/h

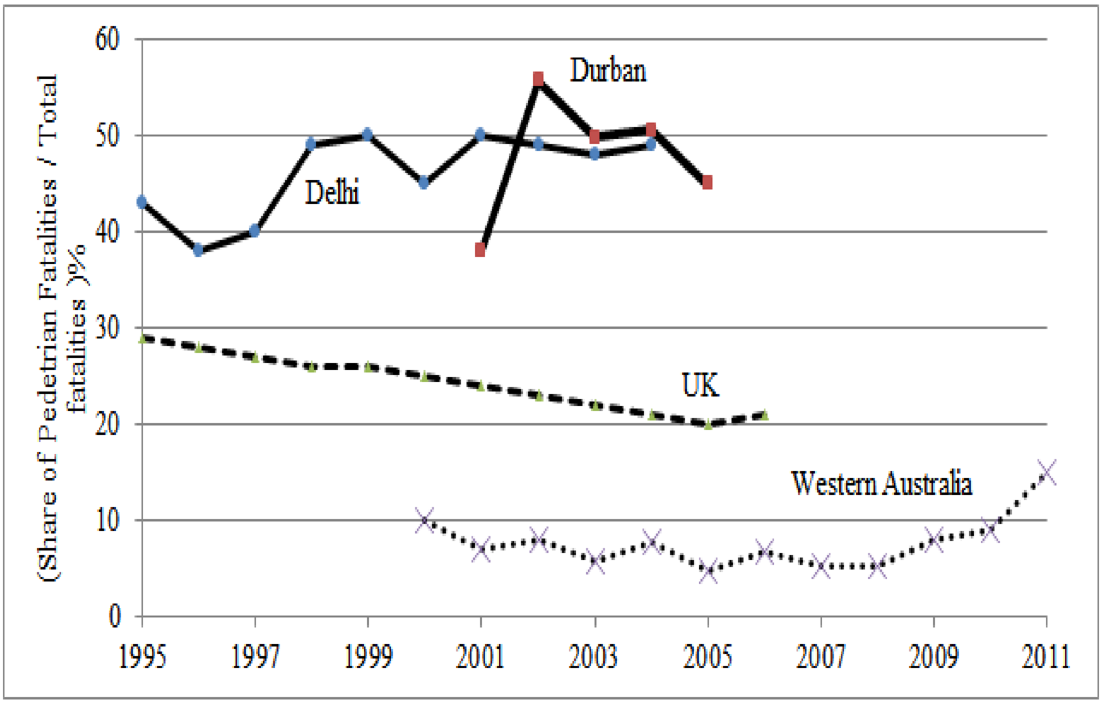
Literature search found no information on reported crashes in 40km/h non-school zones. The concern was that many of the shopping and commercial roads around the Perth CBD (central business district) have a 60km/h limit. The literature shows that crashes with serious or fatal injuries occur on many of the Perth commercial roads with a 60km/h speed limit. The Curtin-Monash Accident Research Centre has called for a 30km/h limit to be tested near shopping centres, hospitals and schools, as pedestrian fatalities have risen on roads with 60km/h limits (O’Connell, 2012). This came after an increase in the incidence of pedestrian crashes and fatalities on 60km/h roads in Perth during 2011. In 2011, of all road user fatalities, 15% were pedestrians. This is the highest number which is 26 and highest proportion of total crashes recorded in the last six years (Shanahan and O’Callaghan, 2012).

The report added that there were two significant groups among the fatally injured pedestrians: males aged 40–60 (30%) and pedestrians aged 70+ (19%). This was also confirmed by a recent report by Thompson et al. (2013) that reported a 50% increase in pedestrian crashes from 2010 to 2011. In fact, in 2011 Perth had its greatest number of pedestrian deaths in 11 years (O’Connell, 2012).

Authorities have experienced a long period of successes in road safety, particularly in reducing pedestrian fatalities, notably in developed countries such as the USA, Europe and Australia. Pedestrian fatalities are also a source of concern for other countries.

Pedestrian crashes continue to cause great concern in many countries in Asia, Africa and the Middle East. Pedestrian fatalities both during the day and at night remain an issue. According to Rumar (2001), there are 200,000 pedestrians killed at night each year worldwide. These types of accidents appear to be resistant to reduction (Ostrom and Erikson, 2001; Mabunda, Swart and Seedat, 2008). Recent research by Griswold et al. (2011) on time of day reported that the first few hours of the night are when most pedestrian fatalities occur. Importantly, the literature revealed that there is a link between travelling speed and severity of crashes (Nilsson, 1984; Kloeden et al., 1997).

A more specific literature search collected and graphed by the study (from a number of sources) to compare Western Australian pedestrian fatalities with data from three other places, and found that pedestrian fatalities vary between continents and countries. Figure 2-6 below shows the share of pedestrian fatalities from each of four the continents. It was collected from the following sources, e.g. for India (Delhi) data appeared in Tiwari et al., 2007, for Africa (Durbin) Milliscent et al., 2008, Europe (UK) Gitelman et al., 2010; for Australian (WA) two sources were collated one from the Western Australian Police, 2011 and the other appeared in Thompson et al., 2013.




Sources: (Ebrahim and Nikraz, 2012).

Figure 2-6: Share of total pedestrian fatalities in samples from four continents

The high fatality numbers in Figure 2-6 may also hide the pedestrian behaviour as a contributing factor in some Asian and African cities. A study by Ebrahim and Nikraz (2011a) reveal that behaviour of pedestrian may not be the same as in Perth. It shows that pedestrian's behaviour are of concern in those cities. Although pedestrian behaviour may be of concern, but this study focus is on speed, speed limit and speeding and speeding enforcement. Particularly on the 60km/h roads where drivers have less time to react. Earlier study recommended lowering speed limits in areas of high pedestrian activity that have 60km/h roads, such as Perth's central business district and urban strip shopping centres. The recommendation was that these areas be rezoned to either 40 or 30 km/h to mitigate and avoid pedestrian-vehicle conflicts (Corben et al., 2009). It is estimated that 12% of all road users who die on Western Australian roads are pedestrians, (Xia, Fonseka and Falkmer, 2011).

Moran (2012) has reported that there is evidence to suggest that every 10km/h reduction in speed below 60km/h will result in a lower likelihood of cyclists and pedestrians being killed in road accidents. The report adds that in a 60km/h zone the risk of a crash injury doubles with every 5km/h increase in speed above the speed limit. VicRoads (2012) confirms that driving at 65km/h in a 60km/h zone can double the chance of an injury-causing crash. Vehicle-pedestrian conflicts need to be minimised by significantly reducing vehicle speeds in areas of pedestrian presence and activity (Gitelman et al., 2010; World Health Organization, 2008).

Research also shows if speed limit is reduced, one fatality, nine serious injury crashes and up to 25 casualty crashes will be prevented every year. It added that statistically, a pedestrian hit at 50km/h has a 15 per cent chance of survival, compared with 75 per cent at 40km/h, Carey (2012).

A number of cities have tried to lower speed limits to 40km/h from 60km/h in order to save lives and reduce harm. A report by the UNC (2011)for the city of Raleigh in North Carolina found that pedestrian crashes were steadily increasing, with an estimated 32% increase in pedestrian casualties from 1997–2009. In terms of speed limits, the report found zero fatalities for roads averaging a speed limit of 36.2km/h (20–25m/hr), three fatalities for roads with an average speed of 52.3km/h (30–35m/hr), and 10 fatalities for roads with an average speed limit of 68.4km/h (40–45m/hr). This indicates that the higher the speed limit, the greater the likelihood of harm to pedestrians.

A recent report by Cleverly (2013) showed that officials in Victoria, Canada are considering lowering the default speed limit on municipal streets to 40km/h. They suggest that by keeping to the 50km/h limit, North American municipalities are falling desperately behind those in many European countries. For example, the European Parliament adopted a resolution calling for local authorities to impose 30km/h limits as a way of reducing the 31,000 deaths annually on Europe's roads. All of the abovementioned literature supports the importance of reducing the speed limit on commercial roads in Perth. This mean that this would have a particular impact on the safety of the older age groups.

***All the above local and international examples reflect the risk of harm associated with having a 60km/h limit along roads in Perth and elsewhere. The literature has demonstrated that the considerable harm from a 60km/h limit can be reduced if the limit is dropped.***

Other road crash literature has shown alarming trends in the involvement of young drivers in road crashes. This is discussed in the next section.

### 2.5.3 Road Crashes Involving Young Drivers

An Australian longitudinal study found that young drivers are consistently over-represented among those injured or killed in road crashes (Smart et al., 2005). Latest reports reveal that the fatality rates for young drivers aged up to 24 are almost double the proportion of their representation in the Western Australian population (Ramsey, 2012a). In addition, male WA drivers are twice as likely to be killed while driving as female drivers (Ramsey, 2012b).

Importantly, a survey from Utah, USA conducted by Ash and Saito (2007) indicated that respondents believed that education should be directed towards all people, but there should be a particular emphasis on younger drivers, who were believed to be less compliant.

The Monash University Accident Research Centre (MUARC) focused on improving young drivers' safety within Victoria during the 90s, and on the problems associated with their behaviour, particularly speeding (Cavallo and Triggs, 2005).

The young age group of 17–24 years in WA has been found to be overrepresented in serious injury crashes (Palamara and Stevenson, 2003). Paddenburg (2013) reports that this same age group also accounts for a third of all serious and fatal crashes, despite making up only about 14% of the driving population. According to recent research, the WA Road Safety Council showed that the same age group (17–24 years) are twice as likely as older drivers to die in an accident (Paddenburg, 2013). The concern is that the fatality rates for young Western Australian drivers aged up to 24 remain almost double their proportion of the population (Ramsey, 2012).

***This raises the important issue of who hits pedestrians, as the majority of studies provide the victims' details. This study will investigate the age group of offenders involved in terms of speeding and pedestrian crashes. A case study can be found in Chapter 4.***

## 2.6 Speeding Attitudes

It should be mentioned in this section that there is a debate about the effectiveness of speed cameras amongst the members of the community in Australia. While some see them as a vital element in road safety programs, others view them as having no impact on driver behaviour, regarding them as a revenue-raising Device.

Creek (2010) has suggested that targeting low level speeders would make authorities become 'addicted' to the revenue. Some drivers are concerned about the way enforcement is conducted; Ducey (2011) reports that drivers believe that there is an element of fundraising involved, due to the operation of cameras outside work hours. Authorities may need to find a balance between safety and the community's mobility needs. Community members in the meantime need to take their share of responsibility along with authorities for the success of comprehensive speeding campaigns.

With regard to attitudes concerning the 40km/h speed limit, the Transport Accident Commission (TAC) (2011) in Victoria, Australia reported that only 46% of drivers believe that driving 10km/h above the speed limit in a 40km/h zone is unacceptable. This means that there is apparently still some tolerance of low level speeding in 40km/h zones. The head of community relations at the TAC said it that it was of great concern that people's attitudes towards speeding had changed little, despite all the TV advertisements and campaigns.

From a psychological viewpoint, Rienstra and Rietveld (1996) showed that decreasing vehicle speed of car drivers will have a positive impact on the environment, pollution and the number of road accidents. They added that when speed policies introduce lower speed limits, the safety aspects need to be emphasised in order to increase public support. However, the psychological factors involved in speeding behaviour may play an important role in this respect. Another study by Haglund (2001) in Sweden reported that drivers' travel speed is influenced by road factors, other road users and enforcement.

***This study will prepare a questionnaire (Chapter 7) to investigate the psychological effect of lower speeds, such as the stress, delays and technical matters. This information will be new and will add to the existing knowledge on speed limit. This is an additional reason for investigating attitudes to the new 40km/h speed limit around shopping centres in Perth.***

In addition to this, an Australian national study on attitudes towards decreasing various speed limits found that female drivers residing in urban areas were more supportive of lower speed limits (Lahaussea et al., 2009). A national survey conducted by the Australian Transport Safety Bureau in 2003 showed that support for the 50km/h urban speed limits initiative had increased to 91% in Western Australia, compared to a 60-69% increase in previous years (Road Safety Council of WA, 2004).

***This means that acceptance levels were lower at the beginning and increased to a higher level at a later stage, which may encourage decision-makers to adopt a speed of 40km/h on Perth commercial roads instead of 60km/h.***

## 2.7 Road User Approval of Speed Enforcement within Australia

The Auditor-General's reports on speed enforcement were included in this study, due to the fact that these are independent professional reports and thus highly regarded. The search was conducted in the even states in Australia, based on the Auditor-General's reports on each state. Each report had certain key recommendations and these were converted to strategic initiatives by the authority that could contribute to a better understanding of speed enforcement towards public perception. Table 2-1 below describes each recommendation and the initiatives mentioned above. The literature search found a total of 10 questionnaires of which five were camera site-related (the study will call these visual) and the other five were policy-related (the study will call them non-visual). Both related to the speed camera system, as shown in Figure 2-7.

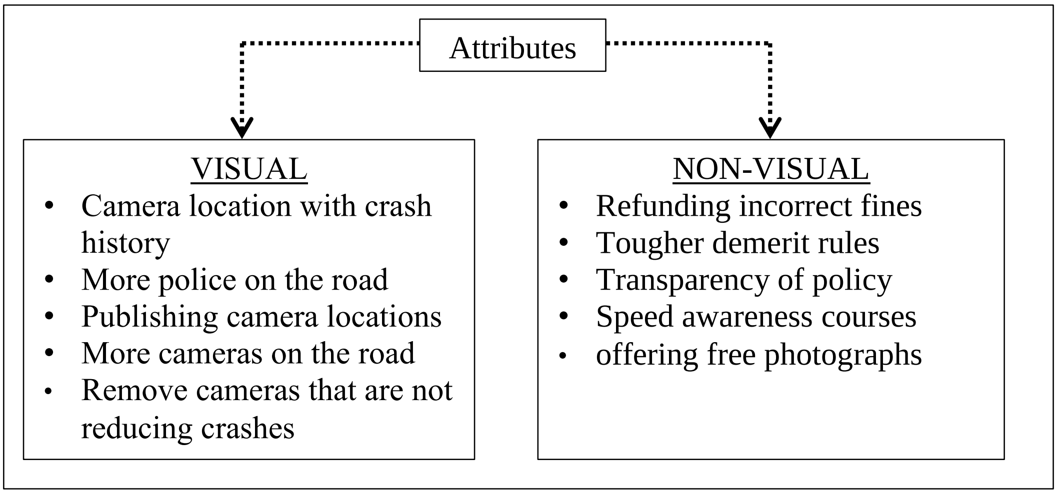



Figure 2-7: Attributes selected from the Auditor-General's reports on speeding cameras

***For the purposes of this study, these attributes (initiatives) will be adopted as questionnaires in order to test road users' approval of such attributes. The aim is to investigate an important issue, being the gap between road users and authorities. It will eventually contribute to knowledge on road user behaviour relating to the ten selected attitudes.***

Table 2-1: Australian Auditor-Generals' Reports collected

| States / Initiatives | NSW (New South Wales) | VIC (Victoria) | WA (Western Australia) | TAS (Tasmania) | ACT (Australian Capital Territory) | Qld (Queensland) | SA (South Australia) |
|---|---|---|---|---|---|---|---|
| Auditor-General key recommendation | Priorities are required for potential sites of cameras based on death or serious injury (Achterstraat, 2011, p. 13). | Department of Justice address misconceptions about camera program (Pearson, 2011, p. 6). | Improve transparency of speeding fines in terms of policy and effective administration (Murphy, 2012). | Provide for more even enforcement relative to serious crashes (Blake, 2009, p. 22), further increase visible presence of police (Wing, 2009, p. 5). | Measures to change attitudes on enforcement and education are of high priority (Pham, 2006, p. 37). | Not Available | Not available |
| Positive initiatives by authority towards public perception | Cameras that were found to be not reducing crashes were removed (Smith, 2011). | Publish the location of mobile speed cameras. The appointment of the road safety camera commissioner to check reliability of the speed camera system as a whole (Moor, 2012). In addition to that, traffic camera photographs free for motorists (Moor, 2013). | Safety Council recommends that 80% of accepted funds be allocated to projects in five priority areas. One of the priorities includes reducing speed that relates to crashes. | Response 31 states that ongoing work to increase resources to increase police presence. According to the Department of Infrastructure Energy and Resources, DIER (2011). | Commissioning feasibility study into Speed Awareness Course for repeat speeding offences (Pham, 2009, p. 23). | According to the RACQ, there is a supports the use of speed cameras in places where there is a history of crashes. (Moore, 2011). | Mentions to the road safety minister, the increase of safety cameras on roads and tougher demerit point system is having the desired effect on motorists. (Nankervis, 2013) |

## 2.8 Conclusions and Research Gaps

1. Adding a flashing light to road signs produces positive results due to better communication with drivers; they may therefore be more effective in reducing speed than the standard signs.

***This study will test the electronic signs that are available in school zones and the new electronic signs in commercial (non-school) zones in Perth. Comparisons will be made between school and non-school zones. (The speed enforcement data will be for two years only since the installation on the commercial road is new, but it is believed that it will add to knowledge about the 85$^{th}$ percentile speed recorded by authorities).***

2. With regard to school zone safety, two pieces of information have surfaced. The positive is that there has been a reduction in crashes involving school children, and the negative is speeding, which still persists despite the attention given to the matter according to the literature search.

***The study will attempt to investigate detection methods to explore speeding behaviours in the 40km/h speed zones i.e. 'on the spot' vs. 'roadside'.***

3. All of the abovementioned local and international examples reflect the risk associated with 60km/h roads in Perth and elsewhere, i.e. in terms of speeding and crashes.

***Research is necessary to prove that 60km/h roads in Perth are contributing to the higher incidence and severity of crashes compared to the existing 40km/h roads. Research is also needed to find out which areas (industrial, commercial, residential, university and/or hospital) on the 60km/h road network are most needed.***

4. Enforcement is an essential process that can monitor, regulate and sustain safe speed. The literature shows that increasing the number of hours of detection or the number of traffic infringement notices (TINs) issued can have an inverse effect on the number of crashes, but that reduction of crashes can reach a diminishing return.

***The study will investigate the 40km/h enforcement measures by testing the relationship and type and strength of trend between the enforcement data and crash data. This will be done in terms of incidents of crashes, hours of detection and the number of TINs (Traffic Infringement Notices) in both 40km/h and 60km/h zones.***

5. The purpose of the covert cameras was to increase the likelihood of detecting speeding drivers. On the spot detection of drivers would be quite effective as punishment is immediate. The literature search revealed that studies were using covert speeding detection (unmarked police cars) as a major source of data on enforcement in terms of number of hours of detection and number of TINs issued.

***This study will attempt to use on the spot (with on the spot issuing of fines). As the on the spot detection will comprise covert and overt type of detection.***

6. Attitudes towards the new 40km/h speed limit around shopping centres in Perth need to be investigated, particularly since it is new to commercial areas. Rather than using the standard survey for traffic safety, the questionnaires will be constructed to include delay, satisfaction and technical knowledge.

***It is expected that the information collected from the questionnaires will be new and will add to the current knowledge by informing decision-makers about how road users think, with the aim of replacing more 60km/h roads in commercial, industrial and hospital areas with 40km/h zones.***

7. No studies were found which detailed those causing pedestrian accidents in 40km/h zones. Majority of studies provide thorough information on pedestrian victims' details on general areas not necessarily on offenders on the 40km/h speed limit.

***This study will therefore investigate the age group of offenders in terms of speeding prediction and pedestrian crashes in the 40km/h zone.***

***8.*** The literature search found that the Auditor-General reports are new approach in reaching to the real response of road users. This study will reveal the size of the gap between the authorities and the road users. The literature search showed that no study has taken this approached before, firstly by collecting all of the recommendations from the Auditor-General's reports, and secondly by collating them into proper questionnaires.

***This will certainly assist the research community in knowing the level of approval (LOA) of road users for these strategic initiatives.***

## 2.9 Research Objectives in Light of Literature Review

Following the literature review, the main objectives of this research will focus on the gaps discussed in section 2.8, as follows:

1. Generate extensive knowledge on the speeding behaviours relating to use of the electronic 40km/h school zone signs, and then compare that to the non-school zones in terms of speeding behaviours and crashes.
2. Compare the incidence of crashes and the speeding behaviour occurring in non-school 40km/h zones on the basis of two engineering measures, i.e. electronic versus standard signs.
3. Identify the age group of the drivers who are at the greatest risk in terms of pedestrian crashes and speeding in 40km/h school and non-school zones.
4. Model the speeding behaviour of drivers before and after the implementation of a 40km/h speed limit within non-school zones.
5. Provide evidence of the contribution made by the electronic 40km/h signs to reducing the incidence and severity of crashes and/or enforcing speed limit in comparison to 60km/h roads with standard signs. This evidence may guide policymakers to further target the reduction of pedestrian KSI (Killed or Seriously Injured) in 60km/h zones by implementing a lower speed limit such as 40km/h, as well as using the electronic signs.
6. Examine behavioural attitudes towards the 40km/h limit and reveal the different social, technical and delay concerns.
7. Reveal the broader attitudes of Perth road users towards the strategic speed enforcement initiatives by converting all of the Australian Auditor-General Reports into questionnaires for use as a survey.

# CHAPTER 3 METHODOLOGY AND ANALYTICAL APPROACH

## 3.1 Introduction

This chapter describes the general research methodologies and approaches employed to achieve the thesis objectives outlined in Chapter 2. This chapter will be divided into the same sections discussed in the literature search, so that these can be easily related to each other.

Six data sets are used in this chapter, similar to those investigated in the literature search. These deal with data analysis in terms of methodology and approach and are as follows:

**3.2 The traffic sign on trial.**
**3.3 The hourly speeding data.**
**3.4 Enforcement-crash relationship.**
**3.5 Road crash data.**
**3.6 40km/h questionnaire data.**
**3.7 Auditor-General's data.**

Each section will have its own methodology followed by its own approach. The methodology will explain the steps taken and the approach will highlight the general objective.

## 3.2 The Traffic Sign on Trial

### 3.2.1 The Traffic Sign on Trial — Methodology

This study examines the use of electronic signs on one of the busiest shopping strips in Perth. These are variable speed signs which were installed at various places along the trialled road, and display a speed of 40km/h (see Figure 3-1).


Figure 3-1: The electronic 40km/h sign under trial

The signs operated from Sunday to Thursday, from 7:30am to 10:00pm, and Friday and Saturday from 7:30am to 1:00am. Outside of these times, the existing 60km/h limit was displayed on the signs instead of 40km/h. At these times there were fewer vehicles and pedestrians. It was anticipated that the trial would be conducted for 18 months to allow the full impact of the work to be assessed with an 'after' study. At the completion of the after study, an appropriate speed limit would implemented.

### 3.2.2 The Traffic Sign on Trial — Approach

The use of the electronic signs is intended to motivate drivers to reduce their speed and comply with the speed limit. Data from this will be analysed in Chapters 4 and 5 to determine the feasibility of the signs in reducing driver speed and contributing to a reduction in crashes. These signs are considered more modern than the standard static signs, and may therefore have a wider application in the future.

## 3.3 The Hourly Speeding Data

### 3.3.1 The Hourly Speeding Data — Methodology

An important feature of this thesis is the use of real raw speeding enforcement data collected from the Western Australia Police Department. This speeding enforcement data was only approved for the period July 2007–June 2011. The importance comes from the fact that data can be statistically analysed and compared within the 40km/h of different zones i.e. the school zones and the non-school zone discussed in Chapter 4. It can also be statistically analysed and compared within non-school zones, which is discussed in Chapter 5, or it can be analysed to compare two different speed limits (40km/h and 60km/h), as discussed in Chapter 6.

With regard to the 40km/h speed limit, the school zone data covers 165 suburbs of the urban area under study in Perth (see Appendix 3-1). The speeding data comprised 74,498 TINs for the period July 2007–June 2011, and examined school zones vs. non-school zones. This data comprised both ‘roadside’ and ‘on-the-spot’ TINs, but due to the unavailability of the ‘roadside’ TINs, data was limited to 46,923 TINs only for the period July 2009–June 2011, as shown in Table 3-1.

Table 3-1: Data used for the 40km/h zones in the period July 2009–June 2011

| | School Zone | | Non-School Zone | |
|---|---|---|---|---|
| Detection / Period | On-the-spot | Roadside | On-the-spot | Roadside |
| July2009–June2011 | 14,638 | 25,840 | 4239 | 2206 |

Please note that, prior to any analysis, data were screened for accuracy of entry and for missing values. The school zone data came from two sources; the direct school zone source, and filtered from the 40km/h speeding data. This latter data was added based on the timing of the speeding offence and the day of the week (including weekend and public holidays), and the distance of each speeding offence from the school zone boundaries. Each case was examined individually and added to the above direct data. A buffer of 10–100m was used, based on the fact that few cases were filtered from the shopping centre strips were school zones existed.

All speeding data relating to 40km/h zones is discussed in Chapters 4 and 5, while Chapter 6 discusses both 40km/h and 60km/h zones. This latter chapter focuses on enforcement crash data. Therefore 60km/h speeding data are not discussed here, but in section 3.4 instead.

### 3.3.2 The Hourly Speeding Data — Approach

The detection data for each of the 165 suburbs was converted into a monthly per hour rate. The laborious calculation involved recording the date and time of each individual incident of each single detection. For instance, if issued 35 TINs in a period of around five hours (continuous or not continuous) on a particular day, the rate would be 7 TINs/hr. Note that whole hours were calculated such that 4 hours and 30 or more minutes would be considered 5 hours, while 4 hours and less than 30 minutes would be considered 4 hours.. In the latter instance, the rate would then be 8.75 TINs/hr instead of 7 TINs/hr. This approach was used systematically throughout the analysis to ensure that the estimated operating hours would be consistent across the board.

Once TINs and hours of exposure were calculated, the next step was to unify the hours of exposure. This was done by arriving at similar hours of exposure for each zone, so that each zone could be compared based on the TINs recorded but with the same hours of exposure. This is what is meant by unifying the hours of exposure. This allowed the comparison of the effect of enforcement by the same dosage of hours given. The only concern in that is the intensity may not be the same as it needs to be systematic if optimal results would need to be achieved. This is difficult to achieve due to availability and the nature of the data. The comparison of hourly TINs rates for school and non-school zones can be seen in Chapters 4, 5 and 6. This rate was based on 'on-the-spot' detection which was found to dominate the roadside detection.

It should be noted that this study has adopted for the first time data analysis using 'on-the-spot' vs. 'roadside' detection. Generally studies have adopted a covert vs. overt enforcement approach.

The covert vs. overt approach can be seen in a number of studies (Cameron, 2009; Cameron and Delaney, 2006; Cameron et al., 2003a; Cameron et al., 2003b). 'On-the-spot' enforcement is what occurs when the infringement is delivered immediately to the speeding drivers on site, whereas the covert method is not necessarily on-the-spot, using either hidden or non-flashing cameras. It appeared that on-the-spot detection showed the more positive side of a police presence and the effectiveness of the role of police officers, as in each case of detection, the police officer will come face-to-face with the offender at the moment of the driver committing the speeding offence. The statistical analyses adopted for this section are discussed below.

*Correspondence Analysis:* This is a (multivariate) descriptive data analytical technique. Correspondence analysis remarkably simplifies complex data and provides a detailed description and full exposure of the data, yielding a simple solution (Greenacre, 2007; Clausen, 1998). This statistical technique was used to understand young drivers' (17–24 years of age) behaviours around school and non-school zones?. All data were analysed using the SPSS statistical package. This case study is discussed in Chapter 4.

*Ordinal Logistic Regression (OLR) & Multinomial Logistic Regression (MLR)*:
The study investigated two methods to fit the speeding data into a proper model. The explanatory variables are age, as a continuous variable, and time of the day, gender and the period of the electronic sign installation as categorical variables. The dependent variable is the four speeding levels above the 40km/h speed limit (less than 9km/h, 10km/h–19km/h, 20km/h–29km/h and 30km/h and more) (see Figure 3-2).

The first method is Ordinal Logistic Regression (OLR) and the second is Multivariate Logistic Regression (MLR). The study attempted initially to examine data fitting to suitable methods to fit the data according the above available data. Following the comparison of the two methods, it was decided to adopt OLR, for two reasons. Firstly, the nature of the dependent variable which is here taken as the speeding levels is of an ordinal nature. Secondly, upon comparison of the two models fitting information it was found that the Pearson *p* value of the ordinal model might produce a better fit.

Table 3-2: Comparison of the OLR and MLR models

| Model fitting details | values | | p | | Remarks |
|---|---|---|---|---|---|
| | OLR | MLR | OLR | MLR | |
| -2 LL ($x^2$) | 172.56 | 236.48 | 0.001 | 0.001 | The change is significant and explains the decrease in unexplained variance, and it is considered a good improvement to the model. |
| Goodness of fit<br>Pearson<br>Deviance | <br>1241<br>979 | <br>1268<br>917 | <br>0.39<br>1.00 | <br>0.14<br>1.00 | The predicted values are not significant and not different from the observed, thus the fit of the model is good. The Pearson p value for the ordinal model is higher, producing a better fit. |
| Pseudo $R^2$<br>Cox and Snell<br>Nagelkerke<br>McFadden | <br>0.08<br>0.10<br>0.05 | <br>0.11<br>0.13<br>0.06 | <br>-<br>-<br>- | <br>-<br>-<br>- | Fairly similar values but MLR values are slightly higher. Still OLR representing a good size effect according to Field (2009). |

The MLR model did give a good competing results against the Ordinal model. Details of the analysis and the OLR model can be found in Case Study One, in Chapter 5. The MLR model was also tested against the Auditor-General's data (Chapter 8 and section 3.7.1 below).

*Chi-Square:* This is a non-parametric test which is used in Chapters 4 and 5 to highlight the level of association between the speeding levels within school and non-school zones. Other analyses are also included.

## 3.4 Enforcement-Crash Relationship

### 3.4.1 Enforcement-Crash Relationship — Methodology

There were two detection types adopted for this research study, similar to those adopted in other major cities in Australia. The first type was the roadside camera placed inside a vehicle or on the ground, both detecting from the side of the road. This is referred to as roadside detection. The second type was on-the-spot detection, involving all traffic pullovers including those using marked/unmarked cars and hand-held detectors. This will be referred to as on-the-spot detection.

The enforcement data is based on 60km/h speeding TINs gathered in 177 suburbs, as shown in Appendix 3-2. The MLR model was also tested against the Auditor-General's data (see Chapter 8 and section 3.7.1 below). The monthly hours of detection were calculated for each suburb from July 2007 to June 2011, and the number TINs for each suburb calculated against the hours of detection. This enabled the calculation of TINs/hr for each suburb, and this rate was converted to a yearly rate which was in turn regressed against the crash/year rate. This enabled the determination of the relationship between the two rates.

This modelled relationship could then be fitted to different forms such as linear, logarithmic, polynomial, exponential and power producing different equations such as:

*Linear* $Y=A+B_1*X$

*Logarithmic* $Y=A+B_1*\ln(X)$

*Polynomial* $Y=A+B_1*X+B_1*X^2$

*Exponential* $Y=A+B_1*X$

*Power* $Y=A+B_1*X$

The relationship was then be checked for statistical significance. It follows that if $x^2$ is close to or above 0.7, then there is a good fit. The closer it is to 1, the better the fit.

### 3.4.2 Enforcement-Crash Relationship — Approach

The approach was based on two frequencies of enforcement: firstly, the estimated operating hours of enforcement, and secondly, the number of TINs issued. The rate of TINS/hr for each of the 177 suburbs was calculated and then, in order to estimate the effect of enforcement on the incidence of crashes, the yearly TINs/hr were calculated, producing four points that could be regressed against the four yearly crash points. This made it possible to determine whether a relationship existed between the two.

Importantly, that if the relationship turned out to be statistically significant, it would enable the most effective number of camera hours to be predicted, which would thus be useful to decision-makers to adopt it as for future calibration.

## 3.5 Road Crash Data

### 3.5.1 Road Crash Data — Methodology

Raw crash data was obtained from main roads of WA (Western Australia). Most of the crash data selected for the study was in two categories, total crashes and pedestrians crashes with a severity level of KSI (killed or Seriously Injured). Crash data that involved person levels (rather than crash number number) was filtered for pedestrian victims. Data was also filtered to collect data on drivers who hit pedestrians.

### 3.5.2 Road Crash Data — Approach

The approach of the study was to apply the crash data at two levels, the first being *severity indicators* (see Chapters 4 and 5), and the second being *enforcement indicators* (see Chapter 7).

## 3.6 40km/h Questionnaire Data

### 3.6.1 40km/h Questionnaire Data — Methodology

Multivariate analysis of variance (MANOVA) was employed to search for differences between the dependent variables. This statistical analysis was employed based on a 10-item questionnaire which collected demographic data and used a range of items constructed specifically for this study. The items were used as dependent variables which were divided in order to target two options, firstly, there was the concern about delay if the 40km/h speed limit were to be implemented during the day (day zone). This was framed as a five item questionnaire shown in Table 3-3 below.

Table 3-3: Items on delay concerns regarding the use of a 40km/h day zone

| Item | Questionnaire | Abbreviated |
|---|---|---|
| 1 | Drivers may find a 40km/h limit too slow during the day. | Speed is too slow |
| 2 | Drivers may find it stressful to drive at a 40km/h limit during the day on roads not busy with pedestrians. | Stressful speed |
| 3 | Drivers may show less tolerance during the day if driving on roads with a 40km/h limit. | Less tolerance |
| 4 | Drivers are likely to think that a 40 km/h limit during the day will slow the flow of traffic. | Slows traffic |
| 5 | Drivers may think that delays in the CBD are due to a 40km/h limit during the day rather than the traffic signals. | Speed delays not due to signals |

Secondly, the option related to the preference for implementing the 40km/h limit at night (night zone). This was also framed as a five item questionnaire with abbreviations, as shown in Table 3-4 below.

The study conducted a reliability test and found Cronbach's alpha to be acceptable, with a value of 0.76. The SPSS software package was utilised to analyse the data. The study further tested the groups for differences, with cluster analyses being performed to separate the four multicultural groups (Australian, African, European and Asian). The study also investigated the opinions of different age groups on the two options discussed (see Chapter 7).

Table 3-4: Items on preference for a 40km/h night zone

| Item | Questionnaire | Abbreviated |
|---|---|---|
| 1 | Drivers are more likely to accept the idea of a 40km/h night zone around entertainment venues. | Accept the idea |
| 2 | Drivers are more likely to observe and obey flashing 40km/h night zone signs. | Obey the speed limit |
| 3 | There may be fewer pedestrian fatalities if 40km/h night zones are introduced around entertainment venues. | Fewer fatalities expected |
| 4 | 40km/h night zone may need to be adopted on weeknights for safety of pedestrians. | Adopt on weeknights |
| 5 | Night zone is similar to the 40km/h school zone limit in terms of pedestrian safety. | Safe as school zone |

### 3.6.2 40km/h Questionnaire Data — Approach

The approach was to measure the level of concern regarding delay during the daytime (day zone delay concern) and the level of acceptance for the40km/h zone at night-time (night zone acceptance). The study gathered more knowledge on traffic delays in addition to collecting opinions on the use of a 40km/h zone in shopping strips compared to school zones (see details in Chapter 6).

## 3.7 Auditor-General’s Data

### 3.7.1 Auditor-General’s Data — Methodology

The Auditor-General’s data was converted into questionnaires that sought road users’ levels of approval (LOA). This approval level will indicate the level of support for the speed camera system. The MLR categorical dependent variable has four levels: Not Approve, Little Approve, Approve, and Strongly Approve. These four levels were converted into binary logistic regression models, with each response variable level compared to a reference level (Not Approve). Hence, four approve levels (k = 4) produced three (k – 1) binary logistic regression models for each approve level.

The little approve, approve and strongly approve with respect to not approve. These levels represented the dependent variable. The five explanatory variables adopted were age and years of driving experience (continuous variables) and gender (female or male), status (single or non-single) and environment of work (industrial or non-industrial)(categorical variables). Data was mainly collected from industrial areas, commercial areas and bank employees, etc.

The multinomial logistic regression model was applied to the above data as it is widely used in transportation research (Yan et al., 2009; D'Souza and Maheshwari, 2012). Like the speeding data which was considered to be ordinal in Case Study One (Chapter 5), this data may fit an ordered model. However, according to Amemiya (1985) it may be preferable to use an unordered model such as MLR to model ordered data. It added that greater caution is needed when using an ordered model as this can lead to serious biases in the estimation of probabilities, unlike the use of an unordered model such MLR where the model parameter estimates remain consistent. However, there is also a loss of efficiency. Washington et al. (2003) also noted that using the ordered probability models such as ordinal models will place restrictions on how variables in x affect outcome probabilities. Therefore, due to the abovementioned reasons, the unordered logistic MLR model was adopted for this study despite the LOAs being ordinal (see details of the MLR model in Chapter 8).

### 3.7.2 Auditor-General's Data — Approach

The approach was to find out how high the approval levels were for many initiatives that were considered important in the Australian jurisdiction. These levels of approval (LOAs) were supplied by road users. The most important three out of the 10 initiatives investigated were the presence of police, tougher demerit rules and the awareness courses. These were considered important because they are common concerns in the media and they represent a very important triangle according to the study.

## 3.8 Summary

This study tests the viability of electronic signs as a future means of traffic control and speed moderators as well as behaviour modifiers which can affect attitudes. In order to do this, the study looks into the four main aspects of speeding, enforcement, crashes and attitudes. These aspects are highlighted throughout this study, with statistical analysis being utilised as a tool for predicting and exploring the available speeding and crash data.

In terms of statistical analysis, the study attempts to conduct two logistic regressions, namely ordinal logistic regression (OLR) in Chapter 5 and multivariate logistic regression (MLR) in Chapter 8. The study adopts correspondence analysis for younger speeding drivers in the case study in Chapter 4. A multivariate analysis of variance (MANOVA) is conducted in Chapter 6 to test drivers' attitudes on the new 40km/h zone along the shopping strip. Cluster analysis is used to separate the respondents into multicultural. A chi-square test is used in Chapters 4 and 5 for testing level of associations in terms of the levels of speeding.

With regard to crash data, the study applied the data at two levels. The first level (Chapters 4 and 5) uses the data as severity indicators. The second level applies the crash data as enforcement indicators (Chapter 6). The relationship between the indicators is tested by fitting a function form, which is then tested for statistical significance.

Finally, the understanding gained of speeding and crashes as behavioural actions can be related to attitude, as attitude is reflected by behaviour.. The study also attempts to collect the opinions of road users on strategic initiatives. The particular focus of this study is on three initiatives that are considered important as they are common concerns in the media and they represent a significant triangle, i.e. police presence, tougher demerit rules, and awareness courses. All data were analysed using the SPSS statistical package.

## Appendix 3-1: Suburbs selected for the 40km/h school zones

1. ALEXANDER HGTS
2. APPLECROSS
3. ASHBY
4. ASHFIELD
5. ATTADALE
6. ATWELL
7. BALCATTA
8. BALGA
9. BALLAJURA
10. BANKSIA GROVE
11. BASSENDEAN
12. BATEMAN
13. BAYSWATER
14. BEACONSFIELD
15. BEDFORD
16. BEECHBORO
17. BEELIAR
18. BELDON
19. BELMONT
20. BENTLEY
21. BIBRA LAKE
22. BRENTWOOD
23. BULL CREEK
24. BURSWOOD
25. CANNING VALE
26. CANNINGTON
27. CARINE
28. CARLISLE
29. CAVERSHAM
30. CHURCHLANDS
31. CITY BEACH
32. CLAREMONT
33. CLOVERDALE
34. COMO
35. COTTESLOE
36. CRAIGIE
37. CRAWLEY
38. CURRAMBINE
39. DAGLISH
40. DALKEITH
41. DARCH
42. DIANELLA
43. DOUBLEVIEW
44. DUNCRAIG
45. EAST FREMANTLE
46. EAST PERTH
47. EAST VIC PARK
48. EDEN HILL
49. EDGEWATER
50. ELLENBROOK
51. EMBLETON
52. FLOREAT
53. FORRESTFIELD
54. FREMANTLE
55. GIRRAWHEEN
56. GLEN FORREST
57. GOSNELLS
58. GUILDFORD
59. GWELUP
60. HAMILTON HILL
61. HAZELMERE
62. HEATHRIDGE
63. HIGH WYCOMBE
64. HIGHGATE
65. HILLARYS
66. HUNTINGDALE
67. INGLEWOOD
68. INNALOO
69. JOLIMONT
70. JOONDALUP
71. JOONDANNA
72. KALAMUNDA
73. KARRINYUP
74. KELMSCOTT
75. KENSINGTON
76. KENWICK
77. KEWDALE
78. KIARA
79. KINGS PARK
80. KINGSLEY
81. KINROSS
82. KOONDOOLA
83. LANDSDALE
84. LANGFORD
85. LATHLAIN
86. LEEDERVILLE
87. LESMURDIE
88. LEXIA
89. LOCKRIDGE
90. LYNWOOD
91. MADDINGTON
92. MADELEY
93. MAIDA VALE
94. MALAGA
95. MANNING
96. MARANGAROO
97. MELVILLE
98. MENORA
99. MERRIWA
100. MIDDLE SWAN
101. MIDLAND
102. MIDVALE
103. MORLEY
104. MT CLAREMONT
105. MT HAWTHORN
106. MT LAWLEY
107. MT PLEASANT
108. MULLALOO
109. MURDOCH
110. MYAREE
111. NEDLANDS
112. NOLLAMARA
113. NORANDA
114. NORTH BEACH
115. NORTH BRIDGE
116. NORTH PERTH
117. OCEAN REEEF
118. OSBORNE PARK
119. PADBURY
120. PALMYRA
121. PEPPERMINT GROVE
122. PERTH
123. PERTH AIRPORT
124. QUEENS PARK
125. QUINNS ROCKS
126. REDCLIFFE
127. RIVERVALE
128. ROSSMOYNE
129. SCARBOROUGH
130. SHENTON PARK
131. SORRENTO
132. S FREMANTLE
133. S GUILDFORD
134. SOUTH LAKE
135. SOUTH PERTH
136. SPEARWOOD
137. STIRLING
138. STRATTON
139. SUBIACO
140. SUCCESS
141. SWAN VIEW
142. TAPPING
143. THORNLIE
144. TOODAY
145. TRIGG
146. TUART HILL
147. UPPER SWAN
148. VICTORIA PARK
149. WANNEROO
150. WARWICK
151. WATTLE GROVE
152. WELSHPOOL
153. WEMBLEY
154. WEMBLEY DOWNS
155. W LEEDERVILLE
156. WEST SWAN
157. WESTFIELD
158. WESTMINSTER
159. WILLETTON
160. WILSON
161. WINTHROP
162. WOODLANDS
163. WOODRIDGE
164. WOODVALE
165. YOKINE

## Appendix 3-2: Suburbs selected for the 60km/h enforcement-crash relationship

1. Alex Heights
2. Alfred Cove
3. Applecross
4. Ardross
5. Ascot
6. Ashfield
7. Attadale
8. Atwell
9. Balcatta
10. Balga
11. Ballajura
12. Morley
13. Bassendean
14. Bayswater
15. Beaconsfield
16. Beckenham
17. Bedford
18. Beechboro
19. Bee liar
20. Beldon
21. Belmont
22. Bentley
23. Bibra Lake
24. Bicton
25. Booragoon
26. Bull Creek
27. Burswood
28. Canning Vale
29. Cannington
30. Carine
31. Carlisle
32. Caversham
33. Churchlands
34. City Beach
35. Claremont
36. Clarkson
37. Cloverdale
38. Como
39. Connolly
40. Cottesloe
41. Craigie
42. Crawley
43. Currambine
44. Daglish
45. Dalkeith
46. Darch
47. Dianella
48. Doubleview
49. Duncraig
50. E Fremantle
51. East parade
52. East Perth
53. East Vic Park
54. Eden Hill
55. Ellenbrook
56. Embleton
57. Floreat
58. Forrestfield
59. Fremantle
60. Girrawheen
61. Glen Forrest
62. Glendalough
63. Gnangara
64. Gosnells
65. Greenmount
66. Greenwood
67. Guildford
68. Gwelup
69. Hamersley
70. Hamilton Hill
71. Hazelmere
72. Heathridge
73. Herne Hill
74. High Wycombe
75. Highgate
76. Hillarys
77. Hilton
78. Hocking
79. Huntingdale
80. Inglewood
81. Innaloo
82. Jolimont
83. Joondalup
84. Joondanna
85. Karrakatta
86. Kardinya
87. Karrinyup
88. Kensington
89. Kenwick
90. Kewdale
91. Kiara
92. Kingsley
93. Kingsway
94. Kinross
95. Koondoola
96. Landsdale
97. Langford
98. Leederville
99. Lockridge
100. Lynwood
101. Maddington
102. Madeley
103. Maida Vale
104. Malaga
105. Manning
106. Marangaroo
107. Maylands
108. Melville
109. Menora
110. Merriwa
111. Middle Swan
112. Midland
113. Midvale
114. Mirrabooka
115. Morley
116. Mosman Park
117. Mt Claremont
118. Mt Hawthorn
119. Mt Lawley
120. Mt Pleasant
121. Murdoch
122. Myaree
123. Nedlands
124. Nollamara
125. Noranda
126. North Beach
127. Northbridge
128. North Coogee
129. North Fremantle
130. North Perth
131. O'Connor
132. Osborne Park
133. Palmyra
134. Peppermint Grove
135. Perth
136. Picton
137. Queens Park
138. Redcliffe
139. Rivervale
140. Rossmoyne
141. Salter Point
142. Scarborough
143. Shenton Park
144. Sorrento
145. South Fremantle
146. South Guildford
147. South Perth
148. South Lake
149. Spearwood
150. St James
151. Stirling
152. Subiaco
153. Success
154. Swan View
155. Tapping
156. Thornlie
157. Trigg
158. Tuart Hill
159. Victoria Park
160. Wangara
161. Wanneroo
162. Warwick
163. Wattle Grove
164. Welshpool
165. Wembley
166. Wembley Downs
167. West Leederville
168. Westminster
169. West Perth
170. West Swan
171. Willagee
172. Willetton
173. Wilson
174. Winthrop
175. Woodlands
176. Woodvale
177. Yokine

# CHAPTER 4 SPEED ENFORCEMENT MEASURES IN 40KM/H ZONES IN TWO DIFFERENT ENVIRONMENTS

## 4.1 Introduction

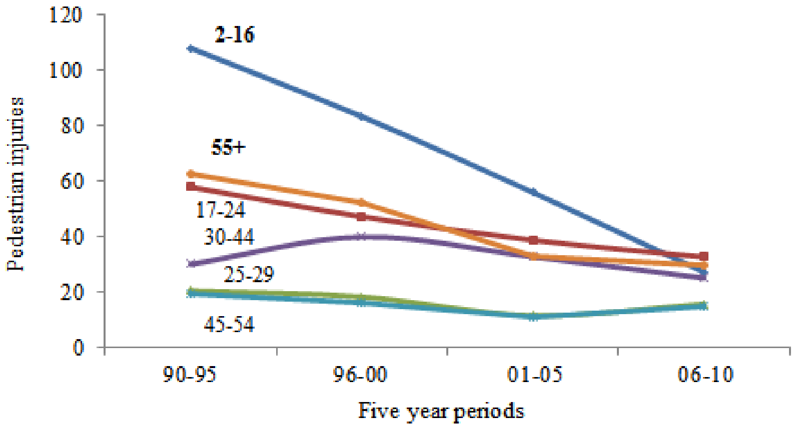
This chapter compares 40km/h zones in two different environments (see Figure 4-1). The 40km/h roads in school zones include both primary and secondary schools, and those in non-school zones include commercial areas around shopping centres and shopping strips, as well as some roadwork sites. The comparison will be made in terms of traffic infringement notices (TINs) as an indication of speeding behaviour. In addition, speeding behaviours will be further explored using the roadside and on-the-spot methods of detection (as described in Chapter 3, section 3.4.1). This will enable the study to find feasible and sustainable approaches to further improve the speeding enforcement system.

This chapter deals with school zone in 165 suburbs of Perth, targeting those suburbs with higher-than-average speeding behaviour. The non-school zone will be two major shopping strips. These two shopping strips are discussed separately in Chapter 5.


Figure 4-1: The school zone sign (left) and the non-school zone sign (right)

## 4.2 Trends in School-Age Crash History

The crash trends illustrated below in Figure 4.2 indicate that the incidence of pedestrian crashes in Perth has decreased, but it appears that in the last 20 years the downward trend for the youngest group (2–16 years) is steeper than for the rest of the age groups. In the urban area under study, there were no fatalities and only three serious injuries during the period of July 2009–June 2011 for this age group. In general, accidents involving this age group as pedestrians occur mainly in school zones.




Source: (Ebrahim and Nikraz, 2014c)

Figure 4-2: Pedestrian crashes in Perth for different age groups

***The figure above indicates that 40km/h school zone signs may be making a positive contribution, particularly it is well documented that 2-16 years group are generally school age group.***

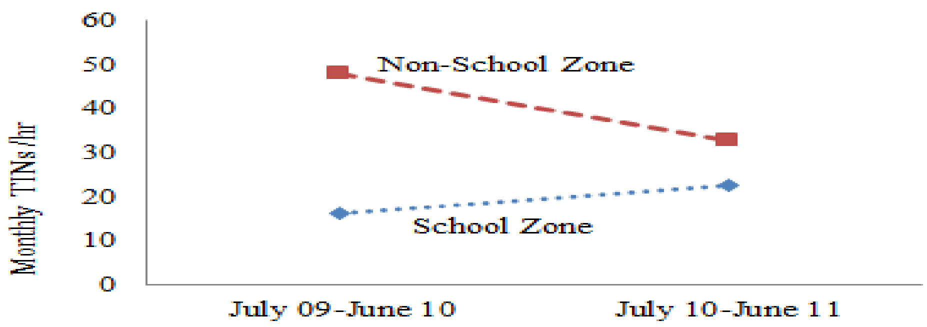
## 4.3 Enforcement in School vs. Non-School Zones

### 4.3.1 Monthly TINs per Hour

The study covers school zones in 165 Perth suburbs. The raw enforcement data consisted of 74,498 TINs for the period July 2007–June 2011. School zones were compared with non-school zones. Due to the unavailability of TINs data for roadside detection in 40km/h non-school zones 2007-2008, the school zones data was limited to 47,119 TINs for the period July 2009–June 2011. Thus both zones were compared for the period 2009-2011 separately for the ‘on the spot’ and the’ roadside’ detection types. The monthly TINs/hr rate was calculated for both roadside and on-the-spot detection of each zone. Detection data in each suburb was converted to a monthly TINs/hr rate by using the date, time and location of each incidence of detection.

When comparing the roadside detection rates in school and non-school zones, two observations were made (see Figure 4.3 below). Firstly, the rate of detection (TINs/hr) around school zones was lower than the rate around non-school zones. It shows that if the detection rate around school zones stays the same, it will continue on the increase; hence this may suggest that this increase in using these roadside cameras might be effective in detecting higher number of local speeding drivers. The rate of detection may eventually be lowered once the specific deterrence (personal experience) increases leading to a higher level of general deterrence (community experience).

On the other hand, it may be argued that school zones differ from 40km/h non-school zones. The former tends to service mainly local drivers including parents of students, whereas non-school zones service both local and non-local drivers. These non-school roads generally exist in and around the Perth CBD (central business district). The author’s observations indicate that many drivers in school zones are more compliant and cautious when it comes to speeding. It is paramount to mention that some drivers from few suburbs are driving outside the safety norm than other drivers from other suburbs. This means that some suburbs showed a higher incidence of drivers driving unsafely. This is discussed in section 4.4.



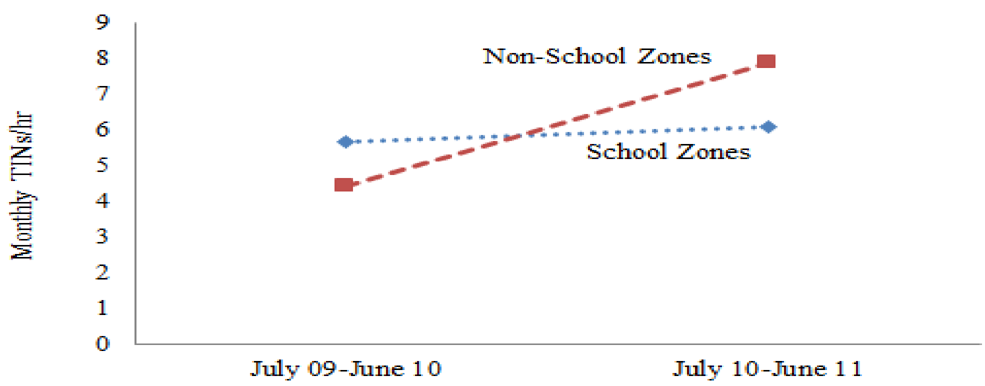

Source: (Ebrahim and Nikraz, 2014c)

Figure 4-3: Roadside speed camera detection of both zone types

Secondly, Figure 4.3 also reveals that the number of TINs/hr in the non-school zones was decreasing, but was still higher than the number of TINs/hr in the school zones. Knowles and Elliot (2012) reported that there was a 28% drop in TINs within Perth. Unlike what is shown here.

It may be that the second half of 2011 witnessed a decrease that is not included in this data. As for the non-school zones, it may be that the period between July 2009 and June 2010 was the time when the 40km/h speed limit was introduced into non-school zones, and drivers showed less compliance at the beginning, as the high number of TINs indicates. Familiarity with camera locations may have an influence when it comes to speeding, as suggested by Carnis et al. (2009).

The other important part of this comparative rate between the school and non-school zones are of TINs is focusing on another type of detection the "on the spot" detection type which showed a stable rate of TINs detected around school zones. This could be due to drivers becoming accustomed to the locations where police officers stand, and the limited number of appropriate locations. By contrast, the detection rate in non-school zones was increasing and may need more concentrated planning (see Figure 4-4).



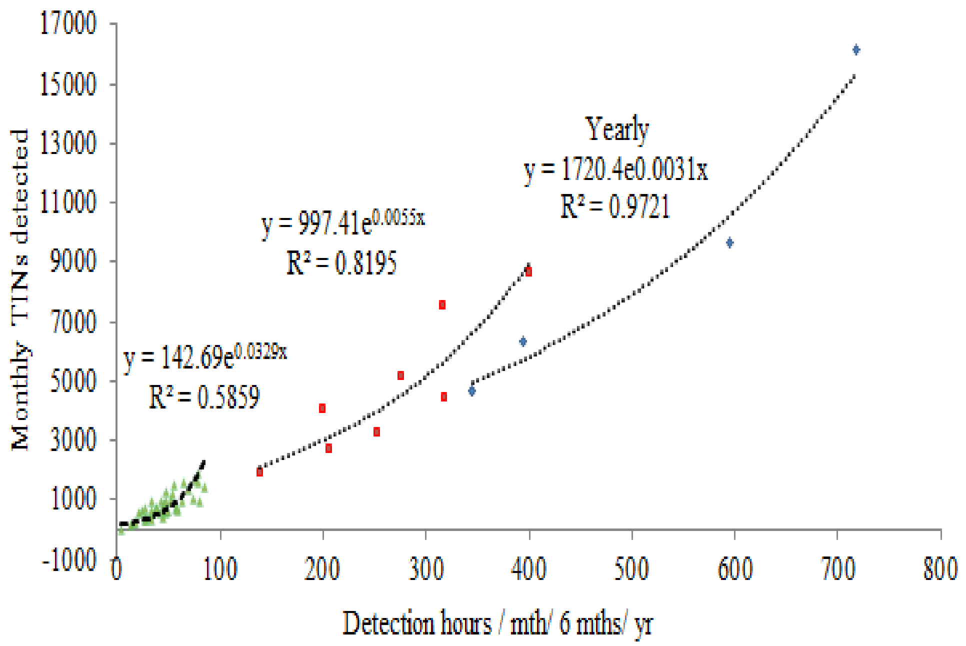

Source: (Ebrahim and Nikraz, 2014c)

Figure 4-4: The on-the-spot camera detections in both zone types

***From a sustainability viewpoint, it is suggested that some of the coercive efforts need to be directed towards increasing roadside camera hours around school zones and increasing on-the-spot detection hours around non-school zones.***

This is suggested for two reasons. Firstly, the idea of having a 40km/h limit in non-school zones is fairly new, and when on-the-spot detection is used, it is more difficult for drivers to notice a police officer around a busy shopping area. This is more pronounced in the evening or during the weekend when there is more pedestrian movement around restaurants and entertainment areas. This type of detection may generally deter drivers from speeding around non-school zones, and by intensifying the hours or implementing more randomised scheduling, as suggested by Cameron (2009), the general effect may be broadened. On-the-spot detection would lead to better harm minimisation by detecting drivers with higher level of speeding. This is discussed in the next section.

Secondly, from a sustainability viewpoint, it is suggested that increasing roadside camera hours around school zones may help to detect drivers exceeding the speed limit. The curves fitted to the roadside TINs data from school zones (see Figure 4-5) show a reserved capacity for the issuing of a greater number of TINs before reaching a diminishing return or decay. It can noticed that data fitted exponntial curves.

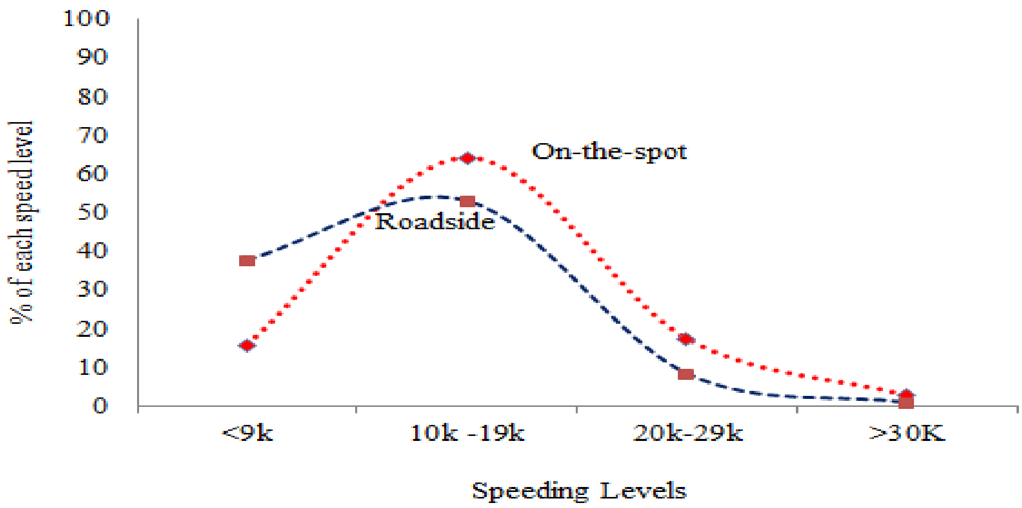



Source: (Ebrahim and Nikraz, 2014c)

Figure 4-5: Roadside detection data from school zones fitted to different functional curves

### 4.3.2 TINs at Different Speeding Levels

This section focuses on the importance of the on-the-spot method in detecting higher levels of speeding and excessive speed (see Figure 4-6).



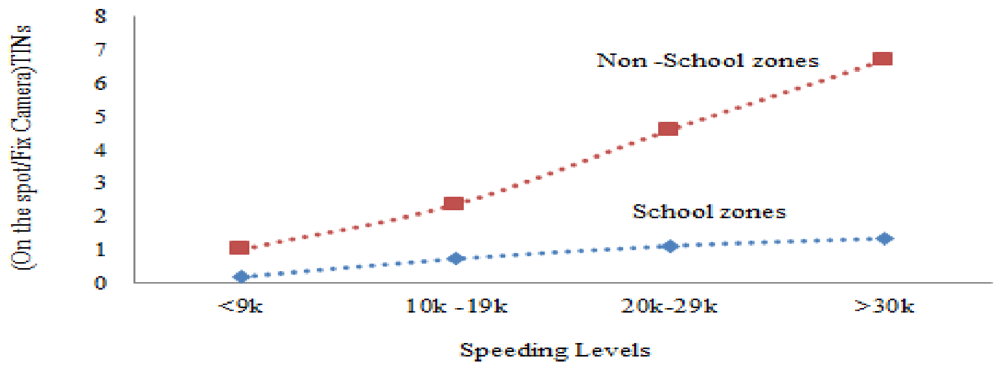

Source: (Ebrahim and Nikraz, 2014c)

Figure 4-6: Comparison of on-the-spot and roadside methods for detecting various excessive speeds in 40km/h zones

***The use of the 'on the spot' type demonstrated its dominance in detecting higher level of speed violations.***

This also reveals that roadside detection results in a higher number of TINs involving mainly the lowest level of speeding which is less than 9km/h over the speed limit. This may need to be addressed in terms of evaluating that particular speeding levels. This low level speeding was suggested by Doecke et al. (2011) and Gavin et al., (2010). In fact, there is a problem in Perth of thousands of 'good' drivers who take frequent small risks such as low-level speeding (O'Leary 2011).

Another way of looking at the dominance of the on-the-spot detection method is to use the ratio between on-the-spot detection and roadside detection (see Figure 4-7). Both curves increase as the speeding level increases. This may also explain the lack of detection of higher speeds by roadside cameras, which may not involve only the driver's familiarity with the location, but also the fact that drivers are able to slow down before reaching the roadside camera. This may be more difficult to do when approaching a police officer at high speed. On-the-spot detection has also been shown to result in a higher number of TINs in general in particular locations, and may contribute strongly to the harm minimisation process in terms of number of offences and excessive speed. It may therefore contribute strongly to reducing pedestrian fatalities and serious injuries.




Source: (Ebrahim and Nikraz, 2014c)

Figure 4-7: Ratio of on-the-spot versus roadside detection methods in school and non-school zones

***The dominance of on-the-spot detection as shown in this figure is vital, as it demonstrates that just a roadside camera is not enough — the presence of a police officer is also very important.***

This is unlike the suggestion by Goldman and Gorham (2006), which states that to rely on cameras for the speeding monitoring system. Whereas this study believe that the presence of police officers is a community desire as was found and discussed in Chapter 8.

***Further this study has used and for the first time data analysis involves 'on- the-spot' vs. 'road side'. Generally studies have adopted the covert vs. overt enforcement,***

Such studies were found in (Cameron, 2009; Cameron and Delaney, 2006; Cameron et al., 2003a; Cameron et al., 2003b). The on-the-spot method entails the immediate delivery of an infringement to speeding drivers, whereas the covert method is not necessarily on-the-spot and can involve hidden or non-flashing cameras. It appears that the results for the on-the-spot method have shown the effectiveness of a police presence.

Chi-square statistical analyses were employed to establish whether there was any association between the school zones and the shopping strips (non-school zones) in terms of the four speeding levels above the 40km/h speed limit (less than 9km/h, 10km/h–19km/h, 20km/h–29km/h and 30km/h and more). After controlling for the hourly rate per month using the on-the-spot detection method, a Chi-square test of independence was conducted. Table 4-1, shows a greater incidence of speeding behaviours along busy road strips as compared to school zones. The data reveals that there exist an association between the level of speeding violations (using the four speed levels and the type of zone (school and non-school). It was concluded that:

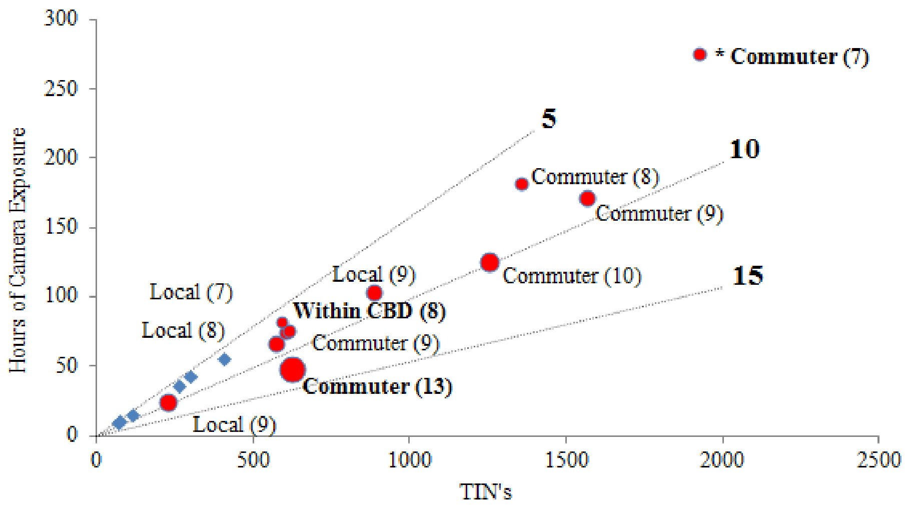
***Speeding levels and environment of the two zones are not independent. The zones are non-school zone recorded higher level of speed violations compared to the school zones with significant $X^2$ (41.31 >12.84 of Chi-square table.)***

Table 4-1: Results of Chi-Square test between school & non-school zones - Four speeding levels

| | Number of Cases | Degrees of Freedom | $X^2$ | *p* |
|---|---|---|---|---|
| Four speeding levels in school and non-school zones | 13,907 | 3 | 41.31 | 0.001 |

## 4.4 Suburbs with Higher than Average Speeding Behaviour in School Zones

The analysis of school zones in 165 suburbs revealed there was a greater incidence of above average speeding behaviours in school zones in some suburbs. Local councils may find some engineering or environmental measures to mitigate such phenomena. It may be that the location of a suburb contributes in some way to speeding behaviour, for example, ***some suburbs service only local traffic while others may service both local and non-local commuters*** **(**see Figure 4-8).




* Value inside ( ) is the rate of TINs/hr

Figure 4-8: Results for suburbs with higher than average speeding rates in school zones

Most of the drivers using these roads are travelling on them during the 60km/h limit period outside of school zone timing. Therefore the results may simply reflect the habit of travelling at speeds closer to 60km/h. In addition, these roads classified as main roads, and wider lanes encourage speeding (as discussed in Chapter 5). This is including drivers speeding on their way to work in the morning. These are clear indications as to why the rate of TINs/hr is high. This should be of concern to authorities, as this habitual risky behaviour could result in crashes involving innocent children walking to school.

## 4.5 Conclusions

From a sustainability viewpoint, it is suggested that some of the concerted effort needs to be directed towards using more roadside camera hours around school zones and more on-the-spot hours around non-school zones. It is suggested that this will deter drivers from speeding in these areas. In addition:

- The study found that the greater the speed above the 40km/h limit, the greater the harm in terms of crashes involving pedestrians.
- The 40km/h signs in school zones are making a positive contribution, as the incidence of crashes involving pedestrians is lowest for the 2–16 years age group. This age group showed the sharpest downward trend.
- Although school zones in a few suburbs had a higher than average number of TINs/hr, the non-school zones on average recorded a higher incidence

of speeding (on-the-spot) compared to the school zones, supported by a significant value of $X^2$.

- The dominance of the on-the-spot detection type over the roadside method is vital as it shows that it is important to have a police officer presence on the road and not to rely solely on roadside cameras.

## 4.6 Case Study: Young Drivers Compered in (40, 50 and 60) km/h Speed Limits

### 4.6.1 Introduction

As highlighted in the literature review, this case study will focus on young drivers. It has been frequently mentioned in the literature that young drivers are of concern in terms of their own safety and that of other road users, particularly the vulnerable pedestrians. The next section will discuss enforcement measures for three different speed limits. The case study will focus on younger drivers aged 17–24 years, compared to older age groups, including young (25–29 years), middle (30–44 years), older middle (45-54 years) and elderly (55+ years).

### 4.6.2 Speed Limit Violations

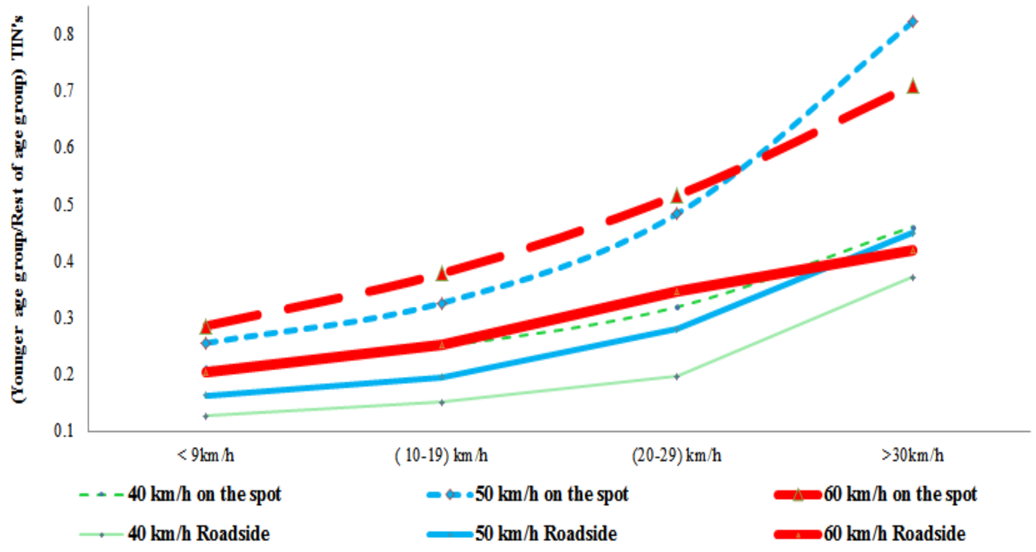
With regard to speed limit violations, three aspects are discussed, including three speed limits, gender, and age groups.

#### 4.6.2.1 Three Speed Limits

The study covers 165 suburbs in urban Perth. The total number of TINs (traffic infringement notices) issued for the period of July 2007–June 2011 was 685,391. Camera detection was employed using two different methods at three different speed limits (40, 50 and 60km/h), in order to highlight the involvement of young drivers in speeding compared to other age groups. The ratio of detection for the younger age group compared to the rest of the age groups was computed and is displayed in Figure 4-9.

Three observations may be made. Firstly, the higher the speed limits, the higher the ratio of young drivers speeding. This means that younger drivers are taking more risks on roads with higher posted speed limits such as 50km/h and 60km/h.

Secondly, regardless of detection type, speeding decreases as speed limits are lowered. This means that detection type does not change the fact that young drivers take more risks on roads with a higher speed limit. Thirdly, the on-the-spot detection method records a higher incidence of young drivers speeding than roadside detection.




Source: (Ebrahim and Nikraz, 2015)

Figure 4-9: The ratio of young speeding drivers to all the rest of the age groups at different speed limits, using two types of detections

***These results suggest that, compared to the roadside detection method, the on-the-spot method detects a greater number of younger drivers speeding with higher speeding levels and with roads of higher speed limits.***

It can be noted that extreme speeding behaviour is also detected in zones with a 50km/h limit, which may indicate why authorities are calling for lower speed limits as a preventive measure.

***As shown in Figure 4-9, the 60km/h limit is the one that needs careful monitoring as it has the highest speeding ratio compared to the two lower speed limits.***

#### 4. 6.2.2 Gender

A Chi-square test for independence was conducted (adopting Pearson values) using the on-the-spot data for the three speed limits 40km/h, 50km/h and 60km/h. The test showed a significant relationship between gender and level of speeding (<9km/h, 10km/h–19km/h, 20km/h–29km/h, and >30km/h above the speed limit). For the three speed limits shown in Table 4-2 below, the null hypothesis rejected the notion that gender and risk-taking through speeding are independent.

***This means that there is a correlation between male drivers and higher speeding levels.***

Male drivers significantly ($p$ <0.05) dominated the risky speeding behaviours at each of the three speed limits, compared to female drivers. Hence at each speed limit, male drivers were speeding and taking greater risks than female drivers. A higher $x^2$ was observed on roads with 50km/h limit around local roads. It may also be noted that Cramer's V values had low effect at all three speed limits.

Table 4-2: Chi-square parameters between speeding levels and gender at three speed limits

| Speed limit | n | DOF* | $x^2$ | $P$** | Cramer's V |
|---|---|---|---|---|---|
| 40km/h | 42,549 | 3 | 130.55 | 0.001 | 0.06 |
| 50km/h | 103,570 | 3 | 1049.14 | 0.001 | 0.10 |
| 60km/h | 109,795 | 3 | 645.73 | 0.001 | 0.08 |

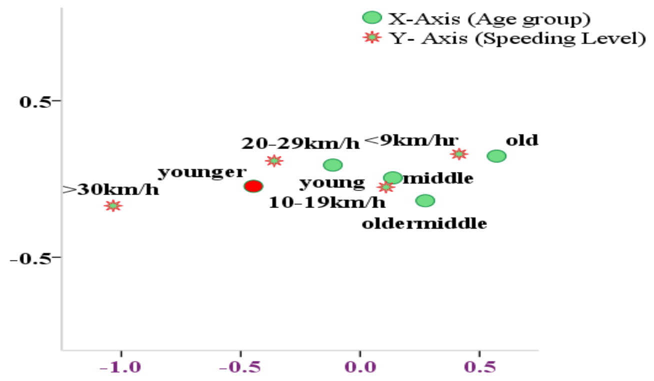
* Degrees of Freedom, ** < 0.05 confidence level

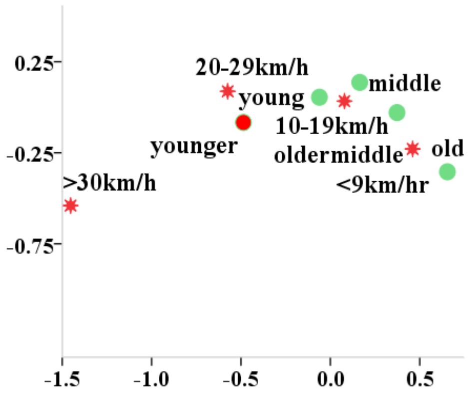
#### 4.6.2.3 Age Groups

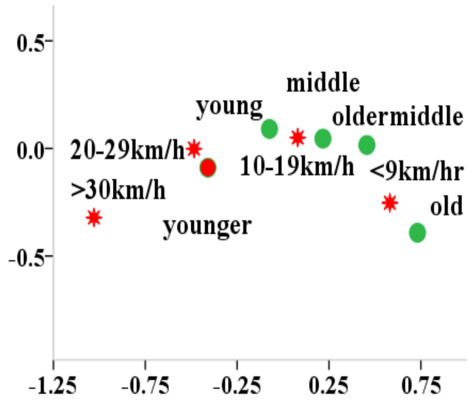
This subsection will focus on younger drivers aged 17–24 years compared to young (25-29 years), middle aged (30–44 years), older middle aged (45-54 years) and elderly (55+ years) drivers. A correspondence analysis was employed in order to find the statistical distances between age group and speeding levels (Clausen, 1998; Greenacre, 2007). The analysis was performed for the on-the-spot detection data for the period

July 2007–June 2011. The graphs shown in Figure 4-10 below compare these distances at the three different speed limits of 40km/h, 50km/h and 60km/h. The younger age group (17–24 years) were the closest distance to the high risk speeding level of 20km/h–29km/h above the speed limit. Of greater concern, they were also closer to the most excessive speed (>30km/h above the speed limit).

The same pattern is seen for the other two higher speed limits in Figure 4-10. On roads with a 40km/h speed limit, the oldest group of drivers is furthest away from the rest in terms of higher speeding levels, which may indicate that older drivers are more cautious on 40km/h roads. By contrast, young drivers (25-29 years) seem to be closer to the high risk speeding level (20km/h–29km/h) on 40km/h roads, compared to their position for the two higher speed limits.




Source: (Ebrahim and Nikraz, 2015)

Figure 4-10: Comparison of younger driver age group with four older age groups on roads with 40km/h (above), 50km/h (left below)and 60km/h (right below) speed limits

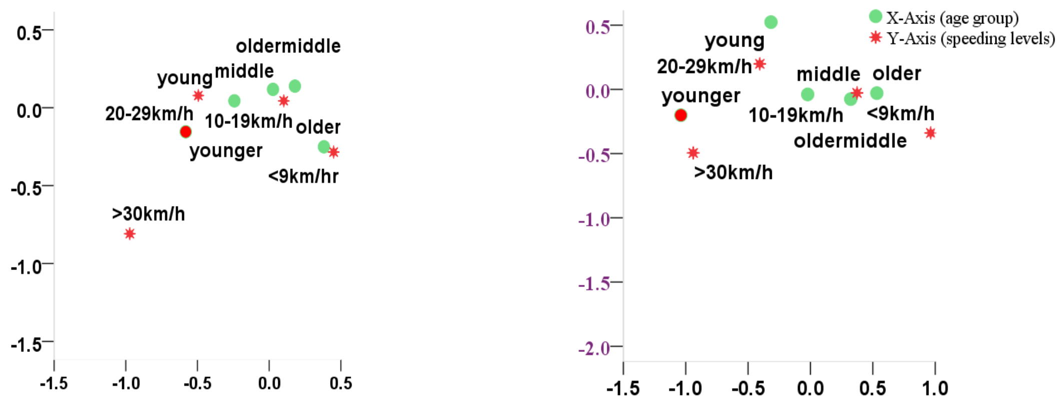
Since the younger age group (17-24 years) dominated in terms of speeding on the 40km/h roads, it was decided to further examine the involvement of this age group in two different environments, namely the school zones (local roads around and outside schools) and non-school zones (roads that belong to shopping strips, CBD and work zones).

#### 4. 6.3 Speeding in 40km/h School and Non-School Zones

This section focuses on the behaviour of younger drivers in two environments with a 40km/h speed limit: the school zone and the non-school zone. The school zone data was derived from two sources; the direct school-zone source and the 40km/h speeding data. The latter data was added based on the timing of the speeding offence and the day of the week (including weekends and public holidays), and the distance of each speeding offence from the school zone boundaries. Each case was examined individually and added to the above direct data. A buffer of 10–100m was used, based on the fact that a few school zones cases were filtered within shopping centre strips.

Knowing how younger drivers contribute to high risk speeding is considered to be vitally important to road safety policymakers. It was therefore decided to determine the distance between speeding levels and different age groups. Correspondence analysis was employed by Le Roux and Rouanet (2010). This study revealed that the younger age group was over-represented as a risk-taking group (See Figure 4-11).

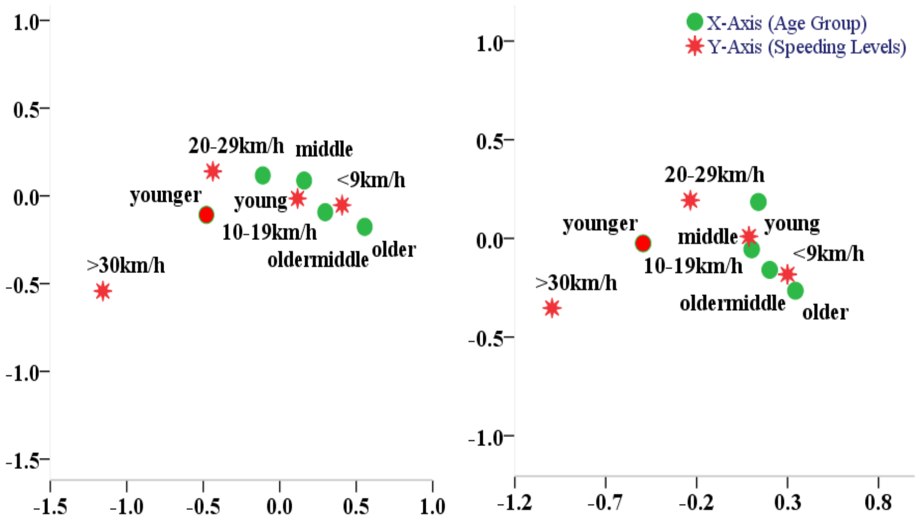
***The results showed that the youngest age group was fairly close to the most extreme speeding level (>30km/h over the speed limit) and this over-representation was more pronounced on roads in non-school zones.***




Source: (Ebrahim and Nikraz, 2015)

Figure 4-11: On-the-spot speeding detection in school (left) and non-school (right) zones: age group vs. risky speeding levels

It can also be seen that the young age group (25-29 years) was close to the youngest group, and also close to the second most dangerous speeding level (20–29km/h above the speed limit). Since the younger group is also involved in risky behaviours in school zones, it was decided to unify the age group data (to get rid of the different age range between age groups). As shown in Figure 4-12, the younger age group remained closest to the extreme speeding level (>30km/h above the speed limit) in both zones, but closest to the extreme speeding level on roads in the non-school zones.




Source: (Ebrahim and Nikraz, 2015)

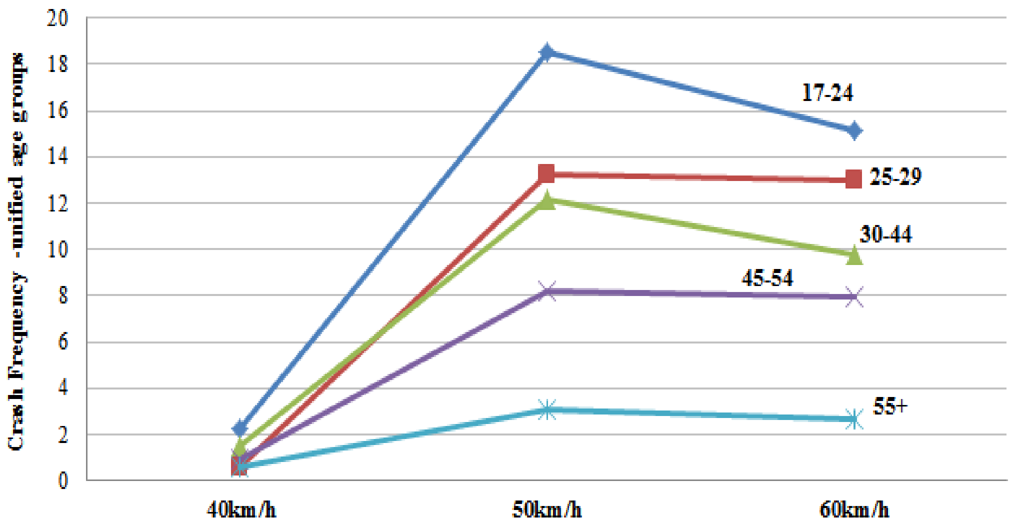
Figure 4-12: School (left) and non-school (right) zones: Unified frequency age groups vs. speeding levels

### 4.6.4 Who is Hitting Pedestrians on 40km/h Roads?

Pedestrian road crashes were found to involve the younger age group as offending drivers. These crashes can be a strong indicator of the risk involvement of different age groups. The crash data displayed in Figure 4-13 indicates that the younger age group (17-24 years) is strongly represented among offending drivers in terms of the risk of hitting pedestrians. All other age groups showed a lower unit rate, with a decreasing rate as driver age increases. The 50km/h speed limit can be cited as the most dangerous, as the highest frequency rate was recorded for all groups at this speed (and similarly, for 60km/h). Figure 4-13 shows that all age groups contribute to hitting pedestrians at 50km/h and 60km/h, but at different frequency rates.

***The younger age group remains the highest contributor to risk compared to the other age groups, regardless of speed limit (40, 50 or 60 km/h).***

Younger drivers (17-24 years) were found to contribute the most to road crashes. If the Towards Zero Strategy is to achieve its goal in Perth, it must research and invest resources into addressing the problem of younger drivers' contribution to road crashes and reducing harm to pedestrians. This concern is demonstrated clearly in Figure 4.13.




Source: (Ebrahim and Nikraz, 2015)

Figure 4-13: Driver age groups involvement as drivers hitting pedestrians at three different speed limits — based on unified rate, using 2006–2011 crash data.

Further to this, Main Roads Western Australia crash data for the Perth metropolitan area was analysed to produce severity percentages for pedestrian victims involved in crashes during the period 2006–2011. Pedestrian crash severity percentages were higher on roads with higher speed limits, such as 60km/h (see Table 4-3). In terms of the roads with a low speed limit such as 40km/h, it was found that roads in non-school zones had higher pedestrian crash severity percentages than those in school zones. This is more pronounced for pedestrians killed and seriously injured (KSI). Table 4.3 reveals that the higher the speed limit, the higher the harm in terms of pedestrian crashes.

Table 4-3: percentages of pedestrian crash severity

| Pedestrian Crashes | 40km/h School | 40km/h Non-School | 50km/h | 60km/h |
|---|---|---|---|---|
| KSI/Total* | 13 | 25 | 32 | 42 |
| All Injuries /Total | 47 | 55 | 65 | 72 |

* Total includes property damage

### 4.6.5 Case Study Discussion

The case study has shown that younger drivers speed more than any other age group at all three speed limits (40km/h, 50km/h and 60km/h).. The 50km/h speed limit may need to be targeted for audit, as it was found that drivers of all ages were contributing to the incidence of pedestrian crashes being almost as high at this speed as for 60km/h. This could be because there are more and longer roads with these two speed limits than other speed limits, but this should not be a reason not to audit such roads and to make them safer for road users.

Research in Australia has found that the chance of a pedestrian surviving if hit at 60km/h is low compared to 40km/h, where the chance of being killed is only 25% (Corben et al., 2004). Due to the recent rise in pedestrian fatalities on 60km/h roads in Perth, the Curtin-Monash Accident Research Centre is calling for lower speed limits near shopping centres and hospitals (O’Connell, 2012). Younger drivers (17–24 years) appear to be the group mostly likely to drive at dangerous and excessive speeds. The study found that male drivers speed more than female drivers. Pedestrian crash data also supports this, revealing that most drivers who hit pedestrians belong to this younger age group. The study also found the younger age group to be a major concern around school zones and around 40km/h roads in non-school zones.

Experience outside Australia has shown similar concern for young drivers. For instance, according to the Dutch Institute for Road Safety Research SWOV, the difference in crash rates between young (18–24 years) and older drivers (30–59 years) is increasing. It found that 20 years ago, the fatal crash involvement rate of young motorists was three times higher than that of older motorists; today it is six times higher. The Institute recommends that the speed limit on roads where there are possible conflicts between cars and unprotected road users may need to be decreased to 40km/h or even lower (SWOV, 2006). A recent proposal discussed in Britain could see younger drivers being banned from carrying non-family passengers. A according to the UK government as younger drivers under the age of 25 represent only one in eight of the driving population, but they account for one third of the number of people who die on UK roads (Millward and Hall, 2012). Recently in Melbourne, the idea of a night curfew for younger drivers stood little chance, as a survey of 16,000 road users showed that only 28% accepted the idea of a night curfew between 10pm and 7am, Moor (2012). Similarly in the UK, only 34% of road users agreed about a night curfew for young drivers between 11pm and 4am, The Guardian (2012). The article adds that survey results suggest that more education and training are needed.

Overall, sustainability is needed in order to bring about a change in young drivers' risk-taking behaviour in favour of safer speeds. The recommendation is that two levels need to be targeted in parallel with enforcement. Firstly, a municipal program may be necessary in order to target 60km/h and 50km/h roads and prepare an 'audit plan' to lower the speed limit on these roads based on harm scaling such as accident history or speeding history and other engineering measures. Secondly, authorities may need to focus on the regulations concerning younger drivers' licences in terms of speeding violations and accident history, and implement more real life scenario training. Authorities may need to be even more stringent with existing regulations where required, more scenarios in general will be implemented for training of young drivers. With such policy direction, a high return on road safety may be achieved that can assist in producing sustainably safer roads.

## 4. 7 Overall Conclusions

The 40km/h limit was found to contribute positively to road safety. The study found that the higher the speed limit is above 40km/h, the higher the harm in terms of pedestrian crashes. In addition, there are several specific conclusions which can be drawn, as follows:

In terms of 40km/h school zones:

- The 40km/h school zone signs may be making a positive contribution, as the pedestrian crash rate for the younger school pedestrians (2–16 years) is low compared to other age groups, and shows the sharpest negative trend.

In terms of 40km/h non-school zones:

- Non-school zones recorded a higher level of speeding (on-the-spot detection) compared to school zones, with the result supported by a significant $X^2$.
- From a sustainability viewpoint, it is suggested that some of the concerted efforts need to be directed towards more roadside camera hours around school zones and more on-the-spot hours around non-school zones.

In terms of young drivers:

- For the first time, this study has used a data analysis approach comparing on-the-spot vs. roadside detection. Other studies have generally adopted a covert vs. overt enforcement approach. The use of the on-the-spot method demonstrated its dominance in detecting a greater number of speed violations. The dominance of this method is vital as it exposes a higher rate of speeding for younger drivers compared to roadside detection, as well as highlighting the importance of having a police officer presence on the road instead of relying solely on roadside cameras.
  - The on-the-spot method is superior in detecting the risk-taking behaviour of young drivers in the three different speed zones demonstrates the significant effect of the on-the-spot method and the risk of the young drivers which is contributed in the three speed limits discussed (40km/h, 50km/h and 60km/h).

- This means that younger drivers are taking more risks on roads with higher posted speed limits such as 50km/h and 60km/h.
- Regardless of the detection types used, younger drivers are taking more risks on higher speed limit roads.
- The on-the-spot method more frequently detects younger drivers speeding, and with higher speeding levels, than the roadside detection method.
- There is an association between male drivers and higher speeding levels.

In terms of suburbs:

- Some suburbs service only local traffic and others may service local and non-local commuters.

# CHAPTER 5 SPEED ENFORCEMENT INTERVENTION IN 40KM/H ALONG SHOPPING STRIP

This chapter consists of two case studies, the first of which involves the analysis of speeding data using OLR (Ordinal logistic regression). This is attempted after the introduction of 40km/h electronic signs along an urban road i.e. a busy shopping strip where the speed was previously 60km/h. The second case study will compare the abovementioned urban road with a similar type of road on two different engineering measures, one being the new electronic signs and the other being the standard signs with standard road markings.

## 5.1 Case Study One: Speeding Analysis using Ordinal Logistic Regression

### 5.1.1 Introduction

The purpose of introducing a variable speed zone was to lower the speed limit from 60km/h to 40km/h during peak periods of pedestrian activity. The initiative aimed to improve safety for pedestrians and other road users. The signs displayed a speed limit 40 km/h from 7.30 am till 10.00 pm (except on Friday and Saturday, when the time was extended till 1:00 am instead of 10:00 pm). The same signs displayed a speed limit of 60km/h outside the abovementioned times.

Each variable to be used in this case study was researched. The literature revealed that gender was a prominent explanatory variable in some studies (Yan, Radwan and Abdul Abdel-Aty, 2005; Yan, Radwan and Mannila, 2009; Oxley et al., 2005) and in older female drivers was attributed to causes such as poor attention, cognition and other age-related reasons.

In terms of the time-of-day effect, Lenny, Triggs and Redman (1997) found that there were impairments in driving performance in the early afternoon that were of similar magnitude to those occurring in the early and late evening. By contrast, a study of industrial accidents in Queensland, Australia found that more injuries occur in the morning in Australia than in the afternoon, on every working day of the week (Wigglesworth, 2006). In Spain, Camino et al. (2011) concluded that most construction industry accidents happened in the afternoon periods, and attributed this to the ‘lunch effect’. According to the study, these accidents occurred in the hours around the lunch break (from 13:00 to 17:00), and were of greater severity and involved more fatalities than those occurring at other times of day.

Banwell et al. (2006) from Australia added another dimension; a survey of construction workers revealed the consumption of alcohol is common in the construction industry, which may explain the occurrence of afternoon accidents.

This case study includes morning and afternoon times as explanatory variables in the model, and will apply OLR (ordinal logistic regression) to speeding levels as a dependent variable, and four other explanatory variables, being age, gender, time detected speeding, and the frequency of speeding periods before and after the installation of electronic signs. The data for this fourth variable consisted of 2077 TINs in total; the before data consisted of only 602 TINs (before 4 August 2009, which is considered to be the date of installation of the electronic signs). This compares to 1475 TINs after the installation, until from 30 June 2011. This data is what was available from the authorities, and may be limited. The next section will discuss the selection of the statistical model. Details can be seen in Ebrahim and Nikraz (2014a). Note that the approach of Multivariate Logistic Regression (MLR) were found discussed in earlier study by Ebrahim and Nikraz (2012b).

### 5.1.2 OLR Application

The study attempted initially to examine data fitting to suitable model to fit the data. The first method was ordinal logistic regression (OLR) and the second was multinomial logistic regression (MLR). Following a comparison of the two methods, it was decided to adopt OLR, for two reasons. Firstly, the dependent variable mentioned above (the speeding level) is ordinal in nature. Secondly, upon comparison of the fitting information for the two models (see Table 3-2), it was found that the Pearson p value for the ordinal model might produce a better fit. It is important to mention that this comparison was undertaken, because the MLR model did give good competing fitting information in comparison with the ordinal model.

### 5.1.3 Classification of Speeding Levels

This study classified the speeding categories into four levels (low, medium, high and extreme). These speed limits were based on the office of road safety of WA.
There were originally five levels as follows:

- Not more than 9km/h
- More than 9km/h but not more than 19km/h
- More than 19km/h but not more than 29km/h
- More than 29km/h but not more than 40km/h
- More than 40km/h

It was decided to join the two highest speeds into one category, as shown in Table 5-1, based on the premise that any speed greater than 30km/h over the speed limit is considered an extremely unsafe speed. Therefore the speeding categories were modified into four speeding levels (low, medium, high and extreme).

Table 5-1: Speeding levels and outcomes

| Km/h above speed limit | Speeding level | Risky speeding outcome |
|---|---|---|
| <9km/h | Low | Low danger |
| 10km/h–19km/h | Intermediate | Moderately dangerous |
| 20km/h–29km/h | High | Highly dangerous |
| >30km/h | Extreme | Excessively dangerous |

### 5.1.4 The Approach Adopted

In Chapter 3 there was an attempt to find a suitable method for testing the speeding data. Two methods were tested, the ordinal logistic regression (OLR) and the multivariate logistic regression (MLR). It was found that both had good model fitting information (see Table 3-2), but the Pearson p value for the OLR model was higher, producing a better fit. Therefore the study has adopting the OLR model.
In addition to that it can be noted that the speeding levels were ordered by nature.

The study will deal with three discrete outcomes as the low speeding levels will be used as a baseline (reference) level. The speeding outcomes will be shown as described in Table 5-1. The study aims to test the probability of the dependent variable speeding level occurring as the values of the independent variable change. In other words, the objective is to find out the magnitude of high speeding levels. This comes from the common concerns in the transportation literature about drivers exceeding the speed limit, with the potential for more severe crashes. Thus, the Y event is very unlikely to occur if f(Y) is close to 0 and it is very likely to occur if f(Y) is close to 1.

### 5.1.5 Modelling Speeding Levels

The first step in the model construction is to get a logit score Y, and then further check the predicted probabilities and scatter them against the Pearson residuals that the model produces. The logit function is given by equation 1, which is derived from different predictors multiplied by their corresponding regression coefficients, where Y is calculated as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n \quad (1)$$

Where $\beta_0$ is the intercept of Y value and when all the predicting variables $X_1, X_2, X_3$ $\ldots X_n$ are equal to zero. The variable Y (logit) is a measure of the sum of the input of all the independent predictor variables used in the model. The variable Y is defined as:

$$(Speeding) = \beta_0 + \beta_1 * Age + \beta_2 * Gender + \beta_3 * Time + \beta_4 * Period \quad (2)$$

Where:

| | | |
|---|---|---|
| Speeding | = | Four levels as shown in Table 5-1 above. |
| Age | = | Recorded age of speeding driver. Continuous variable. |
| Gender | = | Gender of speeding driver. Categorical variable, female = 0 , male = 1. |
| Time | = | Time of day speeding detected. Categorical variable, morning (6.00–11.59 am) = 0, afternoon (12.00–19.00 pm) = 1. |
| Period | = | Frequency of speeding period before and after the installation of the electronic signs. Categorical variable, before installation = 0, after installation = 1. |

Then it is appropriate to calculate the probabilities of that logit, by using equation 3.

$$P(Y) = f(Y) = \frac{1}{1 + e^{-Y}} \tag{3}$$

Where f(Y) is the probability of speeding occurring represented by $Y$ and e is the base of the natural logarithm. For several predictors, the equation would become

$$P(Y) = f(Y) = \frac{1}{1 + e^{-\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n}} \tag{4}$$

Substituting Y of equation (2) into (4), with all predictors, the final probability calculated will become:

$$f(Y) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 * Age + \beta_2 * Gender + \beta_3 * Time + \beta_4 * Period)}} \tag{5}$$

Speeding data will therefore be calculated through OLR using speeding levels and their corresponding probabilities. SPSS software outputs are evaluated and discussed below.

### 5.1.6 Model Evaluation

Two main evaluation steps are discussed below. Firstly, the crucial fitting information that determines the model's good fit, and secondly, the parameter estimates testing the coefficients and the odds ratios of the model.

#### 5.1.6.1 Model Fitting Information

Table 5-2 below discusses the log-likelihood, goodness of fit and pseudo $R^2$. It can be noted that all details are encouraging, showing a good fitting model if the explanatory variables are used.

Table 5-2: Fitting informations including remarks on using the OLR model

| details | value | *p* | Remarks |
|---|---|---|---|
| -2 LL ($x^2$) | 172.56 | 0.001 | The change is significant and explains the decrease in unexplained variance. It is considered a good improvement to the model. |
| Goodness of fit | Pearson =1241<br>Deviance=979 | 0.39<br>1.00 | The predicted values are not significant and not different from the observed, thus the fit of the model is good. |
| Pseudo $R^2$<br>Cox and Snell<br>Nagelkerke<br>McFadden | <br>0.08<br>0.10<br>0.05 | <br>-<br>-<br>- | Fairly similar values and fairly reasonable, representing a good size effect according to Field (2009). |

#### 5.1.6.2 Parameter Estimates

In this section and as shown in Table 5-3 below, particular attention needs to be paid to the odds ratios *Exp (B)* for interpretation of the model values and the decrease and increase of the predictor's effect on speed outcome.

The value of Y calculated from equation 2 is equal to the value of β when all other independent variables are equal to zero. The coefficient is either a positive or a negative one, indicating an increase or a decrease in the probability respectively. Similarly, if the coefficient is high or low, it means that the risk due to speeding strongly or weakly affects the outcome respectively (Petrucci, 2009). The parameter estimates are as follows:

Table 5-3: Model parameter estimates

| Predictors including interactions | *B* (SE) | Wald $x^2$ | 95 CI limits Lower | Upper | Odds ratio *Exp (B)* | *P* - value |
|---|---|---|---|---|---|---|
| Age | -0.01 (0.03) | 12.36 | -0.019 | -.005 | 1.00 | 0.001 |
| Time = 0 | -0.70 (0.10) | 47.34 | -0.90 | -0.50 | 0.50 | 0.001 |
| Time = 1 | 0.0 | | | | | |
| Gender = 0 | -0.02(0.10) | 0.04 | -0.21 | 0.17 | 0.84 | 0.84 |
| Gender = 1 | 0.0 | | | | | |
| Period = 0 | 0.91(0.11) | 67.31 | 0.69 | 1.12 | 2.48 | 0.001 |
| Period = 1 | 0.0 | | | | | |

*Age:* the coefficient for speeders in terms of age is found to be -0.01 and the odds ratio is > 1. Thus, if the speeder's age is increased by one unit (year), the likelihood of a driver speeding decreases by 0.02 units. Older drivers are slightly less likely to speed.

*Time of the day:* the coefficients for time of detection, where 0 = morning and 1 = afternoon appear to be significant predictors. The coefficient is -0.70 and the odds ratio < 1. Hence drivers are more likely to speed in the afternoon than in the morning.

*Gender:* Despite the fact that the coefficient of a person's gender (female=0, male=1) does not significantly predict the speeding of drivers. It is still important to highlight and discuss this explanatory variable, since gender is frequently related to speeding in the literature. It was found that the coefficient was -.02 and the odds ratio was < 1. Thus male drivers are slightly more prone to speeding than female drivers. This also supported by the data displayed in Figure 5-1.

*Period:* This variable is of high importance to this study since it determines the usefulness of the flashing electronic 40km/h sign in reducing speeding. The coefficients for periods (before = 0 and after =1) are 0.91 and the odds ratios > 1. This shows that drivers were speeding more before the installation of the signs than afterwards.

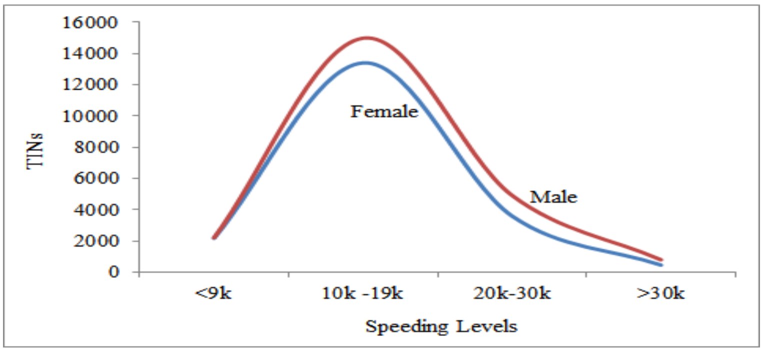
### 5.1.7 Discussion

Three of the four explanatory variables were found to be significant, with the exception of gender. Despite this, gender is still discussed due to its importance as a variable in speeding and safety on the road.

It was found that the age of the driver contributed slightly to speeding. ***Older drivers were slightly less likely to drive faster than the speed limit compared to younger drivers.***

***It is important to mention that time of the day was found to be significant in the model. Drivers were more prone to being detected speeding during the afternoon than in the morning***. When road crash data for the years 2007–2011 was analysed, it was found to be consistent with the above model findings. The analysis showed that only 33% of pedestrian crashes occurred in the morning period (6:00–11:59am), compared with 67% in the afternoon period (12:01–5:59pm). By comparison, 25% of all other crash types occurred in the morning compared with 75% in the afternoon. So, time of day may reveal more information about why drivers speed and how this behaviour may be better monitored, detected and deterred. This may include the development of a strategy for the crucial afternoon hours, such as increasing enforcement at that time of day, at specific locations.. The time period and its risk factors to protect vulnerable road users such as the pedestrians was discussed in Mountain, Hirst and Maher (2005) and also in Corben et al (2008) involving busy shopping strips such the strip under such as the high pedestrian activity.

In terms of gender, it was found that male drivers were slightly more prone to speeding than female drivers, Figure 5-1. The study found that male drivers sped more than female drivers on 40km/h roads in Perth. The figure also shows that males speed more for each speed category, except for the lowest speed above the limit, for which males and females seem to speed equally.




Source: (Ebrahim and Nikraz, 2014a)

Figure 5-1: TINs issued for speeding on 40km/h roads in Perth, by gender and level of speed above the limit, July 2007–June 2011

***The variable relating to the period before and after installation of the signs is also significant. Drivers were found to have slowed down after the installation of the flashing electronic 40km/h signs.***

This has recently been supported by Ebrahim and Nikraz (2013) who found that the incidence of crashes decreased after the installation of the 40km/h electronic speed signs. The signs are therefore contributing to sustainable safe speeds.

### 5.1.8 Conclusion

To conclude, this case study utilised the OLR model to test four predictors, three of which were age, gender of the driver and the time of day the driver was detected speeding. These are explanatory predictors, whereas the fourth one which is the 'period' tested the usefulness of electronic signs and complemented the other three predictors.

The study found that:

- The driver's age contributes slightly to risky speeding behaviours, and older drivers speed less than the younger drivers.
- Time of the day was found to be significant in the model, with a higher number of TINs being recorded in the afternoon than in the morning.
- Although gender was not found to be a significant predictor, it was shown to be produce results similar to those for speeding behaviour with males speeding

slightly more than females. This was more pronounced with higher speeding levels.

- The period variable in the model relating to the installation of the signs was significant, with drivers slowing down after the installation of the flashing electronic 40km/h signs. This proves the usefulness of such signs in reducing speeding.

### 5.1.9 Model Limitations

Certain limitations of the model are worth mentioning, as follows:

- The period of the study needs to be expanded in order to obtain reliable data. The before/after data in particular needs to be unified on the basis of the same number of hours.
- The length of time a driver has been licenced and therefore the amount of experience they've had of driving.
- Extra information on driver history and repeat offending needs to be included among the variables.
- The study looked purely into speed as a risk factor and ignored other safety issues such as seatbelt use or whether the vehicle was safe, etc.

# 5.2 Case Study Two: Non-School Zones of 40km/h with Different Engineering Measures

## 5.2.1 Introduction

This case study will focus on comparing two engineering measures, one where the new electronic signs are used, and the other where the standard signs are used along with standard road markings. In Case Study One earlier in this chapter, the electronic signs were tested on their own using OLR. This case study will compare the same shopping strip with the new electronic signs (in Beaufort Street, which will be called road B), with another shopping strip that has only standard 40km/h signs and standard 40km/h road markings (Albany Highway, which will be called road A). The measures by which the roads will be compared will be the effects of speeding enforcement and crash history. Both roads are popular and cater for shoppers and diners, with a high volume of traffic. Road A (Albany Highway) is shown on the right hand side in Figure 5-2.


Source: (Ebrahim and Nikraz, 2013b)

Figure 5-2: The electronic speed signs on road B (left) compared to the standard 40km/h signs and road markings on road A

## 5.2.2 Data

The study is not based solely on road crashes; therefore data will consist of other information as well as crash history, such as speeding data, including other parameters for both roads. The collected data is shown in Table 5-4, and includes design parameters, traffic volumes and composition, such as commercial vehicle percentages and speed reduction (85$^{th}$ percentile), obtained from local municipalities.

Table 5-4: Data collected for both roads

| Item | Road A (compared ) | Road B (treated) |
|---|---|---|
| Existing design | Two single lanes separated with median or painted median at different locations with parallel parking along each side of the footpath. | Two single lanes separated with median or painted median at different locations with parallel parking along each side of the footpath. |
| Daily traffic volume both directions (veh/day) in 2009, 2010 and 2011 | 5500–7500<br>Fairly consistent | 24,000<br>Fairly consistent |
| Road length (km) | 3.2 | 0.70 |
| Lane width (m) | 3–4.2 | 3.1 |
| Speed reduction (85$^{th}$ percentile) | 3.7 (average of two locations) | 7.65 (average of both bounds) |
| Commercial vehicles (%) | 3–7%<br>from Council | 3–6%<br>from site observation |

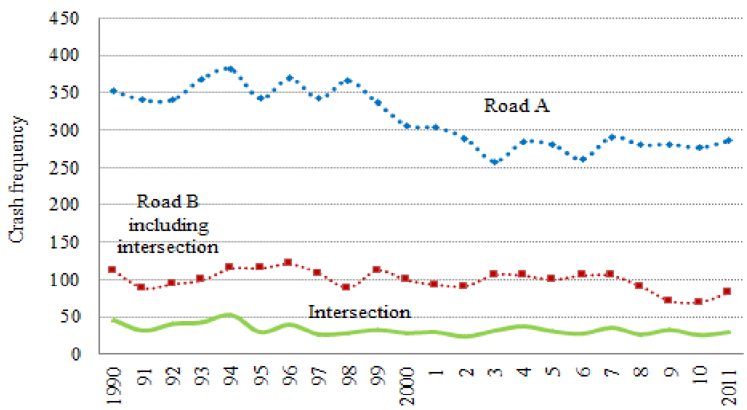
In terms of the 85$^{th}$ percentile speed of the vehicles travelling on the two roads under study, Table 5-4 shows a better reduction rate for the speed on Road B compared to that on Road A (Main Roads , 2011). This obvious reduction demonstrated the initial benefits of using the electronic variable speed signs over the standard signs and road markings. The scope of this paper is to highlight the benefits of the electronic signs from the road safety perspective in terms of crash reductions, speeding reduction and less excessive speeding. Table 5-5 shows details of the before and after schedule for both roads and for speeding and crashes.

Table 5-5: Comparison dates for speeding and crashes for roads A and B

| Measure | Road A (compared) | Road B (treated) |
|---|---|---|
| Speeding before | 13 months<br>5/2009 - 5/2010 | 23 months<br>9/2007 - 7/2009 |
| Speeding after | 13 months<br>6/2010- 6/2011 | 23 months<br>8/2009 6/2011 |
| Crashes before | 19 months<br>11/2008 - 5/2010 | 29 months<br>3/2007- 7/2009 |
| Crashes after | 19 months<br>6/2010 - 12/2011 | 29 months<br>8/2009 - 12/2011 |

### 5.2.3 Crashes Before and After

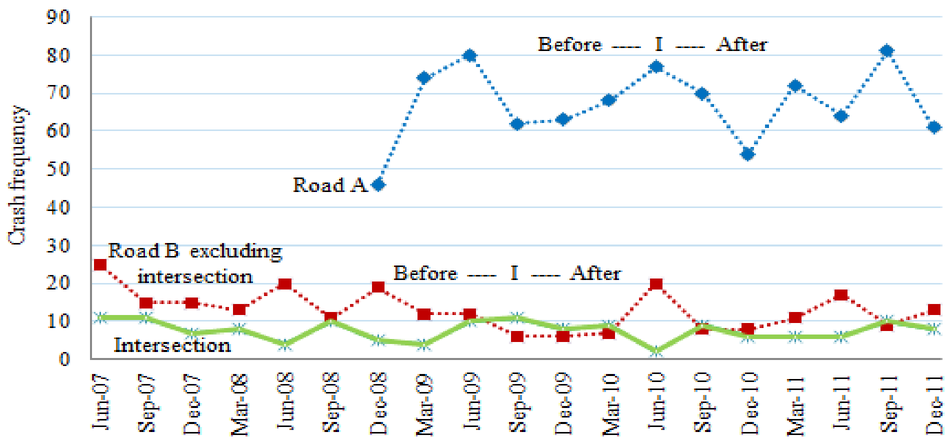
Three general trends are shown in Figure 5-.3 below. They are for the period 1990-2011. Road A is shown here as the compared road and Road B is the treated road. The intersection is part of the treated road in Road B. The addition of the intersection to Figure 5-3 is to highlight the low contribution of the intersection to the outcome of the benefits of the 40km/h variable speed zones. The inclusion of the intersection was found to have had an influence on the decrease in road crashes, unlike the rest of Road B. This is done to show that the benefits of the speeding and crashes reduction are coming from the new signs within the trailed road and not the intersection where the trial starts. More details are discussed below. Importantly it can be learned from Figure 5.3 incidence of crashes over the last five years for road B has been the lowest ever in the last 21 years compared to that of road A. Road A showed lowest recorded crashes in 2003, and 2006 and not recently. Road B has the lowest crash values in the last five years.




Source: (Ebrahim and Nikraz, 2013b)

Figure 5.3: Crashes frequency during 1990-2011

Data was further analysed to compare before-after crash frequency. In Figure 5-4 below focus is on the before after study comparison between the two roads. Road A does not show much reduction after the use of the standard 40km/h signs and road marking. Road B showed on average lower crash frequency of the 40km/h electronic signs.




Source: (Ebrahim and Nikraz, 2013c)

Figure 5-4: The effect of the Electronic signs treatment on reducing crashes in Road B

This crash reduction in Road B without the influence of the intersection would have improved the crash reduction by further 7% as shown in Table 5-6. In fact analysis showed that Road B has zero severe crashes without the influence of the intersection. This is considered significant in terms of KSI (Killed or Seriously Injured) crashes.

Pedestrian crashes were also reduced by 20% since the installation of the electronic signs in Road B presented in Table 5-6 below. Careful interpretations need to be taken into consideration of the pedestrian results for two reasons. Firstly the low number of pedestrian injuries would make it difficult to come to firm percentages conclusions and secondly there need to be more data that is why some of these rates are high.

The study found that long term crash trend seemed to be contributing to the reduction of crashes in the all three entities (Road A, Road B & the intersection of Road B). This is shown in Table 5-6. This trend is added to the study because of it is considered as indicator of the real trend that the road has experience and not because of treatment effect. There may be series of treatments throughout the years to the intersection such as no right turn etc. That is why any recent reduction due to the electronic signs treatment may need to be higher reduction than the crash trend effect. In this case, the crash trend would still leave Road B with reasonable reduction (-18 %) that may overcome regression - to - the – mean. It is a phenomenon that occurs particularly when high number of crashes may regress towards the mean of crashes of that particular road at a later stage, Michaels (1966).

Table 5-6: crash reductions and trends

| location | Total Crashes Reduction % | Pedestrian crashes Reduction % | Injury Reduction % | *Crash Trend % |
|---|---|---|---|---|
| Road A | -7 | -86 | -10 | -18 |
| Road B | *-18* | -20 | -10 | *-11* |
| Intersection of Road B | -7 | Few only | +200** | -16 |

* Crash trend is (1990-2011) ** increasing number of vehicle to vehicle crashes

The 18% reduction of crash trend achieved in Road B may be considered high enough to cater for such phenomena. According to Sharma and Datta (2007), three years of data or more before and after are required to be able to alleviate the regression to the mean effect. In the case of Road B, data used are less than three years but the crash reduction is still considered high, (Hauer 2002; Michaels 1966). It is nearly double the reduction percentage of the crash trend. It follows that if crash reduction may be due to chance when it is not large, but if it is large then it could be attributed to the treatment Hauer (2002).

***Therefore and according to the above argument the (-18%) crash reduction in Road B is sufficient to overcome the crash trend (-11%) and regression towards the mean. Therefore the reduction of crashes seen on Road B is due to the treatment and that is the installation of the electronic signs.***

The data from also may highlight the importance of improving the design and traffic movement of the intersection of Road B. since it is effecting the reduction of crashes of the trail. Therefore the trial may need to be extended beyond the intersection so that drivers are adjusting their speed before approaching the intersection and not at the intersection. See more details in sub section 5.13.4.

### 5.2.4 Speeding Effect

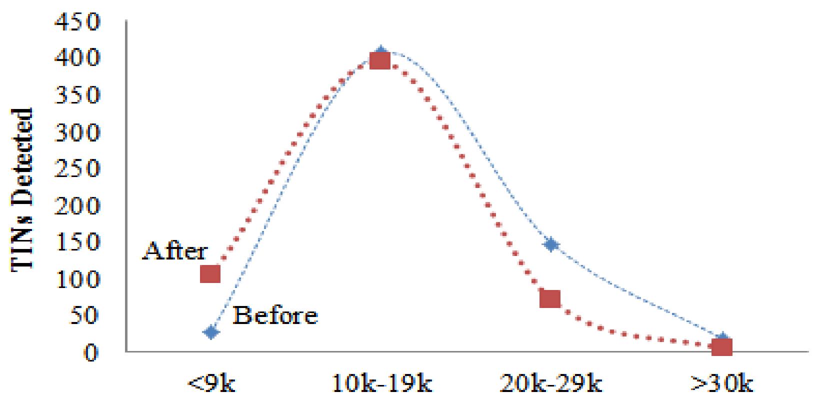
#### 5.2.4.1 Speeding on Road B (before – after)

Statistical analyses were employed using Chi-Square to establish if there is an association between Road B before and after speeding data on four speeding levels (less than 9km/h), (10km/h -19km/h), (20km/h- 29km/h) & (30km/h and more) above the 40km/h speed limit . After controlling for the hourly rate per month using on the spot detection type of enforcement, a Chi-square test of independence was conducted. Table 5-7 and Figure 5.5 show that there is an association between period of data (before or after) and the speeding levels indicating a significant p value of 0.001.

Table 5-7: Chi-Square of Road B (before and after) the electronic signs installation

| Association between | Number of Cases | Degrees of Freedom | $X^2$ | *p* |
|---|---|---|---|---|
| Four speeding levels & Road B Before and after | 1175 | 3 | 81.02 | .001 |

This case is all true except for the lowest speeding level. This indicates that speed levels have dropped after the installation of the electronic signs.




Source: (Ebrahim and Nikraz, 2013d)

Figure 5-5: unified hours of exposure for before and after ‘on the spot’ detection using the electronic speed signs in Road B.

### 5.2.4.2 Speeding between Road A & B

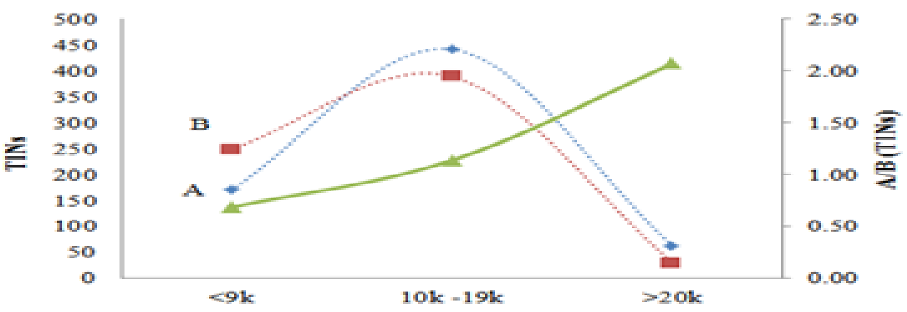
The study employed a Chi-Square to establish if there is an association between the two roads (Road A & Road B) on three speeding levels (less than 9km/h), (10km/h - 19km/h) & (20km/h and more) above the 40km/h speed limit. After controlling for the hourly rate per month using on the spot detection type of enforcement, a Chi-square test of independence was conducted. See Table 5-8.

Table 5-8: Chi-Square of Road A & B (before and after) the electronic signs installation

| Association between | Number of Cases | Degrees of Freedom | $X^2$ | *p* |
|---|---|---|---|---|
| Three speeding levels of Road A & Road B | 1342 | 2 | 29.38 | .001 |

***It was found that there is a significant association between the type of treatment on Roads A & B and the three levels of speeding. If enforcement is assumed the same on both roads then Figure 5.6 shows that the electronic signs outperform the standard 40km/h signs with the standard road marking.***

This may confirm that the electronic signs use and benefits differ from the standard signs in terms of speeding levels. Road A, showed less affect in terms of speeding reductions by the installation of the standard signs compared to the effect on the electronic flashing speed signs of Road B. This is clear except for the lowest speed violation level. See Figure5-6.



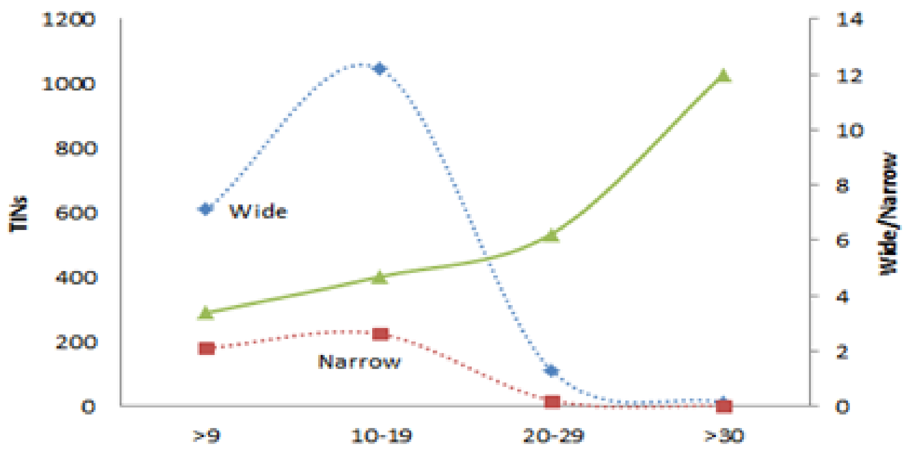

Source: (Ebrahim and Nikraz, 2012c, 2013c)

Figure 5-6: The effect of the Electronic signs treatment on reducing excessive speeding levels “on the spot” .Both Roads A & B

### 5.2.5 Road A Enforcement Peculiarity

Other engineering aspect in this case study was the two parts of road A which has wide segments ranges from (3.8 - 4.2) m and narrow segments ranges from (3.0 - 3.5) m. Figure 5-7 shows that drivers at the wide segments of the roads are speeding and with excessive speed compared to the narrow segment.

***It may be that drivers are travelling with higher speed after passing the narrow segments and taking more risk along Road A, indicating it is better to have the same width of road lane where possible.***

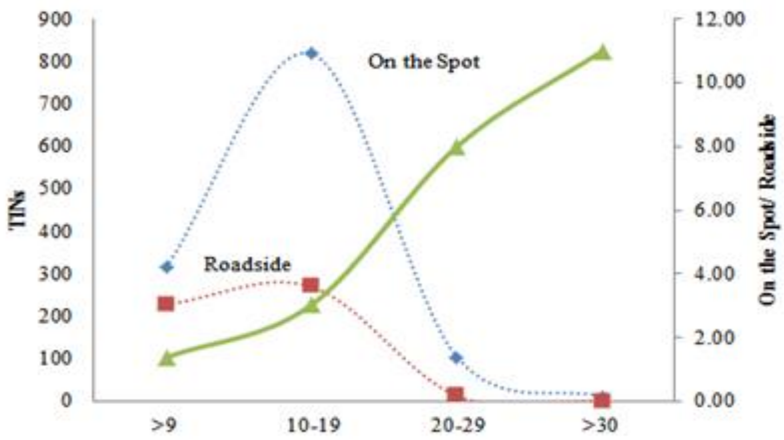



Source: (Ebrahim and Nikraz, 2012c, 2013c)

Figure 5-7: Drivers at road A are slowing down at the narrow segments & not at the wide segments 'on the spot'

The type of speed detection has also shown to be of interest on road A. Data was available for the two types of detection (Figure 5-8).

***It shows the clear dominance of the 'on the spot' detection of higher speeding violation levels and frequency of TINs over the 'roadside' detection in Road A.***




Source: (Ebrahim and Nikraz, 2012c)

Figure 5-8: The dominance of the on the spot detection compared to roadside detection at road A.

### 5.2.6 Road B Enforcement Peculiarity

Following the suggestion to extend the 0.7 km length of Road B beyond the intersection, in section 5-12, the study investigated the performance of speeding enforcement beyond that trailed length. Therefore data was plotted 1km beyond the trailed length. All speeding frequency data were converted to a rate of TINs/hr measure.

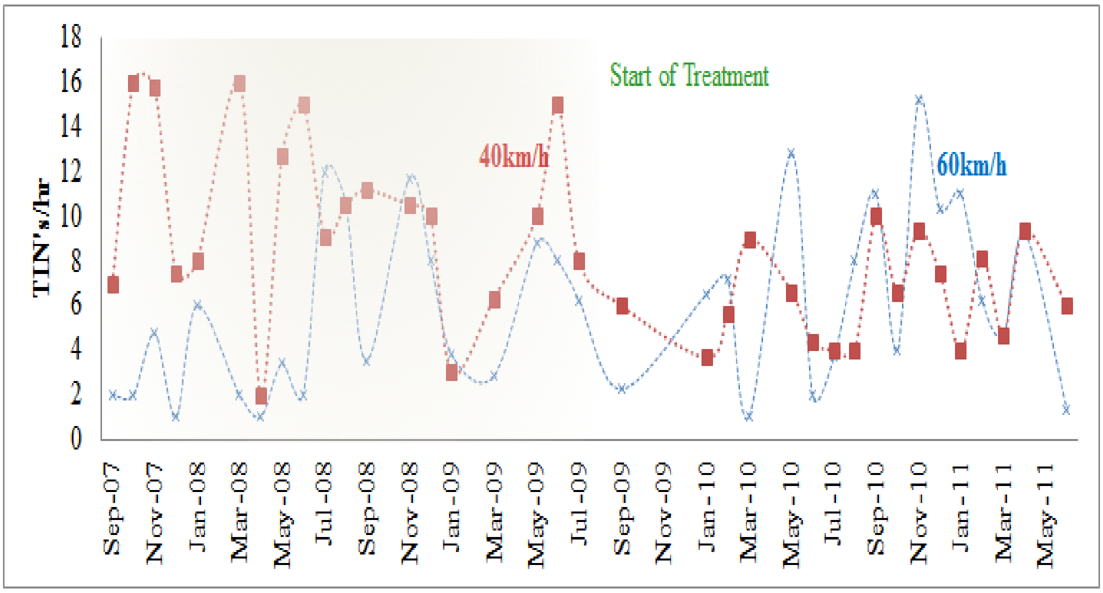
Three observations can be noticed in Figure 5-9. Firstly and despite the 40km/h is much lower speed than 60km/h, but drivers detected per hourly rates were lower in the former indicating that drivers are still speeding as they may enter or exit the 40km/h.

***There seem to be clear indications that enforcement works. Following the installation of the electronic signs in August 2009, the 40km/h speeding behaviour dropped clearly within the trialled area but not outside the trialled area.***

The speeding behaviour on the 60km/h on the contrary has witnessed variability in speeding behaviour with some rates reaching 14TINs/hr. There may be that speeding behaviour is shifting to the neighbouring stretch of road.

***This could indicate 'speeding migration', where instead of speeding in the controlled and treated 40km/h zone, drivers were speeding in the neighbouring 60km/h zone.***

It may be that standard 60km/h signs have less effect than the electronic signs. It may also be that drivers are willing to speed before entering or after passing the 40km/h zone. Most importantly it is important to extend the trailed length so that a better control to the situation including forcing drivers to use the same stretch of road rather than avoiding that small stretch of 0.7km and using side streets.




Source: (Ebrahim and Nikraz, 2013d)

Figure 5-9 – The hourly TIN's rate for the 40km/h speed limit plotted against the 60km/h along the same road

### 5.2.7 Conclusion

There is much evidence in this chapter to suggest that the electronic signs are delivering the purpose of its installation, in terms of improving speeding behaviour and crash reduction.

For instance the speeding that data was modelled showed drivers are slowing down after the installation of the flashing electronic 40km/h signs. Thus it is supporting the usefulness of such signs in reducing speeding.

The time of the day was found to be significant in the model where the afternoon recorded higher number of speeding TINs compared to the morning. Whereas the

Drivers' age is contributing slightly to the risky speeding behaviours and gender is showing similar results.

In case two, the reduction of road crashes proved to have been the result after the installation of the electronic signs. A Chi-Square found that there is an association before or after the installation of the electronic signs and the reduction of the speeding behaviour. Even when compared with another road of different signage system, an association was found between the electronic signs and the reduction of the speeding behaviour. The research adds that if enforcement is assumed the same on both roads then the electronic signs outperform the standard 40km/h signs with the standard road marking.

The research also exposed the weakness of a road on a shopping strip with different lane width that may contribute to speeding behaviour every time the drivers are passing the narrow width they speed within the wider lanes.

Like the dominance of 'on the spot; detection within school zone, this method was found superior than the roadside detection on shopping strips of 40km/h zones which is known the study as non-school zones.

There seem to be a concern in regard to the neighbouring 60km/h of the trialled road of 40km/h. Results in this chapter showed that drivers are complying with speed limit within the trialled 40km/h road but not outside the trialled road, indicating a 'speeding migration' may be occurring that may influence authority to extended short length of the trialled road beyond the 0.7 km. in addition to paying equal attention to the neighbouring road in terms of speeding enforcement.

# CHAPTER 6 IS THERE AN ADVANTAGE OF THE 40KM/H OVER THE 60KM/H ROADS

## 6.1 Introduction

This chapter focus on the safety concern on 60km/h roads. The study will tests the advantage of 'on the spot' type of detection over the roadside detection in the 60km/h roads. Importantly it will test the speed enforcement data by converting the enforcement components into hourly rate of detection exposure. This will allow the study to test it against crash history. It will explain if any enforcement dose effect existed over the crashes reduction response.

Two types of data will be tested against the crash reduction, the hourly rate of enforcement and the TINs (Traffic Infringement Notices) collected on the 60km/h roads. This will allow the same to be done for the 40km/h roads. To show if any advantage of the 40km/h roads over the 60km/h roads. The data will group the 177 suburbs according to the functionality of the suburb i.e. residential, commercial residential and educational/health (university and hospital). The study will attempt to cluster some of the suburbs of these above areas to show any commonality within them. If so, then decision-makers may be able to determine which roads in which suburbs have priority with respect to being converted from 60km/h to 40km/h limit, for the purposes of harm minimisation. Other details of data fitting are also included.

## 6.2 Data

There are 177 suburbs studied in Perth on 60km/h urban roads. Two sources of data were utilised. These are the speeding data and the crash data. The speeding enforcement data for the periods July 2007—June 2011 was collected from the WA (Western Australian) police Department. This speeding data comprises two detection types, similar to other areas in Australia. The first type is the road side cameras placed inside a vehicle or on the ground both will detect from the side of the road. They will be referred to as 'road side' detection. The second type is the on the spot detections which involves all pullovers, including marked/unmarked cars and hand-held detectors, which will be referred to as ‘on the spot’ detection.

The second type of data is the road crash data for the periods August 2007—July 2011. One month lag was adopted behind the speed enforcement effect. The study is target harm minimisation ignores all property damages and include all injury related crashes. (Property damages may be used if requires). They are two types of injuries. , the KSI (killed and seriously injured) and the minor injuries.

## 6.3 Speeding indicator

The analysis of speeding drivers data in the 60km/h roads, revealed that the use of the ‘on the spot’ type has demonstrated its dominance in detecting higher speed violations over the roadside type as shown in Figure 6-1. It also reveals that the latter type detects higher number of TINs that involves mainly the lowest level speeding which is less than 9km/h over the speed limit. Concerns about low-level speeding have been highlighted by (Doecke, Kloeden and McLean 2011; Gavin et al 2010). In fact, similar finding of the dominance of the on the spot detection was found for the 40km/h school zone. Therefore this study will use the on the spot data for further analysis as it seems more effective to use for harm minimisation.

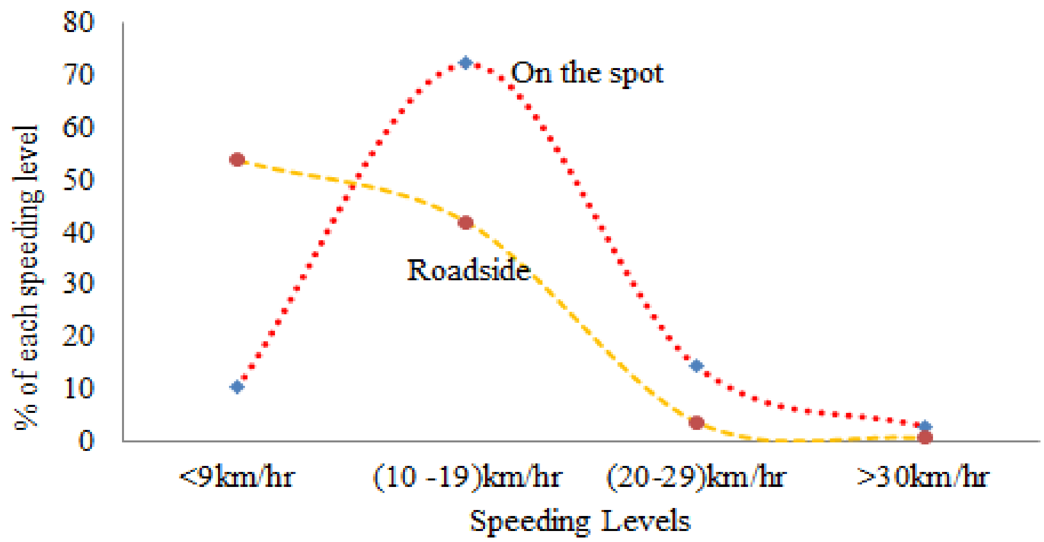



Figure 6-1: The dominance of the ‘on the spot’ over the ‘roadside’in detecting higher excessive speed around the 60km/h roads

There are differences in speeding behaviour at these two speed limits. The study found that the speeding rate in the 40km/h zone was 7 TINs, whereas in the 60km/h zone it was 4 TINs. This was determined by converting the deployment in each suburb to hours, but using the date and time of each incident occurring in the 60km/h zone. Driver behaviour at this speed limit can become more risky and lead to more harm, particularly for vulnerable road users. Moreover, this study found that of all speed limits in Perth, around 38% of road crashes take place on 60km/h roads compared with less than 2% on 40km/h roads. The total TINs and hours of detection over the study period in the 60km/h zone are shown in Figure 6-2.

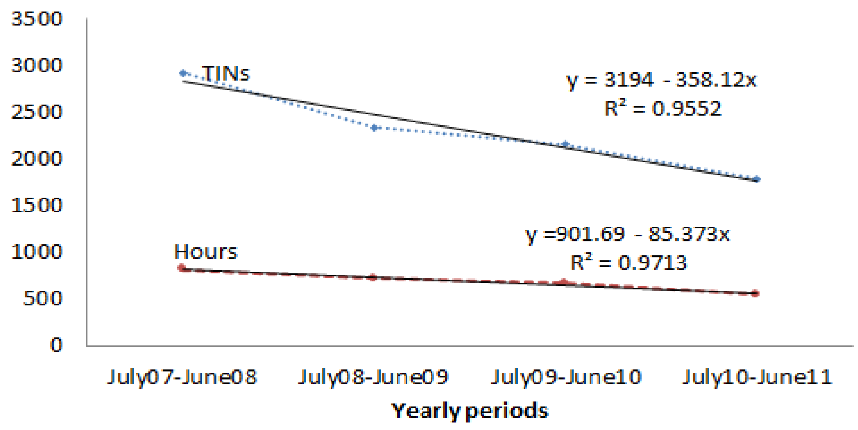



Figure 6-2: On the spot detection hours of speeders in the 60km/h roads

This figure show that driver speeding was declined over a period of time, indicating that there may be a clear effect of speed enforcement during this period. This is supported by a high $R^2$ for a linear trend that fits the data well. Note that a polynomial trend for both of the data points in terms of TINs and the hours fitted the data even better. This linear trend was chosen to show the steady decrease in the TINs and the detection hours for both trend lines.

Figure 6-2 indicates that drivers are slowing down in the 60km/h zone despite the decreasing hours of detection, but only for that period. From a sustainability viewpoint, it is suggested that the hours of detection need to be maintained, particularly since the declining trend may be short-lived with more concerted and continuous planning is needed. When the rate of TINs/hr was calculated (see Figure 6-3), an upward trend was observed with a high value of $R^2$ for a second degree polynomial. This may indicate the need for a continuous increase in detection hours in order to effect a decrease in the TINs rate.

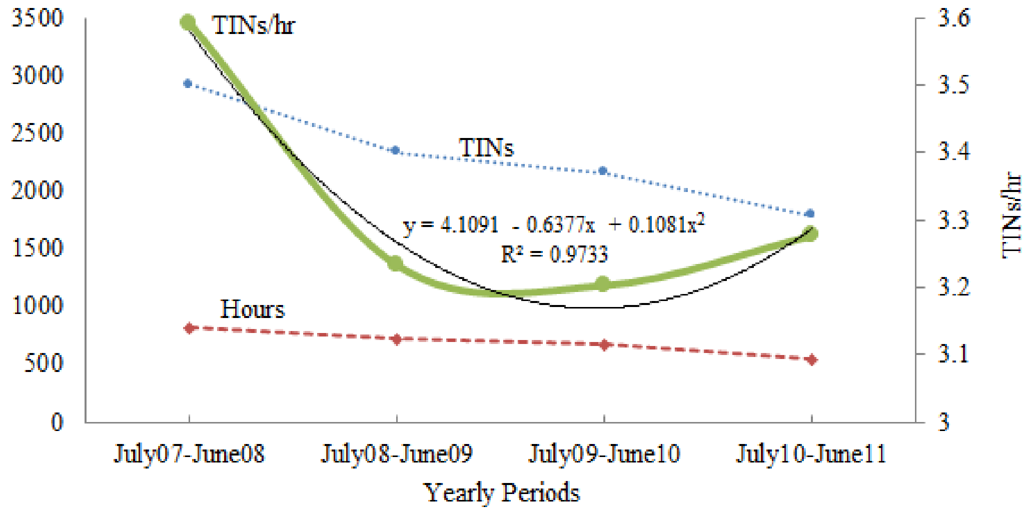



Figure 6-3: The rate of TINs/hr in 60km/h roads for July07-June11

This curve was even more pronounced on 40km/h roads, as shown in Figure 6-4. The curve took a sharp turn, indicating the need for even more hours of detection in order to deter speeding drivers. It was noted that the hours of detection remained reasonably unchanged, but the TINs increased. The rate of TINs/hr also formed a sharp polynomial trend with a high $R^2$. This suggests that the 40km/h zone requires more hours of detection than the 60km/h zone. It must be stated that, because 40km/h is a lower speed limit, more care needed to be taken by drivers than on the 60km/h roads. The important advantage of the 40km/h zone is to reduce harm to road users, as will be seen in the next section.

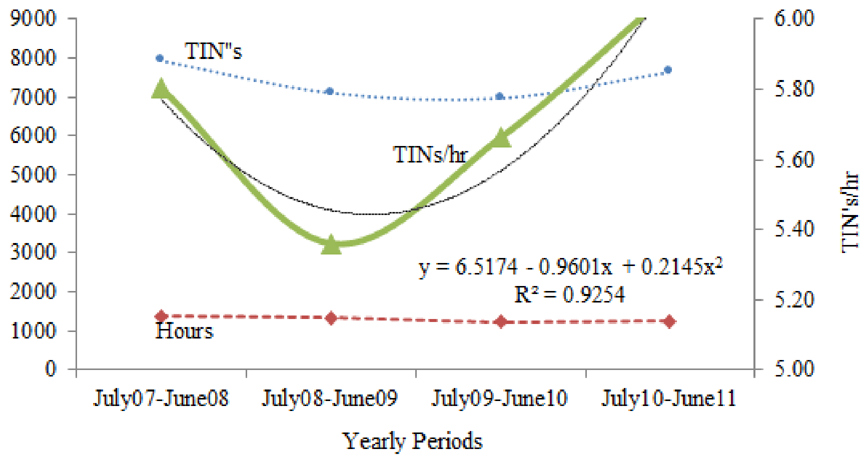



Figure 6-4: The rate of TINs/hr in 40km/h roads for July07-June11

## 6.4 Crashes indicator

Crashes cause severe harm to road users, particularly pedestrians. This is shown in Table 6-1, where total crash severity does not differ much between the two speed limits, but pedestrian crash severity is much higher on 60km/h roads. Which is of great concern. The study finds that the frequency of pedestrian crashes on 60km/h roads in Perth is around 16 times the frequency on 40km/h roads. It is recommended that roads in busy environments may require low speed limit zones, such as 40km/h.

Table 6-1: Severity level on 40km/h & 60km/h

| Severity by crash* type | 40km/h | 60km/h |
|---|---|---|
| % (KSI**/Total Crashes) All | 23 | 25 |
| % (KSI/Total Crashes) pedestrians | 40 | 57 |

* No property damages included ** KSI = Killed or Seriously Injured

The focus should therefore be on determining which roads should have their limit reduced to 40km/h. This was approached by dividing the suburbs into areas according to the functionality of each. The 177 suburbs under study were divided into four groups of 134, 26, 3 and 14 suburbs, which were residential, commercial, university and hospitals and industrial respectively. This grouping was based on certain criteria, i.e. commercial suburbs were selected on the basis of their location from the CBD (central business district), and whether they were considered to be major business and or major shopping facilities.

Table 6-2, shows that some industrial areas did not have a high frequency of pedestrian crashes because many of their roads had other than a 60km/h speed limit. Similarly, residential suburbs may consist mainly of roads with the 50km/h default speed. Table 6-2 also reveals that the highest pedestrian crash severity rate was found in the industrial suburbs and the highest number of pedestrian crashes per suburb was seen in the commercial suburbs. Efforts to convert roads with 60km/h speed limits to 40km/h zones should therefore focus on these two areas. Note that there was one suburb in Perth with a major university and a major hospital, and with limited commercial activities. It was decided to add this to the commercial suburbs (see Figure 6-7), along with the high commuters cluster group.

Table 6-2: Severity of crashes types in 60km/h roads for July07-June11

| Group type | % KSI crashes /total | % KSI pedestrians /total | Total number of pedestrian crashes/Suburb |
|---|---|---|---|
| Industrial | 22 | 63 | 6 |
| Commercial | 21 | 44 | 13 |
| University and hospital | 18 | 47 | 5 |
| Residential | 23 | 53 | 3 |

## 6.5 Speeding – crash indicator

### 6.5.1 General relationship

The importance of speed enforcement measures becomes visible when compared with road crashes. The injury rates shown in Figure 6-5 are affected initially by the high degree of enforcement and show a negative response, which means that more detection hours lead to less road injury crashes. The relationship fits a polynomial curve with a nearly strong $R^2$, showing that as the hours of detection are reduced, the rate of injuries increases. This indicates that the hours of detection may need to be consistent to maintain a lower incidence of injury crashes. In fact, fewer detection hours could even contribute to a higher incidence of speeding drivers. A recent report by Thompson et al. (2013) for the office of Road Safety in WA found that speeding vehicles had increased in 60km/h zones by 3.4 % in 2011 compared to 2010. This may indicate that the rate of speeding vehicles could affect the rate of injury crashes on 60km/h roads.

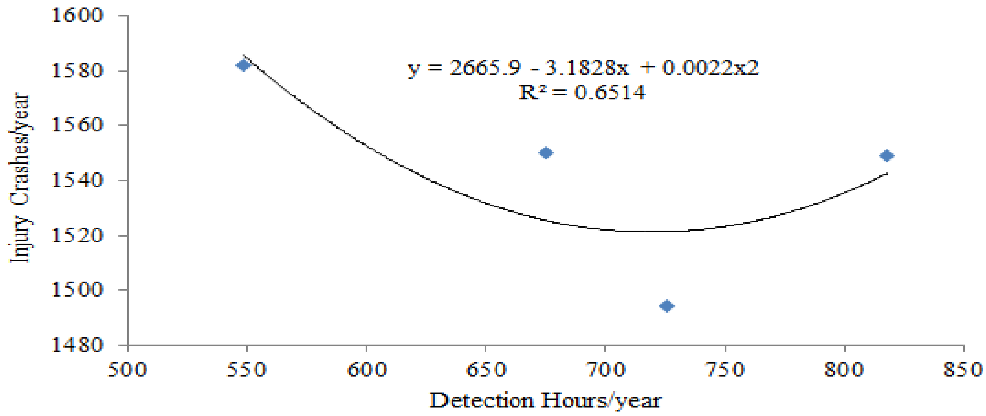



Figure 6-5: Injury crashes rate affected by the number of detection hours in 60km/h roads for Aug07-july11

Pedestrian crashes in 60km/h zones showed a different relationship to the hours of detection (see Figure 6-6). The trend increasing at a decreasing rate indicating that the number of hours of detection had an effect, but only after long hours of detection. This means that pedestrian injury crashes within the 60km/h zone require more on-the-spot hours of enforcement than other injury crashes before enforcement starts to be effective (Figure 6-6). The study can therefore conclude that even more hours of detection are required in 60km/h zones than in 40km/h zones, in order to be effective against pedestrian crashes. .This makes the argument stronger for converting some of the 60km/h roads to 40km/h zones, in order to reduce crashes, regardless of the number of hours of enforcement.

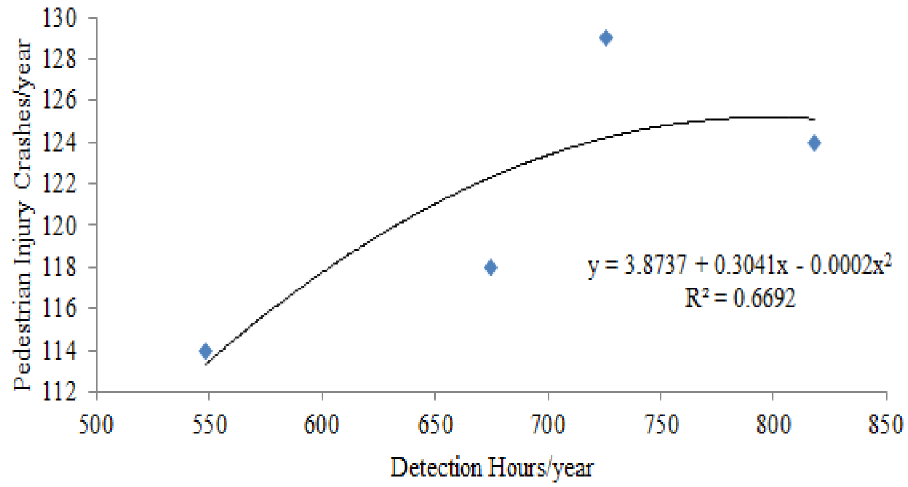



Figure 6-6: Pedestrian injury crashes rate affected by the number of detection hours in 60km/h roads for Aug07-july11.

The relationships between injury crashes and hours of detections needs a larger sample size instead of the four points displayed in Figures 6.5 and 6.6. The roads crashes with 40km/h did not show a strong relationship with the hours of speeding detection, it had very low $R^2$ (0.1240). It may be that low number of data points have contributed to have less reliable conclusion and low $R^2$.

### 6.5.2 Area level relationship

This section focuses on two areas in the study: the commercial areas covering 26 suburbs and the industrial areas covering 14 suburbs. Pedestrian crashes/suburb were not used because of the lower frequency; instead total crashes were used, which was thought would produce more reliable clustered data. For the commercial suburbs there are five clusters, three of which are major shopping centres particularly identified as having a high incidence of crashes (Figure 6-7).

This is followed by the CBD and surrounding suburbs where there were higher TINs/hr but fewer crashes, and there was one group which had fewer crashes but the highest TINs/hr of all commercial suburbs, due to a high volume of commuters. The suburb that originally belonged to the university/hospital group but was subsequently added to the commercial suburbs was found to belong to the cluster group with a high volume of commuters. This may explain the behaviour of speeding drivers in relation to the crashes occurring within a certain group of suburbs. Importantly, some of the 60km/h roads within the commercial suburbs may need to be investigated further with a view to decreasing the speed limit to 40km/h. There has been enough support for the 40kn/hr electronic signs, such as the successful shopping strip road trial in Perth discussed by (Ebrahim and Nikraz, 2013) and in the Melbourne CBD (Carey, 2012). In addition to investigating the safety benefits of the 40km/h variable signs in Perth (Ebrahim and Nikraz, 2013).

Details on Figure 6-7 are tentative and need to be studied further so that it can confirm details of other speed limits such as the 50km/h of each area. This would eventuate in a more acceptable comparisons. It will enable authorities to focus and target roads level rather than areas level particularly local governments. This task of comparison will be carried out following the completion of this thesis. This task will involve large data due to the fact the 50km/h limit comprise a high proportion of Perth roads since it is the default speed of all local government roads.

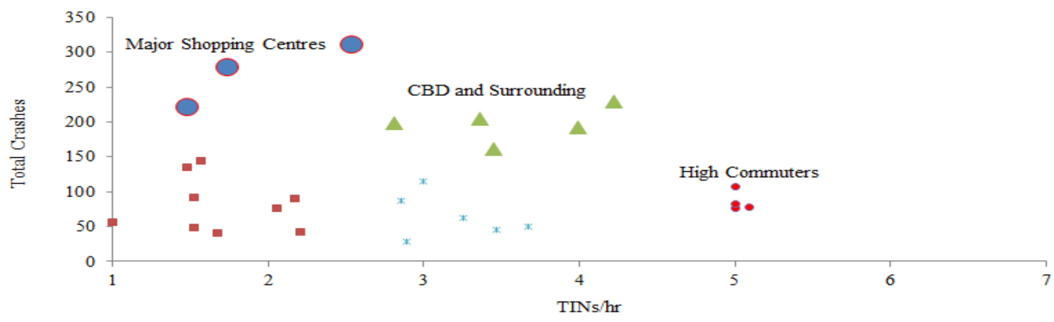



Figure 6-7: TINs/hr in 60km/h roads for July07-June11for the *commercial* areas vs. crashes August 07-July11

Results for the suburbs belonging to the industrial area are shown in Figure 6-8. No clear clusters were formed, but the major suburbs with the strongest activity was shown to be separate from the rest. There were two other major industrial areas close together with a high incidence of crashes and TINs/hr.

Due to the high number of accidents in the commercial suburbs, authorities may need to identify those 60km/h roads that need to be given treatment priority based on the high incidence of crashes and high number of TINs/hr. This is particularly the case with strips that have high levels of pedestrian activity daily, as well as those streets in industrial areas that are connecting residential or commercial activity. These roads may be attracting pedestrians at different times of day.

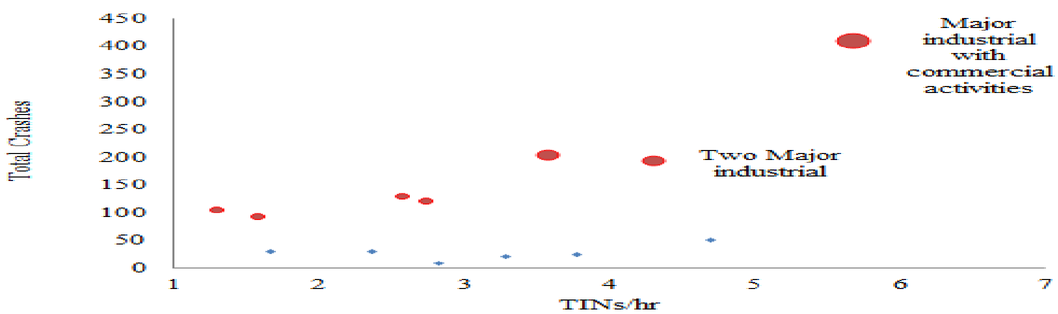



Figure 6-8: TINs/hr in 60km/h roads for July07-June11for the *industrial* areas vs. crashes August 07-July11

## 6.6 Discussions

The sustainability of enforcing a change in risky behaviour and moving towards safer road use is essential in areas with higher speed limits, such as 60km/h zones on urban roads. Of all the speed limits in Perth city, the 60km/h roads contribute around 38% of crashes.

It was found that targeting more speeders on the spot for excessive speeding in the 60km/h zones is a vital strategy. The safety of road users on some of these roads is of concern, since it was found that the percentage of pedestrian crash severity on the 60km/h roads was 57% compared to 40% for the 40km/h roads. Hence it is advisable to convert some of these 60km/h roads that are of concern to 40km/h roads.

The study shows that the TINs/hr rate is higher around 40km/h roads, but also showed that crashes are less frequent and less severe. *Despite the finding that 40km/h zones require more hours of detection than 60km/h zones, from a sustainability viewpoint it is more appropriate to recommend the choice of a higher number of TINS and fewer, less severe crashes than otherwise.* In addition to this, the more roads there are with a speed limit of 40km/h and variable speed signs, the more this would become a practice, which in turn could become a culture, which will contribute to the fundamental aims of the Towards Zero strategy.

***Reducing the incidence of pedestrian industry crashes within 60km/h zones requires greater on-the-spot enforcement before the strategy is effective. In addition, within the 60km/h zones, more hours of detection are required for effective reduction of pedestrian crashes. Regardless of the number of hours of enforcement, this makes the argument stronger for converting some of these 60km/h roads to 40km/h in order to reduce crashes.***

The benefit is safe roads, means greater safety for road users and more savings for everyone in terms of human loss, suffering and costs. The 40km/h variable signs will accommodate mobility, hence 40km/h speed limits are used where and when there are pedestrian/vehicle conflicts and not necessarily on roads that are highly classified.

Thus the suggestion, once implemented, will not interfere with mobility hence, sustainability can be achieved.

***The above argument is consistent with the recommendation of this chapter to increase the number of hours of on-the-spot speed enforcement on 60km/h roads. Therefore, if roads are converted to 40km/h zones with variable signs, the hours of detection will monitor the 40km/h rather than the 60km/h limit. This would increase the level of slower speed awareness, which is another aim of the Towards Zero strategy under the pillar of safe road use.***

## 6.7 Conclusions

The study found that the TINs/hr rate on 40km/h roads is higher than on 60km/h roads, but also showed that crashes are less frequent and less severe on the 40km/h roads, than on 60km/h roads. From a sustainability viewpoint, it is more appropriate to recommend the choice of higher TINs and fewer, less severe crashes than otherwise. Moreover, of all roads in Perth, those with a 60km/h speed limit contribute around 38% of road crashes compared to less than 2% of crashes in 40km/h zones. It is suggested that targeting more speeders on the spot for excessive speeding in 60km/h zones is a vital strategy.

The study concludes that if there are more roads with a 40km/h speed limit, this practice could become a culture that will in turn contribute to the fundamental aims of the Towards Zero strategy. The result is safe roads which mean greater safety for road users and more savings to everyone in terms of human lives loss, injuries and related cost. The 40km/h variable signs will accommodate mobility, hence 40km/h would be used where and when there are pedestrian/vehicle conflicts and not necessarily used on 60km/h roads that are highly classified such as those of arterial nature etc.

Therefore, if roads are converted to a 40km/h limit, the hours of detection will monitor drivers at 40km/h rather than 60km/h. This would increase the awareness of slower speed.

# CHAPTER 7 ROAD USERS ATTITUDES ON 40KM/H SPEED LIMIT AND ITS EXPECTED EFFECTS

## 7.1 Introduction

This chapter will examine the concerns of road users regarding the 40km/h speed limit and its expected effects. A study by Main Roads WA found that drivers in Western Australian customarily experience difficulty in complying sufficiently with the 40km/h speed limit imposed within defined school zones (Radalj and Gibson, 2004).

The study chose two different approaches to those used previously. Firstly, it seeks the attitudes and opinions of four different groups, each belongings to the content of driver's origin (section 7.2). This is because Perth is a cosmopolitan city and driver's community of different origins. Secondly, it will question the concern of introducing the 40km/hr during the day and the approval of night time introduction. This is tested on different levels of stress, delay, traffic signal timing as explained in the approach. This study sought to gain a greater understanding of the attitudes of drivers from different backgrounds on certain variables mentioned below. The reason for using the multicultural groups was to obtain the most realistic random sample of the population possible. Australia, like other countries in the world, is known to have a multicultural society, and the involvement of certain cultural groups in pedestrian accidents is inevitable. Some are involved in greater numbers than others, as seen in the literature search (Figure 2-6); for example, those from Asia and Africa make up a higher proportion of those involved in crashes. Rumar (2001) found that 42% of all traffic fatalities in Asia are pedestrians. Similarly it was reported by the Department of Transportation that foreign-born people make up 36% of NYC (New York City) residents, but comprise 51% of fatalities (Department of Transportation (DOT), 2010).

A comprehensive literature search also found that studies did not examine the possibility of introducing a night zone speed limit similar to the school zone speed limit, but did deal with other relevant issues to improve pedestrian safety e.g. visual contrast (Mather and DeLucia, 2007), biological motion (Tyrell et al., 2009), and manipulating traffic signals (Lenné, Corben and Stephan, 2007). Many researchers around the world have emphasised a single common concern and that is to reduce the speed of the vehicle (Mohan, 2010; Preusser et al., 2002; Oxley, Diamantopoulou and Corben. 2001). Since speeding behaviour is widespread and perhaps socially acceptable (Corbett, 2001), the current study employed a self-reporting methodology to examine attitudes on 40km/h speed zones and to test the concerns of multicultural road users about the potential new 40km/h speed limit. According to Robinson (2010), concern about road safety has risen due to the increase in fatalities from 9% in 2007 and 2008 to 14% in 2009, and most recently due to the high number of fatalities in 2011 (O’Connell, 2012). Data collected from the Western Australia Police indicated that the night-time to daytime ratio of pedestrian fatalities has increased from 9% in 2007 to 57% and 45% in 2008 and 2009 respectively. In an endeavour to target speed reduction, Main Roads WA authority found one stretch of road that had a higher incidence of pedestrian accidents than any other road in the metropolitan area.

This road had a posted speed limit of 60km/h, and the authorities decided to run a trial. They installed electronic 40km/h speed signs along the road (see Figure 7-1 below and Chapters 4 and 5 for more detail).


Figure 7-1: Electronic 40km/h signs at the same location at day and at night

The purpose was to introduce a variable speed zone by lowering travel speeds from 60km/h to 40km/h during peak periods of pedestrian activity, with the aim of improving safety for pedestrians and other road users The signs displayed a 40km/h speed limit from 7.30am till 10.00pm (except on Friday and Saturday when this was extended till 1:00am instead of 10:00pm). The same signs display a 60km/h limit outside the abovementioned times. As enforcement of 40km/h limits began in this road and many others, concerns were raised due to the high number of speeding fines (Robinson, 2010). The most severe increase were of the number of speeding motorists in the 40km/h (non-school zone) areas where 96 drivers were caught daily compared to the 83 the previous year. If drivers' speeding behaviours had continued to increase in a similar way in that zone, there would have been an increase of 4745 speeding fines annually.

It is paramount to select the appropriate speed limit to suit road user's behaviours that can be reflected on their attitudes. By understanding the causes of a maladaptive behaviour to speeding, it can help in the development of methods to select the most appropriate (Harrison 2001). Concerns were also voiced by the Royal Automobile Club of Western Australia (RACWA) about such changes in the speed limit, which they felt might increase travel times and cause confusion (Thomas, 2011). According to a survey of attitudes towards the 40km/h speed limit by the Transport Accident Commission (TAC) in Victoria, Australia, only 46% of drivers believed that driving at 50km/h in a 40km/h zone was unacceptable (TAC, 2011).. This means that there still appears to be some tolerance of low level speeding at speed limits such as 40km/h. Despite all the TV advertisements and campaigns, little had changed in people's attitudes towards speeding from the previous year (TAC, 2011).

In addition to the above, the study sought to examine the night zone option and to test the stress behaviours associated with the 40km/h limit imposed during the day. There was a need to better understand the factors contributing to driver attitudes and behaviours when the 40km/h limit was imposed during the day (Day Zone) and during the night (Night Zone).

## 7.2 Survey Participants

The questionnaire was distributed and collected from four groups of Australians in Perth from different cultural backgrounds, according to their continent of birth i.e., Africa, Asia, Australia and EU countries. Participants from Australia were those born in Australia, and the others were added to one of the three cultural groups according to their birthplace. For instance, participants from Africa included people from South Africa, Zambia, Kenya and Egypt. Participants from Asia were from China, Singapore, Malaysia, Indonesia, Japan, India and Pakistan. Participants from EU countries were from England, Macedonia, the Czech Republic, and the Netherlands. Respondents were also stratified according to gender, marital status and age group (18–29, 30–44 and 45+years), as well as their country of birth. Each cultural group had 75 participants. There were 153 single people (51%). The average age was 33, 27, 36 and 37 years for Africans, Asians, Australian and Europeans respectively.

Respondents were recruited through a network planned by the research team. It was a slow selection process involving face-to-face contact to ensure exclusion or inclusion in the survey. Some participants who had not visited their country of origin in the last five years were excluded from the study. The most important criterion for inclusion in the study was that participants held a current Australian driver's licence. According to the Ethics Committee at Curtin University, all participants were provided with a consent form and information letter along with the questionnaires.

## 7.3 Approach

A 10-item questionnaire collected demographic data using a range of items constructed specifically for this study. Those used as dependent variables (items) were divided and targeted towards the two options (Appendix 7-1). Firstly, the concerns about delay if the 40km/h were to be implemented during the day (day zone) were investigated. The study explored five variables, based on two concepts: the direct delays as in items 1 and 5, and the stressful effect on behaviour due to delays, as in items 2, 3 and 4. Cronbach's alpha was 0.76 which was considered important for the reliability of the analysis. This was a five item questionnaire with abbreviated terms (Table 7-1), addressing the acceptance of the idea, obedience to the flashing sign, contribution to fewer fatalities, safety, adoption of the limit. It was measured on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The study conducted a reliability test and found Cronbach's alpha to be acceptable at 0.76

Table 7-1: Items on delay concerns on the use of 40km/h Day Zone

| Item | Questionnaire | Abbreviated |
|---|---|---|
| 1 | Drivers may find a 40km/h limit too slow during the day. | Too slow speed |
| 2 | Drivers may find it stressful to drive at 40km/h limit during the day on roads not busy with pedestrians. | Stressful speed |
| 3 | Drivers may show less tolerance during the day if driving on roads with a 40km/h limit. | Less tolerance |
| 4 | Drivers are likely think that a 40 km/h limit during the day will slow the flow of traffic. | Slows traffic |
| 5 | Drivers may think that delays in the CBD are due to a 40km/h limit during the day rather than the traffic signals. | Speed delays not signals |

Secondly, the preference to implement the 40km/h limit during the night (Night Zone). This is a 5 – item questionnaire with their abbreviation shown in Table 7-2 below. These nigh time questionnaires relates

Table 7-2: Items on preferring the use of 40km/h Night Zone

| Item | Questionnaire | Abbreviated |
|---|---|---|
| 1 | Drivers are more likely to accept the idea of a 40km/h Night Zone around entertainment venues. | Accept the idea |
| 2 | Driver are more likely to observe and obey flashing 40km/h Night Zone signs. | Obey the sign limit |
| 3 | There may be less pedestrian fatalities if 40km/h Night Zones are introduced around entertainment venues. | Less fatality expected |
| 4 | 40km/h Night Zone may need to be adopted other Weeknights for safety of pedestrians. | Adopt it other weeknights |
| 5 | Night zone is similar to the 40km/h School Zone limit in terms safety for pedestrians. | Safe as School Zone |

## 7.4 Statistical Methods

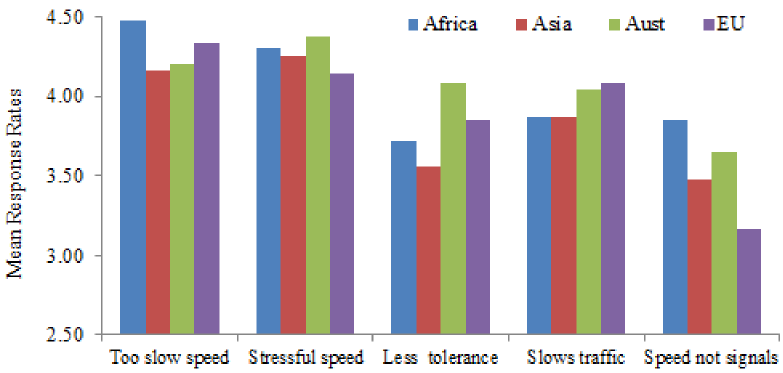
The study adopted the 10 dependent variables as discussed above. The study also included age, gender and marital status as independent variables. For the purpose of this research study, Multivariate Analysis of Variance (MANOVA) was employed to search for differences amongst the dependent variables. The study used 75 cases in each cell and according to Tabachnick and Field (2007), if any violations of normality do exist, they will not affect the robustness of the analysis as long as the cases in each cell exceed 20. Details are discussed in section 7.5.1 for the day zone delay concerns and section 7.5.2 for the night zone option.

To further test the groups for differences, cluster analyses were performed on the data. It was thought appropriate to compare the data of the two sections mentioned above, therefore section 7.5.3 was added for the purpose. In that section, age group was investigated to search for differences. SPSS software (2008) to perform the statistical data analysis.

## 7.5 Results

### 7.5.1 Day Zone Delay Concerns

The study found that the overall mean response rates for the day zone delay concerns were 3.97 (74%). Figure 7-2 shows that some of the differences in the mean response rates concerned delay. This was further examined by using MANOVA to search for significant differences among groups.



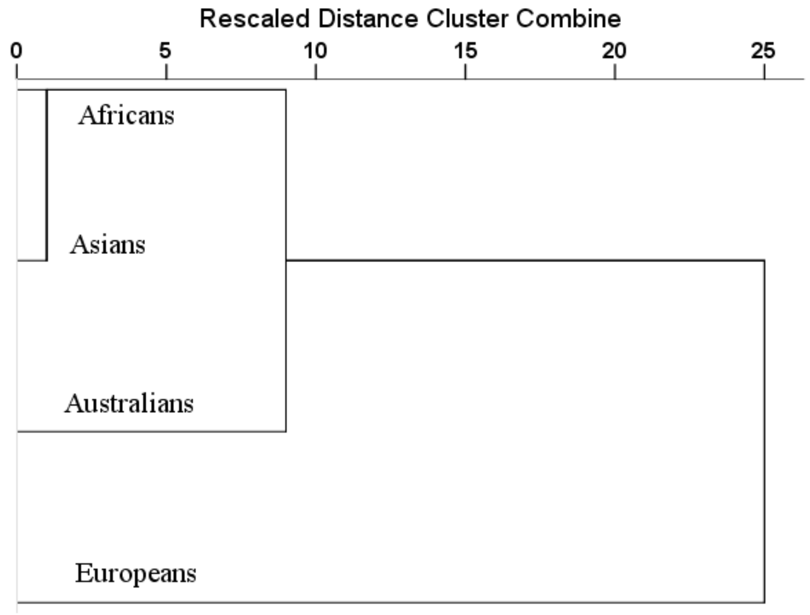

Source: (Ebrahim and Nikraz, 2012a)

Figure 7-2: Examining group differences on Day Zone delay concerns

Results indicate that there was a statistically significant difference between the groups on the combined dependent variables. $F$ (15,806) = 4.2, $p$ = 0.000, Wilks' Lambda = 0.81; partial eta square = 0.07. When the results were considerd seperately, the only item to reach statistical difference using a Bonferroni adjusted alpha level of 0.010, was 'Speed delays not signals'. An inspection of the mean response rates indicated that the European group recorded the lowest mean response rate ($M$ = 3.16, $SD$ = 0.92) of all groups. It was statistically different and much lower than the African mean response rates ($M$ = 3.87, $SD$ = 0.87).

A one-way between-group MANOVA was also performed to investigate gender differences in the delay concerns regarding the day zone. There was a statistically significant difference between the groups on the combined dependent variables: $F$ (5, 294) = 7.42, $p$ = 0.000, Wilks' Lambda = 0.89; partial eta square = 0.11. When the results of the dependent variables were considerd separately, the only item to reach statistical difference using a Bonferroni adjusted alpha level of 0.01, was the 'Too slow speed' item. That difference had $F$ (1,298) = 8.98, $p$= 0.003 and partial eta square = 0.03. An inspection of the mean response rate scores indicated that male drivers reported higher mean response rates ($M$ = 4.43, $SD$ = 0.72), compared to female drivers ($M$ = 4.16, $SD$ = 0.82). There was no statistical difference found on marital status as an independent variable.

When average linkage between groups was performed, cluster analysis revealed that the European group was clearly separated from the rest of the clustered groups (see Figure 6-3). Another separated cluster was the Australian group, with the two highest mean response rates compared to other cultural groups. In the meantime, the dendogram in Figure 7-3 shows that the Australian group is in a common cluster with the Asians and the African groups.

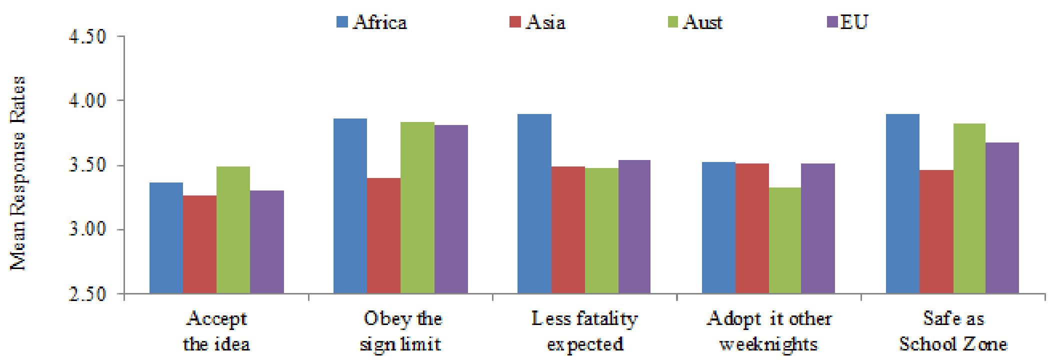



Source: (Ebrahim and Nikraz, 2012a)

Figure 7-3 Dendogram depicts European group is separated from the other three groups

### 7.5.2 Night Zone option

Data analysis indicated that preference for the Night Zone option was 3.57 (64 %) for all groups. In order to examine responses, a between group MANOVA was perform to investigate group differences in response to the five dependent variables used as shown in Figure 7-4 below.




Source: (Ebrahim and Nikraz, 2012a)

Figure 7-4: Examining five variables for the preference of Night Zone option

Results indicated that there was a statistically significant difference between the groups on the combined dependent variables: $F$ (15,882) = 3.32, $p$ = 0.000, Wilks'

Lambda = 0.85; partial eta square = 0.05. When the results were considerd separately, the only items to reach statistical difference using a Bonferroni adjusted alpha level of 0.010, were two items, ‘Obey the sign limit’ and ‘Less fatality expected’. In terms of ‘Obey the sign limit’, it was found that Africans reported higher mean response rates for ‘Obey the sign limit’ (*M* = 3.87, *SD* = 0.66) than Asians (*M* = 3.40, *SD* = 1.08).

In terms of the ‘Less fatality expected’ item, African groups reported a higher rate (*M* = 3.89, *SD* = 0.73) than other groups, particularly the Australian group (*M* = 3.48, *SD = 0.92).* Further analysis in Table 7-3 below shows the details of the significant differences found between groups on the two dependent variables mentioned above.

Table 7.3: Group differences for the preference of Night Zone limit

| Variables | Between groups | Mean Response Rates | *SD* | *F(5,144)** | Partial *Eta* $^{2}$ |
|---|---|---|---|---|---|
| Obey the sign limit | Asians - Africans | 3.40 3.87 | 1.08 .66 | 10.19 | .06 |
| | = - Australians | = 3.84 | = .68 | 8.95 | .06 |
| Less fatality expected | African - Asians | 3.89 3.49 | .73 .96 | 8.23 | .05 |
| | = - Australians | = 3.48 | = .92 | 9.31 | .06 |
| | = - Europeans | = 3.53 | = .83 | 8.00 | .05 |

* P < .01

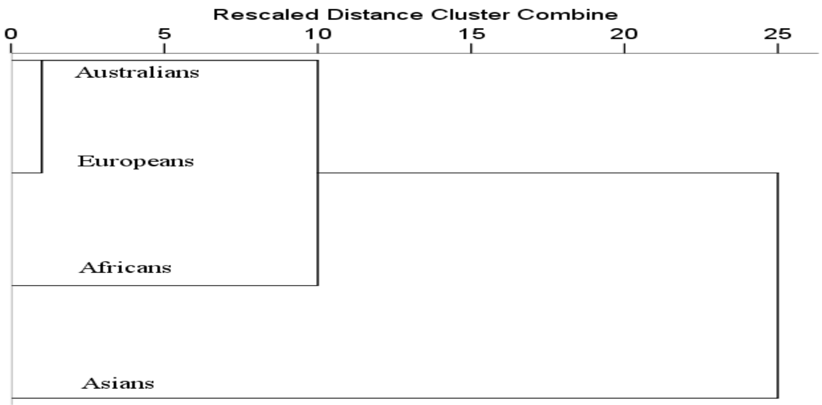
There was no significant difference found in gender (male vs. female) despite the slightly higher mean response rates of males on night zone preference than females on all five variables. When examining marital status (single vs. non-single) as an independent variable with regard to the preference for the night zone option, a one-way MANOVA using categorically independent variables was performed. Results revealed that there was a statistically significant difference between the groups on the combined dependent variables: *F* (5,194) = 3.47, *p* = 0.005, Wilks’ Lambda = 0.82; partial eta square = 0.08. When the results of the dependent variables were considerd separately, single and non-single reached statistical difference using a Bonferroni adjusted alpha level of 0.01, and particularly on two items. Firstly, on accepting the idea of the night zone option and secondly, on believing that the night zone option would be as safe as the school zone (see Table 7-4).

Table 7-4: Marital Status differences for the preference of Night Zone limit

| Variables | Between singles & Non-singles | | Mean Response Rates | | SD | | F(5,294)* | Partial Eta [2] |
|---|---|---|---|---|---|---|---|---|
| Accepting the idea | Singles | Non-Singles | 3.03 | 3.69 | 1.11 | .78 | 35.38 | .11 |
| Safe as School Zone | Singles | Non- Singles | 3.46 | 3.98 | .98 | .61 | 29.34 | .09 |

* P < .01

When an average linkage between groups was performed, the dendogram in Figure 7-5 showed the Asian group clearly separated from the rest of the clustered groups. They recorded the lowest mean response rates (3.43) of all groups, showing the least favour for the night zone preference. The second distanced group was the African group, which recorded the highest mean response rates of all cultural groups, preferring the night zone limit as an option. The Australian and European groups were the closest, indicating some similarity between their mean response rates.




Source: (Ebrahim and Nikraz, 2012a)

Figure 7-5: Dendogram depicts the Asian group away from the other three groups.

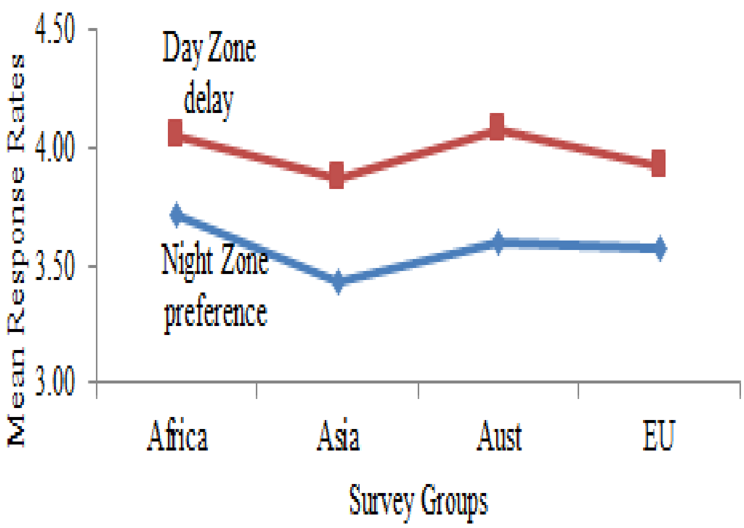
### 7.5.3 Day Zone delay vs. Night Zone preference

The overall mean response rates and percentages of each cultural group on the preference for a 40km/h night zone option and on the delay concerns for the 40km/h day zone option are shown in Table 7-5. It can be seen from Table 7.5 that the overall mean response rates for the 40km/h night zone preference is 3.57 (64%). Compared to the 3.97 (74%) rate for the delay concerns regarding the day zone option, this indicates that the respondents were more in favour of implementing the 40km/h limit during the night than during the day.

Table 7-5: Group responses rates & percentages for the two zones

| Group | *Mean Night Zone Preference Rate* | % Response Rate of the group | *Mean Day Zone delay Rate* | % Response Rate of the group |
|---|---|---|---|---|
| African | ***3.71*** | 68 | ***4.05*** | 76 |
| Asian | 3.43 | 61 | 3.86 | 72 |
| Australian | 3.59 | 65 | ***4.07*** | ***77*** |
| European | 3.57 | 64 | 3.91 | 73 |
| Mean | 3.57 | 64 | 3.97 | 74 |

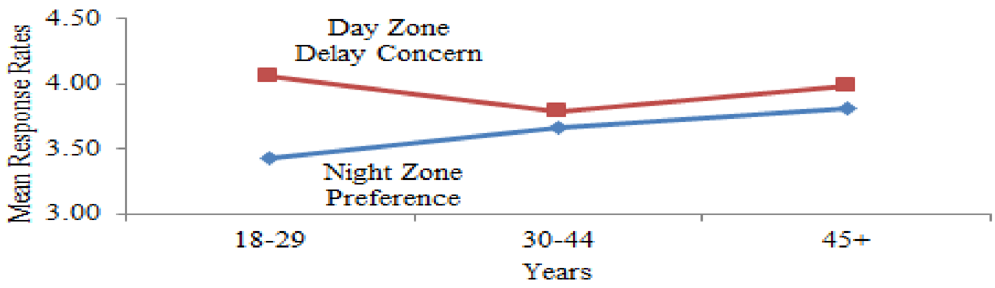
Figure 7-6 also shows that African and Australian groups are in less favour of the day zone option and the African group is strongly in favour, even more than the Australian group, of the Night Zone option. The Asian group had the lowest mean response rates of all cultural groups for both the night zone preference and day zone delay. The European group's mean response rates were also low and particularly lower than the group average on the delay concerns for the 40km/h day zone delay limit.




Source: (Ebrahim and Nikraz, 2012a)

Figure 7-6: Responses of multicultural groups on two zones

The attitudes of the age groups on the preference for the night zone vs. delay concerns for the day zone showed that the younger group (18–29) years was less in favour of the night zone option and strongly rejected the day zone option (see Figure 7.8 below). Another important point to be noted from Figure 7-7 is that the older the age group, the higher the acceptance of the 40km/h night zone option.




Source: (Ebrahim and Nikraz, 2012a)

Figure 7-7: Age groups on the Day Zone delay concern and Nigh Zone preference

Further analysis in Table 7-6 below showed the details of the significant differences found between the younger age group (18–29 years) and the older age groups on three items for the night zone option. Similarly, it showed the middle age group as being statistically different from the other two age groups on one item regarding the delay concerns for the day zone.

Table 7-6: age group differences on both Night Zone preferences & Day Zone delay

| Zone Type | Variables | Between Age groups | Mean Response Rates | *SD* | *F(4,123)** | Partial Eta $^2$ |
|---|---|---|---|---|---|---|
| Night | Accept the idea | 18-29 & 30-44<br>= & 45+ | 3.11 & 3.63<br>3.11 & 3.64 | 1.1 .84<br>1.1 .83 | 13.25<br>11.52 | .05<br>.05 |
| | Adopt it other weak nights | 18-29 & 30-44<br>= & 45+ | 3.33 & 3.73<br>3.33 & 4.02 | .91 .88<br>.90 .85 | 8.79<br>10.92 | .04<br>.05 |
| Day | Speed delays not signals | 30-44 & 18-29<br>= & 45+ | 3.08 & 3.74<br>3.08 & 3.60 | .95 .96<br>.95 .97 | 24.67<br>11.04 | .10<br>.08 |

* P < .01

## 7.6. Discussions

It was learned from the overall results that the delay concerns reached 74 % for the day zone option and 64% for the preference of the night zone 40km/hr with an electronic signs option. This revealed the overall strong rejection of the day zone as an option and shows the respondents' preference for the night zone as a better option.

As hypothesized in sections 7.5.1 and 7.5.2, differences of attitude existed between cultural groups on some dependent variables regarding both the delay concerns for the day zone and the preference for the night zone and options. Two cluster analyses were conducted for each option following MANOVA analysis.

The first dendogram regarding the day zone (Figure 7-3) indicated that the European group was away from the rest of the clustered groups, reporting less concern about implementing the 40km/h day zone limit than the other cultural groups. Particularly with regard to the item of 'Speed delays no signals', lower mean response rate of 3.16 was reported, which means that European group did not believe that the delay would be caused by the 40km/h speed limit, but rather that it would be due to traffic signal timing which contributes to traffic delays. European cities have researched and adopted speed reduction for a long time and have shown that it has saved many lives. The Austroads report revealed that EU countries have utilised harm minimisation principles as the basis for setting EU standards. It added that Australian speed limits tended be to higher than those found elsewhere including in Europe (Austroads, 2005). They recommended that, in order to reduce road injury rates further, more must be done to reduce driving speeds in Australia, and lowering speed limits may be a critical component in achieving this outcome. The European Parliament is currently calling for speed limits on residential roads and single-lane roads without cycle tracks throughout the European community to be reduced to 30km/h in the interests of road safety. That would equate to 20m/h in the UK and the move has been welcomed by the campaign group '20's plenty for us', which lobbies for that limit to be put in place (MacMichael, 2011). In fact, 20m/h speed limits have already been introduced in a number of cities in Britain including Bristol and Liverpool, and other cities looking at 20m/h limits include Cambridge, Norwich, Brighton and Bath, the report added.

By contrast, this study found that the Australian group, was most concerned about the implementation of a 40km/h day zone limit. The group recorded the highest mean response rate 4.07 (77%), which may suggest that Australians are not sure of the safety benefits for pedestrians if the day zone is implemented as an option around the city and elsewhere. The Local Government Authority is suggesting that such speed limits as the 40km/h need to be proven before implementation (Gear, 2011).

The second dendogram for the results regarding the night zone showed the Asian group was somewhat separated from the rest of the groups, followed by the African group. The Asian group recorded the lowest mean response rates for the night zone preference (3.43) compared to the European and the Australian groups (3.57 and 3.59 respectively). The Asian group was less inclined to believe that drivers would obey the 40km/h speed limit sign if the night zone were to be implemented. There was a statistically significant difference between the Asian group and the African and Australian groups, which may reflect the road fatality rate in Asian countries such as China, India and Thailand. A Bangkok-based professor, for instance, argues that drivers can avoid accidents if they are careful, obey the laws, and do not speed (Erickson, 2004). The Asian group had the lowest mean response rate of all the cultural groups for both options, which may also indicate their cautious response to introducing a 40km/h scheme regardless of whether it is at day or night, and further may indicate a preference for the 60km/h limit to remain.

Unlike the Asian group, the African group had the highest mean response rate for preferring the 40km/h night zone, in particularly due to their belief that such a zone will reduce pedestrian fatalities. This belief was statistically significant compared to the rest of the groups. A literature search found that most serious pedestrian casualties in Africa occur during the night. A recent study in Ghana by Damsere-Derry et al. (2010) compared the fatality rates between daytime and night-time, and showed that pedestrian casualties were significantly higher at night-time than during the day ($p < 0.001$), with each severity level being closer to 70% at night compared to day. Similarly, pedestrian deaths in South Africa peaked during the evenings, with the highest incidence between the hours of 18:00 and 21:00, as reported by Milliscent et al (2008). This may also reflect the preference of the African respondents for the

40km/h option at night to reduce pedestrian fatalities. From another point of view, some African respondents commented that 40km/h is slow in the daytime and can be stressful as most drivers are in a hurry to finish some tasks, unlike at night-time which was considered to place less pressure on drivers. A study found that the reduction in stress differs according to the kind of information from slow-moving vehicles ahead (Hamoaka, Nemoto and Shimizu 2005).

In terms of the influence of age groups, the study found that the younger group (18–29 years) was less in favour of the night zone option and reported strong objection to the day zone option. This reveals their desire to keep a 60km/h limit rather than introducing the 40km/h limit. The involvement of male drivers in speeding, particularly the 18–24 year group, is well documented in the literature. In support of this, the study found that the there was a statistical difference between male and female drivers, with the former believing that 40km/h was too slow during the day.

In addition to this, the study also found that the older the age group, the higher the acceptance of the 40km/h night zone option, due to the fact that the older age groups are more involved with teenage children who wish to attend clubs and other entertainment venues, and this might make them more concerned about their children's safety as pedestrians. In this study, non-single drivers were more in favour of the idea" of the night zone option than single drivers, believing that this option would be as safe as the school zone. The reason for this may be that non-single drivers are more likely to have children attending schools and are therefore well informed about the dangers of higher speed, particularly around school areas, unlike the single drivers.

### 7.7 Conclusions

Knowing how road users think in terms of speed reduction may lead to a better understanding of some of the unsafe behaviours relating to speeding that put pedestrians at risk. In fact, pedestrian crashes are of concern to many authorities in Asia including the Arab Gulf Countries. Drivers may need to be educated about the benefit of speed reduction and the tangible benefit of avoiding a crash when lower speed limits are adopted. The mean response rate for delay concerns in the day zone was 74%, whereas preference for a night zone reached 64%. The results showed that

that there were differences in attitude between cultural groups on both the day zone delay concerns and the night zone options, as had been hypothesised. Results showed that the Asian group recorded the lowest rate for the night zone preference, and the cluster analysis depicted that clearly.

There was a statistically significant difference between cultural groups with regard to drivers obeying the 40km/h sign limit, namely between the Asian group and the African and Australian groups. Similarly, cluster analysis regarding the Day Zone showed separation between the European group and the rest of the clustered groups, indicating that Europeans showed less delay concerns about implementing the day zone which may have been due to a particular issue, namely that, “the European group does not believe that the delay is caused by the 40km/h speed limit, but rather they believe it is due to the traffic signals”.

The Australian group were the most concerned about implementing the day zone with regard to delay concerns, as they recorded the highest mean rate response of 77%.

There was a statistically significant difference between singles and non-singles with regard to differences in their preference for a night zone. A statistical difference was also found between male drivers who believed that 40km/h during the day is too slow, compared to female drivers.

Importantly the 18–29 year age group was the most concerned about the implementation of a day zone, compared to other age groups. Surprisingly, they also recorded the lowest mean response rate of all age groups for the implementation of a 40km/h night zone. This revealed their attitudes against implementing the 40km/h limit altogether, and their preference for leaving the 60km/h speed limit unchanged.

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Appendix 7-1: Questionnaire sample on the 40km/h zone along shopping strip

| Statement | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| 1. Drivers may find a 40 km/h limit too slow during the day. | | | | | |
| 2. Drivers may find it stressful to drive at 40 km/h during the day on roads not busy with pedestrians. | | | | | |
| 3. Drivers may show less tolerance during the day if driving on roads with a 40 km/h limit. | | | | | |
| 4. Drivers may think that a 40 km/h limit during the day will slow the flow of traffic. | | | | | |
| 5. Drivers may think that delays in the CBD are due to a 40 km/h limit during the day rather than the traffic signals. | | | | | |
| 6. rivers are more likely to accept the idea of a 40 km/h night zone around entertainment venues. | | | | | |

7. Driver are more likely to observe and obey flashing 40 km/h night zone signs.

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

8. There may be less pedestrian fatalities if 40 km/h night zones are introduced around entertainment venues.

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

9. 40 km/h night zone may need to be implemented during the week near entertainment venues for safety of pedestrians.

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

10. The night zone is similar to the 40 km/h school zone limit in terms better safety for pedestrians.

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

**Your Comment:**

## Participant: Please fill below

**Your Age: --------------------**
**Gender: Male / Female**
**Marital Status: Single /Not Single**
**Born: Africa/ Asia / Australia / Europe**

## THANK YOU

# CHAPTER 8 ROAD USERS APPROVAL ON SPEED ENFORCEMENT INITAITIVES WITHIN AUSTRALIA

## 8.1 Introduction

In Australia, as in many other countries, the Auditor-General plays the role of checking on system fiscal efficiency, performance and effective communications between road safety professionals and the public (road users). The Auditor-General produces independent, professional state-of-the-art reports on speed enforcement in Australia that are highly regarded by the community.

This chapter collects recommendations from the Auditor-General's reports on speed enforcement within Australia, as well as the strategic initiatives that were to be executed by decision-makers in their own states.

Based on the literature review in section 2.7, the initiatives were collated and converted into a questionnaires (10 questions). The questions (initiatives) were divided into groups of five, each group having its own attribute. The first described visual matter (what drivers see on the road, i.e. cameras, police officers, etc.), and the second attribute dealt with non-visual (what drivers do not see on the road, i.e. policy-making and administrative decisions, etc.).See Figure 8-1 below.

These ten questions were intended to measure the level of approval (LOA) of road users, to gauge their level of acceptance of and support for these strategic initiatives. The study will run a multinomial logistic regression (MLR) to determine the significance of these initiatives based on the LOA. Details of LOA for other initiatives are also included.

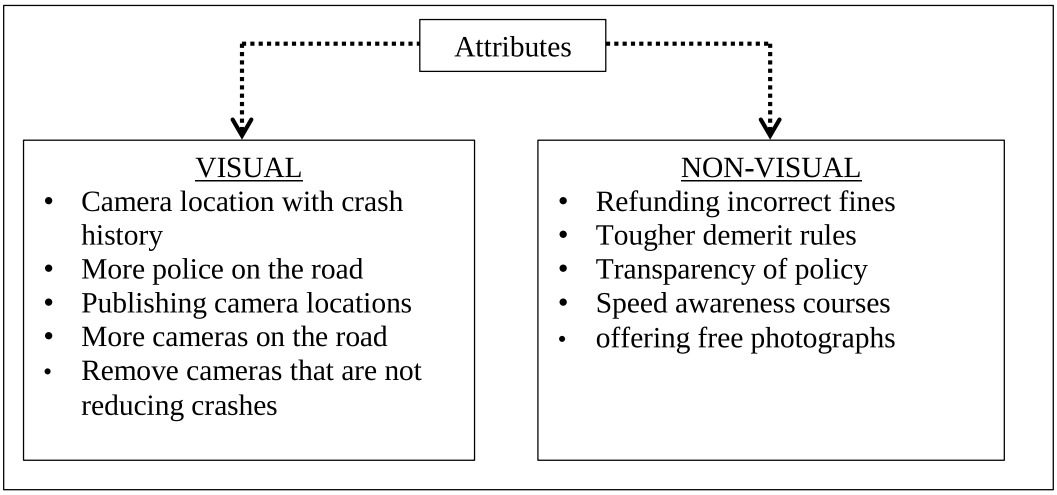



Figure 8.1: Attributes selected from Auditor-Generals' reports on speeding cameras

## 8.2. Participant

The self-administered survey was designed to explore drivers' attitudes, referred to here as the level of approval (LOA) towards initiatives that were considered strategic. Therefore a questionnaire was constructed with a total of 10questions, five of which related to camera sites and the other five to policies relating to the camera system. Distribution and collection of questionnaires was administered in Perth and involved different groups from university, commercial and industry environments. There were a total of 344 participants, consisting of 185 males and 159 females. There were 171 participants from universities and commercial environments, and the remainder were from industrial areas. Two major industrial areas in Perth were selected for the survey.

The most important criterion for inclusion in the study was that participants held a current Australian driver's licence. As directed by the Ethics Committee at Curtin University, all participants were provided with a consent form and information letter along with the questionnaire.

## 8.3. Approach

### 8.3.1 Selection of the Questions

This study has investigated and gathered key recommendations (initiatives) from the Auditor-General's reports, sorting them according to two attributes. The first dealt with visual attributes, i.e. police and cameras numbers and locations, and the second is with non-visual i.e. policy, planning and administration issues. The reports covered seven states in Australia (see Appendix 8.1). There were no Auditor-General reports found for two of the states; instead, items were added from the RACQ comments on Queensland and the road safety minister's comments on South Australia.

There was a report dealing with the employment of public servant and the hiring of contractors to manage camera system in Queensland found in Ironside, (2011). This report was not included as a questionnaire. It was found to be outside the scope of this study and it was mainly a proposal. Importantly this study focus on gap reduction between road users and decision-makers, therefore it excluded any initiatives dealing with increased penalties, revenue etc. But rather concentrated on the key initiatives that drivers would like to approve and prioritise as a measure that various jurisdictions in Australia may take on board. In fact a recent report by Austroads (2013), advocated the idea of decision-making models that are derived from empirical research. Therefore a total of 10 initiatives were selected to construct the questionaries ( Appendix 8-2).

### 8.3.2 MLR Model

Multinomial regression is an important analytical tool in road safety studies. It is attractive to researchers in targeting the effect of independent variables on a binary dichotomous outcome or multi-level outcomes or dependent variables. For example, in terms of speed and speeding concerns, Konga and Yanga (2010) found that higher speed limits contributed to higher risk levels in China. By contrast, Al-Ghamdi (2001) in Saudi Arabia, using the odds ratio concept as an estimate of the logit, found that speed as a cause of accident factor was significantly associated with accident severity.

A study in Australia by Cameron et al. (2003a, 2003b) used logistic regressions and found there was no interaction between the effect of TINs and speed-related publicity awareness on the frequency of casualty crashes. It further found that the increased level of speed camera ticketing was associated monotonically with road crash reduction. Demographics such as age and gender were also used in research studies.

Another study (Abdel-Aty, Chen and Schott, 1998), using a log-linear regression analysis, found that driver age was a contributing factor to crash severity. In addition to that, Yan, Radwan and Abdel-Aty (2005) found that the striking drivers with relatively larger accident propensity tend to be male drivers, younger than 26 years, or older than >75 years. For striking drivers, accident propensity appeared to decrease with increasing age until the age of 56–65, and then increase to a higher accident involvement for the age group older than 75 years.

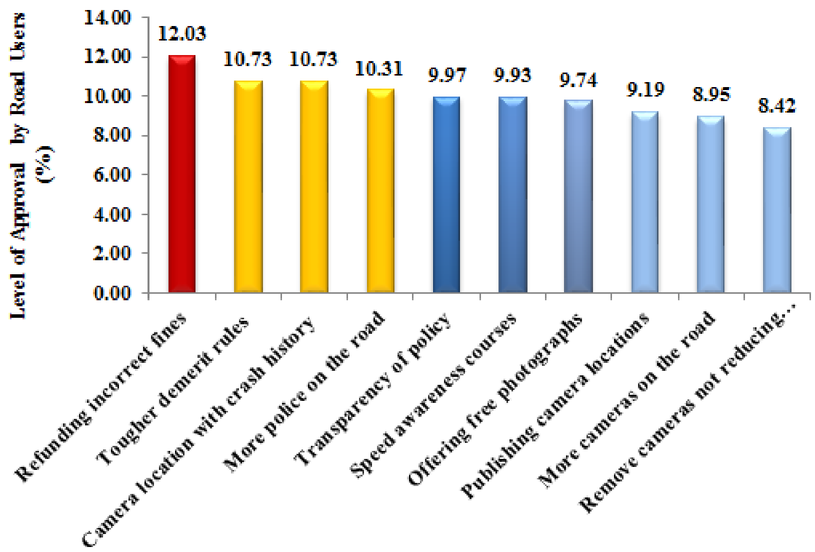
This study utilised the LOA as a dependent variable, with four categorical levels (disapprove, slightly approve, approve and strongly approve). This may be considered as ordinal data, hence the ordinal logistic regression (OLR) is applicable. But according to Amemiya (1985), it may be preferable to use an unordered model such as multinomial logistic regression (MLR) to model ordered data. Amemiya (1985) added that caution is needed if an ordered model is to be used, as it can lead to serious biases in the estimation of the probabilities, unlike the use of an unordered model such MLR where the model parameter estimates remain consistent (although there is a loss of efficiency).

In addition to this, Washington, Karlaftis and Mannering (2003) have said that using the ordered probability models such as ordinal models will place restrictions on how variables in x affect outcome probabilities. Therefore, due to the above reasons, an unordered logistic model (MLR) will be adopted for this study even though the LOAs are ordinal. The use of the MLR will deal with three discrete outcomes (slightly approve, approve and strongly approve), and the disapprove level will be used as a baseline (reference) level.

### 8.3.3 Data Filtering

The 10 initiatives were then converted to 10-item questions, divided into four groups (regardless of visual and non-visual initiatives) in order of their importance for LOA, and the importance of the initiatives to road users (Figure 8.2). Note that visual initiatives involving police and camera on the road have only two high LOAs, namely the camera location with crash history, which will increase public confidence, and the presence of more police on the road encouraging safer driver behaviour. The other three visual initiatives were at the lower end of the LOA scale. This indicates that the authorities need to select the right camera location in order to effect crash reduction, and that it is better to get it right at the start rather than moving the camera at a later stage. Most interestingly, road users showed little approval for publishing camera locations.

In terms of non-visual initiatives such as those involving policymaking, it was found that refunding incorrect fines was recorded as the highest LOA, but this initiative was not a common concern for all states, particularly where road users expect cameras to be highly accurate. Only in Victoria was this particular initiative a concern.
(Appendix 8.1). Nonetheless, the camera accuracy remains one of the highest priorities to road users. This is followed by the second LOA group, showing the importance of tougher demerit rules in deterring speeding drivers.




Source: (Ebrahim and Nikraz, 2013a, 2014b)

Figure 8-2: Percentages of Level of Approval by road user's visual and non-visual attributes

The initial run of the MLR showed that four initiatives appeared to have a significant $p$ value with an acceptable $X^2$ value (Table 8.1). Each initiative has its own vital importance for reducing the gap between the authorities and the road users, but due to the importance of this chapter, only the speed awareness courses will be discussed further with a complete MLR investigation. This was also chosen as it appears to be the latest initiative that has been used successfully in the UK (Millward, 2012a). This initiative was described with the following statement: "introducing speed awareness courses for repeat speeders would result in better speed behaviour". The initiative is also educational, which complements other enforcement measures and engineering interventions aimed at reducing road crashes.

Table 8.1 Statistically significant initiative from MLR

| Authority Initiatives | LOA % | Groups in terms of LOA % | Model fitting *P* | Model $X^2$ |
|---|---|---|---|---|
| Tougher demerit rules | 10.73 | 2 | 0.012 | 29.90 |
| Speed awareness courses | 9.93 | 3 | 0.001 | 43.11 |
| Publishing camera locations | 9.19 | 4 | 0.005 | 32.65 |
| Remove unwanted cameras | 8.42 | 4 | 0.021 | 27.97 |

## 8.4. Statistical Method

As discussed above, it was decided to use MLR for modelling the running of speed awareness courses for repeat speeding offenders. In order to build the model, the first step was to construct the model to get a logit score Y, after which the study would further check the predicted probabilities and scatter them against the Pearson residuals that the model produces.

The study aimed to test the probability of the dependent variable in approval level by road users occurring as the values of the IVs change. In other words, the objective was to find out the magnitude of approval by road users for these initiatives. Thus, the Y event is very unlikely to occur if f(Y) is close to 0, and it is very likely to occur if f(Y) is close to 1.

The logit function is given by equation 1 which is derived from different predictors multiplied by their corresponding regression coefficients, where Y is calculated as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n \quad (1)$$

Where $\beta_0$ is the intercept of the value of Y when all the predicting variables $X_1, X_2, X_3 \dots X_n$ are equal to zero.

The variable Y (logit) is a measure of the sum of the input of all the independent predictor variables used in the model. The variable Y is defined as:

$$LOA = \beta_0 + \beta_1 * Yrsexp + \beta_2 * Age + \beta_3 * Envmt + \beta_4 * Gender\ + \beta_4 * Status\ (2)$$

Where,

LOA = Four levels, disapproval levels is a reference category, compared to other three levels.

Yrsexp = Years of experience, Continuous variable.

Age = Age of participant driver, Continuous variable.

Envmt = Two Environments, Categorical variable,
Non-industrial =0, Industrial=1.

Gender = Gender of detected speeding driver. Categorical variable,
Female=0, male=1.

Status = marital status of participant driver. Categorical variable,
Single=0, Non- single=1.

Further to equation 2, it is mentioned in Field (2009) that reference category with other categories consecutively in pairs and would results in three pairs; each comparison is using the low level speeding category. Since this would calculate the log-odds, it is appropriate to calculate the probabilities of that logit, by using equation 3.

$$P(Y) = f(Y) = \frac{1}{1 + e^{-Y}} \qquad (3)$$

Where f($Y$) is the probabilities of approval level measures represented by $Y$ and e is the base of natural logarithm. For several predictors, the equation would become

$$P(Y) = f(Y) = \frac{1}{1 + e^{-\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots\ + \beta_n X_n}} \qquad (4)$$

Substituting Y of equation (2) in (4), with all predictors, the final probability calculated will become:

$$f(Y) = \frac{1}{1+\, e^{-(\beta_0+\beta_1*Yrsexp+\beta_2*Age+\beta_3*Envmt+\beta_4*\, Gender+\beta_5*Status)}} \quad (5)$$

LOA data will therefore be analysed through MLR using LOA and their corresponding probabilities. The SPSS (2008) output is evaluated and discussed below.

## 8.5. Model Evaluation

Three steps are discussed below that involve different aspects of evaluations. Firstly the crucial fitting information that determines the goodness of the fit of the model, then the parameter estimates testing the coefficients and the odds ratios of the model, and finally the plotting of Pearson residuals against the predicted probabilities.

### 8.5.1 Model Fitting Information

Table 8-2 below discusses the log likelihood, AIC, goodness of fit and pseudo $R^2$. It can be seen that all details are encroaching, which indicates a good fitting model if these explanatory variables are used.

Table 8.2: Model fitting information including remarks

| Model fitting details | value | *p* | Remarks |
|---|---|---|---|
| -2 LL ($x^2$) | 43.11 | 0.001 | The change is good and it explains the decrease in unexplained variance and it is considered as a good improvement to the model. |
| AIC | 803-790= 13 | - | Value of AIC has lowered when model introduced indicating a good fit. |
| Goodness of fit | Pearson =742<br>Deviance=686 | 0.36<br>0.87 | The predicted values are not significant and not different from the observed, thus the fit of the model is good. |
| Pseudo $R^2$<br>Cox and Snell<br>Nagelkerke<br>McFadden | <br>0.12<br>0.13<br>0.05 | <br>-<br>-<br>- | Fairly similar values and fairly reasonable as it represents a good size effect according to, Field (2009). |

### 8.5.2 Parameter estimates

In this section, three comparisons are executed, revealing the parameter values of the mode. Table 8-2 above shows the details of significant parameters, and particular attention needs to be paid to the odds ratios *Exp (B)* for interpretation of the model. The parameter estimates are as follows:

Table 8.3: Model parameter estimates

| Predictors including interactions | B (SE) | Wald $x^2$ | 95 CI limits Lower | Upper | Odds Ratio *Exp (B)* | *P* - value |
|---|---|---|---|---|---|---|
| | Slightly approve vs. Disapprove | | | | | |
| Intercept | - 4.50 (1.64) | 7.49 | | | | |
| Yrsexp | - 0.17 (0.09) | 3.49 | 0.71 | 1.00 | 0.21 | 0.062** |
| Age | 0.22 (0.09) | 6.05 | 1.05 | 1.45 | 1.24 | 0.014 |
| Envmt = 0 | 0.86 (0.43) | 4.09 | 1.3 | 5.49 | 2.37 | 0.043 |
| Envmt = 1 | 0.00 | | | | | |
| Gender = 0 | - 0.01(0.38) | 0.00 | 0.47 | 2.11 | 1.00 | N/S* |
| Gender | 0.00 | | | | | |
| Status = 0 | 0.32(0.40) | 0.67 | 0.64 | 3.00 | 1.38 | N/S* |
| Status = 1 | 0.00 | | | | | |
| | Approve vs. Disapprove | | | | | |
| Intercept | -3.76(1.59) | 5.58 | | | | |
| Yrsexp | - 0.18(0.09) | 4.21 | 0.70 | 0.99 | 0.21 | 0.040 |
| Age | 0.22 (0.09) | 6.19 | 1.05 | 1.47 | 1.24 | 0.014 |
| Envmt = 0 | 1.19(0.39) | 9.14 | 1.52 | 7.10 | 3.29 | 0.003 |
| Envmt = 1 | 0.00 | | | | | |
| Gender = 0 | 0.06(0.34) | 0.03 | 0.53 | 2.17 | 1.06 | N/S* |
| Gender = 1 | 0.00 | | | | | |
| Status = 0 | -0.03(0.36) | 0.01 | 0.48 | 1.97 | 0.97 | N/S* |
| Status = 1 | 0.00 | | | | | |
| | Strongly approve vs. Disapprove | | | | | |
| Intercept | -6.10(1.70) | 12.73 | | | | |
| Yrsexp | -0.22(0.09) | 5.89 | 0.67 | 0.96 | 0.81 | 0.018 |
| Age | 0.28 (0.09) | 9.53 | 1.11 | 1.58 | 1.32 | 0.002 |
| Envmt = 0 | 1.55(0.46) | 10.66 | 1.89 | 11.94 | 4.71 | 0.001 |
| Envmt = 1 | 0.00 | | | | | |
| Gender = 0 | -0.07(0.42) | 0.03 | | | | N/S* |
| Gender = 1 | 0.00 | | | | | |
| Status = 0 | -0.76(0.45) | 2.83 | 0.19 | 1.13 | 0.47 | 0.092** |
| Status =1 | 0.00 | | | | | |

N/S* = Not Significant, ** = p < 0.10

*Years of driving experience (Yrsexp):* The coefficient for slightly approve compared to disapprove is found to be -0.17 and the odds ratio (Exp B) is 0.21. Thus, if the years of driving experience is increased by one unit (year), the likelihood of slightly approval versus disapprove is expected to decrease by 0.17 units. Drivers with long experience are slightly less likely to slightly approve awareness courses. The case is the same for the coefficients of approve and strongly approve where drivers with long experience slightly less likely to approve the courses.

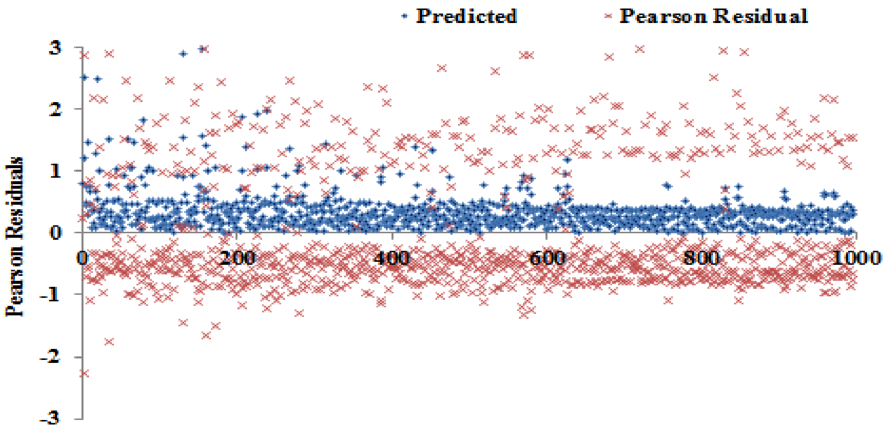
*Age:* the coefficient for slightly approve compared to disapprove is found to be 0.22 and the odds ratio (Exp B) is 1.24. Thus, if age is increased by one unit (year), the likelihood of slightly approve of awareness courses compared to disapprove is increased by o.22 units. This means that older drivers are slightly more likely to slightly approve of awareness courses. The case is the same for other two coefficients. Where older drivers are slightly more likely to approve and strongly approve an awareness courses for repeat offenders. This age coefficients may contradict the above findings of years of experience but it may be due to other variable such as the environment of the road users as discussed below. Note that gender coefficient is not significant on all three comparison levels.

*Environment of road users (Envmt):* This coefficient is of high importance to this study since it determines the usefulness of differentiating between two environments and how drivers think in terms of authorities' initiatives. The coefficient for slightly approving compared to disapproving in terms of the environment was 0.86 and the odds ratio (Exp B) was 2.37. Hence drivers coming from an office environment such as in the commercial sector, universities etc. are more likely to slightly approve of the awareness courses for repeat offenders. This significance increases significantly as approval strength increases, indicating that those from industrial areas are less likely to approve of the idea of running awareness courses than drivers from a non-industrial environment. It should be noted that older drivers from industrial areas are slightly less likely to approve of these courses compared to their same age counterparts. This may now explain the reason for the above years of experience and age coefficients and their effect from industrial point of view.

*Status:* this coefficients was found to be not significant similar to gender.

### 8.5.3 Predicted probabilities

Graphically, it can be seen in Figure 8.3 below that the random scatter of the Pearson residual data against the predicted probabilities concentrating between 1 and -1 range. It also shows no trend or pattern formed. This means it is contributing to the accuracy of the model. (SPSS 2008; Landwehr, Pregibon and Shoemaker 1984).




Source: (Ebrahim and Nikraz, 2013a, 2014b)

Figure 8.3 – Pearson residuals scattered randomly against predicted probabilities

## 8.6. Simulation

The study used an Excel based Monte Carlo simulation for checking the validity of the MLR model. These methodology of generating random conditions from probability distributions of the random variables was based on simulation models developed by Albright and Winston (2005) and was adopted by D'Souza and Maheshwari (2012),. The simulation is accomplished by replicating each random value of the four variables into equations 1 and 5, where y and f(y) calculated. This will calculate all probabilities of the new values of each variable. Each equation was simulated for about 1000 replications to obtain random values that could be checked and compared with the MLR model (Appendix 8-3). The comparison also included graphs to illustrate the findings of the simulation. The study used a lookup argument for continuous variables and if argument for categorical variables. In this manner, an agreement was found between the simulation and statistical prediction of the model. However, it is important to highlight here that age and years of experience would generally produce similar behaviour. In this case it did not. It may be that there were fewer participants belonging to older groups from non-industrial areas interviewed. It is believed that the survey used in this study can be expanded, which would solve the matter of the older drivers in both industrial and non-industrial environments.

In addition, there were a few limitations that should be mentioned, which, if available, would have improved the model outcome:

- Extra information on driver speeding history such as repeat offending may need to be included which could have been added to the independent variables.
- The study has ignored the issue of the values of fines. This may be of importance to some road users in terms of reducing the gap between the jurisdiction's initiatives and the road user's approval levels for such initiatives. The Authors believe that avoiding the issue of fines, money and revenue raising which is heard in the media may make the study a step further, as the study focused on empirical positive data that could produce flowing recommendations rather than still ideas such as fines.
- The study focused on only two major industrial areas in the Perth metropolitan area and did not include other industrial areas.

## 8.7 Conclusions

Ten questions in total were devised in order to measure drivers' level of approval (LOA) for the strategic initiatives to be executed by decision-makers. An initial run of the multinomial logistic regression (MLR) showed that four initiatives have a significant *p* value with an acceptable $X^2$ value, but due to the limitations of this chapter, only the speed awareness courses were explored further with a complete MLR investigation. This initiative is educational and complements the other enforcement measures and engineering interventions needed to reduce road crashes.

The equations used in this paper were to predict probabilities of LOA (Level of Approval) on road users on five independent variables in the process i.e. age, years of experience, status, gender and environment of the drivers. Results found that environment of the driver were a significant independent variable in terms of approving speed awareness courses. In other word drivers from non-industrial environment were more likely to approve the idea of speed awareness courses than drivers from industrial areas. Other chief findings were the importance of the tougher demerit rules and the importance of presence of police.

Out of the five visual initiatives, it found that camera location with crash history will increase public confidence and it has a high level of approval by road users similarly for the presence of more police on the road for safer speed behaviour. Other three are at the lower end of the LOA scale. It indicates that authority needs to select the right location that deals with crash reductions. This means that it is better to get it right at the start rather than removing the camera at a later stage. Most interestingly, road users showed little approval to publishing camera locations.

In terms of non-visual initiatives such as those that deal with policymaking, it was found that refunding incorrect fines received the highest LOA, but this was not common to all of the states’ systems, particularly where road users expected cameras to be of high accuracy. This case only occurred in Victoria (see Appendix 8.1), however it remains one of the highest priorities for road users. The second highest set of LOA results show the importance of tougher demerit rules required to deter speeding drivers. This high percentage could be common to all states and it appears to be of high priority, similarly to the LOA regarding the presence of police on the road. Hence, both tougher demerit rules and police presence may be regarded by authorities as priorities for road users. In the case of tougher demerits for repeat offenders, most comments suggested that tougher demerits would remove dangerous drivers from the road system, resulting in fewer dangerous drivers on the road. Similarly, the presence of police recorded a higher LOA. A greater number of police on the road may deter drivers from speeding, helping to ensure safety.

This chapter has investigated five independent variables (age, years of experience, environment, gender and status) using MLR. It found that the environment from which road users came (industrial and non-industrial) was a significant factor. Drivers from industrial areas were more reluctant to approve of awareness courses for offenders, unlike those from shops, offices and university backgrounds. In a recent study by Ebrahim and Nikraz (2014) and as shown in Figure 8-4, it was found that the number of traffic infringement notices (TINs) issued to drivers on the spot by police is consistently higher in industrial areas than in other areas. The study found that 4 TINs/hr were issued in industrial areas compared to 3 TINs/hr in residential areas.

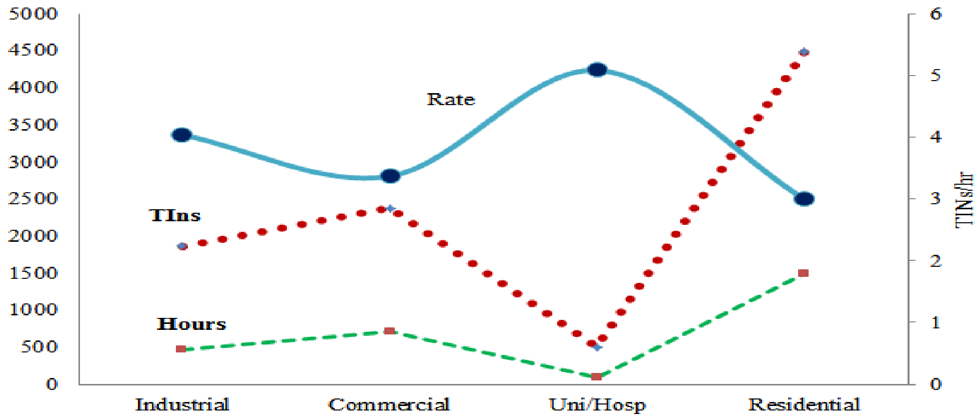



Figure 8-4 – Rate of TIN's of four suburban areas

Age was found to be slightly significant compared to environment. In any event, speed awareness courses for repeat offenders are an essential complement to tougher demerit rules for repeat offenders. Some repeat offenders, having received the required education from such courses, may re-join the road system with a different attitude Speed awareness courses started in the UK after national speed awareness schemes were investigated by Fylan et al. (2006) and have been running ever since, giving drivers the option of saving demerit points. At the same time as offenders receive education about the risk and trauma associated with speeding, the money collected from the courses is used to fund speeding cameras (Millward, 2012). In other words, once the program will sustain the courses, then cameras will be sustained by these courses as speeding offenders may drop but, courses funding will continue to create new cameras as required.

To conclude, the aim of this paper was to close the gap between road users and decision-makers. This was done by revealing the strategic initiatives outlined by different states in Australia, and giving road users the opportunity to indicate their level of approval (LOA) for these initiatives. Having information on the road users' approval of, for example, tougher demerit rules and the presence of police, could contribute to improving the system

***A similar initiative has been adopted and used successfully in the UK (Millward, 2012a). If executed correctly, this could be a promising tool for educating those who break the speed limit, even if it is 40km/h, rather than punishing them. Many countries, including Australia, the US and others, might wish to introduce something similar to the four hour theory courses costing around $100 (Millward, 2012b).. The camera enforcement system would be sustained through the awareness courses, and in turn, the courses would sustain the camera system. Hence, sustaining camera through courses and sustaining courses through cameras.***

Appendix 8.1: Auditor-General Reports and initiatives by authorities including references.

| States / Initiatives | NSW (New South Wales) | VIC (Victoria) | WA (Western Australia) | TAS (Tasmania) | ACT (Australian Capital Territory) | Qld (Queensland) | SA (South Australia) |
|---|---|---|---|---|---|---|---|
| Auditor –General key recommendation | Achterstraat (2011) priorities are required for potential sites of cameras based on death or serious injury. Page 13. | Department of Justice .address misconceptions about camera program Pearson (2011) to Page 6. | Improve transparency of speeding fines in terms of policy and effective administration Murphy (2012) | Provide for more even enforcement relative to serious crashes page22 Blake (2009) further increase visible presence of police. Wing (2009) page5. | Pham (2006) measure to change attitude on enforcement and education is of high priority. Page 37. | Not Available | Not available |
| Initiatives by authority Towards Public perception | Cameras that were found to be not reducing crashes were removed. Smith (2011). | Publish the location of mobile speed cameras. The appointment of the road safety camera commissioner To check reliability of the speed camera system as a whole. Moor (2012 A, B). In addition to that Traffic camera photographs free for motorist Moor (2013.) | Safety Council recommendations that 80% of accepted funds be allocated to projects in five priority areas. One of the priorities includes reducing speed that relate to crashes. | Response 31 states that ongoing work to increase resources to increase police presence. DIER (2011). | Pham (2009) Commissioning feasibility study into Speed Awareness Course for repeat speeding offences page23. | According to RACQ* it said that need to be support for speed cameras where there was a history of crashes. Moore (2011). | According to the road safety minister the increase of safety cameras on roads and a much tougher demerit point system is having the desired effect on motorists, Nankervis(2013) |

Appendix 8.2: Auditor-General Reports Questionnaires

| Statement | | | | |
|---|---|---|---|---|
| **1. Increasing the number of police on the road would result in safer speeding behaviours.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |
| **2. Drivers are slowing down because of too many speed cameras on the road.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |
| **3. Removing speed cameras that are not reducing road crashes would result in more positive drivers.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |
| **4. Offering speed camera photographs free to motorists would make drivers confident in the camera system.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |
| **5. Introducing speed awareness courses for repeat speeders would result in better speed behaviour.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |
| **6. Making tougher demerit rules for repeat speeders would result in cautious and safe speed behaviour.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |
| **7. Improving transparency of speeding fines in terms of policy & administration, would result in higher driver confidence.** | **Disapprove** | **Little approve** | **Approve** | **Strongly approve** |

Appendix 8.2: Auditor-General Reports Questionnaires (Cont)

**8. Publishing the location of mobile speed cameras would Improve driver confidence in the camera system.**

Disapprove | Little approve | Approve | Strongly approve

**9. Refunding incorrect speeding fines would result in more public confidence in speed cameras.**

Disapprove | Little approve | Approve | Strongly approve

**10. If a camera location has a history of speed related crashes it would increase public confidence on speed cameras.**

Disapprove | Little approve | Approve | Strongly approve

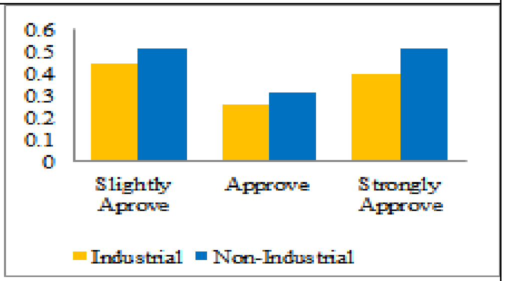
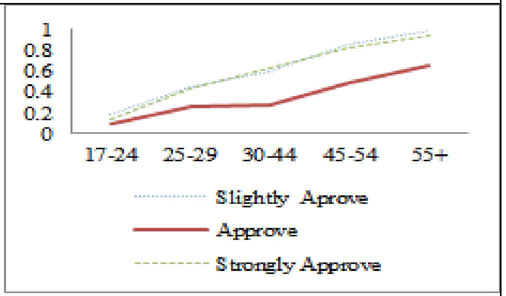
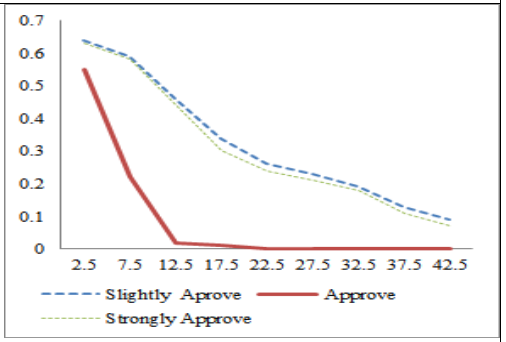
**What is your opinion?**

**Please tell us (optional)**

**Participant: Please fill below**
**Gender: Male / Female** **Age: --------------------**
**Status: Single /Not Single** **Years of driving experience: ---------------------**

**T H A N K   Y O U**

Appendix 8.3: Comparisons between the data simulation and the MLR Model results

| | MLR Model | Simulated Output | Simulated Output in a graph |
|---|---|---|---|
| Envmt | Drivers who come from non-industrial areas are likely to approve the awareness courses for repeat offenders than industrial areas. it was found that older drivers from industrial areas are slightly less likely to approve these courses compared to their same age counterparts. See age below. | When validated, it was found that the probability of drivers from non-industrial areas is less likely to approve the idea of speeding awareness courses. Hence, the simulation is matching the MLR model results. |   |
| Age | Where older drivers are slightly more likely to approve and strongly approve an awareness courses for repeat offenders. | The probability of driver's approving the awareness courses increasing with age. Thus the simulation is matching the MLR model results. |   |
| Yrsexp | Drivers with long experience are slightly less likely to slightly approve awareness courses. The case is the same for the coefficients of approve and strongly approve where drivers with long experience slightly less likely to approve the courses. It may be the environment of the older drivers that make them differ. These are also less experiences drivers from non-industrial areas. | The probability of drivers approving speed awareness courses, seem to be dropping with age. It is similar to the Model results. |   |

# CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

## 9.1 Introduction

This chapter summarises the key research outcomes from this thesis Overall, the thesis has delivered new insights into the reality of road users' behaviours to 40km/h zones in terms of speeding, crashes and their attitudes towards the speed limit.

This study has found that the electronic 40km/h signs are a promising engineering measures for use outside the school zone environment, which supports the Towards Zero Strategy by reducing drivers' speeding and reducing the incidence of crashes. This research developed a new method to expose the effect of the on-the-spot detection method versus the roadside method, whereas most studies have previously relied upon on the covert vs. overt type of detections. In addition for the first time in Australia, information from the Australian Auditor-General's reports was utilised to devise a questionnaire for determining road users' opinions on vital road safety concerns.

Finally, it was concluded that despite a higher rate of speeding in 40km/h zones, research has revealed a large reduction in pedestrian and other type of crashes, unlike the 60km/h zones where the rate and severity of crashes are higher, particularly for pedestrians.

The study shows that, out of all of the age groups, drivers in the youngest age group (17–24 years of age) have contributed the most to road crashes in 40km/h zones in Perth. This was even more pronounced in non-school zones outside the school zone environment. Therefore, these drivers need to be targeted for education, i.e. speeding awareness courses, and warned that if they repeat the offences, it may affect their demerit points and licence status etc.

## 9.2 Conclusions

### 9.2.1 Effect of the 40km/h Electronic Signs

The 40km/h limit is found to contribute positively to safety on the road. The study found that the higher the speed limit is than 40km/h, the higher the harm in terms of pedestrian crashes. All of the salient findings are grouped together in point form below to illustrate these contributions, such as the findings on school zones, non-school zones and the concerns of young drivers. These are as follows:

**In terms of 40km/h school zones:**

- There may be a positive contribution coming from the 40km/h school zone signs, as the pedestrian crash rate for the younger school pedestrians (2-16 years of age) is low compared to other age groups, and shows the sharpest decline.
- Speeding behaviour seems to be lower within school zones than in non-school zones. Further investigation may be needed to determine why drivers in school zones prompted to drive safely where elsewhere they are not. They are the same drivers, but on different segments of the road network. This safe driving behaviour needs to be extended to roads outside the school zones.

**In terms of 40km/h non-school zones**

- Based on chi-square analysis, roads within non-school zones recorded higher level of speeding through on-the-spot detection compared to school zones.
- From a sustainability viewpoint, it is suggested that concerted effort needs to be directed towards using more roadside camera hours around school zones and more on-the-spot hours around non-school zones.
- There is much evidence to suggest that, within the non-school zones, the electronic signs are delivering on the purpose of their installation, by improving speeding behaviour and reducing the incidence of crashes. For instance, modelling the speeding data showed that drivers slowed down after the installation of the flashing electronic 40km/h signs, thus supporting the usefulness of such signs in reducing speeding.

- Time of day was found to be significant in the model for non-school zones, where a higher number of speeding TINs was recorded in the afternoon than in the morning.
- The research found that the electronic signs outperform the standard 40km/h signs with standard road markings within non-school zones.
- The research also exposed the weakness of a road on a shopping strip with a 40km/h limit, finding that different lane widths may contribute to speeding behaviour by encouraging drivers to speed in the wider lanes after they have left the narrow lanes.
- There seemed to be concern regarding the neighbouring 60km/h zone outside the trialled 40km/h road along the shopping strip. Results showed that drivers complied with the speed limit within the trialled 40km/h road, but not outside the trialled road, indicating that 'speeding migration' may be occurring. This may influence the authorities to extend the length of the trialled road beyond the original 0.7 km, as well as to monitor the neighbouring 60km/h zone in terms of speeding enforcement.

**In terms of young drivers:**

- This study used for the first time a data analysis approach comparing on-the-spot and roadside methods. Generally studies have adopted covert vs. overt enforcement. The use of the on-the-spot method demonstrated its dominance in detecting more speed violations than the roadside type. This dominance of on-the-spot detection was vital as it exposed the higher rate of speeding by younger drivers compared to roadside detection, and also the need to have a tangible police officer presence on the road and not to rely solely on cameras.
- It is clearly demonstrated the significant effects of the on-the-spot method and the risks taken by young drivers in the three road limit zones (40, 50, 60 km/h) discussed.
- This means that younger drivers are taking more risks on roads with higher posted speed limits such as 50km/h and 60km/h.
- Regardless of detection type, younger drivers are taking more risks on higher speed limit roads.

- Using on-the-spot detection, younger drivers are more effectively detected speeding with higher speeding levels compared to the roadside detection method.
- Data analysis revealed an association between male drivers and higher speeding levels.

**In terms of suburbs:**

- Some suburbs service only local traffic while others may service local and non-local commuters. It was found that those suburbs that service commuters are more likely to experience a higher incidence of speeding drivers.

### 9.2.2 Effect of the 60km/h Limit

- The study found that the TINs/hr rate around 40km/h roads is higher than on 60km/h roads, but also showed importantly that there were fewer, less severe crashes on 40km/h roads than on 60km/h roads. From a sustainability viewpoint, it is more appropriate to recommend choosing a higher number of TINs and fewer, less severe crashes than otherwise. Of all the speed limits in Perth, 60km/h roads record around 38% of road crashes compared with less than 2% of crashes in 40km/h zones. Targeting more speeders on the spot for excessive speeding in the 60km/h zones is therefore vital.
- The study concluded that increasing the 40km/h roads make this speed become a practice for road users, which in turn will become a culture that contributes to achieving the fundamental aims of the Towards Zero Strategy.
- The 40km/h variable signs will accommodate mobility, hence a 40km/h limit can be used where and when there are pedestrian/vehicle conflicts and not necessarily used on roads that are highly classified. Thus the suggestion once implemented will not interfere with mobility.
- The study found that it was crucial to increase the hours of on-the-spot speed enforcement on roads with a 60km/h limit. Therefore, if roads are converted to a 40km/h limit, the hours of detection will monitor the 40km/h speed rather than 60km/h, which would increase the awareness of slower speed, another aim of the Towards Zero strategy under the pillar of safe road use.

- The public and politicians may need to support such socio-political decisions as converting some of the risky 60km/h roads into 40km/h roads where appropriate for the benefit of community.

### 9.2.3 Significance of Attitudes

**In terms of the 40km/h limit**

- The mean response rate for the delay concerns about the day zone reached 74%, whereas acceptance of the night zone idea reached 64%. This shows that drivers are willing to apply the 40km/h limit only at night-time when roads are quiet.
- Based on MANOVA analysis, there was a statistically significant difference among drivers obeying the 40km/h limit. The Australian group was the most concerned about implementing the day zone in terms of their concern about delays, recording the highest mean response rate of 77 %.
- The European group was separated from the rest of the three clustered groups, showing that they were less concerned about delays arising from implementing the day zone with statistically significant difference. They did not believe that delays are caused by the 40km/h speed limit, but rather by traffic signals.
- A statistical difference was also found between male and female drivers, with male drivers believing that 40km/h during the day is too slow.
- Importantly the 18-29 years age group was the most concerned about the implementation of the 40km/h day zone compared to other age groups. Surprisingly, they also recorded the lowest mean response rate of all age groups for the implementation of the 40km/h night zone limit. They revealed their attitudes against implementing the 40km/h limit altogether, preferring to leave the 60km/h speed limit unchanged.

**In terms of the approval level of speed enforcement**

- Drivers from non-industrial environments were more likely to approve the idea of speed awareness courses than drivers from industrial areas.
- Out of the five visual initiatives, it was found that the presence of more police on the road for safer speed behaviour was considered most important.
- Similarly, camera location with crash history will increase public confidence, and has a high level of approval by road users.

- Based on their approval level, drivers indicated that authorities need to select the right location to effect a reduction in the incidence of crashes. This means that it is better to get it right at the start rather than removing the camera at a later stage. Most interestingly, road users showed little approval for publishing camera locations.
- In terms of non-visual initiatives such as those that dealing with policymaking, the importance of tougher demerit rules required to deter speeding drivers is highlighted. This high percentage of LOA of tougher demerits may be a common issue for all states and it appears to be of high priority, similar to the LOA regarding the presence of police on the road. Hence it is advised that authorities recognise that tougher demerit rules and increased police presence are a priority for road users. In the case of tougher demerits for repeat offenders, most comments suggested that tougher demerits would remove dangerous drivers from the road system, and the roads would have fewer dangerous drivers as a result of removing repeat offenders. Similarly, police presence would focus on the same target by deterring drivers from speeding. Better safety would therefore be achieved through both of these important initiatives.
- Finally, the introduction of the speeding awareness courses is a crucial step towards decreasing the number of speeders on the road. This strategy has been adopted in the UK (Millward, 2012a) and if executed correctly, could be a promising tool for educating those who break the speed limit rather than punishing them. Many countries including Australia, the USA and others who wish to introduce such four hour theory awareness courses for nearly $100 (Millward, 2012b), would surely have an advantage over those who do not run such awareness courses.

## 9.3 Recommendations

- Further investigation may be needed to determine why drivers are prompted to drive safely in school zones but not elsewhere. They are the same drivers, but on different segments of the road network. This safe driving behaviour needs to be shifted to roads outside the school zones as well, which would enhance safety within shopping centres and contribute to the Towards Zero Strategy.

- Converting some of the commercial and industrial 60km/h roads to 40km/h would sustain safety and contribute strongly to achieving the aims of the Towards Zero Strategy.
- The presence of police was found to be essential. It is a public wish and contributes strongly towards safety. This was illustrated through using the on-the-spot' speed detection method, as the punishment is immediate, and also through the road users' approval of the police presence on the road which was found to be regarded highly.
- Awareness courses for speeding offenders will need to be introduced and could sustain the camera enforcement system, while the camera system would in turn sustain the courses. In other word, sustaining speeding camera through courses and sustaining courses through speeding cameras.

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