How can speed enforcement be made more effective?

An investigation into the effect of police presence, speed awareness training and roadside publicity on drivers' choice of speed

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Acknowledgements

Abstract

The effectiveness of police strategy in influencing motorists' choice of speed must be questioned because speeding has remained a consistent factor in accidents to this day. In light of this persistence, the objective of this research is to develop more effective speed enforcement by investigating the effects of police presence, motorists' training, and roadside publicity on motorists' choice of speed. These factors are the most widespread interventions implemented by police all over the world, although only few have investigated how effective these interventions in fact are either as a single or as a combined intervention.

This study was conducted in Indonesian road and applied a factorial experiment design where police, training and publicity were operated as the intervention factors. Participants' responses were recorded during driving throughout prearranged test routes. Further, a traffic survey and questionnaires for motorists and police officers were utilized to support the study's results.

A survey of motorists shows that they are aware of the consequences of speeding, although prefer softer approaches to handle it, while a survey of police forces shows a high level of satisfaction for existing measures, including the new proposed speed enforcement program. There are still many aspects yet undiscovered that correlate to public attitude and police officer job satisfaction to current speed enforcement methods.

One important finding of this research is the discovery of a three-way interaction effect on dual carriageways, which means that the addition of training and publicity to police interventions increases the effectiveness of speed enforcement. However, on single carriageways, the only significant effect was produced by police presence. The combination of three factors not only reduced mean speed by 14% and 10% on dual and single carriageways respectively, but also increased compliance by 72% and 33% until the end of test route. The estimated fatal casualty reductions are 52% and 33% for single and dual carriageways. Surprisingly, the training as single factor has increased travel speeds on dual carriageways, although the effect has changed drastically when combined with police and roadside publicity. This finding could only be justified by the fact that training increase motorists' confidence. Thus, we need guidance to avoid the confidence bias. Also, different distances of Halo effect were observed on both routes in relation to combination of intervention applied.

Finally, the result shows that there is potential for further development of speed enforcement programs by combining training and roadside publicity into police enforcement. In addition, this study also proposes a number of policies so that enforcement agencies can increase the effectiveness police enforcement.

List of abbreviations

ANOVA	Analysis of Variance
BPS	Biro Pusat Statistik (Indonesian Office of National Statistic)
CI	Confidence Interval
DC60	Dual Carriageway 60 km/h
DF	Degree of Freedom
DfT	Department for Transport
DOA	Decade of Action
ECMT	European Conference of Ministers of Transport
EINRIP	Eastern Indonesia National Road Improvement Project
GPS	Global Positioning System
GRSP	Global Road Safety Partnership
HGV	Heavy Goods Vehicle
INPTC	Indonesian National Police Traffic Corps
IQR	Inter Quartile Range
IRSMS	Indonesian Road Safety Management System
IRSP	Indonesian Road Safety Plan
ITERATE	Information Technology for Error Remediation and Trapping Emergencies
KSI	Killed or Seriously Injured
LGV	Large Goods Vehicle
LMIC	Low and Middle-Income Countries
OECD	Organisation for Economic Co-Operation and Development
PAQ	Public Attitude Questionnaire
PCU	Passenger Car Unit
PSQ	Police Job Satisfaction Questionnaire
PTA	Proportion of Travel Time Above Speed Limit
RAC	Royal Automobile Club
RoSPA	Royal Society for The Prevention of Accidents
SC50	Single Carriageway 50 km/h
SD	Standard Deviation
SEARO	South East Asian Regional Office
Seg.	Segment of test route
TRL	Transport Research Laboratory
WHO	World Health Organization

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Chapter 1

Motivation and background for the study

1.1   Introduction

The central question in this study asks how speed enforcement can be made more effective in influencing drivers' choice of speed, and thereby increasing the speed limit compliance, henceforth to reduce the risk of accidents. Speed is recognised as a major contributing factor in accidents. Therefore, speed enforcement is a critical component in the road safety system. It plays a key role in managing speeds on the road by influencing motorists' behaviour. Several intriguing questions that motivated researchers are: How much influence does police enforcement have on motorists' choice of speed? How long do the effects last? Does enforcement become more effective if it is combined with other efforts? The present study aims to understand how speed enforcement affects drivers' choice of speed and to investigate the answers to the aforementioned questions.

This chapter provides a discussion of some of this study's background and motivation. In it, I present an introduction to the current state of road safety and speed enforcement, globally (in various countries) and specifically in Indonesia and other Low and Middle-Income Countries (LMIC).[1] In this chapter, I also introduce a summary of the development of speed enforcement in those countries.

1.2   Motivation for the research

In this section, I briefly discuss the considerations motivating this research. Firstly, this study is about investigating how regularly-used speed enforcement procedures by police and other enforcement authorities influence the motorists' choice of speed and increase the speed limit compliance. As is widely known, most of the safety programs that focus on managing motor vehicles' speed through enforcement incorporate measures other than simple enforcement, particularly publicity and training (WHO, 2017). Reports state that training and publicity should lead to greater compliance with regulations (TRL, 2008; Tay, 2005b; Verschuur, 1993; Box,

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[1] The World Bank Group's classification is used to define income status of a country based on gross national income (GNI) per capita. Indonesia belongs to the group of LMIC, with a GNI per capital of $1,046 to $4,125.

2012). In contrast, other studies have argued that providing information to drivers and improving skill through training does not always lead to a change in on-road behaviour (TRL, 2008; Christie, 2001). Questions have arisen regarding how to better understand the effectiveness of police enforcement together with the presence of these additional measures in reducing accident fatalities.

Secondly, one important aspect of police function in society is ensuring the efficient movement of traffic and protecting all road users against the harmful consequences of (a small number of) non-conforming motorists. Given the importance of police traffic regulation, police enforcement strategies must be adapted towards the role, the function and the duty that can give the best outcomes for the community they serve (Greene and Mastrofski, 1988; Elvik, 2016; Sharp and Atherton, 2007; Hawdon et al., 2003). Nevertheless, there is no clear evidence about what enforcement quantity, strategy, and practical procedures would be the best to achieve the desired level of safety.

Thirdly, the majority of studies that provide evidence of connections between police enforcement on the road and motorists' choice of speed have used results from survey studies carried out in high-income countries. The present study was an exceptional chance to investigate the influence of police enforcement procedures on motorists' choice of speed in a field study outside the usual research base of high-income countries. In Indonesia, a location where speed enforcement has been reported not effectively established, the influence of speed enforcement is believed not to produce similar results to the reports carried out in high-income countries. The success of this research depends to a large extent on the proper selection of the study site, as well as access to resources, materials, and equipment. All the work described in this dissertation was conducted with the collaboration of the Indonesian National Police Traffic Corps (INPTC). INPTC works nationally, and its power to allocate resources to lower levels of the police force helped this study to proceed efficiently.

Finally, the author has served as a traffic police officer for more than 20 years, and hence has a good understanding of the role of the INPTC in Indonesian road safety development. Over the past decade, the INPTC has followed through on its great ambitions to achieve an organisational and cultural transformation—from crime and justice to safety, security, and environment-oriented duty. Currently, in accordance with the United Nations Decade of Action (UNDoA) for Road Safety 2011—2020, the INPTC has shown a strong commitment to accomplishing the UN's vision by developing the Indonesian Road Safety Plan (IRSP) 2011—2020 and implementing it in the police operation. The target of this resolution is very much in line with the INPTC's vision for internal reforms, where one of the objectives is to improve the

effectiveness of speed enforcement in order to contribute to road fatality reduction in Indonesia.

1.3 Background

Worldwide deaths from traffic accidents have reached an alarming level. Every year, approximately 1.24 million people die on the road. There has been no reduction in the number of people killed on the world's roads since 2009, and the annual death toll is predicted to triple by 2030 (WHO, 2013). Low and Middle-Income Countries (LMIC) account for nearly 90% of the traffic fatalities. While fatalities are predicted to decrease by 27% in high-income countries in next decade, they are estimated to increase by 83% in LMIC (WHO, 2004). For instance, the South-East Asia Region (SEAR)[2], of which almost all member states belong to the group of LMICs, contributes 25% of global road traffic deaths. In Indonesia, a SEAR member, 31,234 people were reported to have died on the road in 2010, a number which increased to 32,567 in 2011. Approximately 80 people die in vain on Indonesian roads every day (INPTC, 2011).

Numerous factors have been considered to be the cause of the increased casualties, such as unsafe road environments (Tjahjono, 2010; Hidayati et al., 2012), rapid motorization and the high proportion of motorcycles in traffic, lack of vehicle safety features and personal protection (Conrad et al., 1996; Widyastuti, 2012) and motorists' dangerous behaviour (Sutomo, 2000; Umar, 2006). In addition, legislation that aims at managing and controlling road user behaviour, particularly speed-related behaviour, was observed not to be comprehensive enough, and enforcement action was also perceived to be low or less effective than that found in high-income countries (WHO, 2013).

Speed-related behaviour has been identified in the accident databases as one of the leading causes of vehicle crashes in all countries, including high-income countries. A survey of road safety performance carried out by European Conference of Ministers of Transport (ECMT) member countries showed that excessive and inappropriate speed is the number one road safety problem, often contributing to as much as one-third of fatal accidents (OECD/ECMT, 2006).

In LMIC, this proportion is likely to be greater; furthermore, the highest number of casualties are pedestrians, motorcyclists, and non-motorized road users. Statistics show that speeding accounts for about 60% of road traffic crashes in some LMIC countries (WHO, 2013). Indonesian National Police, for instance, reported that 40% of fatalities were due to speeding

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[2] The WHO South East Asia Region has 11 Member States: Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand, and Timor—Leste.

(INPTC, 2015). The foremost driver error identified by police investigators across the many cases was loss of control or aggressive driving behaviour, with the underlying factor being excessive speed, i.e., driving too fast for the conditions.

High speeds offer positive and negative effects to road users. Driving quickly reduces the journey time, enhancing mobility and thereby contributing to improvements in general quality of life (OECD/ECMT, 2006). At the same time, speed has some strong negative consequences on the speeding driver and their surroundings, such as high number of accidents on urban roads and CO_2 emissions on 70 mph roads (Lai et al., 2012). In many high-income countries, typically 40% to 50% of the drivers travel faster than the speed limit (OECD/ECMT, 2006). Even so, people rarely see themselves as speeding "unacceptably" (Silcock and Smith, 2000) and may not even consider speeding to be a real crime (Corbett, 2000a). Furthermore, many drivers offered self-description with the reference to their considerable experience as 'good' or 'safe' drivers, which involved claims as a 'blameless 40-year driving history', 'lifetime No Claims Bonus' or 'clean license for 30 years', before concluding that their speeding history does not lead to the history of accident involvement (Wells, 2011).

Correspondingly, the WHO (2017) stated that a similar proportion of vehicles travelling at excessive speeds had been found in LMIC as compared to high-income countries. Nonetheless, the actual number of vehicles travelling at unacceptable speeds could be worse, given that speed enforcement is a huge challenge for police and other road safety authorities in LMIC (Afukaar, 2003). Excessive and inappropriate speed is thus far the most common and the most severe road safety problem in LMIC countries.

The speeding problem in LMIC countries is very severe. It originates from incomprehensive legislation, as well as the rare and sporadic speed enforcement operations carried out by authorities, a lack of technology, and the police's tendency to focus more on traffic congestion, which is a primary concern to the public and the government, than on speed enforcement. Moreover, corrupt practices, including bribery, have created a disreputable image of the road policing apparatus in the eyes of the public, including offenders (Rahardjo, 2006). Thus, if speed enforcement is not effective, it is highly unlikely that the motorists observe the speed limit. The probability that speed limit regulations influence motorists' choice of speed would, in this scenario, be very low.

There are numerous strategies influencing motorists' behaviour, in particular for managing vehicle speeds. A well-recognised systematic approach is the three E's: education, engineering, and enforcement (RoSPA, 2004); another is the Safe System approach (OECD/ITF, 2008). In the first approach, all three E's are important: engineering affects the way motorists behave in relation to road and vehicle engineering measures include the speed hump on the road and

speed limiter in vehicle; education would provide drivers with the appropriate knowledge, skills, and attitudes to behave safely on the roads; and enforcement could target illegal and dangerous driving behaviour that puts other road users at risk.

The second approach is the Safe System, which adds management and strategy aspects to the road safety system and also recognises that crashes will occur. This approach is built on existing road safety interventions, but it reframes the way in which road safety is viewed and managed within the community. The Safe System approach emphasises that safe journeys can only be achieved if the road users are aware and if they appreciate the importance of driving at safe speeds on roads. The Safe System suggests that enforcement is a fundamental component of speed management to be complemented by other methods, such as engineering measures, education, training, and publicity (Box, 2012; Howard et al., 2008).

In both the three E's approach and the Safe System approach, speed is at the centre of the road safety problem, so its management is crucial. The objectives of traffic enforcement are to ensure the effectiveness and efficiency of road traffic while ensuring the safety of all road users (Zaal, 1994). Nevertheless, despite the efforts that can be made by traffic enforcement, speed enforcement is only effective if road users conform to it.

The importance of traffic enforcement in speed management, particularly enforcement actions that modify road users' behaviour, has been discussed in many studies. It is encouraging to observe that police enforcement does have an effect on drivers' choice of speed and on the occurrence of accidents (Hauer et al., 1982; Hakinen, 1988; Wesemann, 1988; Bjørnskau and Elvik, 1992; Zaidel, 2002b). Furthermore, Elvik (2011) predicted that fatal accidents in particular could be reduced if excessive speeds could be eliminated or prevented. Difficulties arise, however, when different levels of compliance are expressed by motorists during their journeys, or when different parts of the road environment cause difficulties. The risk might be difference for different proportion of compliance across different locations.

So far, various enforcement methods have been used by the police all over the world to increase compliance to the posted speed limit. In principle, these methods can be categorised into two groups: manual policing, i.e. physical policing, and automated enforcement (De Waard and Rooijers, 1994; Corbett et al., 1999; McInerney et al., 2001; Tay, 2009). The first method, physical policing, makes use of police units to detect and apprehend the offenders, whereas the second method, automated enforcement, aims to detect speed limit offenders automatically by means of a sensor, radar, or camera. Automated speed detectors can be fixed at a particular point or attached to a vehicle to make a mobile speed camera (Pilkington and Kinra, 2005; Elvik and Christensen, 2007). In either case, offender would receive notification of their violation indirectly (i.e., by mail). Speed detectors or cameras can also be operated as

part of a manned police control effort, being fixed either in a visible or a hidden police vehicle (Keall et al., 2001).

The effectiveness of police enforcement methods continues to be debated, whether a particular method more effective in improving motorists' choice of speed (i.e., their compliance with the speed limit), as well as further helping to reduce the fatality of any accidents. For instance, the effectiveness of physical policing has been questioned, since it is considerably more labour-intensive and more expensive than automated approaches, and additionally it is almost impossible for physical policing to reach the same enforcement level as speed cameras or other automated systems (Martens, 2013). However, physical policing has the advantage that motorists can receive immediate feedback on their driving behaviour. In contrast, speed cameras appear to have been effective in helping in changing drivers' behaviour (Pilkington and Kinra, 2005) and in reducing traffic crashes and injuries around the speed camera location (Wilson et al., 2012).

However, the use of speed cameras does not guarantee the achievement of speed enforcement goals, such as increased compliance to the speed limit and decrease in the number of casualties caused by accidents (Campbell and Stradling, 2002). More recent arguments against the use of speed cameras have revealed that motorists do not gain useful knowledge or skills on speed limit compliance or safer speed choice after interactions with the speed cameras (Tay, 2010). Similarly, a finding from a study carried out in urban areas of Brazil demonstrated that the presence of speed cameras had a great impact on speed around the installation points, but that their presence failed to ensure compliance with speed limits by a significant share of motorists at a distance of 200 meters away from (i.e., after) the cameras (Oliveira et al., 2015). These results would seem to suggest that the deterrence effect of speed cameras is not greater than the deterrence effect provided by the presence of police on the roads.

Furthermore, as discussed in the motivation for this study, in many studies of police enforcement, enforcement efforts are typically accompanied by publicity and education (Watson, 1986; De Waard and Rooijers, 1994; OECD/ECMT, 2006; Phillips et al., 2011; WHO, 2017). It is expected that publicity and education can lead the motorists to greater compliance with speed regulations. Accompanying publicity was reported to increase road users' awareness of speed enforcement, at the same time also increases the subjective chance of apprehension (OECD/ECMT, 2006). However, such expositions are unsatisfactory because most of the studies have not treated enforcement efforts which included education and publicity factors in much detail. Delhomme et al., (1999) described the empirical evidence that the 8.5% reduction in accidents during campaign periods was not possible to judge as the

effect of publicity, as these results must be attributed to the combined effect of the campaign, including measures such as enforcement, legislation, and education. Nevertheless, publicity and education are seen as mutually reinforcing methods of deterrence, but questions have been raised about the collective effect of these measures on motorists' choice of speed in the presence or the absence of police enforcement.

Only a handful of studies have specifically examined enforcement procedures, which have been combined with these measures in detail analyses. Thus, it is still not convincing whether the roadside publicity was effective in the absence of police and whether the knowledge and skill gained from training has helped motorists to comply with the speed limit for the whole trip they conducted.

Regarding time and space, it is a stimulating question for "how long and how far" the effect of police enforcement continues to influence motorists' choice of speed (also known as the "Halo effect"). Larger distance Halo effects seem to be associated with physical presence of police (Elliott and Broughton, 2005). The distance Halo effect found at speed camera sites is about 500 metres, almost five times smaller than the minimum distance Halo effect of physical policing, 2400 metres (Sisiopiku and Patel, 1999).

Up to this day, there is little evidence that can explain the relationship between police enforcement and drivers' choice of speed. A variety of methods, procedures, techniques, and tactics have been used; the level or intensity of police enforcement has varied; and new policing strategies have been introduced in combination. All these factors have made speed enforcement more complex to understand. Consequently, there is uncertainty surrounding the effect of speed enforcement as a means of changing drivers' choice of speed. This uncertainty is due to the complexity of the speed enforcement system and its interaction with other factors.

The deficiency of information concerning the effectiveness of speed enforcement procedures is disappointing. It is also necessary to carry out a detailed evaluation of whether the application of a program that included additional procedures increases the effectiveness of speed enforcement compared to a program with only basic enforcement measures. In another word, the application of additional procedures may not necessarily deliver a significant effect on motorists' choice of speed.

Hence, this study aims to explore more factors of speed enforcement and to investigate their effectiveness in enhancing motorists' choice of speed. This study used Indonesia as an example: this country was considered to be a suitable site for speed enforcement research, given aspects that are discussed in a later section of this report.

This study provides an important opportunity to advance speed enforcement strategies by exploring the effectiveness of existing speed enforcement measures in reducing the risk of accidents. Moreover, understanding the relationship among speed enforcement, drivers' choice of speed, and the risk of accidents can help to reveal the underlying logic of police operations and help all road safety stakeholders evaluate their strategies. Finally, knowledge of the impact that enforcement has on drivers' behaviour can help the police to achieve the major goals of traffic law enforcement, i.e., the safety of all road users and the efficient movement of traffic.

1.4   Problem statement

The proportion of accidents caused by excessive speed remains high, regardless of the type of established speed management strategies applied by the authorities. In many LMIC, such as Indonesia, speed enforcement as a means of deterrence is perceived to be ineffective. Rapid motorisation or fast increase of vehicle population without an adequate level of speed enforcement has brought serious consequences for road users' safety. However, convincing motorists to comply with the speed limit and to travel at safe speeds in this environment is a challenging task. Moreover, current information and training programs that are supportive of drivers' knowledge of speed and safety are insufficient. As outlined in the previous sections, there has been a relatively small number of studies aiming to understand the determinants of speeding behaviours. There is not enough data to assess the current speeding problem and its impact on road safety. Without sufficient knowledge, it is very difficult to design a program to effectively modify motorists' choice of speed to be safer and more compliant to regulations.

In Indonesia, police forces are continuously improving their methods and tactics of enforcement by adopting an enforcement strategy based upon "anytime, anywhere"[3] approach and aiming to deliver uncompromisingly severe sanctions to deter all offending drivers—although actual speed enforcement on the road is rare and uncommon. Widespread roadside publicity and personal training approaches are often operated by police, in the hopes that they would increase motorist compliance to the speed limit and to fine-tune drivers' choice of speed against any adverse road traffic conditions. The police's message is very strong that speeding is illegal; speeding is against the law, and it is unacceptable behaviour, which can risk someone's life. However, the outcome of current efforts is not significant enough to substantially minimize drivers' dangerous speed behaviour.

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[3] Police ability to track a speeding vehicle on any road type (anywhere) continuously day and night (anytime)

Therefore, with respect to police enforcement strategy, this study focussed on the overall examination of the speed enforcement effect on drivers' choice of speed. The Indonesian National Police has provided resources (such as personnel, vehicles, equipment, and related resources) to help them learn the effectiveness of speed enforcement scientifically. Specifically, this study has concentrated on exploring more effective speed enforcement procedures—which include motorist training on speed awareness, police presence and roadside publicity, whether as single procedures or as combined procedures—on influencing drivers' choice of speed

1.5   Aims and objectives

Based on the background and context of this study, the main issue addressed in this report is speed enforcement and drivers' choice of speed. The purpose and aim of this study is to develop a more effective speed enforcement strategy using various procedures that can be implemented by police, which can be taken as a model for a nationwide enforcement strategy for influencing drivers' choice of speed to increase their compliance to the speed limit.

In accordance with the stated aim, the objectives of this study are:
1. To measure drivers' choice of speed for each enforcement strategy that involved the consideration of three factors (motorists' training, police presence, and roadside publicity) by running a test on pre-arranged routes,
2. To estimate the effect of combined intervention on accident risk using Nilsson power model.
3. To measures the "Halo effect" during the presence of police on speed enforcement location, and
4. To obtain information about public perceptions of current road safety developments, speed practices, speeding tendencies and police speed enforcement,
5. To obtain information on police job satisfaction on current speed enforcement strategies,
6. To provide practical recommendations based on scientific approach, aiming to improve the police enforcement strategy for a larger area of implementation.

1.6   Scope and limitations of study

This study has undertaken investigations into particular aspects of speed enforcement and drivers' choice of speed, although it primarily focuses on the effectiveness of police presence combined with driver training and roadside publicity. There are several issues surrounding speed enforcement, but the closest issues to speeding and speed enforcement are legislation and penalty. Enforcement is not limited to police action on the road; rather, each specific rule is based on written legislation and unwritten social norms. Court decisions or punishment

imposed on offenders are an important factor of speed enforcement: they act as tools for influencing drivers' choice of speed. Nevertheless, these judicial factors must be accepted as limitations on this study since this study was limited to the effectiveness of police strategies on influencing drivers' choice of speed and did not include measures taken by courts. In future research, further study of these factors, including written legislation, social norms underlying the drivers' choice of speed, and sanctions imposed on offenders, is needed to develop more effective and reputable speed enforcement.

Furthermore, the variables in this study are designed to be fixed factors. There is no intention to represent all police strategies or tactics on speed enforcement, some of which are described in the literature reviews. The investigation of "stationary and visible" police presence factor and its levels that this study is intended to. This consideration is also applicable for other factors, such as speed awareness training and roadside publicity (using billboards as the media). Hence, all factors in this study are fixed which means they are expected to produce fixed effects.

1.7   Structure of the report

This report is divided into ten chapters and is organised as follows:

Chapter 1: Introduction. The first chapter of this paper contains a motivational background for the study, an overview of the problem, and outlines the major deficiencies in the literature and the importance of the research.

Chapter 2: Overview of Indonesian road safety. This section includes information about drivers' general road safety performance, road casualty statistics, the motorcycle safety issue, and traffic legislation and police enforcement on Indonesian roads.

Chapter 3: Literature Review. This chapter begins by laying out the theoretical dimensions of the research, and further looks at how speed enforcement and driver education become important factors in the road safety system. There are three major theoretical perspectives discussed in this chapter: namely, police enforcement, drivers' choice of speed, the risk of accidents, as well as the additional issue of motorcycle safety. A construct has tied together the variables and provide an overarching explanation for how and why one would expect speed enforcement to affect drivers' choice of speed and to modify (ideally, significantly decrease) the risk of accidents.

Chapter 4: Methodology. This chapter describes the general design of this study. Therefore, the sections in this chapter explain the approach to and method of research, the participants,

the variables, the formulation of the data collection process, and the data analysis techniques to be used in this study, as well as potential risks to the study.

Chapter 5: Site selection and results of traffic survey on selected sites. This chapter describes the analysis of the spot speed survey for which results have been collected in six locations. The sections in this chapter include an introduction, method, result, and discussion.

Chapter 6: Police job satisfaction survey and public attitude survey to the current speed, safety, and speed enforcement situation in Indonesia.

Chapter 7: Baseline and single intervention effect; results and analysis of the experimental study where one factor, training, police and publicity, was applied individually. Overview of experimental result and the baseline of motorists' choice of speed

Chapter 8: Combined intervention effect. Results and analysis of the experimental study where all factor, training, police and publicity, was combined into one study.

Chapter 9: Halo effect of police presence. This chapter aimed to determine the relative effectiveness of interventions including: training, police presence, if and when participants changed their speed after passing the police checkpoint.

Chapter 10: General discussion and conclusion. This chapter brings together separate findings that have been presented in different chapters, then interprets and describes these findings into one unified explanation.

Chapter 2

Overview of Indonesian road safety

It is important to give a complete picture of the study site to provide the reader with more information on the setting in which the research has been conducted. This overview is associated with the road safety situation, current speed enforcement effectiveness, and traffic conditions that are dominated by motorcycles in Indonesia. In addition, the purpose of this chapter is to reinforce the problem of speeding and ineffectiveness of enforcement that occurred in Indonesia and its consequences as discussed in the problem formulation of Chapter 1.

The source for the information reported this section is road safety data obtained from the Indonesian police accident database (also known as the Integrated Road Safety Management System (IRSMS), as well as the official websites of international, national, and district level organisations; finally, a local government's library was accessed. Moreover, much information was also obtained from the website of the Bureau for National Statistics, the Ministry of Transport, and the Indonesian National Police Traffic Corps (INPTC).

2.1 General road safety performance

Figure 1: Map of Indonesia (Source: http://www.un.org)

Indonesia, known as the largest archipelago country in the world, is located in the South-East Asia region (see Figure 1). Its growing population and rapid motorization in the last decade present serious road safety issues. The low level of discipline and compliance with traffic regulations occurred throughout Indonesia. After the 1997 Indonesian economic crisis, the motorists' discipline was down drastically (Agung, 2005). The set back of the level of drivers' discipline and badly-behaved road users was reflected in the chaotic traffic conditions.

A recent Global Status Report on Road Safety pronounce Indonesia, together with India, China, Brazil, and the USA as the five countries with the highest number of road death casualties (WHO, 2013). According to official reports of the Indonesian police and the WHO, in 2010, road traffic accidents in Indonesia resulted in 31,234 deaths, which equates to approximately 86 people dying every day. The death toll was increased to 32,657 people in 2011, or 4.5% higher than in the previous year. The annual accident casualties' data and trendline in Indonesia are presented in Figure 2.
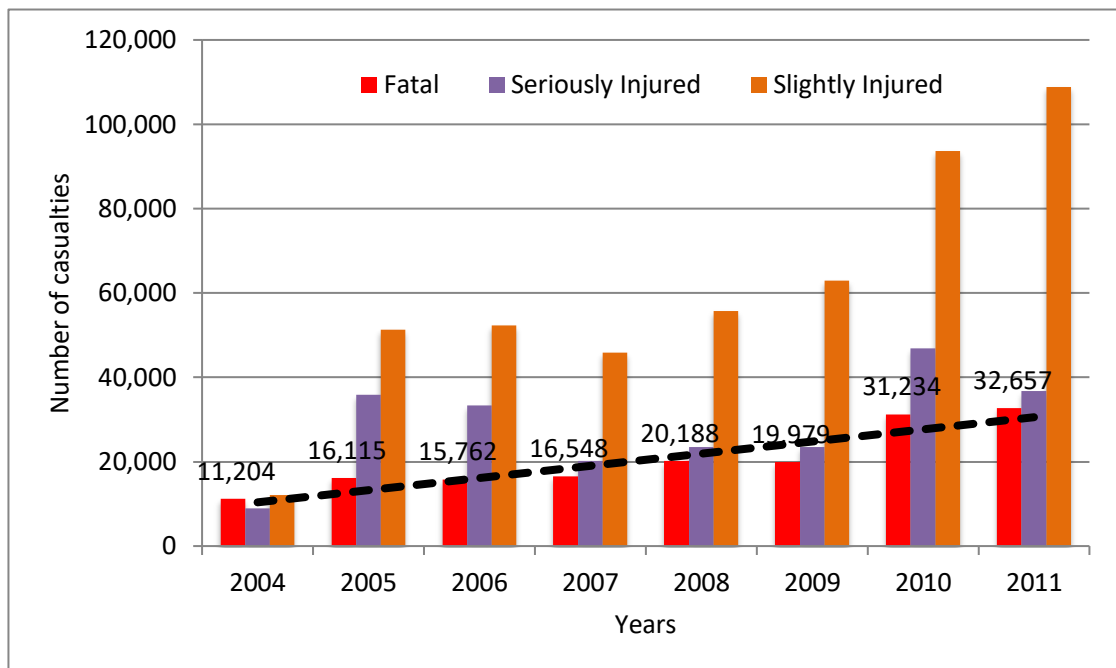
Figure 2: Indonesian accident casualties' data 2004–2011 (INTPC, 2013)

The road death trend line continues to rise from year to year. The death toll was almost tripled for a seven-year period, from 2004 to 2011. In addition, there has been a dramatic change in the relative numbers of the different severities. In 2004, there were supposedly the same number of slights as fatal. This unusual proportion indicated that reporting quality has changed, since the introduction of new Police Act (no.2/2002) and new Road Traffic Act (22/2009). Both legislations emphasize the role of police in road policing and road safety.

Yahya et al. (2010), using the results of Jacobs and Cutting (1986), refined Smeed's model[4] for LMIC to predict that the accident fatalities in Indonesia could reach 40,462 deaths by 2025 if no specific actions are taken by Indonesian road safety authorities. Furthermore, the impact of traffic accidents on the injured parties and their families leads to high economic risks on the national level which were predicted to cause a national economic loss of 2.9% per year of gross domestic product (GDP)(Sutomo and Purwoto, 2010).

Several studies concerning road safety have tried to explain the magnitude of the road safety problem in Indonesia (Soehodho, 2009; Soehodho, 2007). The reports generally divide the cause of accidents into to three main factors: namely, human factors, vehicle factors, and road and environmental factors, where human factors are most often the main cause of the accident. Table 1 shows the contribution of the three factors in traffic accidents as recorded by police.

Table 1: Contribution of three factors in accident occurrences (INPTC, 2015)

Factors	Proportion of accidents	Fatal	Seriously injured	Slightly injured
Human	93%	92%	90%	90%
Vehicle	4%	5%	6%	7%
Road and environment	3%	3%	4%	3%

The current approach is insufficient to bring down the road casualty numbers significantly. Therefore, in 2011, in recognition of the scale of this road safety problem and the possibility to impact upon it, the Indonesian government ratified a UN resolution as part of the Decade of Action for Road Safety (2011–2020). The resolution called on the member states to take the necessary steps to make their roads safer, additionally calling for the WHO to monitor the situation (WHO, 2013; WHO, 2016). Under this declaration, the government of Indonesia has set a target to reduce the number of deaths from traffic accidents by 50% by 2020 and 80% by 2035, using the baseline data for 2010 (Yahya et al., 2013). Indonesia is projected to be the best country in the field of road safety in the South-East Asia region by 2035.

In conjunction with the commencement of the UN Decade of Action, Indonesian road safety stakeholders have adopted the Safe System approach in running traffic safety programs across the country. A grand strategy was developed: it is called the National General Plan for Traffic and Road Transportation Safety (RUNK). RUNK has provided guidelines, policy directions, and

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[4] Smeed's model was presented by Reuben Jacob Smeed CBE (1909–1976), a British statistician and transport researcher, in 1949 that predicts the number of deaths in traffic accidents in a country, normalized to the number of vehicles in it. An increase in motor vehicle registrations leads to an increase in fatalities per capita, but a decrease in fatalities per vehicle.

strategies for all stakeholders for the development and improvement of road safety in Indonesia (as mandated in Road Traffic Act, Decree No. 22 of the year 2009 Article 203). RUNK has replaced traditional approaches to accident prevention, setting up three key priorities: speed management, vehicle safety, and road infrastructure and environment safety. Nevertheless, a big question at this point is how to implement knowledge gained about these three factors into a tangible program that can create visible results.

2.2   Road casualty statistics

Information about the circumstances of an accident is the base for all targeted road safety interventions. Accident reports are probably the most common source of traffic accident data analysis (Shinar et al., 1983). As in many countries, traffic accident data collection in Indonesia is conducted by the police. Tjahjono (2009) and Hartanto et al. (2009) found that data concerning speed-related accidents were unreliable.

Nevertheless, not only in LMIC, but also in HIC the accident data quality was questioned in many scholar reports as incomplete, inaccurate or under-reported (Shinar, Treat and Mc Donald ,1983, Elvik 2004, Ward 2005). In Indonesia Tjahjono (2009), Hartanto & Wimpy (2009). The informativeness of the police reports with respect to driver/vehicle characteristics was practically has no value, with the exception of driver age, sex, vehicle type, and death, even at the level of reporting accident frequencies. WHO described that data concerning speed and/or accidents can be unreliable. It is therefore highly likely that the true effects of speed on road safety are underestimated in a study.

Most of the statistics in this chapter are based on information about accidents reported to the police (using the IRSMS database). However, as recommended by other accident database systems, other sources such as mortality and survey data were also used to provide a wider context, as were population and traffic data. Reports of death casualty data in traffic accidents generally have a higher degree of accuracy compared with other types of accident victims. With all these limitations, this research aims to compile a source of comprehensive knowledge of accident data covering the following factors: information about road users, vehicles, roads, and the environment, as well as legislation underlying law enforcement activities on the road by the traffic police.

2.2.1   Road user factors

The Indonesian population in 2015 was approximately 249 million. In the last decade, it has grown by 1.4% annually (BPS, 2013) and is projected to increase to 270 million by 2025, over 285 million by 2035, and 290 million by 2045.
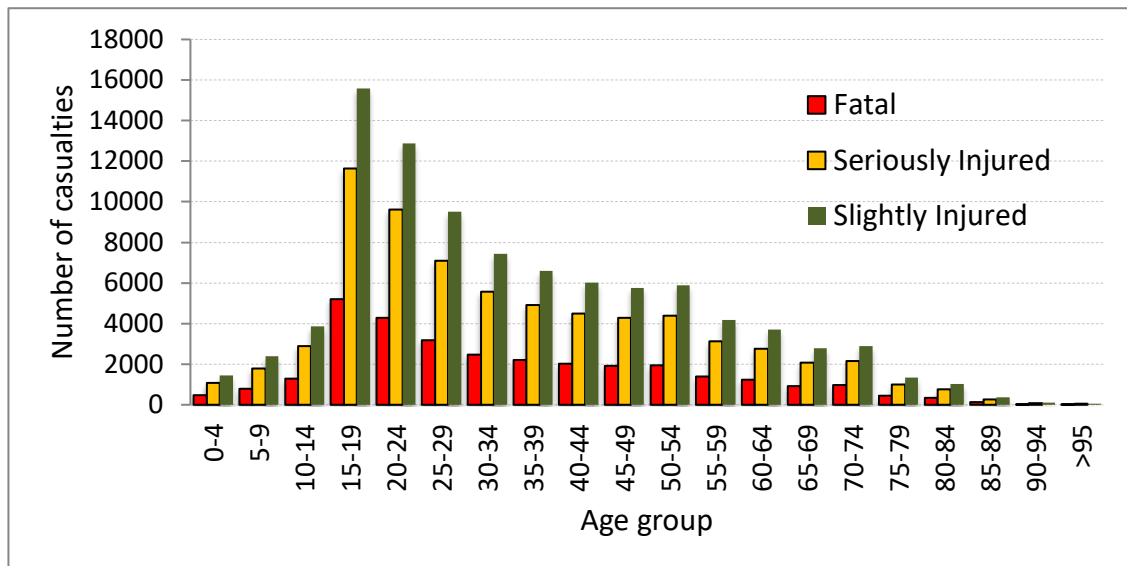
Figure 3: Road casualties based on age group (INPTC, 2011)

Consistent with the population growth, the number of road casualties continues to increase from year to year. Actual road casualty growth rates are difficult to determine due to differences in the classification of fatalities adopted before and after the introduction of the new definition in Traffic Act 2009, as well as between agencies, such as police, hospitals, insurance companies, and the local government's registry office[5].

Nevertheless, an official police report has revealed that the number of casualties by age group is dominated by younger ages. Figure 3 shows that road users between the ages of 15—19 years suffer the most from traffic accidents for all injury categories. It is evident that there is a spike occurring in the age group of 15—19 years old compared to the younger age group. The most reasonable explanation of this phenomenon is that in this age bracket (specifically, at 17) a person begins to apply for a driver's license for a motorcycle type. Thus, they are a novice and less experienced. Additionally, based on research observations, many teenagers aged 15—16 years old (high school students) use motorcycles illegally, e.g. to get to school. Many parents have allowed their children to ride motorcycles illegally to go to school, since they provide a transportation option when the school locations are not covered by public transport networks.

These results are also in line with the injury data based on the type of road users. Figure 4 shows that motorcyclists, i.e. two- or three-wheel riders, made up the highest number of casualties, followed by drivers and passengers of buses, as well as pedestrians. Moreover, when combined with all levels of injury, 60–70% of all road trauma is suffered by motorcyclist.

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[5] Before the introduction of new definition of traffic fatality in Traffic Act 22/2009, only the death on the accident spot was recorded as death. After this new act, the road users who die within 30 days from the day of accident is recorded as death.
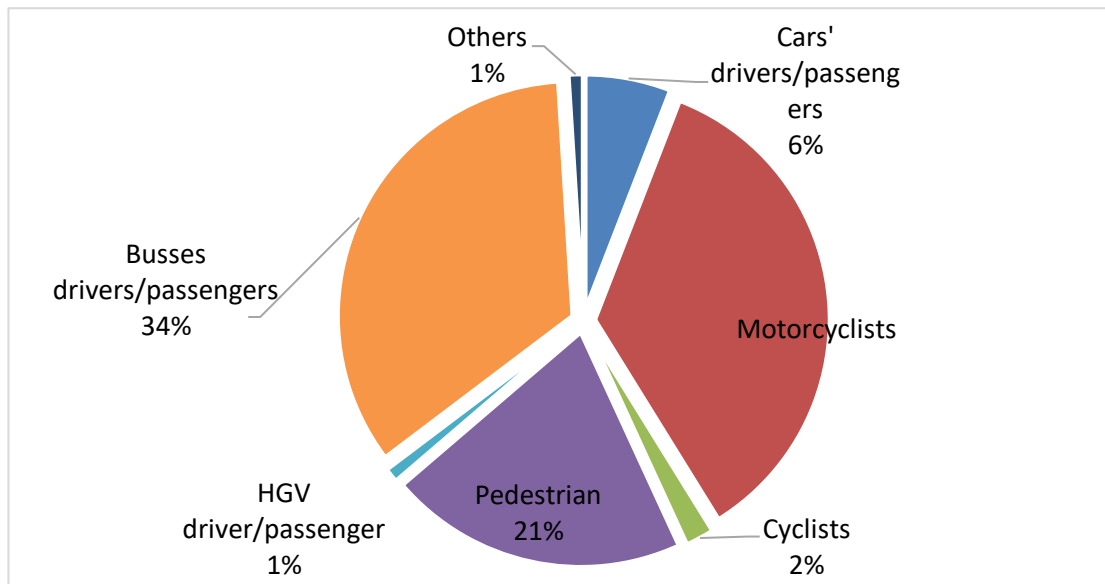
Figure 4: Death by road user category (Source: INPTC, 2011)

Although no single underlying factor drives road casualties, several reports have concluded that human factors, as discussed earlier, account for more than 90% of accidents. The most common error noted in the police report is a failure to look for oncoming traffic, which features in more than 20% of accident statistics, as presented in Table 2.

Table 2: Driver/rider behaviour that contributes to road casualties (INPTC, 2014)

Accident casualty and driver/rider behaviour		
Driver/Rider Behaviour	Percentage KSI	Percentage of Slightly Injured
Distracted	2.14	1.11
Wrong signage	0.30	0.37
Failed to sign before manoeuvre	1.86	1.95
Fatigue/sleepy	2.12	1.07
Using mobile phone	0.14	0.07
Sudden stop	0.44	0.56
Reducing the speed suddenly	**2.20**	**1.50**
Unsafe overtaking	**17.70**	**13.76**
Failed to look oncoming traffic	20.96	23.50
Failed to negotiate the curve	**9.22**	**16.43**
Reverse carelessly	0.44	0.20
Overtaking on the curve	0.67	0.33
Wrong park	1.04	0.69
Red light breaking	0.50	1.00
Not keeping the lane	3.27	3.17
Over-speeding	**12.01**	**8.13**
Violate continues lane	5.79	5.36
Neglecting the authorised order	0.00	0.07
Making a U-turn	0.25	0.22
Breaking the sign and mark	1.04	1.13
Following too closely	**11.24**	**11.82**
Failed to look for pedestrian	7.34	7.58
Total	100.00	100.00

Source: Author's own works based on IRSMS report 2011—2013.

Some speed-related behaviour—namely overtaking, speeding, failing to negotiate the curve, and following too closely—have been found to contribute to nearly 50% of the recorded accidents. Among these factors, unsafe overtaking is considered to be the dominant cause of accidents, followed by over-speeding and motorists' failure to negotiate curves. Moreover, these factors are not only related to vehicle speed, but are also an indicator of driver's aggressive behaviour. The steadily growing population and unsafe behaviour on the part of road users, particularly speeding, may soon become significant causes of increased traffic accidents and road casualties.

2.2.2 Vehicle factors

Various researchers have investigated the relationship between vehicle population and road casualties. The overall assumption is that accidents and casualties increase as the vehicle population increases in a country. This assumption is justified as follows: the main reason for this increase is that economic growth is followed by an increase in traffic volumes (DfT, 2014a). Greater traffic volumes then result in more incidents. This pattern continues until a critical threshold in economic development is reached. Recent vehicle populations and fatality trends in Indonesia are presented in Figure 5.
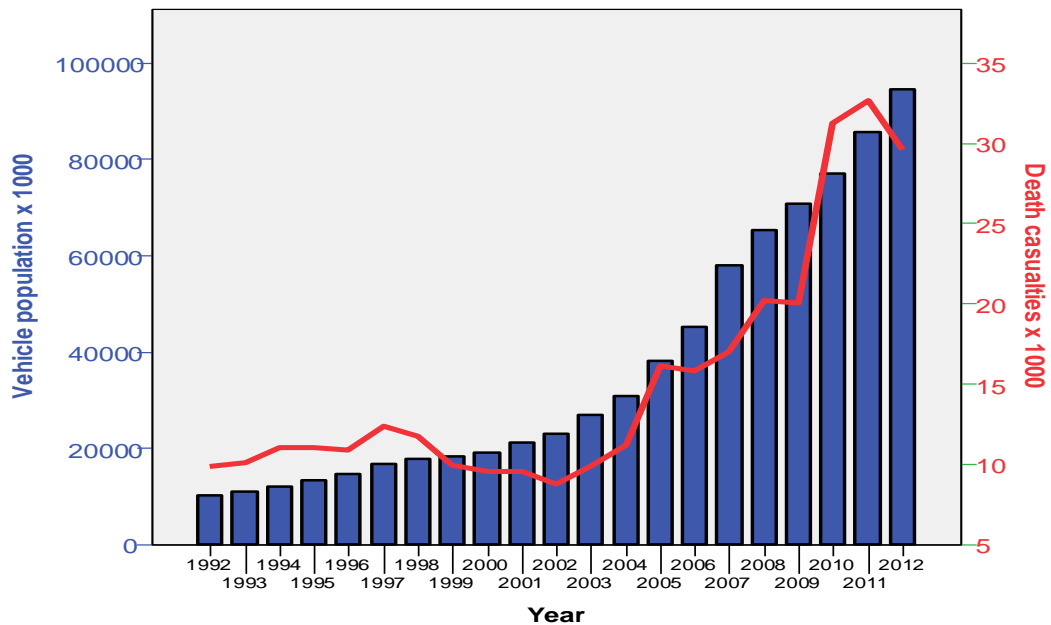
Figure 5: Death casualties and vehicle population in Indonesia (1992-2012) (BPS, 2013)

Figure 5 shows that before 2004 there is the shallow growth of vehicles each year. However, after 2004, growth increased very quickly. In 2009, the number of motor vehicles rose to two times higher than before, then increased to three times higher in 2012 compared to 2004. Correspondingly, casualties fluctuated at around 10,000 people for more than ten years since 1992. A sharp increase occurred between 2004 and 2008, which was then followed by a spike in 2010 and 2011 that brought the number of deaths yearly to 30,000.
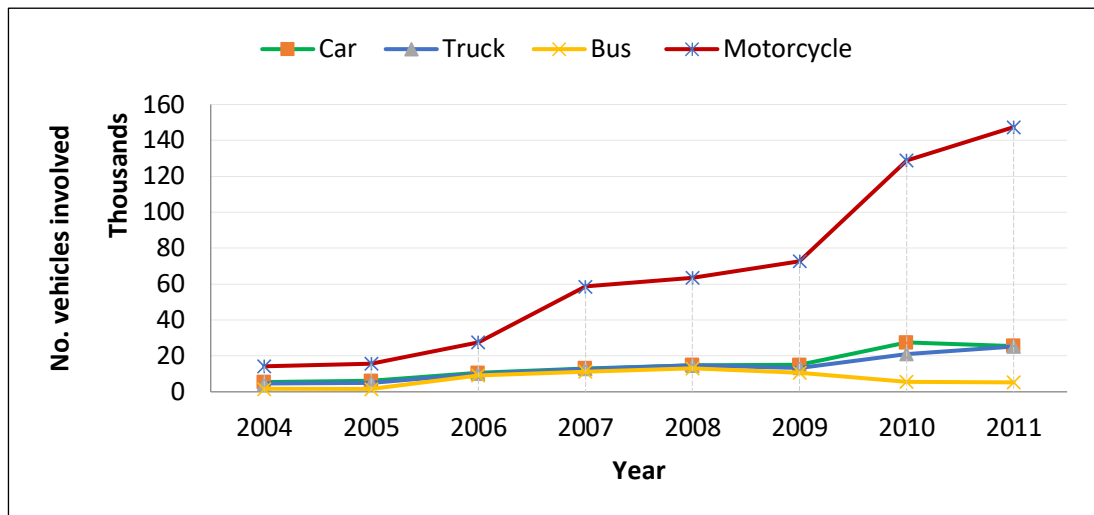
Figure 6: Vehicles involved in the accident based on vehicle category (INPTC, 2011)

Furthermore, the number of vehicles involved in accidents based on the vehicle's category, as shown in Figure 6, reveals that motorcycles always represent the highest number of vehicles involved in an accident. This number does not only represent the large population of the motorcycles but also correlates with dangerous motorcyclist behaviour, as discussed in Section 2.1.1 above. Further discussions about motorcycle involvement in accidents can be found in an earlier section.
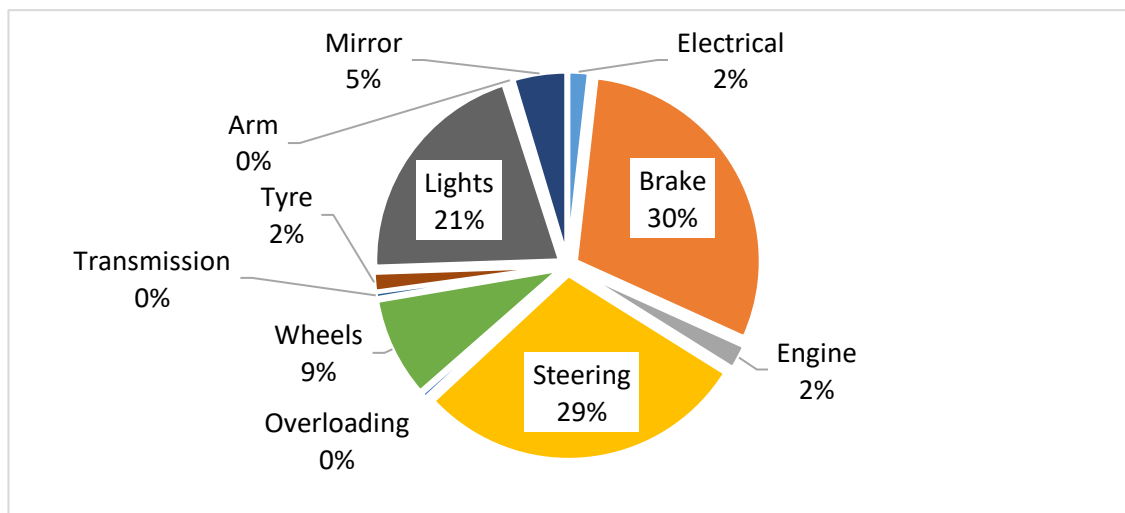
Figure 7: Contributing factors to accidents by vehicle part (INPTC, 2016)

Police accident reports from the years 2012—2015 reveal the vehicle factors that were suspected to contribute to accidents, as shown in Figure 7. Brake, steering, and light failures were the major factors reported in accidents, with suspected vehicle factor, 30%, 29%, and 21% respectively. Also, wheels and tire failures, problems with electrical parts, and mirror and engine problems were assigned to be responsible for the rest of the accidents.

Several studies have argued that a lack of maintenance increases the risk of fatalities. The WHO (2015) reported that regulations on vehicle standards and assessments are not

consistently applied in Indonesia. The roadworthiness of vehicles has often been neglected by the owner as well as by the agency in charge.

Recently, a brief list of annual major accidents in Indonesia, 2015, released by the INPTC exposed at least four major accidents caused by brake failure. (If the number of casualties in an incident reached five people or more, then the incident belongs to the major incidents category.) The types of the vehicle involved in the accident were all buses. The government has ordered a thorough investigation into the major crashes as well as improvements to the safety of buses. Further investigation by police revealed that a build-up of heat had caused brake fade on the braking surfaces. The reduction in stopping power occurred after repeated or sustained application of the brakes due to a high load or high-speed preconditions of the vehicle. Therefore, the brake failure occurred most often during high-speed driving or when going down a long and steep hill.

In conclusion, speeding was evidenced to play an important to contribute in an accident that suspected due to vehicle part failure or breakdown. It's just that the speeding factor is often hidden behind the failure of the system or parts of the vehicle not working properly as it appears to be the cause of the accident.

2.2.3   Road and environmental factor

Road and environmental factors are two of the contributing factors of traffic accidents. In Indonesia, the growth of road infrastructure is far behind the growth in number of motor vehicles, as shown in Figure 8.
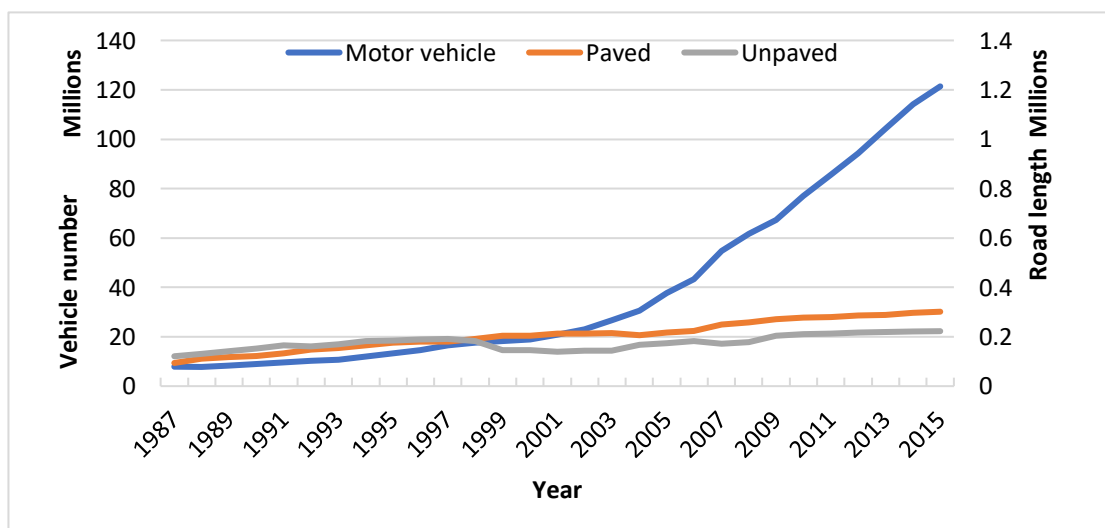
Figure 8: Road and motor vehicle growth 1987—2015 (BPS, 2016)

Two decades ago, motor vehicle numbers and road infrastructure grew at a similar rate. In 2003, motor vehicle growth made an exponential-like hike, while the road infrastructure development rate was nearly flat. In real life, this gap causes traffic problems, especially in the

cities, where traffic jams occur for longer periods than normal peak hours (Sutomo, 2010). Based on researcher own experience, many drivers compensate for the long travel time within the city by speeding after the congested point. Similarly, there are those who choose to avoid the peak hours; then, they would drive at high speed to get to their destination.

Many of the existing roads were naturally developed (Tjahjono, 2010). In the past, they were footpaths; then, road authorities began to pave them as more people made use of the paths. As a result, the roads have been inconsistently designed. The visibility conditions, gradient, curve radius, and lane width are often inconsistent with the standard. In addition, road alignment, both horizontal and vertical, is very influential on motorists' visibility (Tjahjono, 2003). In some cases, the roads are wide, which on the one hand provides comfort for vehicle's movement, but on the other hand, it can pose a safety threat since wider roads allow for higher vehicle speed.

The development of infrastructure and transportation facilities shows great improvement in many aspects that have an impact on traffic safety. Roads are paved and furnished with signs and other markings to help to manage traffic flow. Traffic islands, lane separators, traffic lights, safety fences, and other traffic engineering measures are now at acceptable levels, particularly within the city. However, the absence of pedestrian facilities is upsetting.
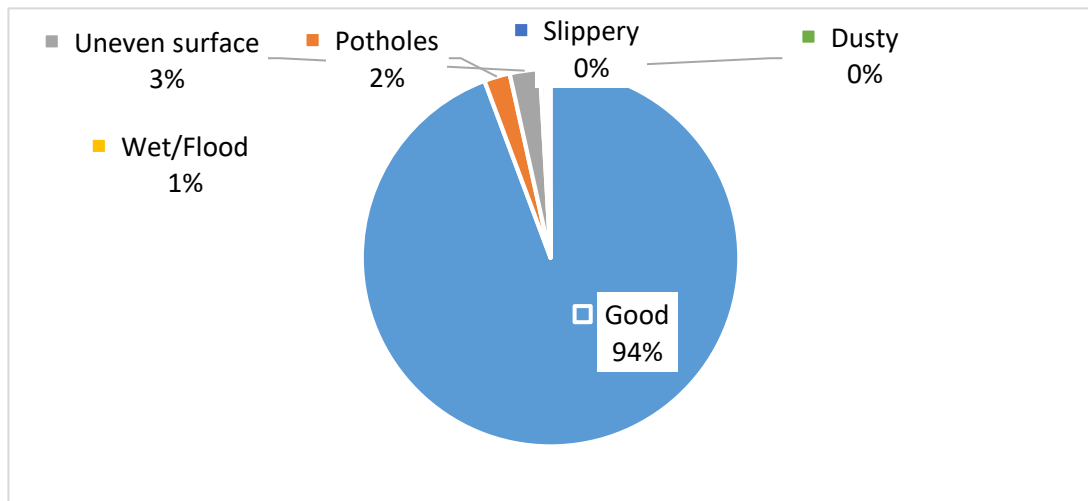
Figure 9: Road conditions at the time of the accident (INPTC, 2016)

As described earlier in section 2.2.1 about road user factors, pedestrians are physically exposed to the dangers of traffic, not only to the more "superior" motor vehicle movement, but also the lack of facilities or protective infrastructure, resulting in the higher risk of being involved in traffic accidents. Figure 9 describes the road conditions recorded in accident reports at the time of the accident. Police accident records show that more than 90% of the crashes take place on roads with good surface conditions (INPTC, 2016). In situations where surface conditions were a problem, the prominent factor related to road condition deficiency

was the uneven road surface and the presence of potholes, 3% and 2% respectively. Wet or flooded surfaces were recorded in 1% of accidents.

2.3 Indonesian road traffic: the motorcycle safety issue

Any discussions about transport and traffic in Indonesia requires further understanding of the actual Indonesian context. One of the most challenging issues related to current Indonesian traffic safety is the motorcycle issue. The motorcycle has become the most common mode of transportation these days. Motorcycles contribute not only to the rapid growth of the vehicle population, but presumably also to causing the traffic congestion (Hustim and Isran, 2013; Sutomo, 2007) and the high fatality rate of accidents (Indriastuti and Sulistio, 2010b; Suraji and Tjahjono, 2012).

Various research concerning the characteristics of motorcycle accidents have been undertaken by academic researchers all over the world, including in Indonesia. Many study authors claim that the motorcyclist is one of the most vulnerable road users (Methorst, 2002; Elliott et al., 2003; Huang and Preston, 2004). They tend to suffer more severe injuries than any other road users. Many countries have implemented different strategies when dealing with motorcyclists in traffic.

The safety of motorcyclists in LMIC has suffered from the lack of investigation into what causes this high rate of serious injury and fatality (Solagberu and Ofoegbu, 2006). In Indonesia, for instance, although motorcycles account for more than 60% of the vehicle population, their safety has been ignored. Since this study has taken place in Indonesia, the upcoming section, therefore, discuss the growth and proportion of motorcycle in traffic, and how to mitigate vulnerability and make motorcyclist and other members of traffic safer.

2.3.1 Vehicle growth and proportion of traffic

Indonesians are among the most frequent motorcycle users (WHO, 2013). The number of motorcycles has reached 82 million units (INPTC, 2013). The growth of motorcycle usage was noticeable when the total population approached 80 million units, as described by Figure 10. The composition of vehicle ownership in Indonesia in 2012, as reported by the Indonesian National Traffic Police Corps (INTPC) and the National Statistical Bureau (BPS), was as follows: 70.83% motorcycles, 15.23% passenger cars, 8.89% trucks, and 5.05% buses (INPTC, 2013). With a population of approximately 237 million people, there is one motorcycle for every three people in Indonesia. Each year, the number of vehicles increases nearly 12%. Typically, people use small and medium motorcycles or scooters to commute (Susilo et al., 2015).
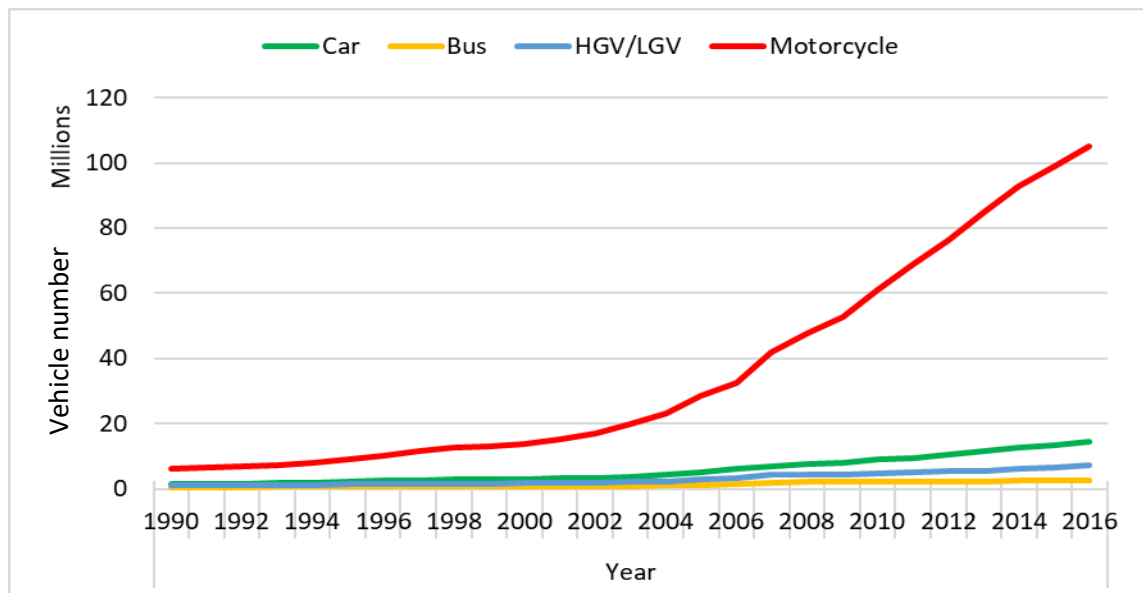
Figure 10: Vehicles growth in Indonesia, 1987 – 2012 (INTPC, 2017)

Reports by the Eastern Indonesia National Road Improvement Project (EINRIP) revealed that motorcycle traffic had been growing much faster than other vehicle types have been. The EINRIP's survey during 2008–2012 in ten Eastern Indonesia cities showed that the higher increase of motorcycle proportion in traffic was at 8.8% and the lower growth was 7.5 % per year (EINRIP, 2013). The average proportion of motorcycles to other vehicles in traffic has exceeded 50% of total volume in most cities, as specified in Table 3.

Table 3: Proportion of motorcycle in traffic based on EINRIP survey (EINRIP, 2013)

Survey Location ID	Years				
	2008	2009	2010	2011	2012
1	0.545	0.554	0.550	0.570	0.548
2	0.788	0.800	0.730	0.770	0.713
3	0.817	0.777	0.626	0.760	0.735
4	0.417	0.464	0.470	0.480	0.465
5	0.568	0.548	0.550	0.550	1.474
6	0.466	0.441	0.441	0.480	0.497
7	0.603	0.590	0.581	0.620	0.616
8	0.690	0.730	0.702	0.740	0.745
9	0.672	0.599	0.676	0.690	0.677
10	0.413	0.408	0.426	0.450	0.410
Average	0.598	0.591	0.575	0.611	0.688

The increase in the proportion of motorcycles is surprisingly large. In 2012, the average proportion of motorcycles on the road was close to 70%, which is in line with the population of motorcycles in the country. This large motorcycle population and their proportion in traffic have together become an important characteristics of road traffic in Indonesia (Conrad et al., 1996; Indriastuti and Sulistio, 2010a). This motorcycle issue has emerged as a crucial problem in traffic safety: 65% of traffic accidents in Indonesia in 2007 were motorcycle-involved accidents (INPTC, 2015).

Motorcycle safety has recently become a growing concern of road safety stakeholders all over the world (Sexton et al., 2004; Peden et al., 2004). In order to improve the safety of motorcycles currently on the road, there is a need to facilitate motorcycling as a choice of travel within a safe and sustainable transport framework (DfT, 2005). Motorcyclists have the right to expect all authorities to take account of the presence of motorcycles in the transportation planning process when designing and maintaining the road network, and when managing traffic and when considering safety. In return, motorcyclists must recognise their responsibilities to ride sensibly and safely within the law and to be considerate to other road users.

2.3.2   Motorcycles as vulnerable road users

One indicator of the under-consideration of motorcycles by the transport system is the high level of risk they are faced with (Van Elslande and Elvik, 2012). Motorcycle riders, along with pedestrians and cyclists, are among the road users who are most vulnerable to road hazards (WHO, 2009). Evidence has shown that motorcyclists have an increased likelihood of being involved in an accident compared with drivers of other vehicles (Mannering and Grodsky, 1995).

A study by Global Road Safety Partnership (GRSP) shows that, in India, 27% of road deaths are motorcycle users. In Malaysia, they are about 60% of total fatalities, and in Thailand over 70% of the fatalities are drivers of motorised two-wheelers (GRSP, 2013). Most deaths worldwide from motorcycle accidents occurred in Asia: there, the proportion has reached 78% (WHO, 2013).

Table 4: Proportion of vehicle involved in fatal accidents (INTPC, 2015)

No	Vehicle type	Number of vehicle involved	%
1	Motorcycle	120.226	72 %
2	Car	19.783	12 %
3	Bus	9.242	5 %
4	Truck	14.367	9 %
5	Special vehicle	659	0,001 %
6	Non-motorized vehicle	3.444	2 %
Total		167.721	100 %

In Indonesia, as shown in Table 4, the proportion of motorcycles involved in accidents, 72%, was recorded as being greater than their proportion in traffic, 68.8%. Probably, three out of four accidents in Indonesia involved motorcycles and it may also be in an accident involving more than one motorcycle.

Various studies all over the world have tried to investigate the cause, pattern, and factors related to a motorcycle accident and the cause. An in-depth study of motorcycles' safety in the

UK argued about three of the most common types of motorcycle accidents: right of way violations, losing control on bends, and motorcycle manoeuvrability accidents (Clarke et al., 2004). These types of accidents relate to circumstances where motorcyclists have to compete against cars, buses, and trucks (i.e., mixed traffic). Simultaneously, they travel as fast as other vehicles, but do not have the same physical protection. Motorcycles have poor stability, with riders and passengers often being thrown from bikes and colliding with other vehicles, curbs, and lampposts.

A recent study indicated that young-male riders were more likely to disobey traffic regulations, and that they had a higher tendency towards negligence, potentially risky behaviours, and motorcycle safety checks (Chang and Yeh, 2006). In the UK, speeding was found to be common among motorcyclists, with 58% admitting to always or frequently breaking the speed limit (Clarke et al., 2004). Some studies consider whether this easy manoeuvre has contributed to the high accident rate. With their manoeuvrability, motorcycles are assumed to be able to overtake other vehicles more easily than their counterparts in traffic, especially in slow traffic (i.e., congested) situations. Accidents occur when riders take the opportunity to pass slow-moving or stationary traffic, which is referred to as 'filtering'. Figure 11 shows how the motorcycle's manoeuvre was hardly seen by the driver, and at the same time how the rider failed to respond the turning traffic. However, the main cause of the motorcycle accident illustrated is not due to the ease of manoeuvring, but rather the fault of the rider.
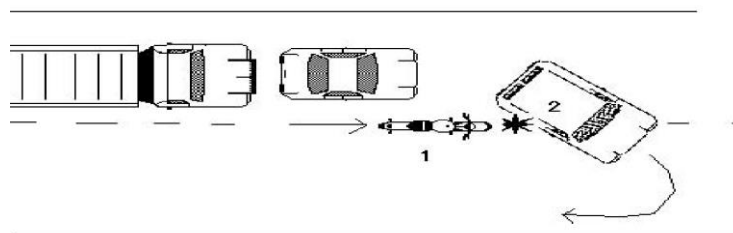
Figure 11: Illustration of a motorcycle "filtering" (Clarke et.al., 2004)

Regarding human errors, some common types of crashes involving motorcyclists are failures to negotiate bends on rural roads, collisions at junctions, collisions while overtaking other drivers, and riders losing control without another vehicle being involved. The question is whether the perceived level of risk by motorcyclists are close to actual level. If the motorcyclist misjudges (i.e., underestimates) the actual risk, then the likelihood of them being involved in an accident is increased. Then, the person that responsible for the motorcycle accident become more difficult to decide. There are no reports available to assess this issue in Indonesia; however, a study of accident records in the UK, for instance, indicates that both motorcyclists and car drivers made violations, mistakes, or errors which lead to accidents (Clarke et al., 2004).

2.3.3 Motorcyclists' choice of speed

Studies of motorcycle accidents show that over 38% of the motorcyclists involved in fatal accidents were judged to have been speeding before the collision (RoSPA, 2006).[6] Another study identified misjudging the speed required to negotiate a bend as the most common cause of motorcycle-only crashes (Clarke et al., 2004). Correspondingly, speeding was found to be common among motorcyclists, with 58% admitting to always or frequently breaking the speed limit (Clarke et al., 2004).

Similar findings have recently been revealed by Lubis et al. (2009), who determined that the rapid increase of the number of motorcycles in Indonesia has resulted in increased number of vehicle accidents. Motorcycles have been mistreated in the traffic system, through measures such as lack of facilities, poor traffic management, and lack of measures that control the motorcyclists' choice of speed. As a result of the lack of these measures, motorcycles' performance in traffic had affected overall traffic performance, for instance, the degree of saturation, operational speed, and traffic behaviour of motorcyclists.
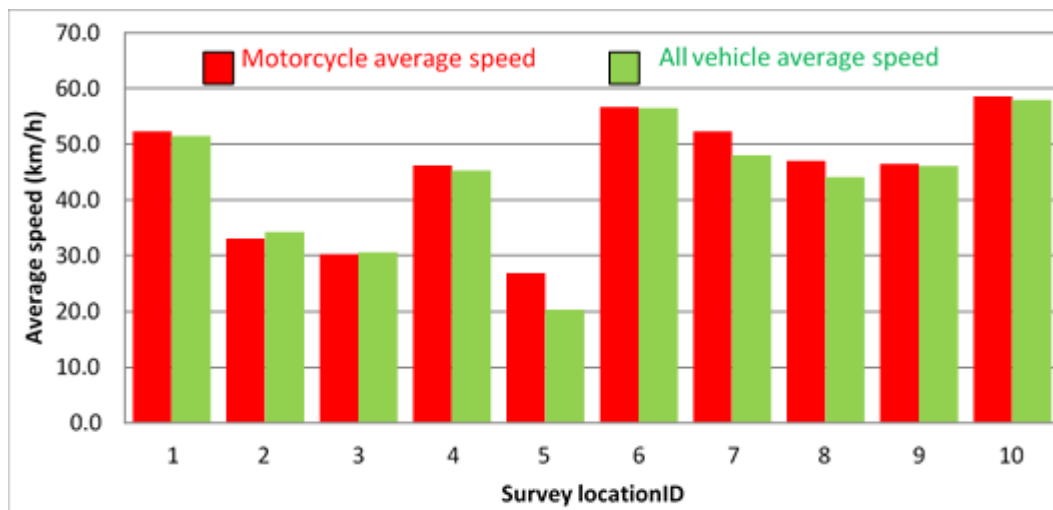
Figure 12: Comparison of motorcycles' and overall vehicles' average speed (EINRIP, 2013)

Correspondingly, the EINRIP's report shows that motorcycles' average speeds are as fast as overall vehicles' average speeds, as shown in Figure 12. Despite the fact that motorcyclists lack protective equipment, the road features do not provide a sealed hard shoulder which the motorcyclists could use as a separate, safer, lane. In this situation, without protection or other barriers, the crash impact can be catastrophic. There are several explanations for the high speeds of motorcyclists, but the two main contributing factors are likely to be the low perceived likelihood of being detected by enforcement and the desire to test themselves in this challenging road environment (Thomas et al., 2011).

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[6] Available at: https://www.rospa.com/roadsafety/advice/motorcyclists/policy-statements/.

Nevertheless, the motorcycle safety issue is not just a problem of LMIC, but also many the developed countries across the globe. If the aim of enforcement and other safety measures is to make motorcycles a safe and enjoyable mode of transport, then the needs of motorcyclists must be taken into account as fully as those of operators of any other transport mode.

2.4 Ineffectiveness of speed enforcement

One of the important issues highlighted in the WHO reports (2013, 2015) regarding Indonesian road safety is the ineffectiveness of legislation and law enforcement regarding some key factors that have a high impact on the number accidents and deaths, including setting and enforcing speed limits, requiring seatbelts and child restraints for all occupants under a certain age or height, and enforcing the helmet requirement for motorised two-wheelers; and, additionally, enforcing blood alcohol limits for drivers, with random breath-testing at check-points.

Today, the legislative framework for road safety in Indonesia is primarily provided by Law No. 22 Year 2009, which relates to Road Traffic and Transportation. That is, the primary responsibility for road safety rests with the INPTC rather than with Indonesian transport or public works agencies, although these other organisations retain road safety structures (Yahya et al., 2013). Under this act, the INPTC is responsible for road traffic control and transport safety, which include traffic law enforcement, accident investigation, vehicle and driver licencing, road users' education and the promotion of road safety, as well as traffic management.

Police responsibility is extensive. Indonesian legislation requires police to manage and regulate traffic to ensure its smooth flow. In the author's experience as a police officer, cases often arose in which police boards were frustrated by congestion issues and the poor discipline of road users, with motorcycle riders being the most salient group in the latter category. High-risk driving behaviours are frequently observed. In intersections or roundabouts, the right of way is often unclear and the environment harsh: the "bravest driver" go first. Traffic offences such as overloading, speeding, and careless and dangerous driving or riding are prevalent.

A police vehicle with lights and sirens is often ignored as just another vehicle trying to negotiate the heavy traffic. Road users seem to be unaffected by the presence of police on the road; police presence does not, in fact, seem to serve as a deterrent to travelling at high speeds. Often, police vehicles are passed by a higher-speed vehicle (20—30 km/h higher than the police vehicles, which often constitutes speeding) without any initiative for apprehension on the part of the police officers. No enforcement action is expected or taken in most cases, and the perceived freedom to speed continues unaffected. The public gives the impression

that they underestimate or ignore the negative consequences that arise from speeding behaviour.

Meanwhile, based on the author's knowledge and experience, police found the speeding offender apprehension procedures to be problematic. In many cases, police enforcement, has been discouraged by the courts: evidence has often been refused when presented in the trial. Refused evidence includes the officer's direct observation of driver speed, their recording of information, and justification of speed checks through traditional time over distance or speedometer comparison methods, as well as evidence produced by using technical support equipment such as speed guns or radar; in addition, the integrity of the officer's evidence is sometimes generally challenged.

Nevertheless, the recent legislative framework and the increased profile of the INPTC, with the stated aim for continuous improvement and an excellent public relations focus, provides a strong foundation to move traffic law enforcement reform forward. As one of the key stakeholders, the INPTC has responded by showing a strong commitment to overcome the problem of traffic dangers, as well as to achieve the vision of RUNK. One concrete action the INPTC has taken has been drawing up the Police Action Plan for Road Safety to ensure the realisation of this ambitious vision of fatality reduction on Indonesian roads. The ability to conduct effective speed enforcement is one of the major challenges emphasized in these documents (BPHN, 2013). Nevertheless, the challenge is how to bring this knowledge into police operation, thus translating the vision and the plan into real actions.

2.5 Conclusion

This chapter has shown that the road death trend in Indonesia continues to rise from year to year. The current approach is insufficient to bring down the road casualty trend significantly. Indonesian traffic is dominated by motorcycles. Motorcycle use has grown at 8.8% per year, and the average motorcycle proportion in traffic has exceeded 50% of total volume in most cities.

Police reports have concluded that human factors account for more than 90% of accidents, where speed-related behaviour has been found in nearly 50% of the recorded accidents. The vehicle type most frequently involved in accidents is the motorcycle. It does not only represent the large population of motorcyclists, but is also correlated with dangerous motorcyclist behaviour. Motorcyclists' travel speeds are as fast as speeds for vehicles overall, despite the fact that they lack protective equipment. Despite these dangerous conditions, the two main contributing factors for the high speeds of motorcyclists are the low perceived likelihood of being detected and the desire to test themselves in a challenging road environment.

Moreover, police accident records show that more than 90% of the crashes take place in good road surface conditions. Only on the good quality road surface speeding would definitely take place. Therefore, the relevance of speeding problem is clearly supported by current Indonesian road safety statistics. Police enforcement of speed regulations and some other key factors of road safety were reported ineffective. Nevertheless, the police have responded by showing a strong commitment to overcome this problem, for instance by drawing up of the Police Action Plan for Road Safety with effective speed enforcement as one of the main goals.

Chapter 3

Literature Review

This chapter covers the identification of a systematic theory, concepts, key ideas, generalisations, findings and analyses about the fundamental problems in the existing research, and in it the author also provides a conceptual framework that helps to identify gaps in the existing literatures. Several arguments, discussions, figures and rationales are presented in this section to help explain the speed enforcement and motorists' choice of speed, and, furthermore, to provide the justifications for expectation or prediction of the effect of enforcement.

The purpose of this review is to show what is already known about the domain of research and to determine the conceptual framework of related variables theoretically and empirically so that the research direction becomes clear and sharp. The conceptual framework is also needed to limit the scope and focus more on the problems examined. As well as being systematic, this section tried to be critical and evaluative of the studies and the ideas that they present.

As the problem statement in Chapter 1 and the overview of Indonesian road safety in Chapter 2 emphasised, the focus of this study is the effectiveness of speed enforcement on motorists' choice of speed, and the goal is to develop more effective speed enforcement procedures. This chapter discusses the major theoretical perspectives and report of studies result from the UK and other countries that considered important for current study in Indonesia, namely: drivers' choice of speed, motorcycle safety, the risk of accidents, and police enforcement. A construct would tie together the variables and provide an overarching explanation for how and why one would expect the speed enforcement to affect drivers' choice of speed and modify the risk of accidents.

3.1   The choice of speed

The objective of this study is to develop more effective speed enforcement practices by relating speed enforcement procedures to motorists' speed choice. One of the fundamental ideas on this subject is that it is important to understand the factors that determines drivers' choice of speed. It is widely recognised that motorists' decisions about choice of speeds are guided by many factors, such as travel time, safety, the road environment, the risk of coming

up against enforcement, fuel use, and several other factors. The relationship of these factors to the choice of speed is complex, especially to find the most influential factor and how each factor has affected motorists' choice of speed. Furthermore, there is a need to understand how many factors collectively and simultaneously affect the motorists' decisions. This section explores factors that affect drivers' choice of speed, as well as the influence of speed management efforts on motorists' choice of speed.

3.1.1   The factors that influence drivers' choice of speed

Drivers' choice of speed is defined as the speed at which drivers choose to travel in relation to various road and traffic conditions. Choice of speed is a major component of drivers' behaviour on the road and plays a major role in the frequency and severity of accidents (Quimby et al., 1999). In recent times, extensive studies have been conducted in order to research the factors that influence the speeds adopted by individual drivers. However, drivers' choice of speed is still not well understood, and there is a need for more such information to develop more effective measures to influencing drivers' speed choice and improve road safety.

Quimby et al. (1999) studied several psychological variables in an effort to predict drivers' choice of speed. They found some interesting factors that influence drivers' choice of speed. The largest positive association arose from ranking on the violation scale[7] (an 8% effect), compared to effects from annual mileage and trip frequency, the drivers' occupational group, and the following driving conditions: driving to or from work, driving without a passenger, and the engine size of the car being driven. Drivers' age was still the best predictor of speed (an 11% effect). However, there is insufficient detail regarding why violation scale was positively correlated with drivers' choice of speed, for instance whether drivers learn from their speeding offences. Furthermore, mild social deviances and sensation-seeking factors were found to be positive speed predictors, although they were no longer so when age and other explanatory variables were added to the model. More information about the factors is detailed in Table 5.

The ITERATE report (Information Technology for Error Remediation And Trapping Emergencies) indicates that the age and experience variables did not eliminate sensation seeking, although sensation seeking was shown to be a stronger indicator for men than for women (Oppenheim et al., 2012). However, the ITERATE study does not give a complete explanation whether this predilection to sensation seeking is an actual effect of attitude or personality, or whether it is

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[7] The violation scale was developed by Reason et al., (1991). This scale measures a driver's self-reported frequency of committing traffic violations (including speeding), which has been linked to accident liability.

an effect of the categorization into sensation seeking. It is hard to explain why non-sensation seeking was less valid for women.

Table 5: Factors influencing driver behaviour (Quimby et al., 1999).

Categories	Driver factors	Categories	Other factors
Demographics	Age/driving experience Sex Exposure (annual mileage, type of road, light/dark etc.) Occupational group	**Trip characteristics**	Length Purpose Urgency
Visual ability	Static and dynamic acuity Visual field Field dependence	**Car characteristics**	Performance Comfort
Driving skill	Car handling ability Hazard perception Judgmental skills	**Road environment**	Road type Design speed Speed limit Enforcement levels Maintenance
Psychological factors	Risk tolerance Social/driving deviance Thrill/sensation seeking	**Environmental factors**	Presence of passengers Presence of pedestrians Time of day Signs/warnings Local knowledge Weather
Temporary states	Mood Fatigue Impairment due to drink or drugs Illness Speed adaptation		

Correspondingly, Stradling and Gormley (2007), in their study about drivers' motives for exceeding speed limits, asked the drivers how likely they were to exceed the speed limit under several conditions. The result showed that 65% of drivers are likely or very likely to exceed the speed limit when overtaking another vehicle. The least popular motives, revealed by only 2% of drivers, was speeding to stay awake. Table 6 below explains the complete result of their study.

Motivated by the evidence, Stradling & Gormley (2007) concluded that there are four categories of drivers. These categories are low-risk threshold, high-risk threshold, opportunistic, and reactive. If the speed limit has been set (for instance based on 85th

percentile), engineering measures have been applied, and drivers have been informed, and, the unintentional excessive speed is an exception.

Table 6: Percentage of participants likely to break the speed limit under each circumstance (Stradling & Gormley, 2007)

Circumstances	%
On an empty road, in the daytime	39%
On an empty road, at night	40%
When I am running late	41%
When overtaking	63%
Just to keep up with traffic	45%
When my passenger is running late	19%
When I thought, the speed limit is too low for the road	24%
When I am feeling stressed	14%
When I am feeling angry	15%
In order to stay awake	2%
When trying to see what my car can do	7%
When someone is driving close behind me	15%

However, unintentional speeding could be an important factor leading road user to drive at excessive speeds. Recent development of an in-car technology can automatically prevent drivers from exceeding the speed limits. Speed limiting technology may be appropriate for drivers who want to ensure they avoid speeding by unintentionally exceeding the speed limit. Ford, for instance, use the forward-facing stereo camera to scan for speed limit signs, then feeds the image into character recognition software and relays them in the speedometer. In a similar way, ISA enables drivers to select an option where acceleration is stopped automatically at the speed limit specific to any road.

Evidence from an ISA study from the UK suggested that when ISA support was turned off, drivers who had the intention to drive at a speed less than the posted speed limit exceeded the speed limit (Tate and Carsten, 2008; Jamson, 2008). This finding has sparked criticism of speed enforcement whether the offenders who speed unintentionally need to be punished. Thus, speed enforcement should merely target the intentional speeders, especially the excessive speeders.

Under the current automated speed enforcement, police target not only the fastest group of motorists but also unintentional speeders who travel slightly above the speed limit. Precisely, the objects of enforcement are the average drivers who are making a momentary mistake.

It is my opinion that police should focus on enforcement of dangerous drivers. For instance, speed enforcement should only target the top 2–5%. Because speed limits are set according to

the standards of 85th percentile method — the desirable speed where 85% of motorist travel at this speed or below — average drivers are included within the 15% of vehicles travelling above the posted speed limit. According to this view, the actual enforcement target are drivers that travel above the 95th percentile. The gap between the speed limit line, the 85th percentile and 95th percentile is a space which needs to be tolerated by the police.

Although there is no complete explanation why motorists do not want to slow down when they know what speed is posted. The report of ISA study would have been more interesting if it had included the factors and motives which influence speed choice at an individual level, as well as the extent to which these factors and motives are situation-dependent. An effective speed enforcement is still a big problem.

3.1.2 Speed management and its effect on speed choice

As it is introduced in an early chapter of this report, there are two established approaches to influencing drivers' choice of speed: the three E's, which are education, engineering, and enforcement (RoSPA, 2004) and the safe system (OECD, 2009). In both approaches, speed is at the core of the road safety problem, and its management is crucial. Managing speed requires a broad range of measures including engineering measures designed to reduce speeds, enforcement measures (such as speed limits being set), publicity campaigns, and education to raise public awareness of the dangers of excess speed. The most appropriate combinations of measures are differed with circumstances. In principle, effective speed management requires a systematic and integrated approach which may include (but is not limited to) the following steps: setting speed limits, providing information about the speed limit, road engineering measures, and police enforcement to control the intentional speeder (Wegman and Oppe, 2010).

However, a more effective method is required to tackle current increasing road casualties. Evidence shows that excessive speeds are still a major cause of accidents. The safe journey can only be achieved if the road users are alert and appreciate the importance of following a safe speed on roads (OECD/ITF, 2008). Then, when a crash occurs, death and serious injury are minimised. Figure 13 illustrates the components of the Safe System.

Several factors are incorporated in the Safe System, such as regulations and admittance to the system, education and information supporting road users, and legislation and enforcement of road rules. The Safe System provides a comprehensive vision of the ways that road safety can be improved, although there are still question marks about the effectiveness of this system and all its factors. There are still questions regarding the effect of each factor, and how these factors interact and work together. There is no evidence up to this date that a set of

countermeasures — for instance, the combined strategy of enforcement and education —has necessarily increased the effectiveness of the Safe System's components.
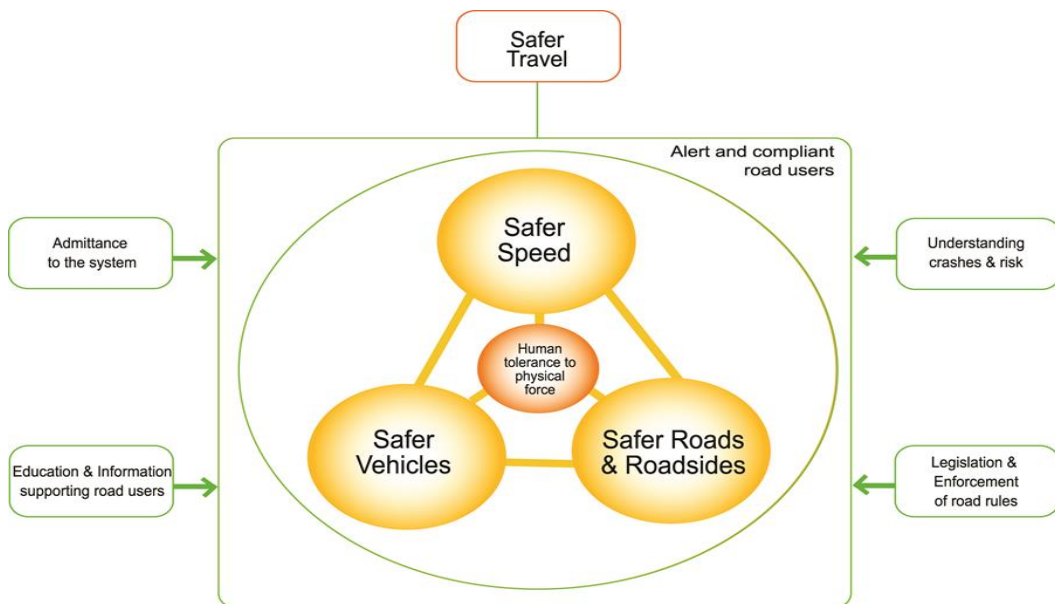
Figure 13: The Safe System Approach (OECD/ECMT, 2009)

Numerous studies have been conducted to assess the potential effects of speed reduction measures. Work by Nilsson in Sweden showed that a change in average speed of 1 km/h would result in a change in accident numbers ranging between 2% for a 120 km/h road and 4% for a 50 km/h road (Nilsson, 2004; Cameron and Elvik, 2010). Similarly, in Britain, empirical studies have determined that changes in accident numbers associated with a 1 km/h change in speed vary between 1—4% for urban roads and 2.5—5.5% for rural roads, with the lower value reflecting good quality roads and the higher value reflecting poorer quality roads (Taylor et al., 2000).

However, despite all this research, speed management is still a complex issue and remains one of the biggest challenges facing road safety experts and practitioners around the world. Many LMIC have suffered a serious road safety problem due to their failure to control the speed on the road. The mixed nature of traffic, and traffic's domination by motorcycles, have resulted in speed being harder to control. Managing speed is only possible if the required speed enforcement is provided (Yılmaz, 2013). Therefore, many researchers have asked whether strict police enforcement should accompany speed management to achieve more effectiveness.

Although the traffic characteristics are different in each study and each situation, lessons and experiences from successfully implemented speed management, for example from the UK and Australia, are important in order to develop more effective tools for speed enforcement. A recent report from the UK DfT (2014) shows that a decrease of one percentage point in cars

exceeding the 70-mph speed limit on motorways between 2011—2012. Furthermore, the proportion of cars exceeding 70 mph fell from 57% in 2003 to 49% in 2010. Figure 14 shows the successful reduction of cars exceeding the speed limit in the UK.
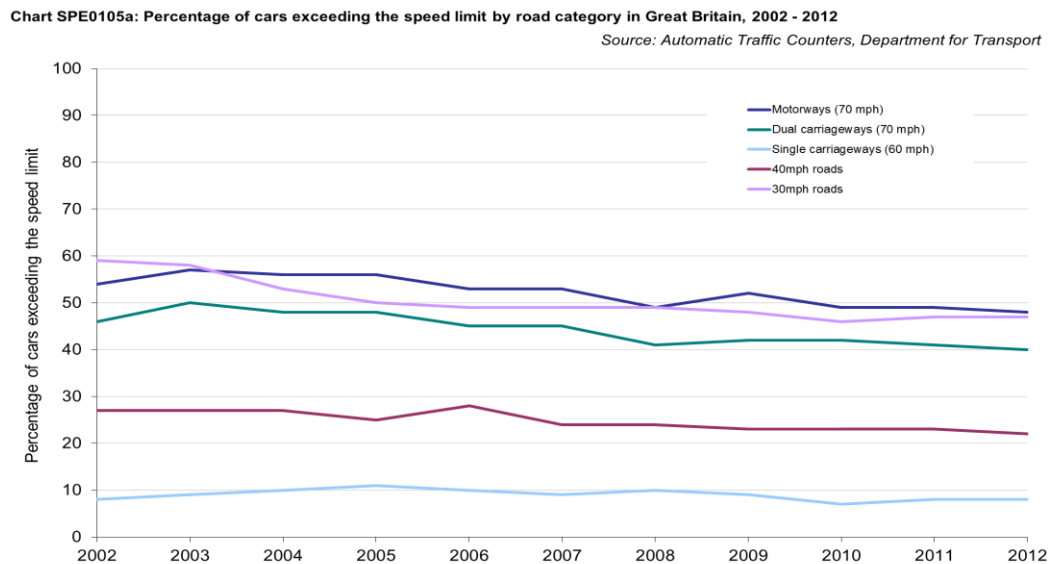
Figure 14: Percentage of cars exceeding the speed limit by road category in Great Britain, 2002-2012 (DfT, 2014b)

The UK DfT report also explained that the number of speed limit offences (fixed penalty notices, convictions in court, and written warnings) in England and Wales had declined rapidly in the past few years after a massive escalation in the 1990s. In 1985, there were 300,000 speed-related offences, and then in 1995, there were 680,000 offences. In 2005 there were a peak number of 2,087,000 offences, and then the number declined to 1,270,000 offences in 2009 (DfT, 2011) as shown in Figure 15.
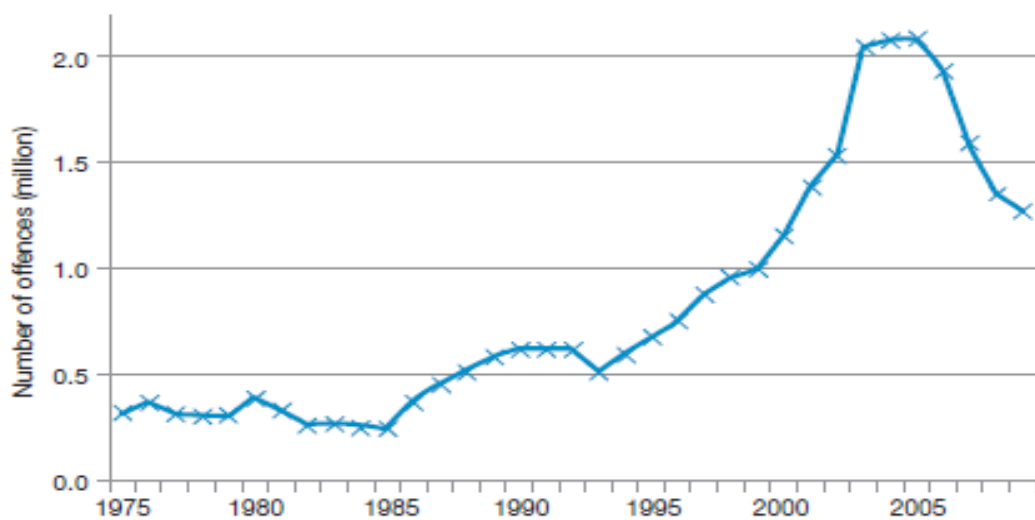
Figure 15: Speed limit offences by motorists in England and Wales (DfT, 2011)

Similarly, the UK Royal Automobile Club (Spero, 2012) pronounced that the percentage of vehicles exceeding the limit on 30 mph roads has fallen for every vehicle type, excluding motorcycles, which has increased by three percentage points (DfT, 2014b). In 1998, 69% of cars on 30 mph roads were above the limit; by 2010, the figure had fallen to 46%. The RAC's 2012 Annual Report argued that much of the recent decrease in offences (about 60%) could reasonably be ascribed to better speed limit compliance, while the rest could largely be due to more drivers being offered speed awareness courses (Mitchell, 2012). However, this claim has not been clearly corroborated by studies. Up to now, no study has investigated how drivers' speed behaviour changes from time to time and what factors lie behind this change. The process is a difficult one to examine, but it is not impossible to discover the motive behind this attitudinal change.

Finally, although it is accepted that there are major safety benefits attached to any reduction in driving speeds, it is not yet clear how such a reduction could best be achieved effectively.

3.2   Speed and risk of accident

This section reviews several models based which are discussed in recent literatures. A general definition of risk in the English dictionary is the possibility of incurring misfortune or loss in an unintentional event (Dictionary.com, 2014). The risk of a road traffic accident is a concept, which has frequently been discussed in road safety research. Early work in road safety research by Silva (1942) defined the risk as "the degree of hazard to which a driver is subjected" (Summala, 1996; Kloeden et al., 1997). However, today, more researchers recognise risk as the expected loss arising from the probability of an unwanted event, as well as the consequences of the event (Elvik et al., 2009).

The risk of an accident is equal to the probability of unwanted event and consequences of the event, where the probability is calculated as: number of accident divide by the amount of exposure. Furthermore, exposure is the volume of activity generating risk, or the amount of traffic and travel conducted by the individual. The consequences are the extent of damage, the severity of personal injuries, and the number of fatalities resulting from the event. Hence, the model of the relationship between the risk and the consequences is:

$$accidents \ = \ exposure \ \times \ risk$$

The model for predicting accident risk is mostly based on European road traffic conditions, which are dominated by cars and have a well-mannered road traffic environment. The present study in Indonesia where traffic is mixed, and motorcycles make up the highest proportion of vehicle population. Therefore, it is beneficial to understand the contributors to accident risk, particularly relating to drivers' choice of speed.

There are many variables in a road traffic accident that affect the injury severity of the people involved. These include factors related to the casualty (age, gender, biomechanical tolerance, seat belt wearing, etc.), factors related to the vehicle (size, shape, impact speed, effectiveness of absorbing impact energy, etc.), and factors related to the wider environment (characteristics of the object hit, effectiveness of the medical treatment, etc.) (Richards, 2010). All these variables have a significant relationship to the injury severity of the casualty.

Nevertheless, one of the most widely studied variables is speed. There is a strong correlation between speed and accident risk. A higher speed increases the likelihood of an accident. An explanation for this relationship is that when drivers travel at high speed, they reduce the possibility to respond in time, when it is necessary. A sufficient reaction time is needed to process information, to decide whether to react or not and finally to execute a reaction. The distances available to stop a vehicle depend on drivers' reaction time and choice of speed. At high speeds, the distance covered during the reaction time and braking period is longer. The braking distance is proportional to the square of the speed (v^2). In other words, the possibility of avoiding a collision becomes smaller as the speed increases. The relationship between speed and accident risk is well illustrated by Finch (1994).
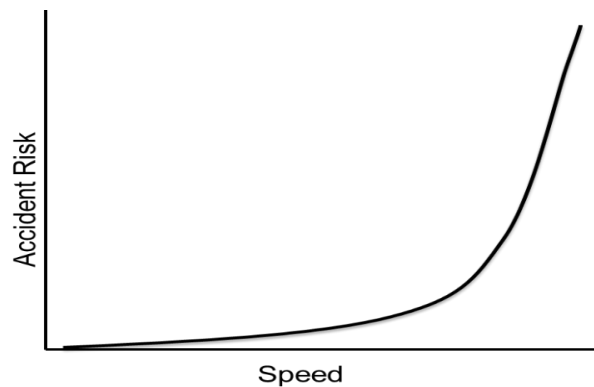
Figure 16: The relationship between speed and accident risk (Finch, 1994)

Figure 16 shows that the higher the speed, the higher is the accident risk. The risk increases sharply at a certain speed. Several studies have argued that injury is the result of "energy interchange" (WHO, 2013). During a collision, the injury results from the transfer of energy to the human body, in the amounts and at the rates that damage the cellular structure, tissues, blood vessels and other human body structures. In a serious and fatal crash, damages are caused by the transfer of energy from the accelerating/decelerating mass of the car – energies exceeding those that the body can tolerate.

However, the relationship between individual speed and individual accident involvement is not well known. Most studies that have investigated this relationship have relied on inappropriate

study designs and potentially misleading functions to describe the relationship between speed and accident involvement.
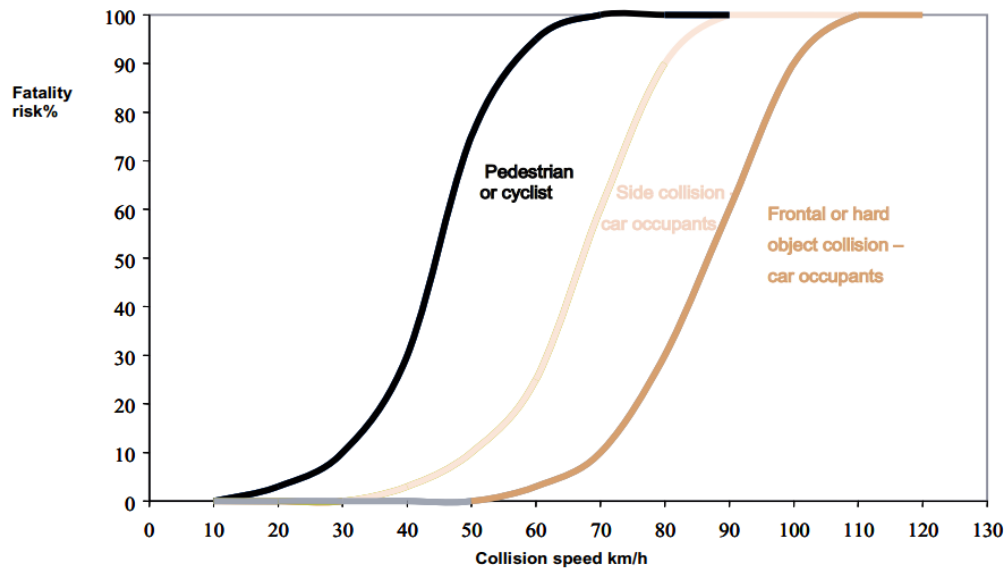
Figure 17: Fatality risk for pedestrian speed impact (Peden et al., 2004)

Furthermore, the human tolerance to injury when directly hit by a car are exceeded if the vehicle is travelling at more than 30 km/h. Pedestrians, as illustrated in Figure 17, incur a risk of about 80% of being killed at a collision speed of 50 km/h (Lai and Carsten, 2012). Another situation where humans risk their lives during travel is when a vehicle-on-vehicle crash occurs. The rapid change in velocity of the vehicles is accepted as the measure of acceleration that is most closely linked to injury severity. Car occupants who wear seat belts and use well-designed vehicles, can generally receive adequate structural protection up to a maximum of 70 km/h in frontal impacts and 50 km/h in most side impacts (Carter et al., 2014).

In the case where a vehicle loses control or hits a roadside structure, both vehicle speed and physical characteristics of the structure determine how severe the injury is, and hence both must be considered when trying to reduce injury. Higher speeds could be tolerated if the interface between the road infrastructure and the vehicle were well designed and crash protective — for example, crash cushions can be installed on sharp ends of roadside barriers (Howard et al., 2008). However, most road systems allow much higher speeds without any protective barriers between vehicles and roadside objects, even in particularly dangerous environments.

Many studies, based on the principles of kinetic energy and validated by empirical data, try to understand the underlying characteristics and mechanisms of traffic accidents in order to develop a measure for speeding behaviour (Quimby et al., 1999). The general form of relationship between speed and number of accident, developed by Nilsson (1981, 2004) and called the power model, is:

$$A_2 = A_1 \left(\frac{v_2}{v_1}\right)^2$$

for speed, and fatal accident:

$$A_2 = A_1 \left(\frac{v_2}{v_1}\right)^4$$

This formula shows that the number of injury accidents after the change in speed A_2 equals the number of accidents before the change A_1 multiplied by the new average speed v_2 divided by the earlier average speed v_1, raised to the square power for all injury accident and fourth power for fatal accident.

Nilsson's power model was empirically derived based on speed changes and crash effects resulting from a large number of rural speed limit changes (Cameron and Elvik, 2010). Elvik et al. (2004) undertook a meta-analysis to test the assumption that Nilsson's model is equally applicable in all road environments, including urban arterial roads, residential streets, rural highways, and freeways. There are a number of similarities between Nilsson's and Elvik's model. The summary of Nilsson's power model is presented in the equation below:

Number of fatal accidents:

$$Y_1 = \left(\frac{v_1}{v_0}\right)^4 Y_0$$

Number of fatal casualties:

$$Z_1 = \left(\frac{v_1}{v_0}\right)^4 Y_0 + \left(\frac{v_1}{v_0}\right)^8 (Z_0 - Y_0)$$

Number of fatal and serious injury accidents:

$$Y_1 = \left(\frac{v_1}{v_0}\right)^3 Y_0$$

Number of fatalities and serious injury casualties:

$$Z_1 = \left(\frac{v_1}{v_0}\right)^3 Y_0 + \left(\frac{v_1}{v_0}\right)^6 (Z_0 - Y_0)$$

Number of all injury accidents:

$$Y_1 = \left(\frac{v_1}{v_0}\right)^2 Y_0$$

Number of all injury casualties:

$$Z_1 = \left(\frac{v_1}{v_0}\right)^2 Y_0 + \left(\frac{v_1}{v_0}\right)^2 (Z_0 - Y_0)$$

Speed is denoted by v, accidents by Y, and accident victims by Z. Furthermore, a 0 subscript denotes the values observed before a change in mean speed, and a 1 subscript denotes the values observed after a change in mean speed.

Nilsson Power was tested in other country, such as Indonesia, which concluded that the models can be used for all environmental conditions (Prasetyanto and Santosa, 2011). The

change of speed for this model can be either an increase or a decrease in speed. Nevertheless, the speed used is the mean speed in the traffic, while other speed characteristics such as 85th percentile or variance were not investigated. There are no restrictions on the value of the traffic speed used by the model.

Elvik (2013) add several new data and proposed a new power model, called the exponential model, which estimates that changes in the number of accident casualties is equivalent to changes in the mean speed. Figure 18 presents a graphical depiction of the relationship between speed and number of fatal accidents suggested in Elvik (2013):
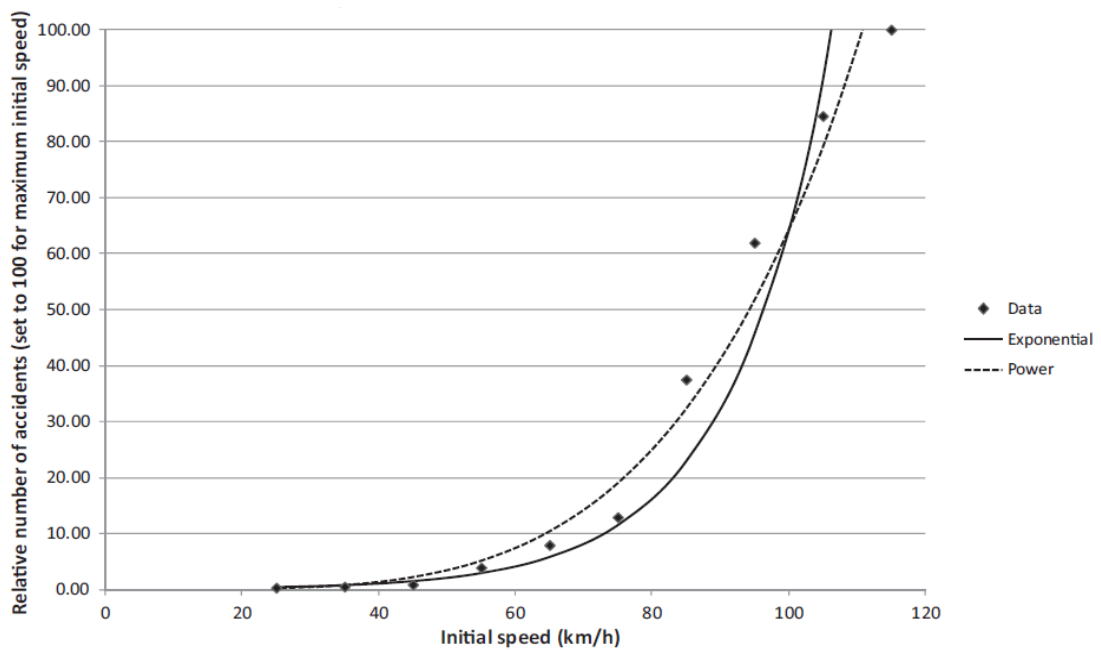
Figure 18: Power and exponential model of speed and fatal accidents (Elvik, 2013)

These models have recently been challenged by another study of speed and crash relationships, which demonstrated that a single speed parameter (such as the mean speed) is not sufficient to represent the complex relationship between speed and number of crashes. It is necessary to consider other speed metrics, such as the mathematical average, the coefficient of variation, and the measures of (high) extreme speeds (Baruya, 1998; Taylor et al., 2000). Thus, a countermeasure that results in lower mean speed may not have the expected positive effect on road safety if, for example, speed variation remains high.

Several studies have attempted to establish a relationship between speed variation and crash risk. The early work by Solomon (1964) establishes that when speed differences increase, the accident risk increases. The larger the difference between travelling speed and the average speed, the higher the accident risk (Hauer, 2009). Further studies correspondingly showed that speed variation on the road influences the chance of an accident (Garber and Gadirau, 1988;

Boonsiripant, 2007). However, because more overtaking manoeuvres and more encounters in general occur during daytime on urban roads, the risk is less predictable (DaCoTA, 2012).
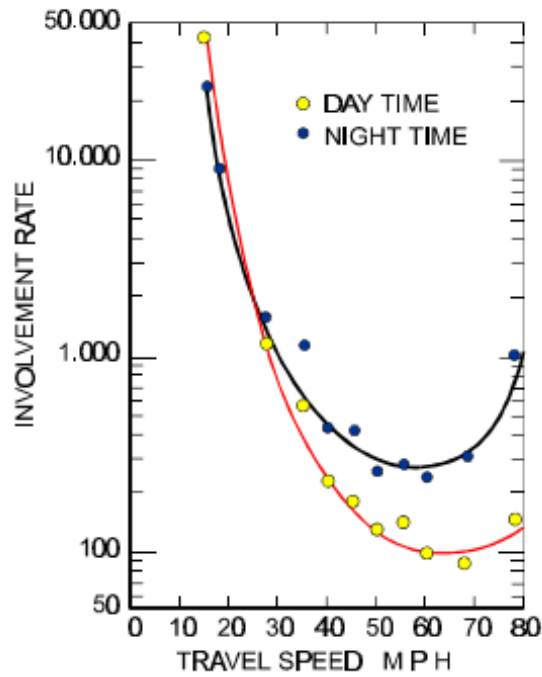
(a)
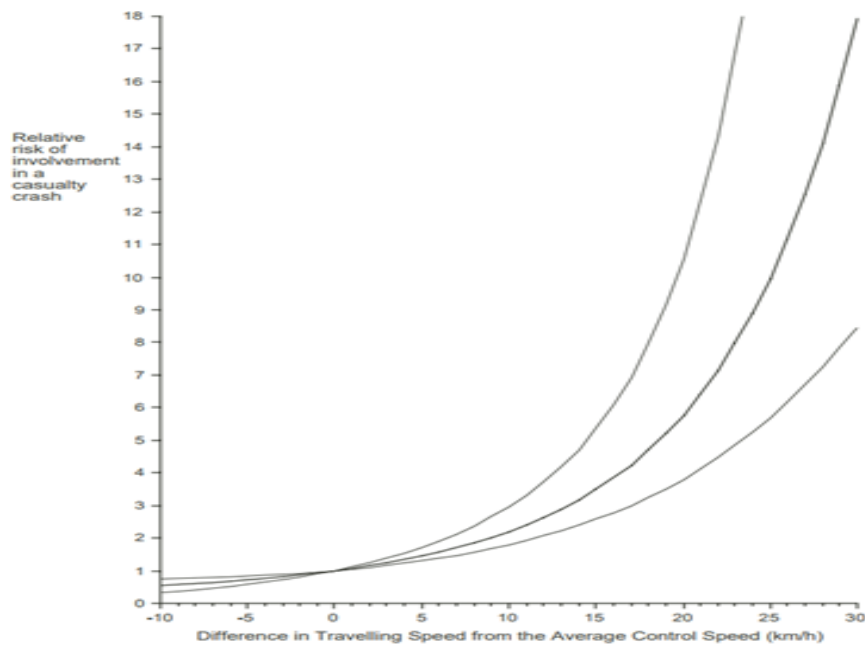
(b)

Figure 19: (a) Accident involvement rate by variation of average speed on the section, day and night (Solomon, 1964); (b) the risk of involvement in a casualty crash relative to travelling at the average control speed (Kloeden et al., 2001)

Nevertheless, despite these results, the relationship between speed variation and crash is still debated in many studies. If high speed is seen as a factor strongly related to the occurrence of

accidents, there is a doubt whether the same risk be faced by drivers who drive much slower than the average speed.

Figure 19 (a) is taken from Solomon (1964), which shows a similar risk for a vehicle travelling below the average speed. The lowest accident involvement rate is defined as a vehicle travelling at average speed up to 10 mph higher than average speed. A motorist who travels 20 mph below the average encounters a similar risk to someone travelling 25 mph above the average on daytime. On the contrary, in recent works researchers present no evidence whereby slower vehicles were also at greater risk, related to Solomon's U-shaped risk curve (Kloeden et al., 1997; Kloeden et al., 2001).

Figure 19 (b), vehicle that travel 20 km/h above the average speed bears nearly six times the risk of involvement in a casualty crash as the average speed of non-crash involved vehicles while travelling 10 km/h above the average speed produce two times higher risk. The increase in risk is associated with longer stopping distances, increased crash energy and more likely loss of control (Kloeden et al., 2001).

It is obvious that both concepts have a similar idea about the danger of speeding, the first idea expressed the risk of individual speed, i.e travelling above the speed limit, while the second idea tries to relate the risk driving above the average speed of traffic. Thus, both condition increased the risk of accident whether driving above the existing speed limit or driving at speeds above the average traffic speed.

Furthermore, Taylor et al., (2000) found that the accident risk is higher as the complexity of the road increases. Figure 20 illustrates the risk for each type of road:
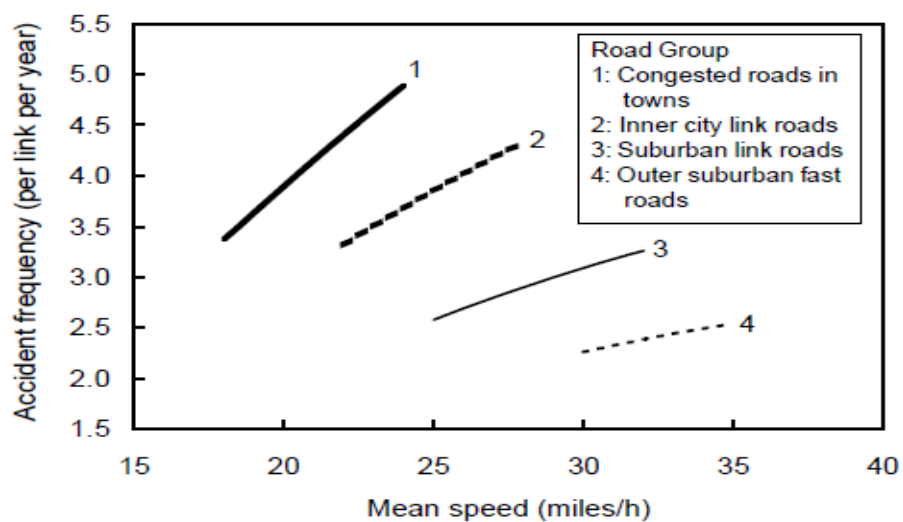
Figure 20: Accident risk for different types of roads (Taylor et al., 2000)

There are many differences in road environments depending on the situation. On some roads, traffic conditions are more complex than on other roads. Conditions depend, for example, on

the number and type of intersections, as well as the absence or presence of pedestrians, cyclists, or agricultural vehicles. Motorways, for instance, have a lower complexity compared to urban arterial roads; hence, the accident frequency per year on motorways is lower than on another road type. Interestingly, congested roads in towns have the highest accident frequency per year, even though traffic speeds on those roads are lower than on other roads. The current statistics show similar significance as presented in Figure 21.
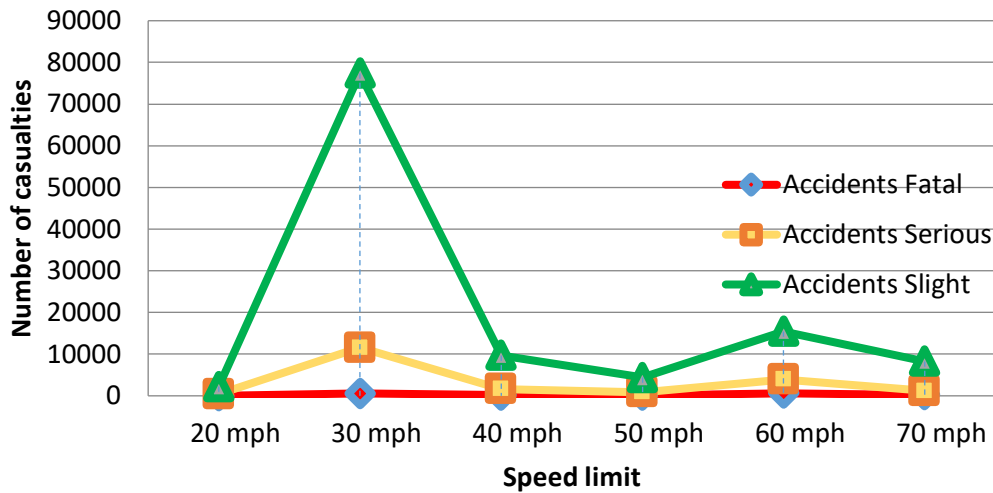
Figure 21: Reported accidents and casualties by severity and speed limit, Great Britain, 2013 (RRCGB, 2013)

The graph shows that the roads with 30 mph and 60 mph limit are more dangerous than another road. The road with limit 20 mph and 50 mph appeared safer than another road. 30 mph mostly represent the city's traffic while 60 mph mostly posted on the rural single carriageway.

Nowadays, in many LMIC, many sections of roads in the city suffer from severe congestion. A mix of traffic that is dominated by motorcycles has increased the complexity of traffic. An interesting question is whether this complexity leads to increased accidents and casualties as discussed above. Therefore, the large speed variation should be reduced by applying the appropriate speed limit and speeding countermeasures that work simultaneously to lower the average speed chosen by drivers and at the same time decrease the speed variation. Still, no reliable relationship has been established to link the change of speed, variation in speed, and the risk of an accident. The relationship between speed and accident risk remains a complex problem.

3.3 Speed enforcement and its effectiveness on influencing choice of speed

The time is right for law enforcement management to closely examine its current approach and strategy. This section discusses the state of traffic legislation, methods and tactics taken by

road policing, the deterrence effect of traffic enforcement, and measures to support enforcement as a combined strategy to influence drivers' choice of speed.

3.3.1 The role police enforcement in road safety

The police comprise one of the arms of the state administration which are given the right to use coercive force to maintain security and public order, to enforce the law, to provide protection and guidance, and to serve to the community (Klockars, 1985). The main task of the police is to protect and to serve the people where they operate, though the organisational form and specific operation of police may vary among countries.

The role of police has changed dramatically in the last few decades. The rapid growth of motor vehicles has affected police departments' organisation and their role in dealing with the problems encountered (WHO, 2004). Motor vehicles have become a part of peoples' everyday life. Police executives, academics, and legal scholars have sought to better understand the effect of traffic law enforcement on road safety to continue improving the level of service and protection offered to the community.

Rothengatter et al., (1989) in his early works, described the actual process of traffic law enforcement, consisting of three specific step-wise components. The first is legislative, and it specifies the laws and regulations, governing the safe use of the traffic system by road users. The second is traffic policing, which ensures that road users comply with any specified legislation. The final step is judicial, and it is that of legal sanctions imposed on the road user when a breach of the legislation has been committed.

Like many issues in policing, the police enforcement effect on road safety has revolved around a curious mixture of research, law, police resource allocation, and politics. Police officers, particularly those officers interested in traffic safety, have encouraged the notion that traffic law enforcement can provide road safety benefits to communities (SafetyNet, 2009). These states of the affair have resulted in the creation of new traffic regulations that aim to minimise the negative consequences of speeding and also maximise the benefits of motorised traffic and accompanying technology. The legislation is the most basic mechanism for attempting to influence road user behaviour.

The aim of traffic legislation and enforcement is to ensure the effectiveness and efficiency of road traffic, with one of its primary objectives being the safety of all road users (Zaal, 1994). Many studies have provided evidence of the connections between traffic legislation and police enforcement, which has implications on road users, particularly drivers, including their behaviour and the number of traffic accidents (WHO, 2013; Radun et al., 2011). However, in some countries, the existing legislation fails to resolve the problem and has been found not to

be comprehensive enough to tackle the road safety problem (Howard et al., 2008; WHO, 2017). The comprehensive legislation covers only 7% of the world's population for all key risk factors (WHO, 2013).

New regulations and laws have also driven organisational change and influenced the new role of the police in the whole world. Police enforcement has become an important means of improving traffic safety. According to RoSPA (2004), more people are killed on the road than by any form of crime. Granting that the police is concerned with the safety and security of the public, and that they have to deal with many problems in society, such as drugs and the prevention of terrorism — nevertheless, the safety of road users should receive greater attention.

Various studies have recognised the role of the police in road safety development, particularly in accident reduction. ROSPA, (2004) identified eight main areas that road policing relates to:

1. Deterrence of illegal, dangerous, and careless behaviour on the road,

2. Detection of illegal, dangerous, and careless behaviour on the road,

3. Investigation of any crashes to identify the offenders and prosecute them,

4. Collection of accident data to discover the cause of crashes, thus making crash trend monitoring possible,

5. Changing the attitude of road users and helping to change social attitudes in general,

6. Educating road users: the police are often directly involved in training schemes; especially when a new regulation needs to be disseminated, the police advise and warn offenders for a short period before starting to enforce it,

7. Prevention of other forms of crime by targeting serious traffic offenders; road policing could be used as a tool to disrupt mainstream crime, and

8. Identification and removal of dangerous vehicles: usually, a substantial proportion of the speeding vehicles have serious defects, or their drivers have contravened drivers' hour's regulations.

Elliot and Broughton (2004) postulated a theoretical relationship between the level of policing and accident casualty rate as shown in Figure 22. At zero enforcement level, accidents and casualties are expected to be at their highest levels. An increase in enforcement has no noticeable effect at first. However, at a certain level of enforcement, motorists become aware of the police presence and can hence be expected to modify their behaviour (i.e., to reduce their violations), so that the number of accidents and casualties would start to drop. As enforcement increases, the numbers of accidents and casualties can be expected to decrease, but only up to a certain point, after which increased enforcement would have little or no effect because of a saturation effect (Elliott and Broughton, 2005).
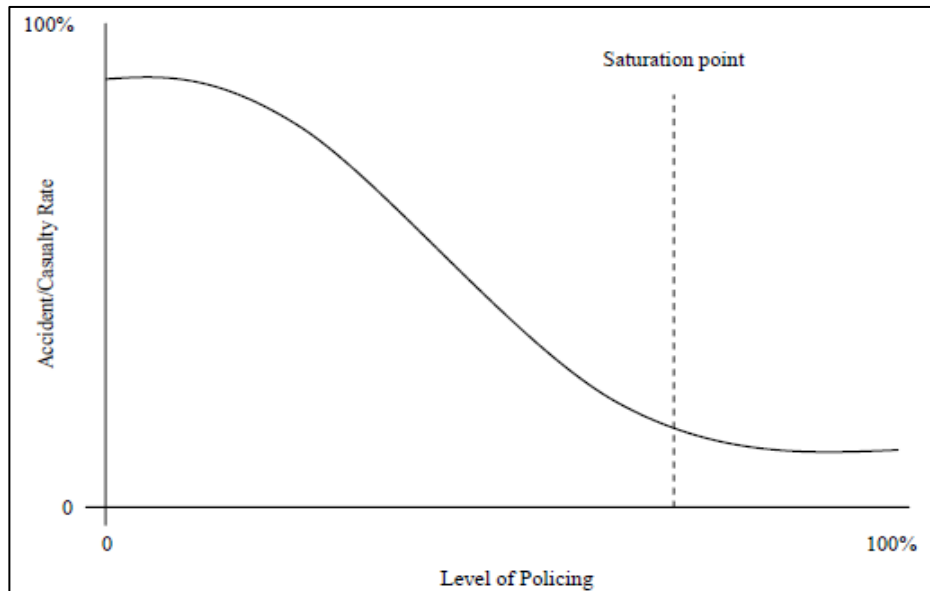
Figure 22: Theoretical relationship between level of policing and accident casualties (Elliott and Broughton, 2005)

The problem for this theoretical relationship between the level of policing and accident casualties is there is no exact definition of the level of policing enforcement. Most of the studies do not provide enough information about the level of enforcement. These studies try to develop definitions by only quantifying a particular aspect of enforcement, for instance, the percentage of vehicles or drivers stopped (De Waard and Roijers, 1994), patrolling hours per day (Vaa et al., 1995), and number of speed tickets (Cameron et al., 2003). No two studies were found to use an identical measure of the level of enforcement. Up to this date, there is no report that able to demonstrate whether adding more procedures to policing would bring the level of casualty rate down, as well as follow the saturated model.

Dissimilarities in different studies' definition of level of enforcement point to the complexity of police enforcement on the road, although it is accepted that police enforcement contributes to road safety improvement (Hauer et al., 1982; Bjørnskau and Elvik, 1992; Vaa, 1997; Newstead et al., 2001). Moreover, this difference in definitions is consistent with the principle that the roles and responsibilities of the police may vary from one locale to another. With regard to speed enforcement, police enforcement strategy must be adapted towards the role that is expected to yield the best outcomes for the community they serve. Nevertheless, it is not clear what enforcement strategy and what amount of enforcement might be the best to achieve a greater impact on road users' behaviour, especially on their choice of speed.

The average police officer is neither a legal expert nor a road safety professional. They have been trained on enforcement and administration protocol, but likely have insufficient

knowledge about all the complexities of traffic laws, as well as road policing strategy and its relationship with drivers' behaviour. In Indonesia, for example, for most of the Indonesian police, speed enforcement is rare and unusual activity. The procedure of using electronic devices, such as handheld speed gun, for speed detection is new. Thus, if speed enforcement becomes a new program run by organizations, officers' level of job satisfaction plays a key role in determining the ease or difficulties of this new development and implementation of speed enforcement.

3.3.2 The effectiveness of police enforcement

Effectiveness has been defined in general terms as the extent to which a particular resource accomplishes its purpose and getting the right things done (Drucker, 2007a; Drucker, 2007b). Elvik et al., (2009) discuss the effectiveness of police enforcement in accident and casualty reduction. Eleven measures are introduced based on the amount of research evaluating the effects of police enforcement procedures on traffic safety. These measures are:

1. Stationary speed enforcement,
2. Patrolling,
3. Blood alcohol concentration legislation,
4. Drunk driving enforcement and measures against recidivism,
5. Seat belt enforcement,
6. Speed camera (automatic enforcement),
7. Red light camera,
8. Fixed penalties,
9. Fines and imprisonment,
10. Warning letters, demerit point and driving license suspension, and
11. Motor vehicle insurance.

Among these measures, methods that are related to drivers' choice of speed are stationary speed enforcement, patrolling, speed cameras, red light camera fines and other punitive measures, as well as demerit points and license suspension. This section explains the effectiveness of methods and tactics of road policing, discussing the general and specific deterrence effect of enforcement and Halo effects in space and time.

Methods and tactics of road policing and their effectiveness

"Tactics and methods," in police terminology, simply refers to arrangements of specific tasks and general approaches to accomplishing police constitutional goals. This review identified the most common policing methods and tactics and assess the available evidence about their effectiveness.

Police are continuously improving the methods and tactics of road policing by adopting enforcement strategies based upon the "anytime, anywhere" approach. Reviews of several kinds of literature reveal that the literature mainly discusses two methods of speed enforcement. The first method is checking drivers alongside the road and stopping offenders, and the second one is automatic speed camera enforcement.

In the literature, the first method is often called stationary enforcement or physical policing. Physical policing makes use of a visible or invisible surveillance group where the offenders are spotted and a visible apprehension unit where the offenders are stopped, both of which have a physical (i.e., human) police presence (SafetyNet, 2009). When physical policing is randomised in time and location over a large part of the road network, this type of enforcement is called random road watch or network-wide random enforcement

Several techniques are commonly practised by police on the road while conducting stationary speed enforcement, such as using radar or instruments that measure mean speed between two fixed points and a stopping point staffed by uniformed police and cars.

Another technique is referred to as stationary "American style." This style of speed enforcement is well-known since people often see it in the movies. The police observer measures speed and then pursues the offending vehicles straight away and punishes the speeding driver. However, this might be the most challenging and dangerous style of enforcement, since it requires officers with safe pursuit skills and vehicles capable of chasing the offender. The pursuit of offenders is not as simple as it would seem in the movies, because police must take into their consideration the safety of other road users who might be put in danger by the movement of the offender's and the police's vehicles. In the real world, when an "American style" chase occurs, the runaway offender is often associated with other crime such as car theft, drug dealing, carrying illegal goods — or, in other words, "they are not clear" (Bayley, 1986; Sherman and Weisburd, 1995). Police have much discretion in exercising power on the roads; police leniency towards certain factors has brought the police much attention in the public eye since these practices were perceived to be discriminatory for several types of drivers. Stationary and visible enforcement effects have drawn numerous researchers to evaluate their effectiveness on drivers' behaviour and road safety performance.

Vaa (1997) investigated the effect of increased police enforcement on motorists' speed of travel. The results showed that average speeds were reduced by 0.9—4.8 km/h in both speed-limit zones (60 km/h and 80 km/h zones) and for all times of the day. A weakness of this study is the length of police presence on the road: the length of presence in this study was 9 hours, which seems to be unrealistic within the confines of normal work.

In contrast, Bjornskau and Elvik (1992) asked whether the effects of traffic law enforcement would be able to reduce the number of accidents permanently. In their studies, they applied a game-theoretic model to manipulate the "dose of response" to enforcement. They concluded that most attempts at enforcing road traffic legislation did not have any lasting effects, either on road-user behaviour or on the occurrence of accidents. Furthermore, imposing stricter penalties (in the form of higher fines or longer prison sentences) would not affect road-user behaviour, but would reduce the level of enforcement.

More study examined the relationship between the intensity of enforcement and the change in the number of injury accidents. The study found that the largest increase in effectiveness is when doubling or tripling the enforcement intensity (Elvik, 2001). However, further increase of intensity only added a smaller increase of the effects, as depicted in Figure 23.
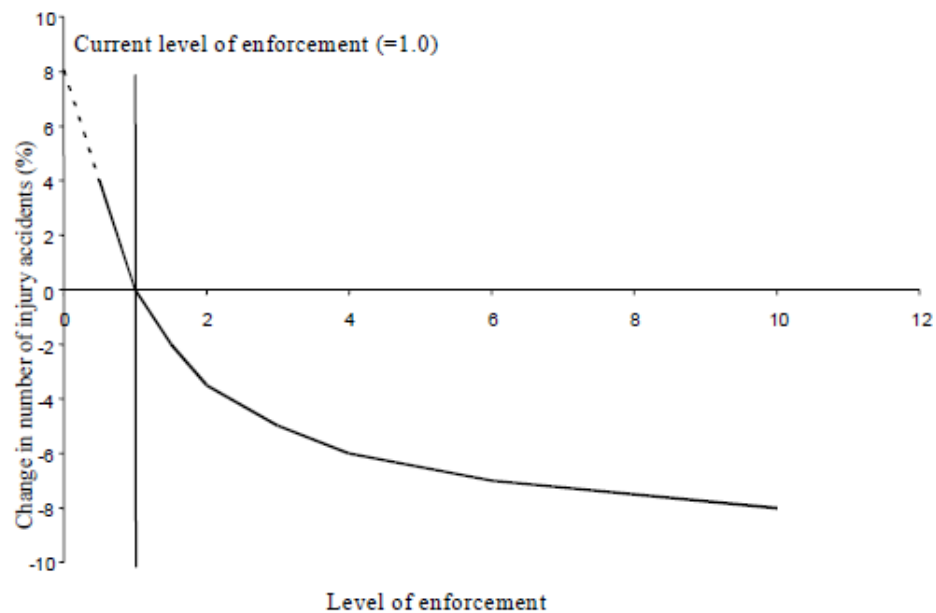
Figure 23: The relationship between the intensity of enforcement and change in the number of accidents (Elvik, 2001)

Furthermore, a similar function called an accident modification function for speed enforcement was developed refers to the effects of speed enforcement on injury accidents (Elvik, 2011), which is relating the size of the effect on accidents to the intensity or level of enforcement introduced. The function is a dose-response curve for police enforcement, showing how the dose of enforcement is related to the response in terms of changes in the number of accidents. (Elvik, 2011). Nevertheless, the new function that was developed was found consistent with the previous study.

Correspondingly, De Waard and Rooijers (1994) conducted an experiment to investigate the effects of three levels of intensity of police enforcement on driving speed and speeding violations on motorways in the Netherlands. Enforcement had no effect on driving speed when

the police stopped every 100th offender. Then, when every 25th offender was stopped, there was a significant effect. Speed reductions from pre-enforcement to during enforcement were between 0.6 and 1.2 km/h. When every 6th offender was stopped, the average speed was reduced by between 2.7 and 5.2 km/h. Finally, after the enforcement period ended, mean speeds began to increase back to pre-enforcement levels. However, when every 6th offender was stopped, mean speeds remained about 2 km/h slower than they were pre-enforcement. Figure 24 shows the effectiveness of these three levels of police enforcement in the study.
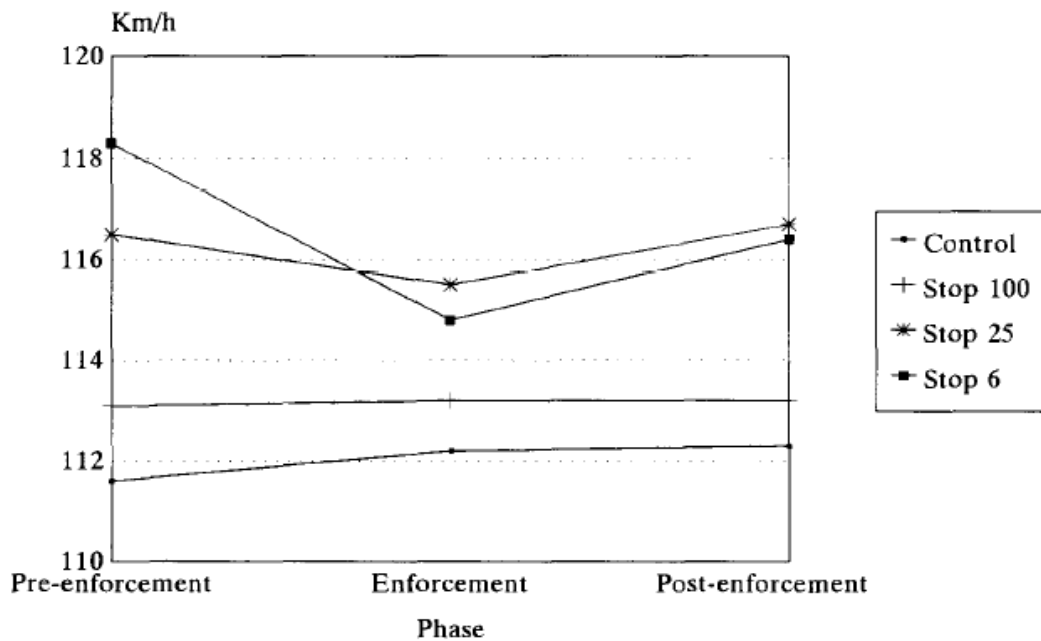
Figure 24: Effectiveness of enforcement on driving speed (De Waard and Rooijers, 1994)

However, the effectiveness of physical policing has been questioned, since it is considerably more labour-intensive than automated methods, and it almost impossible to reach the same enforcement level as with speed cameras. A major criticism of physical policing is that it is too selective, sporadic, inconsistent, and in the end, rather expensive and ineffective, although it has the advantage that drivers can receive immediate feedback on their driving behaviour.

The second method of speed enforcement is to use automatic enforcement: for example, a camera can be used to detect speed offenders (Harper, 1991; Elvik, 1997; Bjørnskau and Elvik, 1992). It is not necessary to stop the offenders. Instead, they receive a notice by mail of their offence and the corresponding fine. Speed cameras give several advantages; they can be installed and operated at fixed locations, and they offer flexibility in that they can be operated automatically (unmanned) or as part of a manned control (either in a visible or a hidden car or van).

Automatic speed enforcement using cameras appears to be rapidly replacing physical policing. Various studies have reported the benefits and drawbacks of speed camera usage, mainly looking into their implementation in developed countries. Keall et al. (2001) reported on the

trial of speed cameras in New Zealand, where a 1.4 mph mean speed reduction was found at the speed camera sites and a 1 mph mean speed reduction was found in all areas during the first year of the trial. Similarly, a 3% reduction in mean speed was also found as a result of an unmarked police van equipped with automatic speed enforcement photo radar in British Columbia (Chen et al., 2002). Despite these apparently positive results, others have argued that physical enforcement by police on the road, as well as publicity, are needed to improve the public's perceived risk of detection and apprehension (Jamson and Rudin-brown, 2013).

One of the latest techniques of speed camera implementation which has recently attracted enforcement experts is average speed control systems, which measure the average speed over a section of road (Soole et al., 2013). Average speed camera systems utilise state of the art video system with Automatic Number Plate Reading (ANPR) digital technology. The average speed is calculated based on the time interval between two points at the start and the end of enforcement section. Unlike fixed speed cameras which capture motorists' speed at a certain point in the road, average speed control work and track the speed over a set distance (Ricour, 2016).

Although speed cameras have the ability to be implemented equally well in all road conditions, the effectiveness of this measure has been questioned by numerous studies. Perhaps the most serious disadvantage of the speed camera effect is that drivers do not immediately gain useful skills or knowledge that helps them to improve their speed limit compliance. Additionally, the speed camera program has lately sparked an intense criticism: many people say that the implementation of such a program is typically about revenue for the relevant administration and not necessarily about safety.

In this study, physical policing was applied first, where a stationary and visible police presence observed vehicle speed using a handheld speed gun. It is beyond the scope of this study to examine the fix speed camera's impact on drivers' choice of speed. This choice is also related to practical constraints, given that speed cameras are not yet used in Indonesia. The study of speed camera implementation might be useful when such instruments becomes more common as tools of speed enforcement in the future.

General and specific deterrent effects of traffic enforcement

Gibbs (1975) one of the proponents of deterrence theory, stated that the rate of a crime occurring is inversely proportional to the celerity, certainty, and severity of punishment for such crimes. Here, the punishment includes not only the sentence imposed by the judge in court (substantial punishment) but also the overall law enforcement process before the decision of the court, which puts a burden on the suspect or defendant (procedural

punishment). Specifically, the target of law enforcement is the offenders who tend to commit unlawful actions, but in general, law enforcement also prevents the public from committing infractions against the law by giving the belief of the procedural burden and severe sanctions that would be encountered.

Deterrence and prevention of crime are two philosophies that form the basis of modern law enforcement. One of the early works in this area began with the introduction of Feuerbach's theory of psychological coercion, which concluded that law enforcement has always functioned as a social and psychological threat. It argued that general prevention could not be achieved through criminal deterrence, but through the threat of criminal legislation or positive law (Andenaes, 1952). That was one reason why ancient criminal law sanctions were developed to be so cruel, and why execution should be done in public: the authors of these sanctions aimed to provide a threat to the general public.

In the field of police studies, particularly traffic law enforcement, the relationship between the determinations of police officers and trends of traffic accidents fatalities, drunk driving, speeding, and seat belt usage was found to be significant (Muhammad, 1998). There is a relationship between the determination of the police unit and unlawful acts, which is explained by the idea of deterrence. A remarkable report of seat belt enforcement in British Columbia similarly revealed that a strict, zero-tolerance enforcement approach by traffic police significantly correlates with driver compliance, as the provisions of the law intended (Watson, 1986). However, it is predictable that the same risk of punishment does not have the same effect on every individual in a population. The punishments or penalties imposed against the offender result in different behaviours in reaction to the rules. For example, £100 fines for speeding offence yields a greater "gain" for a driver with a lower income than for a driver with a higher one.

Deterrence theory has been the dominant paradigm underpinning attempts at behavioural control in road safety around the world (Elliott, 2008). Traffic enforcement has influenced driving behaviour through two types of deterrence: general deterrence and specific deterrence. General deterrence can be defined as the impact of the threat of legal punishment on the public at large, while specific deterrence refers to the implications of legal punishment on those who are apprehended. Thus, general deterrence is arising from the public's perception that traffic laws are enforced and hence that there is a risk of detection and punishment when traffic laws are violated. Specific deterrence results from offender's actual experiences with detection, prosecution, and punishment.

However, one criticism of deterrence is the following: the question of whether deterrence modifies the drivers' behaviour, since behaviour, especially choice of speed, is influenced by

many factors beyond deterrence. Also, the deterrence idea fails to note that the primary objective of modern police enforcement, particularly regarding traffic enforcement, should not be achieved by increasing the number of apprehensions, but through the prevention, pre-emptive operation, and problem-solving oriented tasks. There is some consensus among police and law enforcement agencies that a strategy based on punishment and deterrence is inferior to one based on persuasion, education, and cooperation.

The Halo effect of police enforcement

Roadside police strategies have always been based on two propositions: firstly, that a visible police presence prevents speeding by deterring potential offenders; and secondly, that the public's concern about speeding offences is diminished by such a police presence (Holland and Conner, 1996). Thus, a routine, preventative police patrol is thought to both prevent offences and reassure the public.

Some studies have attempted to summarise and systematise the effect of police enforcement on drivers' behaviour, particularly on drivers' choice of speed. Some consistency appears to have developed in the literature regarding the effects of speed enforcement. They can be categorised as "time Halo" and "distance Halo" effects or "generalized effects" (Vaa, 1997; Sisiopiku and Patel, 1999; Elliott and Broughton, 2005; Yannis et al., 2008; Stanojevic et al., 2013; Holland and Conner, 1996).

The time Halo effect is defined as the length of time during which the effect of enforcement is still present after police activity has been withdrawn. For instance, Holland and Corner (1996) reported that fewer people broke the speed limit during the police intervention than before. The effect was lasting up to 9 weeks after police activity ceased and 8 weeks after signs were removed.

The distance Halo effect is the number of kilometres from the enforcement site, whether downstream or upstream, along which the effect is maintained. The effect of police presence on driving speeds typically lasted between 2.4 and 8 km. Moreover, in relation to speed, the enforcement effects of visible and stationary policing on driving speeds are halved for every 900 metres downstream of the enforcement site (Elliott & Broughton, 2004). In a study that measured enforcement's effect on speed, Halo effects have been determined to have led to a reduction in average speed (2 km/h less) (Elvik, 2009).

Police presence can have considerably larger distance Halo effects (e.g. up to 22 km) if visible stationary enforcement is used randomly on a large part of the road network; this type of scheme would require a large-scale enforcement effort and high unpredictability of checks (Sisiopiku & Patel, 1999). Patrolling enforcement procedures can cover a large area and a

longer time span of vehicle operations, thus having an effect on a larger area and for a longer period of time.

The measure of an effect from an enforcement measure is typically some speed parameter, often the average speed of traffic, which is collected at a specific point of observation along the road. Nevertheless, the mechanisms which explain the impact of enforcement upon drivers' behaviour, for how long and how far the effect could be effectively sustained, still seem to be far from fully understood.

3.4   Measures to support police enforcement

Effective policing on the road is a critical component of road safety. There is a lot of programs emerge as new enforcement strategy that is expected to make a significant impact on reducing road casualties. Law enforcement agencies throughout the world are increasingly adopting combined enforcement strategies, especially strategies that include publicity and training. The goal is to enhance the police capabilities in apprehension and prevention of speeding, expand communication with the public, and accelerate the tiresome, expensive, and time-consuming policing process.

Information and training for motorists are important factors for raising traffic safety awareness and drivers' compliance with road traffic regulations. With regard to speeding and enforcement, road users need to be exposed to information on the problem of speeding, what the speed limit system is based on, and what additional enforcement measures are taken and why, and preferably also the (positive) outcomes of these measures.

Therefore, this section tries to explore the potential and limitations of motorists' education and training and information given as a means to influence general driving behaviour, and speed behaviour in particular.

3.4.1   The publicity campaign for increasing awareness and acceptance of speed enforcement

Traffic enforcement is about changing driver behaviour through guiding, enforcing, and promoting safe road use within the road transport system. Typically, when people think of traffic policing, they think of enforcement alone, i.e., the detection, ticketing, and penalties or apprehension. However, traffic policing has traditionally been much more than that. The role of the police in road safety has become more complex over time.

Police integrated publicity to support the enforcement where the specific messages related police enforcement are designed. The importance of the use of publicity is its potential effect on social and community acceptance, as well as to increase the awareness of enforcement.

Increasing the awareness of enforcement

Police enforcement remain necessary to control motorists who exceed the speed limit. The effects of enforcement are substantially increased when supported by publicity and information (OECD/ECMT, 2006). The use of publicity, whether it takes the form of announcements of speed enforcement on certain roads or in media such as newspapers, radio or TV, enhances the effect on speed compared to speed enforcement alone (Zaal, 1994).

Roadside publicity may also help to ensure that motorists comply with the speed limit or maintain a safe speed by increasing the awareness of police enforcement, thus increasing the subjective chance of apprehension (Tay, 2005b). The use of local media or roadside billboard with the message that police is enforcing the speed limit on particular road segment is the example of publicity that supports enforcement. Zaal (1994) found that the publicity increased the perceived risk of being caught by raising the expectation that enforcement activities would be encountered by the offender. Furthermore, he reported that the use of publicity and media, as announcements of speed enforcement on certain roads, in newspapers, radio or TV, enhances the effect on speed compared to speed enforcement alone. Nevertheless, he also referred that publicity should not be used as the only measure for a reduction in driving speeds, but rather as a supportive measure for other activities.

The main focus of publicity is to create awareness for an organisation, individual, or particular issue. One of the most important factors that influence a motorists' decision to comply with the speed limit or travel at an appropriate speed is how police deliver their speed-related messages as they carry out their enforcement operations. Announcing police enforcement by signage was found to be effective in reducing speeds in an experiment conducted in England (Holland and Conner, 1996).

The power of publicity may result in a major increase in speed limit compliance, thus improving road safety quality. Publicity can play a part in restoring motorists' perceptions that speed enforcement happens and that there are risks to speeding. Mass-media publicity that accompanied the enforcement was considered as a potential explanatory factor.

Increasing acceptance of enforcement

An important mechanism of the use of publicity is its potential effect on social and community acceptance. Public acceptance of enforcement plays an important role in the process of changing behaviour, and media publicity can create a supportive climate of public opinion in which enforcement measures can be introduced (Elliot, 1993; Zaal, 1994). One of a good example for the use of publicity in increasing public acceptance is "THINK! Drink Drive campaign 2015" in the UK. Evaluation of this campaign has shown that 'risky drivers' were

more likely to recognise the campaign and, post-campaign, were more accepting of the idea that they could be over the limit after two drinks (TNS, 2016)[8].

Publicity may contain information that explains the reason behind the enforcement action. For example, the media can be used to give feedback for motorists about the speeding risk/effect or consequences and in contrast introduce the advantage and safety benefit of speed compliance.

To conclude this section, to have any effect on speed, it seems necessary that announcements made about police enforcement must be realistic. Placing and spreading a message about speed enforcement, but not really doing it may not have any effect, or just a momentary effect. This failure can also be a barrier to the success of future enforcement efforts (OECD/ECMT, 2006; WHO, 2017). Information or messages on the publicity should be well designed to achieve effective communication that can associate with the increasing public acceptance and awareness, thus initiating changes in attitude. Nonetheless, up to this date, there is no study has been carried out to investigate the effect of publicity in terms of actual speed choice.

3.4.2   Motorists training scheme for attitude and skills improvement

Another challenge related to making road user behaviour safer is the challenge of education or training. The safety effect of education or training is widely discussed in the research literature. There is no standard definition of education as used in relation to road safety. Education in road safety includes the passing on of skills, knowledge, and activities aimed at informing, persuading, or convincing road users to make a trip most safely. Generally, the term "education" is used to refer to a diverse range of activities, from early childhood road training to driver training to attitude-changing programs.

Early childhood road training is where children are taught the basic informational skills of how to observe the danger of traffic while walking, crossing, or playing on the street. Similarly, initial driver training introduces the basic informational skills necessary to operate a vehicle safely. It is also possible, motorists take training which improves specific driving skills that focus on particular driving conditions, such as slippery roads, handling curve, and other manoeuvring skills. Attitude-changing programs are intended to inform adult road users of the need to change existing dangerous practices, e.g. drinking and driving, speeding, and not wearing seatbelts. However, the practising skills and attitude-changing program that related to speeding is the interest of this study.

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[8] Available at https://www.gov.uk/government/publications/think-drink-drive-campaign-2015-evaluation

Attitude changing program

The majority of driver take part in training is only to prepare for the driving test. This training is mostly inadequate to deal with rapid and complex driving problem that have safety implications. There must be an effort to improve the quality of the driver so that they become a safe driver. As a result, the Police often work with other agencies to conduct education or training for motorists. Even, the Police are directly involved in training schemes. In the UK, for example, the BikeSafe[9] Scheme was led by police, and supported by Department for Transport, Driving & Vehicle Standards Agency and some voluntary organisation. The BikeSafe is aimed at full licence holders and is designed to enhance existing skills with the goals is to reduce motorcyclist casualties through a range of activities, including assessment, workshop and classroom-based courses. After having had the BikeSafe assessment, riders can go on to undertake further training from the range of organisations that provide post-test training.

Other examples of the attitude changing program are pass plus, graduated licencing and speed awareness courses, which are aimed at post-licence training (McKenna, 2006; Wells et al., 2008). The characteristic of the latest training scheme, the speed awareness courses, that it constitutes an alternative to the awarding of points. The course also designed to improve motorists' perception on the acceptability of speed regulation and its enforcement. The aim is to improve the public acceptability of enforcement by replacing punishment with education and persuasion.

Several reports have shown that speed enforcement awareness and an understanding of the consequences of speeding is needed to support drivers' self-assessment as they choose their speed. Nonetheless, there is continuing public and media debate about the worth of training for motorists as a means of improving driver behaviour and reducing road crash involvement. In view of this debate, it is necessary to understand the benefits and the effectiveness of training as a means of influencing drivers' choice of speed, to raise general standards of driving, and to discourage speeding.

Reports from speed awareness training results have argued that the thought of having to undergo compulsory re-training seems to be a particularly effective deterrent to those drivers with the highest opinion of their own driving abilities (Stephenson et al., 2010). This finding links to views on using appropriate penalties and reinforces the recommendation that a wider range of penalties can be used. However, some question that needs to be asked is why the

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[9] BikeSafe is the police led motorcycle project that is run by most forces throughout the UK, by improving skills, knowledge and hazard awareness to make riding safer and more enjoyable.

training about speed has to be undertaken after the speeding conviction before or during a short period after the possession of the driving licence.

Improving skills program

Operating a motor vehicle involves degrees of skill and risk, which are often seen as independent aspects of performance. Many researchers have drawn a distinction between driving skill and driving style (West et al., 1993; Elander et al., 1993; Evans, 1991; Lajunen et al., 1997; Summala, 1987), while others use a similar distinction when referring to driving errors and violations (Reason et al., 1990). Errors refer to a skill-based failure in information processing, whereas violations refer to risk-taking behaviour that involves a deliberate infringement of regulation. It has been proposed that these two dimensions are conceptually distinct, empirically separate, and may have different psychological origins, which may require different remedial interventions (Parker et al., 1995; Reason et al., 1990).

The question of whether these different dimensions require different modes of remediation is of particular interest, and was the question investigated in the present work, in which we examined the effect of a skill-based training program on risk-taking measures. If skill and risk-taking are independent, as argued above, then skill-based training should have no impact on risk-taking. However, there are also arguments supporting both alternative possibilities: (a) that skills training may increase risk-taking or (b) that skills training may decrease risk taking. The practical consequences of the impact of training on risk-taking behaviours are of considerable importance. Policymakers may find it possible to support training that decreases risk-taking but feels compelled to oppose training that increases it.

The increase in risky behaviours such as speeding as a result of training is a major concern in previous research (Henderson, 1991; Stradling, et.al., 2003). Stradling, et.al., (2003) expressed concern that there was an increase in the proportion of riders that indicated they would ride at higher speeds on the open road, as they perceived their skills to increase as a result of the course. A similar result also found in anti-skid training from countries where snow cause slippery road conditions (Katila et al., 1996; Engström et al., 2004; Tronsmoen, 2010; Beanland et al., 2013). Manoeuvring skill training can result in overconfidence in the ability to handle the vehicle and feel more competence after the training, without actually having improved their skills (OECD/ECMT, 2006). As performance increases, risk behaviour may also unfortunately increase. In other words, what knowledge and what skill people have, did not imply to what people chooses to do.

To conclude the reviews about the measure that potentially increase the effectiveness of speed enforcement, this report has pointed out that speed enforcement procedures are

essentially examples of an extrinsic motivational approach, which relies on negative-external factors like fear of punishment to change drivers' speed behaviour. Publicity and training are always seen as mutually reinforcing methods of enforcement and increasing the effectiveness of enforcement procedures applied, while there are evidence that publicity alone has little or no effect and training that bring overconfidence, which could lead to increased risk. Nevertheless, a question then arises as to whether these publicity and training programs can produce safer road users on their own and whether combining them with other types of intervention can add to the effectiveness police enforcement. They are still a big question.

3.5 Traffic enforcement officers' job satisfaction

The impact of job satisfaction on job performance has been investigated by numerous studies. It is found to be related to many individuals and occupational environmental characteristics and as a predictor of many outcomes (Bono et al., 2001; Ozbaran, 2010; Nwidag and Okwendi, 2015). Member of the workforce who are satisfied with their work are more motivated to perform the required task and more likely to commit to the goals of the organization (Miller et al., 2009).

Employee job satisfaction depends on satisfaction with job components, such as the work itself (Luthans, 2011). Fallis et al. (2014) define the work itself as the extent to which the work provides individuals with stimulating tasks, opportunities for learning and personal growth, and an opportunity to be responsible and responsible for the outcome. Similarly, the link between employee job satisfaction and productivity and organizational commitment are consistently found in various report and reviews (Gerhart, 1990; Mobley, 1977; Johnson, 2012; Vinokur-Kaplan et al., 1994). It determines the successfulness of organizational policy implementation (Frederick Herzberg, 1959). In contrast, Herzberg (1993) argued that apart from the importance of the work itself, other attributes such as the responsibility that comes with the job and the recognition one receives from work greatly influence job satisfaction.

With regard to police job satisfaction and the importance or their work in keeping the community safe and secure, Skolnick (1966) argues that police develop a "working personality" as a consequence of their work environment, especially because of the essential elements of their work conditions—danger, authority, and efficiency. This finding is in accordance with fact or reality, based on researcher personal experience as a police officer that the potential dangers of police work lead police officers to develop feelings of suspicion towards, and isolation from, the public. When police perform an action, for instance enforcement procedures on the road, it limits people's liberty. This situation has led to some people resisting or challenging police officers' authority and that this response reinforces the danger

in police work. Nevertheless, whether police officer prefers jobs that present them with task that are mentally challenging and also require their competencies on a variety of tasks are correlated to police officer job satisfaction need to be understood.

Examining determinants comprising individual and organizational factors on police officers' job satisfaction were reported by many scholars. There is a strong positive relationship between individual performance and management support (Zhao et al., 1999; Johnson, 2012; Wang, 2006); the higher the management support for the officers, the higher is the overall agency performance (Brough and Williams, 2007). The other important issues of organizational and community factors, including job challenges, social networks, and citizen cooperation on job satisfaction (Zhao et al., 1999; Jang et al., 2010).

Furthermore, based on an extensive literature review, Zeitz et al. (1997), in their study of Total Quality Management practices and culture, developed five essential dimensions of organizational culture. The instruments developed by Zeitz et al. have been utilized in various studies and, the scales have very acceptable psychometric properties in measuring culture attributes (Zeitz et al., 1997; Boke and Nalla, 2009). These dimensions are: (1) management support, (2) job challenges, (3) loyalty, (4) social cohesion, and (5) citizen cooperation.

If the job satisfaction of traffic enforcement officers affects the officers' performance and, particularly the effectiveness of speed enforcement, which gives a brief explanation of current enforcement effectiveness from police officer's point of view, it is important to understand what factor influence traffic enforcement officers' job satisfaction. Moreover, considering these reviews, this study assumes that higher levels of job satisfaction of traffic officers increase the effectiveness of their performance. Therefore, five dimensions of organizational culture were used to measure the perceptions of police officers and their relationships to job satisfaction.

3.6 Research questions

Based on the reviews of literatures, this study centres on the examination of the effectiveness of speed enforcement on drivers' choice of speed in Indonesia. The dependent variable (DV) for this study is drivers' choice of speed, while the independent variables (IV) are speed awareness training, police presence, and roadside publicity of enforcement. These interventions investigated were selected based on the UK and other countries studies. Since, this study was focused on the Indonesian context, there were some modifications of the procedures to allow these variables being tested in Indonesian road.

Research questions to be addressed in this study are:

1. Does motorists' training, police presence, or roadside publicity of enforcement have a significant effect on for drivers' choice of speed?

2. Are there significant interactions between the three interventions (speed awareness training, police presence, and publicity) on drivers' choice of speed?

3. What is the estimated impact of changes in motorists' speed choice on accident and casualty risk related to intervention applied?

4. Is there a Halo effect of the presence of police on test routes? If yes, how long does the effect last in space and time?

5. What is the current public attitude toward safety, speed, speeding and speed enforcement in Indonesia?

6. What are the current police officers' attitudes toward road safety, speeding and speed enforcement procedures?

7. What is the baseline of drivers' choice of speed in the absence of police intervention?

3.7 Conceptual framework

It is true that a number of significant studies have recently been carried out on how police enforcement is related to speed reduction and the reduction of accident number (Sisiopiku and Patel 1999; Scott 2010; Stanojevic et al. 2013), and further accident severity reduction (Sisiopiku and Patel, 1999; Scott, 2010; Bjørnskau and Elvik, 1992; Carsten et al., 2008; Stanojevic et al., 2013; Zaal, 1994).

It is obvious that a study of the effect of speed enforcement on drivers' choice of speed requires multi-disciplinary knowledge and a multi-disciplinary approach. The majorities of the police use publicity to increase the effectiveness of enforcement and public acceptance (Tay, 2005a; Rothengatter, 1997; TNS, 2016; Rothengatter et al., 1989). Moreover, the police often involved and led the training programs to promote attitude changing and improving skills to create safer and competent drivers (Stephenson et al., 2010; TNS, 2016).

Nevertheless, the question of the effect of combining of several enforcement strategies to influence drivers' speed behaviour has rarely been considered. There are some difficulties in investigating the multidimensional approaches due to simultaneous effect of several intervention, especially to estimate the effect of single intervention when other intervention changes.

Consequently, we have insufficient evidence, other than our own experience of what works, from which to devise a speed enforcement method that influence drivers to choose a safer speed. Hence, this study gives the focus on the combined intervention factors to investigate their effect of motorists' choice of speed, thus make speed enforcement more effective.

The diagram in Figure 25 reflects the goal and limitations of this study. The goal of this study is to develop more effective speed enforcement by testing the enforcement method (visible, stationary, scheduled and manual) that supported by roadside publicity and training. In addition, the survey of job satisfaction of officers of the Indonesian National Police believed to provide many benefits to the development of speed enforcement guideline. In addition, given the fact that public attitude to speed and speed enforcement is at an unknown level, the public survey is needed to support the development of more effective speed enforcement. Factors such as legislation, drivers' visual ability and psychological factors, vehicle factor and road and environment factor are believed to contribute to drivers' choice of speed, but they are the limitation to this study.

In spite of these many factors, this study focused on speed enforcement procedures that involve motorists' training, visible and stationary police presence, and roadside publicity. The conceptual framework presented in Figure 25 is a diagram which outlines the variables and elements of this study.
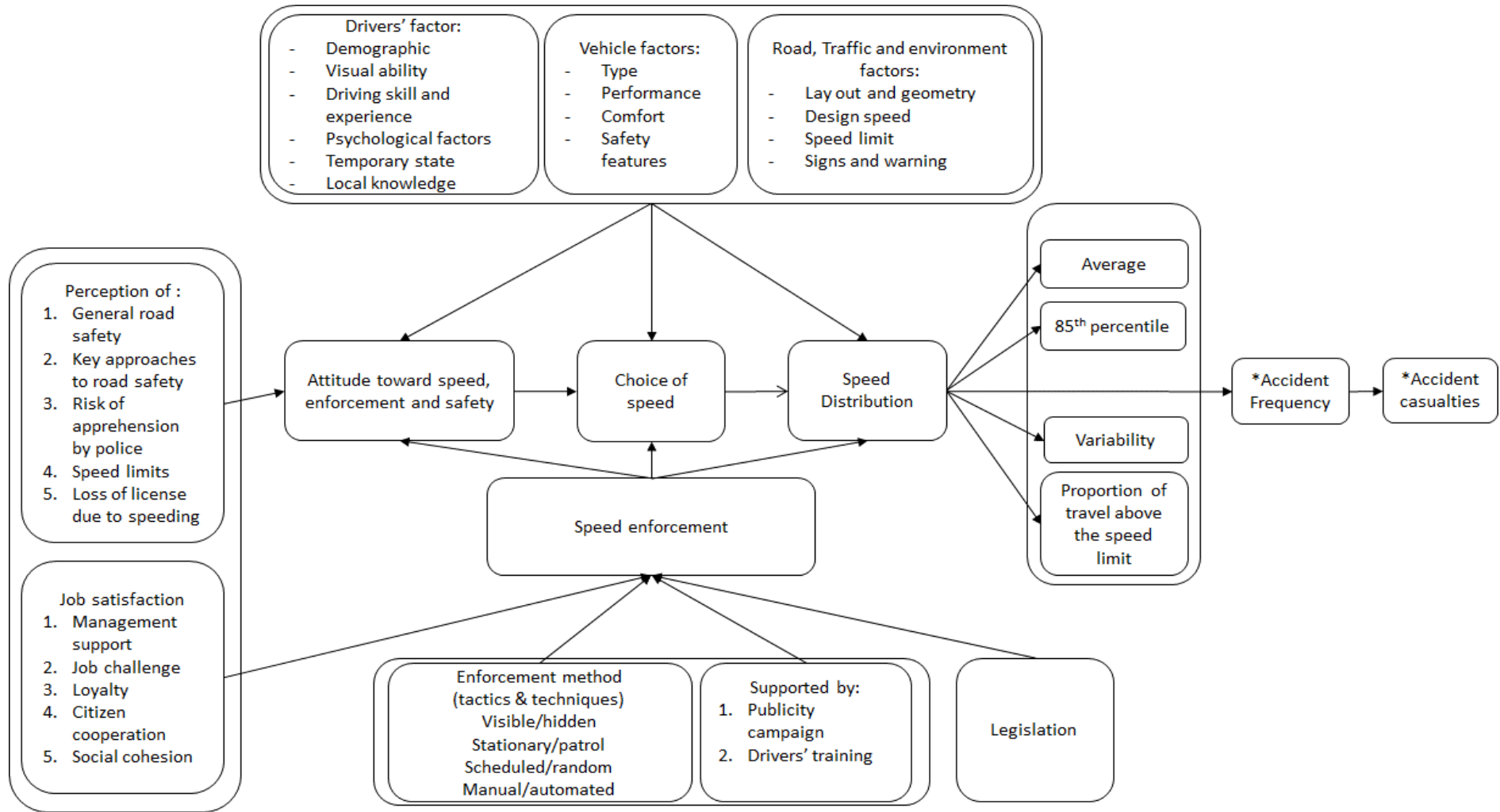
Figure 25: Theoretical framework for the study

Chapter 4

Methodology

4.1 Introduction

The purpose of this chapter is to provide an outline of the various different methodologies that have been used to explore the research questions outlined in Chapter 3. Besides, this chapter explains the data collection procedures and data analysis. Moreover, an explanation of the statistical procedures used to analyse the data is also discussed.

The methods used in this study were mixed. Although the main study about combined intervention effect on motorists' choice of speed was conducted by the experimental approach, several surveys, discussion and documents examination were also applied to support the method development as well as the analysis and interpretation of study result in a later stage.

Therefore, this chapter begins the discussion with the reason for selection of approach and method of this study, then followed by identifying all of the factors that relate to the components of the study, i.e., the types of variables, study sites and nature of the study, participants' characteristics and recruitment, data collection procedures and data analysis, and other factors related to research design.

4.2 Selection of approach and method

Certain types of research problems call for specific approaches. A research problem is an issue or concern that needs to be addressed (e.g., whether one type of intervention works better than another type of intervention). If the problem is to identify factors that influence an outcome, the utility of an intervention, or best predictors of outcomes, then a quantitative approach is best (Creswell, 2013).

The main subject addressed in the present study is the effectiveness of police speed enforcement strategies on drivers' choice of speed in order to reduce the risk of an accident. It is important to understand how police enforcement on the road influence drivers' choice of speed in connection with the particular enforcement strategy or combination of strategies.

Several methods were considered before the present method was developed, such as randomized control trial experiment for investigating the effect of the combined intervention, before and after survey, as well as a subjective method. Each method offered advantages and disadvantage (Gitelman and Hakkert, 1999; Creswell, 2013), for instance between-subject design requires a larger sample than within-subject design. However, if the objective of the study is to investigate the interaction effect of 2 or more factors, a factorial design experiment is the best choice.

This study aimed to answer several questions related to speed enforcement procedures. Hence, different methods and procedures were used in this study. At the outset, an unobtrusive traffic survey was conducted, consisting of a traffic flow survey, a spot speed survey, and an inventory of the road's characteristics. The purpose of this survey was to provide information that could be used for the selection of sites, vehicle types, and optimal procedures of the experiment. Presumably the unobtrusive traffic survey would reduce the biases that result from the intrusion of the researcher or measurement instrument, thus provide true speed and flow of particular segment of road (Highways Agency, 2011).

Then, public attitudes toward speed, speeding, and police enforcement are an important aspect of speed enforcement (Cao et al., 1998; Musselwhite et al., 2010). Therefore, the public survey was administered to acquire the public's general attitude toward speed, safety, and speed enforcement situation. The purpose of the public questionnaire is to understand the public attitude toward safety, speed, speeding and speed enforcement. This questionnaire was also developed as an instrument for approaching and recruiting experimental study participants.

Moreover, self-completion questionnaires were employed by the police force to obtain information regarding police officers' satisfaction with current speed enforcement approaches and rationale behind the police activities. This questionnaire was important for the understanding the level of police satisfaction with current speed enforcement practices. As speed enforcement would be new, just starting out, a program run by organizations, officers' level of job satisfaction plays a key role in determining the successfulness of policy implementation.

Furthermore, one of the objectives of this study is to determine if there is an interaction effect between the combined intervention of training, police presence, and roadside publicity on motorists' choice of speed, an experiment was designed to examine the impact of the treatment variations. In other words, the experimental method was employed to establish causal relationships between variables: a variable of interest is manipulated systematically (independent variable), then the effect (dependent variable) on the targeted individual or

group are observed. Therefore, the purpose of the experiment in this study was to examine the individual and the combined effects of three types of interventions—police presence, roadside publicity, and driver training.

The experiment was conducted by applying a factorial design that created a 2 x 2 x 2 or 2^3 full factorial design. Consequently, eight groups were formed, with each participant being assigned randomly to a specific group. The groups and participants were independent, which means each participant could only join one group. The complete design of factors, levels, and groups are discussed in the later sections. Participants' choice of speed was recorded using a 1 Hz GPS data logger.

To achieve the objectives in this study, the methods and approaches were designed carefully as presented in the schematic representation of study tasks in Figure 26.
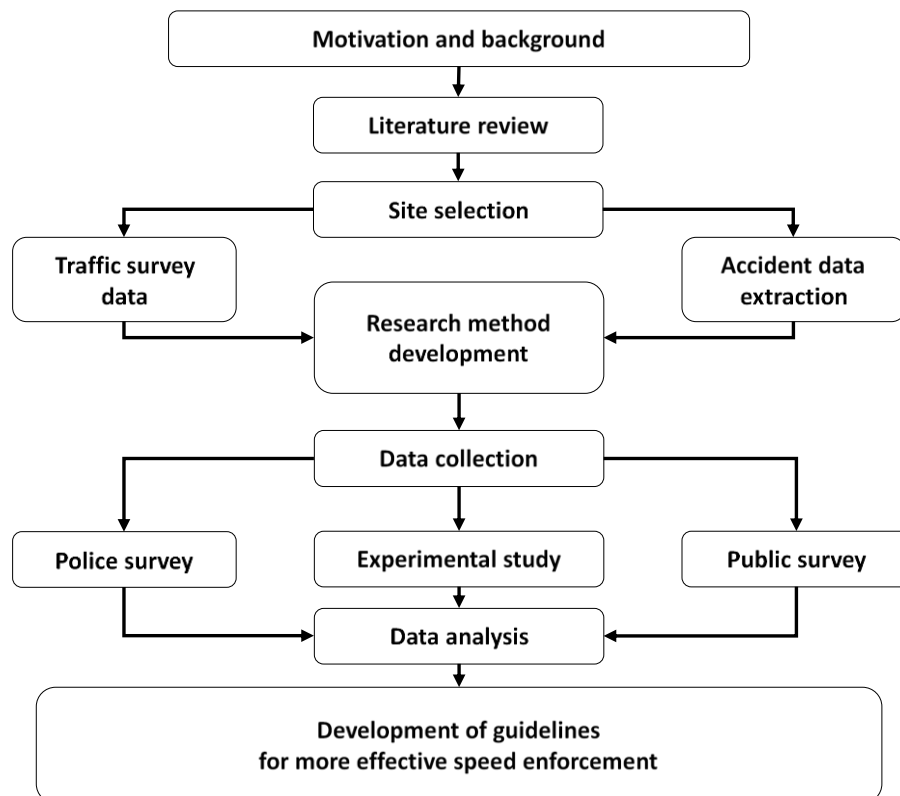
Figure 26: Schematic representation of the study task

To sum up, the overall study task involved in conducting this research were:

1. At the outset, an unobtrusive traffic survey was conducted which consisted of road characteristic inventory, traffic flow and spot speed survey. Accident data were extracted for the survey sites.

2. Self-completion questionnaires were utilised to obtain information regarding:

    a. Police officers' satisfaction on current speed enforcement approaches (Police job satisfaction questionnaire), and

b. Public's perception on current speed enforcement (Public attitude toward speed, safety and enforcement questionnaire).

3. Finally, participants, who voluntarily participate in test-drive based on the approval that they provide at the time of the public's perception survey, drove in their own vehicle around a selected study route (public roads) while their speeds were recorded using a GPS data logger. Some of participants attended speed awareness training/course prior to on road test-drive.

4.3 Participants

There are two potential group of participants in this study. First category is the motorists of selected mode of vehicle (car and motorcycle) who travel on free-flow speed traffic and, the second is traffic police officers from enforcement division. The characteristics for the motorists are, both male and female, aged 16 years and over, and hold a valid driving licence.

The second category of participant is traffic police officer from enforcement division. The characteristics are their status as traffic police officers, including both male and female, aged 19 years and over, and assigned in enforcement division/unit. Police officer only participated in survey.

Regarding the motorists' participant selection, currently, police do not have the record of speeding offences, therefore the participants were selected among drivers who observed exceed the posted speed limit. Hence, police conducted speed enforcement around the road network on roadside using speed gun. Police officer, then, requested motorists to stop and explain the recorded speed, speed limit, and, if applicable, inappropriate speed to the condition at the time. Police officer introduced the researcher and, at the same time, offered the drivers to participate in the study.

Participants were not under any obligation to take part if they choose not to do so. Hence, they took part in the experiment individually and voluntarily, having been selected randomly during the public attitude survey period. Following up on a statement of approval attached to their driver's attitude questionnaire, the participant was contacted a few days before the test drive schedule and asked to come to the meeting point on the agreed day and time. The participant was assured that their participation was voluntary, and they may withdraw from the experiment at any point. The process of participant identification and recruitment is presented in detail in Appendix A: Ethical review documents.

In conclusion, depending on the aspect of research they are taking part in, the participants were asked to took part in a survey or questionnaire study. They also took part in speed awareness training—approximately 2 hours at secure/safe location and convenient for the

participant (Safety Driving Centre). Finally, they took part in on-road test drive where they would drive normally as they do in their daily activity.

4.4 Apparatus and materials

Police laser speed gun and handy talkie

A police team conducted the speed enforcement using handheld speed gun. Police would aim the devices towards the traffic stream, as if targeting speed offenders, to give participants the impression that speed enforcement is in operation along the route (see Figure 27). The speed gun type currently used by Indonesian traffic police is the LIDAR Stalker Handheld, with specifications as follow:

1. Target-specific identification, including through glass, HUD (Head-Up Display), pinpoint targeting with aiming tile, and audio tone feedback to indicate target vehicle acquired
2. Speed range 0—320 km/h
3. Speed accuracy ± 2 km/h
4. Continuous and single-shot measurement
5. Continuous speed display tracking history, updating a minimum of 3 times per second
6. Selectable direction (approaching, receding, both)

The device was tested and used in the pre-study survey. In addition, to support communication between the speed gun operator and other police officers on the road, a walkie-talkie was used to communicate.

Figure 27: Police officers conducted speed enforcement using handheld speed gun

Portable traffic signs

Some traffic signs were used during the study. They were additional to existing speed signs. These additional signs were not only used for the treatment but also to provide safety and

security around the refuge area on the roadside during survey of drivers. The meaningful signs as presented in Figure 28 shows speed limit signs for "60 km/h," "50 km/h," "40 km/h," "20 km/h," "End of speed limit," and "SLOW." There were several additional warning/informational traffic signs to be used to manipulate drivers' choice of speed and to ensure the safety of all parties involved in the experiment, as well as other road users.

Figure 28: Portable speed limit signs used in the experiment

Furthermore, it is important to note that a few of the traffic signs used not common in Indonesia, such as "speed camera" and "SLOW" sign. Speed camera signs and automated enforcement signs have never been used in Indonesia. Up to this date, the police have not implemented the automated system in their activities. Nevertheless, recent developments in road safety and enforcement technology in Indonesia may introduce such signs in the very near future. In this study, the signs were intended to be introduced for study participants to influence their speed choice at the location of the sign.

Roadside billboard

Three roadside billboards were placed along test drive routes, as presented in Figure 29. They consist of pictures, messages, and police taglines. Sequentially from left to right, the first billboard is called "speed limit awareness" with the English translation of its message being "obey the speed limit on this road," (50 km/h or 60 km/h) whilst the second is called "anti-speeding campaign" with the message "the higher the speed, the greater the risk, the higher the severity". The last billboard is "motivational communication" with the message is "your family is waiting at home; speeding may result in death".

Figure 29: Roadside billboard used as publicity media

The size of each billboard is 4x6 metres with portrait orientation, established on the hard ground, approximately 5—6 metres from the edge of the road, and facing the traffic stream at 30 to 45 degrees in order to give them an "easy to see" position. Visual identity (INPTC logos, mascots, and slogan) were included in this publicity effort, not only as identifiers but also to indicate police support of this project.

Drivers training module for speed training

There are many types of driver training, particularly post-licence training as discussed in Chapter 3. One type of training after motorists has been caught speeding is speed awareness course (McKenna, 2006). Hence this study tried to conduct similar training where participants were caught travelling above the speed limit during the public attitude survey. Nevertheless,

there was no penalty applied by police during the detection process, as well as no points were awarded related to motorists' participation in training.

Driver training required training material. Therefore, a manual was developed by selecting some key topics from UK speed awareness topics that are relevant to understanding, knowledge, attitudes, and skill related to speed and safety, which include:

1. The benefits of complying with speed limits
2. Attitudes surrounding misuse of speed
3. The consequences of speeding
4. Knowledge and skills
5. Personal responsibility
6. What difference does your driving speed make?
7. Impact of your behaviour on other road users

Two approved training providers delivered the module, which took place in Riau Safety Driving Centre, in Pekanbaru City, Indonesia. The training was conducted in a classroom where the instructors use the power point that contained the above-mentioned materials. Participants could ask at any time and there was a discussion at the end of the training session. The training was conducted before the participants carried out the test drive, because the between-subject design applied in this study has allowed the results of this training to be analysed against the control group. Further discussion about training result analysis is presented in section 7.4.2 and 7.5.2.

GPS receiver and data logger

A GPS receiver and data logger were used to record participants' speed choice during the test drive. There are ten available devices: 3 are Qstarz BT-Q1000eX and 7 are Holux RCV-3000. The device settings were set to:

1. 1Hz log rate, which allowed the research team to log one position per second, thus providing a more accurate measurement of the track, speed, and distance than lower logging rate devices.
2. Time zone: Western Indonesia or GMT +7
3. Speed recorded in standard metric format (km/h)

According to the device manual, 8MB memory size in each device is able to log 200,000 to 400,000 waypoints. The battery life is approximately 42 hours. The devices, shown in Figure 30, are to be installed or mounted to participants' vehicles. Both devices have been tested during the pilot study and have been determined to provide data in accordance with the desired requirements. See Appendix for GPS specifications. The included software can explore diversified data, present the data by graph or chart, and export the data to GPS exchange

format or text. There is no difference found in the final result after the exported GPX file was converted into text format or CSV version.

Figure 30: BT-Q1000eX and Holux RCV-3000 are a GPS receiver and data logger with 1Hz log rate

Computer and Laptop

A personal computer and a laptop with pre-installed Windows 10, MS Office 2013, Google Earth Pro, and GPS vendor software were used to download the test drive data from the GPS devices. All computers and their applications were simultaneously used to export the downloaded data into GPS Exchange format (GPX), to project the track onto the map, and to store the data in various formats (GPX, KMZ, CSV and Excel).

4.5   Data collection procedures

Different data collection procedures involved in this study. At the outset, an unobtrusive traffic survey was conducted, consisting of a traffic flow survey, a spot speed survey, and an inventory of the road's characteristics. Then, self-completion questionnaires were employed within the police force and in the public to obtain information regarding police officers' satisfaction with current speed enforcement approaches and the public's attitude toward speed, safety and enforcement. These questionnaires are important for understanding the level of police satisfaction with current speed enforcement practices and the public's general

attitude toward speed, safety, and speed enforcement situation, while they were also developed as an instrument for approaching and recruiting experimental study participants.

The survey study was followed by the experiment. The experiment was designed using a factorial design that created a 2 x 2 x 2 or 2^3 full factorial design which required eight independent groups. The complete design of factor, level, and group are discussed in the later sections. Participants' choice of speed was recorded using a 1 Hz GPS data logger. Among eight groups in this experiment, three groups received single intervention and one group experienced no intervention. As well as three groups who assigned by two factors intervention and one group for three factors intervention.

The procedures used in this study were approved by the University of Leeds ethical board with a favourable ethical opinion (Reference no. 14-185, 16th October 2015) before this research was carried out.

4.6 Data analysis

4.6.1 Speed profile graph analysis

Speed profiles are useful in studies and evaluations of road safety. To understand drivers' choice of speed, it is necessary to relate the speed changes to the intervention factor applied, the road characteristics, and the traffic conditions. In this study, one of the tasks is to extract details about the speed from the massive amount of data, which reveals, in a graph or histogram or bar chart, as a speed profile.

The contents of speed profiles vary but features that are commonly included are the chosen (operational) speed, the posted speed limit, and the intervention line. In the present study, data for participants' choice of speed that had already been smoothed and validated was computed to produce an aggregated, averaged (mean) speed either based on individual average speed or 85th percentile segment speed. Then, speed profiles were produced as graphical representations of speed features plotted by time or location (distance).

The drivers' choice of speed is to be analysed in detail using the following procedure:

1. Drivers' choice of speed before being exposed to the speed enforcement factors, as the control roads
2. Drivers' choice of speed while approaching, passing, and leaving each treatment site (except training), as the treatment roads
3. Determining the different choices of speed during this process, the point of maximum and minimum speed, incline and decline in speed (acceleration and deceleration), and other variable factors

4. Recognizing drivers' behaviour (e.g. passing, stopping, and irregularities of speed)

In the context of the factorial design of the experiment, the research team explored graphical data techniques that are commonly employed such as normal plots, three-axis plots, and interaction plots. These techniques are useful when there is a single response in each cell. In this study, however, the response in each cell is a series of 15 observations. With the challenge of this volume of data, an exploratory technique has been chosen to investigate the possible trend in choices of speed over the test segments. The contrast series and the cumulative sum (CuSum) of a contrasting series were introduced; these are quantities often applied in experimental design when there is a time series response in each cell. The contrast series was utilized to explore the differences between responses at the high and low level of the interventions, while Cusum was used to plot the sums of these contrasts (Matsumura and Tucker, 1996).

In addition, participants' tracks were binned into the specified distance threshold, i.e. 50 metres, to provide better details for their speed profile. The consideration was to allow several speed records to be joined into one aggregated value. As the log rate was set to 1 Hz (one record for every second), it is expected that these aggregated points would possess 3—5 original speed records. It is confirmed to the observed free-flow traffic on the test routes where the separation from a front vehicle was minimum 3 seconds.

As part of this procedure, the variation of speeds at each aggregated point has been noted, and the longitudinal connections between the points have been maintained. Although the variation of individual speed profiles was not visible, the general response was still recognizable from the shape of the graph. A different treatment was assumed to produce a different speed choice.

4.6.2   Statistical analysis

To analyse the all type of data, in the first step, descriptive statistics were used to describe or summarise the data. Descriptive statistics was used as an exploratory method to examine the variables of interest before inferential statistical analysis was conducted. Research questions that were proposed in this study were addressed using proper and justified statistical tests.

In a survey study, the same participants are being measured on a different variable using the same measurement scale. Multiple regression is used to determine a participant attitude on speeding, speed enforcement and safety based on multiple independent variables.

For experimental data that produce participants' choice of speed (responses) during the experiment, speed profile graphs were plotted to graphically show participants' choice of speed while experiencing different types of treatment along the test routes. Among eight

groups in this experiment, three groups received single intervention and one group experienced no intervention. Their data were used to analyse the single intervention effect. The combined interventions' analysis was conducted after that.

The drivers' choice of speed was analysed using appropriate statistical tests to determine if there are differences in the mean scores of a dependent variable between three or more conditions/treatments, either as single or combined intervention. No pre-test measurement was taken by the participant. Statistical tests were utilized, such as one sample t-test, paired t-test, One-way ANOVA, and Factorial ANOVA. If there are any differences, a post hoc test or custom contrasts is applied to know where any differences lie.

In addition, the Kaplan-Meier method or test for survival analysis was used to understand the Halo effect (based on distance until driving above the speed limit) for participants who experience the presence of police, included when it was combined with other interventions.

Prior to running a statistical test, basic requirements and assumptions were checked and tested. The justification for each statistical test employed is explained in detail in the statistical analysis sections.

Chapter 5

Preliminary study for further development of methodology

5.1 Introduction

The purpose of this study is to develop more effective speed enforcement measures in order to influence motorists' choice of speed. In order to maximise the impact of any intervention, factors such as road characteristics, traffic characteristics, and accident records should be considered. Consequently, road, traffic, and accident data were considered before selecting an appropriate study site and participants.

However, obtaining data and information regarding road traffic, primarily speed related data, was difficult in Indonesia. As a result, to fulfil this requirement, it was necessary to conduct a preliminary study phase that focused on the use of a traffic survey to collect and analyse traffic speed data on different road sections in Indonesia.

The survey was initially intended to identify the free-flowing speed of traffic to ensure that motorists are not prevented from driving at the speed of their own choice by the proximity of other vehicles. In free flow conditions, headways and lateral displacements are usually large; for instance, a 3— 5-second separation may be present between cars (Highways Agency, 2005). Free-flow traffic is one of the circumstances which would provide insight that would assist in this investigation of motorists' choice of speed.

This chapter describes the study site selection process for the experimental phase of this study (see Chapter IV), which consisted of accident data collection for the proposed location, as well as road condition and traffic survey results that have been conducted on the proposed location. Also, as part of this study, constructive discussions were carried out with the Indonesian National Police Traffic Corps (INPTC) and related stakeholders concerning the speed enforcement experiment.

Therefore, from of March 9th–21st, 2015, road condition surveys, mid-link classified counts, and spot speed surveys were performed at six locations in Indonesia. Surveys were run at a morning peak, between 07.00hrs and 09.00 hrs, and during off-peak hours, between 10.00 hrs and 12.00 hrs. Simultaneously, road inventory portrayed the road geometry and layout,

including the pavement conditions, the number of lanes, and the occurrence of any provisions for road users (i.e. pedestrian facility, bus shelter).

5.2 Road and traffic survey method

Initially, the purpose of this survey was to provide information that could be used for the selection of sites, vehicle types, ideal participants' characteristics, and optimal procedures of the experiment. Therefore, it was necessary to conduct a road traffic survey in each of the six proposed sites, consisting of a traffic count and a spot speed survey. In addition, this initial survey was also planned to investigate road condition, particularly surface quality, layout and geometry, in order to select an appropriate survey location, refuge area, roadside publicity locations and checkpoint for the researcher and police team, including the speed gun operator.

5.2.1 Defining criteria for the sites

The choice of speed is influenced by a number of factors, including driver-related factors, vehicle factors, road and environment-related factors, and traffic-related factors (Haglund, 2001; Elliott and Broughton, 2005; Allan Quimby, Maycock, Palmer and Grayson, 1999; Allan Quimby, Maycock, Palmer and Buttress, 1999; Maycock, 1997; OECD/ECMT, 2006). The first step of the site selection process was to develop criteria for how to select study locations. Therefore, based on the literature cited above, the criteria specified, among others, are road characteristics (urban/rural, single/dual carriageway), traffic flow, traffic speed, speed limit, vehicle type, records of speeding violations, and records of fatal accidents. Besides, for the present study, one of the most critical requirements was the proximity to training facilities to be used during the experiment.

INPTC agreed to provide access to two of their reputable training centres in Indonesia. The first one, a traffic police training facility, is in Pusdik Lantas Polri in Tangerang city (west of Jakarta), and the second is Riau Safety Driving Centre in Pekanbaru city. A room and computer to be used during the data collection were provided. Therefore, the study sites needed to be close enough to the training facilities to allow for effective, efficient, and convenient training for participants.

5.2.2 Accident data extraction for proposed location

Based on these criteria, the next step was to explore the accident records using the police accident database. The Indonesian police accident database is managed in an electronic form by the Law Enforcement Division of INPTC, which is called Integrated Road Safety Management (IRSMS) database. IRSMS provides comprehensive traffic accidents data, particularly with the

availability of crash locations in the form of GPS coordinates which can be displayed on Google Map.

The selection process was followed by an investigation of speed related accidents. Each accident record needs to be assessed which also be discussed with police investigator to assure the speed related accidents were happen the selected accidents. Only accident records with injury casualties were selected, which means damage-only accidents were excluded.

5.2.3   Road condition survey

The road condition survey was a survey to collect data on road characteristics, particularly road dimensions and geometry. The road survey consists of measurements of the length of road, the width of the road, the number of traffic lanes, shoulder width, median width, width of the sidewalk, horizontal alignment, and vertical alignment.

In the present study, road condition surveys were carried out using a car equipped with a camera. Trips using this car were completed in both directions, and the results then discussed with a police team to decide the appropriate location for conducting the traffic survey (i.e., traffic count and spot speed survey) and media placement for roadside publicity. A refuge area to be used in the experimental study also needed to be identified.

The survey was conducted manually by taking notes and photos. Some relevant information regarding road characteristics and conditions were discussed with local police and the road authority, such as black spots related to speeding, road status, road layout and geometry, road surface quality, roadside activity, speed limit, and traffic stream.

5.2.4   Traffic count

Traffic counts were taken to record the number of vehicles using a traffic lane. The information collected in the present study includes direction of traffic, classification of the vehicle, peak and off-peak hour volume, and average daily traffic. Therefore, based on the vehicle flow surveys guideline (O'Flaherty, 2007; Highways Agency, 2011) several specifications have been determined, such as:

1. The survey was carried out over two weekdays and one weekend,
2. The survey was started at 07.00 and finished at 09.00 for morning period and 10.00 to 12.00 for afternoon period, and
3. Vehicle classifications were distinguished in five types: motorcycle, car, bus, LGV and HGV.

In general, counts were conducted manually, using locally recruited staff under the supervision of the researcher. The observer used a simple mechanical hand counter with five tally counters. Each tally counter was labelled with types of vehicles. Two surveyors were

assigned to observe and record all the traffic that passed by within a 10-minute period. Observers were stationed at a refuge area, which was a space with a suitable lay-by width of at least 10 metres, covered by traffic cones. When the counting period ended, the data was recorded in a prepared survey form.

5.2.5 Spot speed survey

Various methods are well known to study traffic speed, such as measuring the travel time over a certain distance manually using a stopwatch or mechanically using devices such as pneumatic pipes. Another method is to record the vehicle speed electronically using devices such as speed radar gun or by using ultrasonic or infrared (O'Flaherty, 2007; Highways Agency, 2011; Skszek, 2004; De Waard and Rooijers, 1994) (see Figure 31).
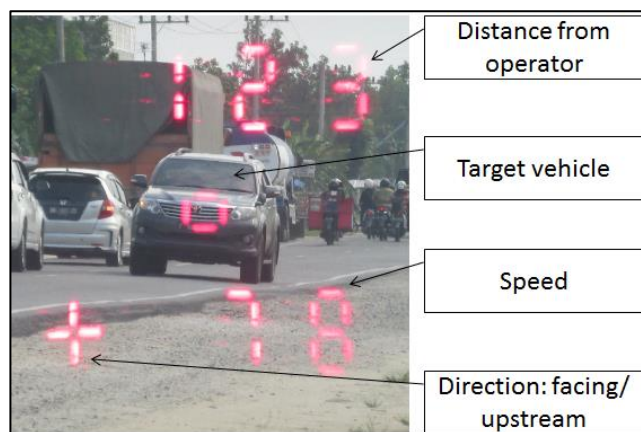
Figure 31: Speed gun display used in spot speed survey

In this study, vehicle spot-speeds were obtained by using a police laser speed gun, positioned alongside the road. Several specifications were determined to allow for better speed survey results, such as:

1. The survey was unobtrusive to all road users; the operator and the equipment were not visible to motorists.

2. The speed gun was mounted inside an unmarked vehicle that was parked off the main carriageway in a prepared refuge area and set to record traffic from the facing direction only along a 400-metre range.

3. The length of observation road section was approximately 400 metres, starting from a specific point (such as a telephone/electricity pole or a building) and finishing at the point where the observer stood.

4. Since it was not possible to record the speed of all vehicles, surveys picked up the speed of every fifth vehicle as a sample regardless of vehicle type.

5. Vehicle types were distinguished into five types: motorcycle, car, bus, LGV, and HGV.

6. The speed was recorded in kilometres per hour (km/h).

Two surveyors were assigned to observe and record as much information as possible about vehicle speed within a ten-minute period. When the target vehicle's speed was acquired, an observer who operated the speed gun read aloud the spotted speed and vehicle type. The other observer then logged these data in the prepared survey form. Similar to with traffic count, the period of observation was 2 hours, divided into 10-minute cycles.

5.3   Accident data investigation result

The accident records around Jakarta and Pekanbaru were collected from the police accident database for a period of two years (2013 and 2014). Records of 13,211 accidents were found around Jakarta and 641 accidents around Pekanbaru. The selection process continued through an investigation of speed-related accidents, which was a difficult part of the process due to accident records being inaccurate and incomplete. Instead of continuing to investigate the accident reports, I ask the officers help to indicate the location of accident with speed as the contributory factor, based on officers' experience and accident record in my hand. Police investigators indicated some locations as accident spots that were potentially have speed a related factor. Six locations were nominated to be investigated further: two sites in Pekanbaru and four in Jakarta, as shown in Figure 32.

Figure 32: Map of proposed survey locations in proximity to training facilities

The selection area was, then, focused down to particular roads to allow for the assessment of each accident record. Only accident records with injury casualties were selected, which means damage-only accidents were excluded. The results of this selection process are presented in Figure 33. A red pin in the map represents an accident where at least one death occurred; an orange pin represents an accident where there was at least one seriously injured casualty; and a yellow pin represents an accident where there was at least one slight injury.
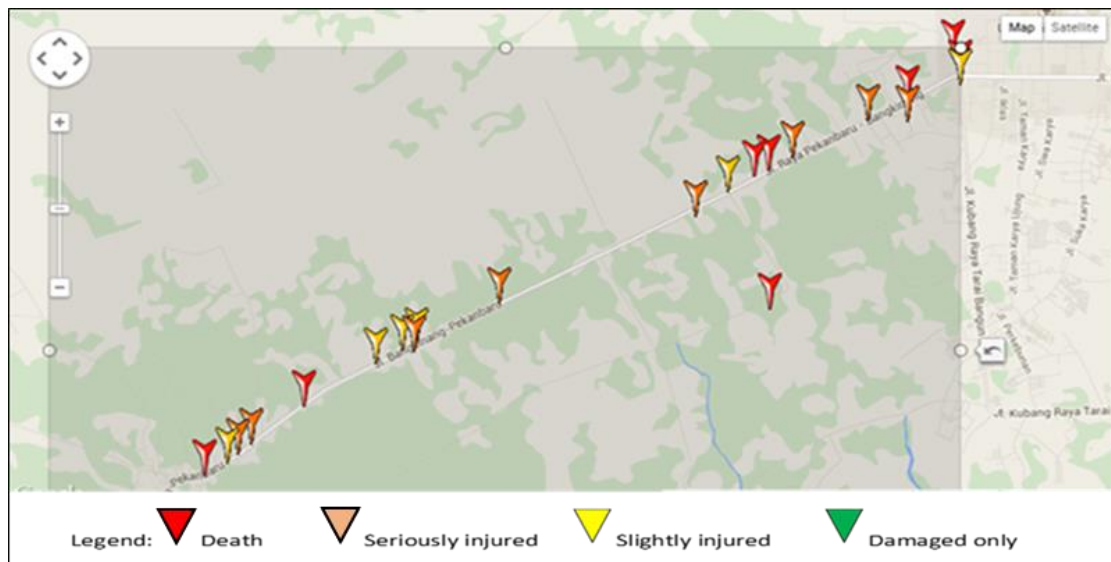
Figure 33: Example of map with plotting of accident data around a survey location.

Then, accident records nearby to proposed survey location were summarised in Table 7 below.

Table 7: Accident record of survey locations based on IRSMS data 2013-2014

Site no.	Location	Number of accident	Number or casualties		
			Fatal	Serious	Slight
1	Bekasi	57	6	64	11
2	Cikupa	23	2	20	24
3	Cibungur	47	13	18	44
4	Kalijati	50	15	46	33
5	Kulim	28	9	9	27
6	Rimbo	25	13	18	26

The highest accident number was found in Bekasi, where 70 fatal or seriously injured casualty was recorded.

5.4 Road and traffic characteristics of survey result

All selected sites were along major roads connecting rural and urban areas. In addition, the chosen spots also provided connection links between two cities. Road type, area development, speed limit, and road surface information were observed. A summary of road survey results is presented in Table 8.

Table 8: Survey locations and road characteristics

Site no.	Route	Road type	Lanes	Area	Speed Limit	Road surface
1	Bekasi	Dual Carriageway	2	Urban	50	Good
2	Cikupa	Dual Carriageway	2	Urban	50	Good
3	Cibungur	Single Carriageway	1	Rural	60	Good
4	Kalijati	Single Carriageway	1	Rural	60	Good
5	Kulim	Single Carriageway	1	Urban	50	Good
6	Rimbo	Dual Carriageway	2	Rural	60	Good

Among the six selected sites, there were four single carriageways and two dual carriageways. Three of the selected sites were urban with a posted speed limit of 50 km/h, while the other three were rural sites with a posted 60 km/h speed limit.

The proposed sites 1, 2, and 6 were dual carriageways, having two lanes for travelling in each direction. The other three sites were single carriageways, featuring a single lane in each direction. The surveys also confirmed that the road surface in all locations was in good quality, good condition, which made it possible to obtain accurate results from the speed survey. An uneven road surface and pothole would make the free-flow travel difficult.

5.5 Traffic counts results and analysis

The traffic volume survey for the morning period started at 07.00 hrs and finished at 09.00 hrs, while the afternoon period took place between 10.00 hrs and 12.00 hrs. The survey was conducted on weekdays and weekends, except at the Kalijati location, where the weekend survey was interrupted due to severe weather conditions. The volume of traffic recorded in the survey form was the volume of vehicles approaching the observer in all lane only.

The traffic count survey successfully recorded 92,278 vehicles across the six survey locations. The highest volume of vehicles was recorded in Cikupa during weekday mornings, while the lowest was in Kulim on weekend mornings. Motorcycles accounted for 67.94% of the observed traffic. The average volume per hour for each location is presented in Figure 34.
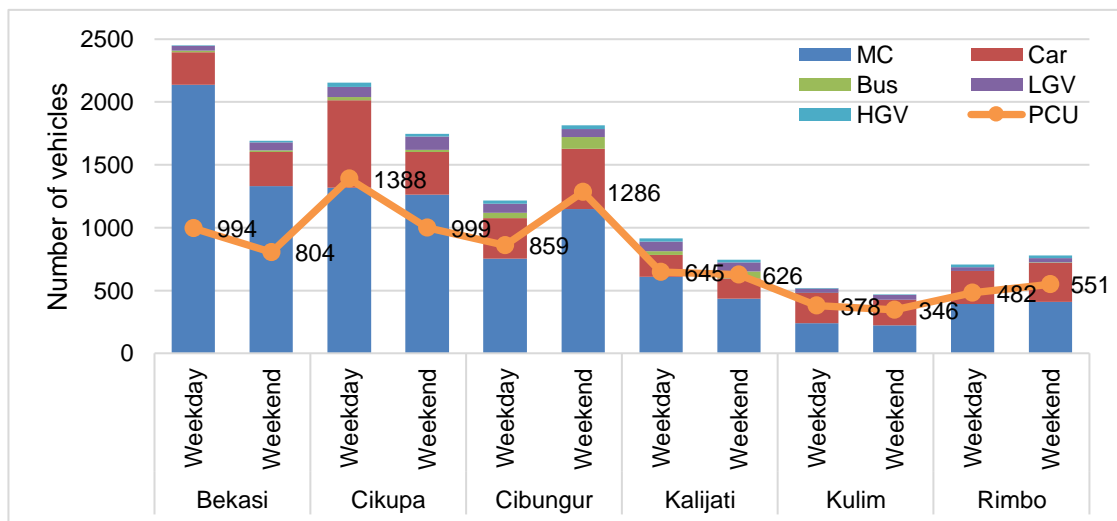
Figure 34: Average number of vehicles and converted passenger car unit (PCU)[10] per hour for at all survey locations

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[10] Passenger car unit (PCU) is a metric used in transportation engineering to assess traffic flow rate on a road. This study used the Indonesian Road Study Manual's values for PCU as

An interesting result was found at the Cibungur and Rimbo sites, where the weekend traffic volume is higher compared to weekday traffic. A possible explanation for this trend is that trips to Cibungur and Rimbo are associated with leisure trips to popular tourism or shopping places which attract residents to spend a weekend at or around these two sites.

Three locations, Bekasi, Cikupa and Cibungur, have a traffic volume of around 1000 PCU (refer to footnote 10 above) per hour both during weekdays and weekends, which means it is difficult to find free flow of traffic in these locations. Kulim and Rimbo, on the contrary, have a lower flow for both weekdays and weekends. The difference between morning and afternoon traffic was found to be minor, except in Cikupa.

The highest proportion of motorcycles to other vehicles out of all six locations was found in Bekasi. In contrast, the highest proportion of cars was recorded in Kulim, and the lowest in Bekasi. The average proportion of cars to other vehicles for all locations is 24%. To sum up, motorcycles and cars are the most likely targets of traffic enforcement to be included in this study, since they were the most common type of vehicle observed in all locations.

In conclusion, high volumes were observed in Bekasi, Cikupa and Cibungur, on both weekdays and weekends; also, free-flowing traffic would not be likely to be found on a weekday in Kalijati. The Kulim and Rimbo locations would provide a greater chance of observing free-flowing movement. Nevertheless, the spot speed survey data is needed to confirm the results of this traffic count survey before it can be concluded which location is best to be the site of the study.

5.6   Spot speed survey results and analysis

5.6.1   Overview of spot speed data

A total of 22,372 observations were made at the six selected sites. The minimum speed recorded was 1 km/h, and the maximum was 104 km/h. The highest mean speed was 57.33 km/h (SD = 11.53), observed at the Rimbo site, while the lowest mean speed was 40.31 km/h (SD = 10.32) at the Cikupa site. Table 9 shows the results of the spot speed survey.

Most of the mean speeds were below the speed limit, except for at the Kulim site, where the mean speed was found to be 51.61 km/h, which is 1.61 km/h higher than the speed limit. In contrast, all 85th percentile speeds were equal to or higher than the speed limit. The highest proportion of vehicles travelling above the speed limit was recorded in Kulim: a proportion as

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follows: car = 1 PCU, motorcycle = 0.3 PCU, LGV = 2.5 PCU, Bus = 3 PCU, and HGV = 3.5 PCU.

high as 51.6%. Even, 20.5% of motorists in Kulim travel at a speed 10 km/h higher than the posted speed limit.

Table 9: Summary of spot speed survey for all locations

Statistics	Survey location					
	Bekasi	Cikupa	Cibungur	Kalijati	Kulim	Rimbo
No. observation	2105	3656	4983	2817	4540	4271
Speed limit km/h	50	50	60	60	50	60
Mean	42.36	40.31	52.42	46.40	51.61	57.32
Median	41.00	40.00	52.00	46.00	51.00	57.00
Std. Deviation	10.42	10.32	10.18	9.37	10.76	11.53
Maximum	81.00	80.00	96.00	82.00	97.00	104.00
85th percentile	53.00	50.00	62.00	57.00	63.00	70.00
% Exceed	20.1	14.5	21.1	7.9	51.6	37.5
% Exceed +5 km/h	11.4	6.9	10.9	1.6	34.8	23.8
% Exceed +10 km/h	6.0	2.4	4.7	.6	20.5	12.9

The cumulative percentage of vehicles travelling at different speeds across all locations grouped by speed limit is shown in Figure 35.
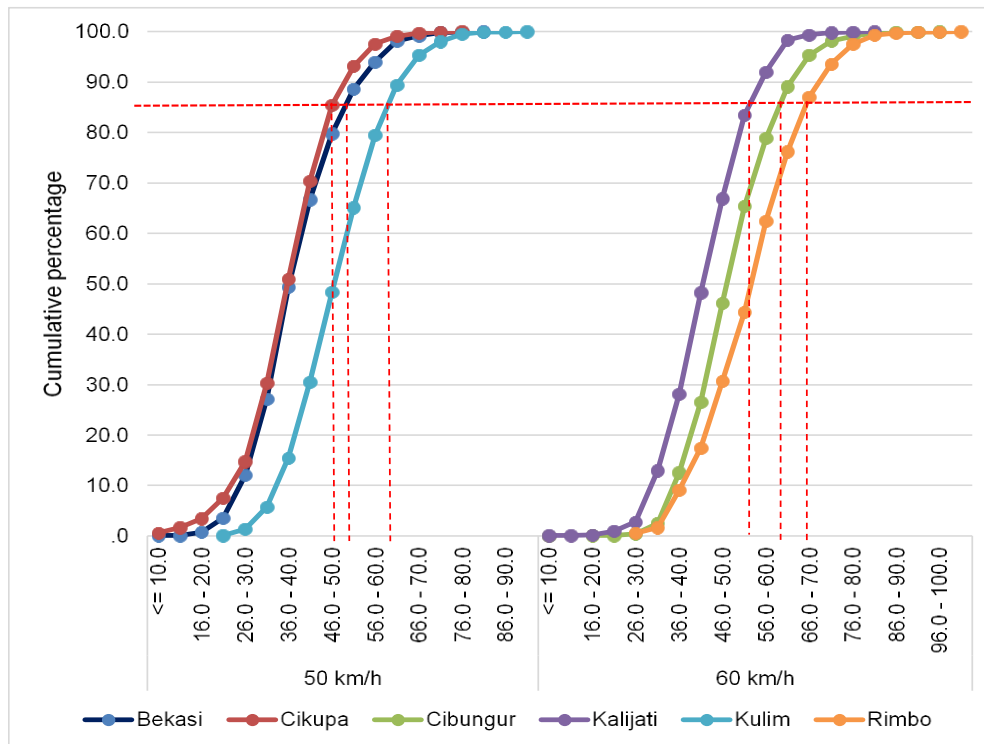
Figure 35: Cumulative percentage (trendlines labelled by location) and 85th percentile speed at all location (the red dashed line)

It is generally accepted that the 85th percentile speed is the basis for the speed limits that are ultimately set (Montella et al., 2015; OECD/ECMT, 2006). There is a strong relationship between 85th percentile speed and posted speed limit at all survey sites, although, in some cases, the posted speed limit was found below the 85th percentile value.

Furthermore, the 90th percentile speed in both Rimbo and Kulim was observed to be more than 10 km/h above the posted limit, which means that 10% per cent of vehicles exceed this speed. 20.5% and 12.9% of vehicles exceeded the speed limit by 10 km/h or more in both Kulim and Rimbo

5.6.2 Speed based on vehicle type

Research has shown that different drivers select different speeds, and that drivers' choice of speed depends upon many variables, including vehicle type (Carsten et al., 2013) None of the survey sites had different speed restrictions based on the type of vehicle. Nevertheless, variations were observed: speed distribution for each speed limit based on vehicle type is presented in Figure 36, as well as the proportion of travelling above the speed limit.
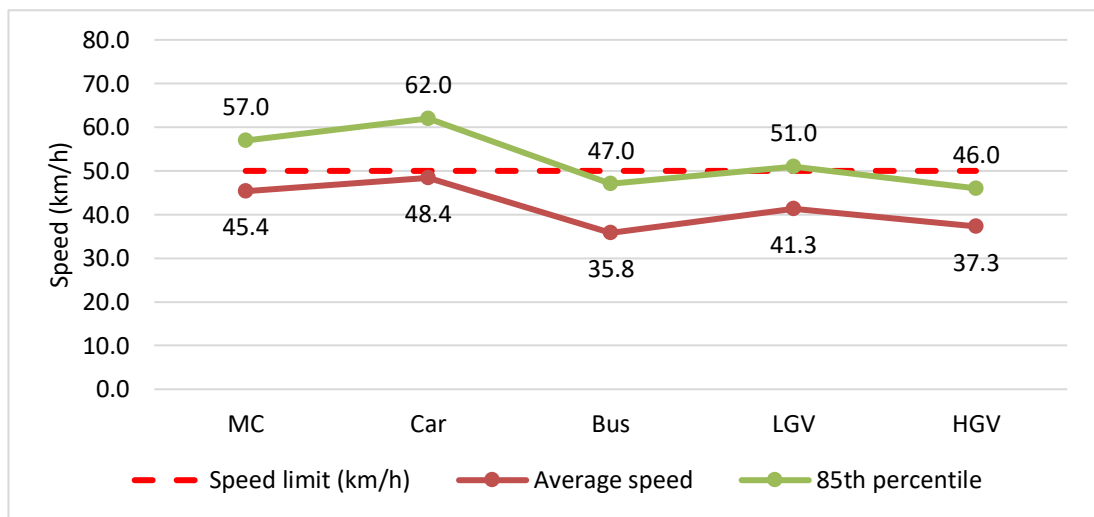
Figure 36: Average speed (red line) and 85th percentile speed (green line)
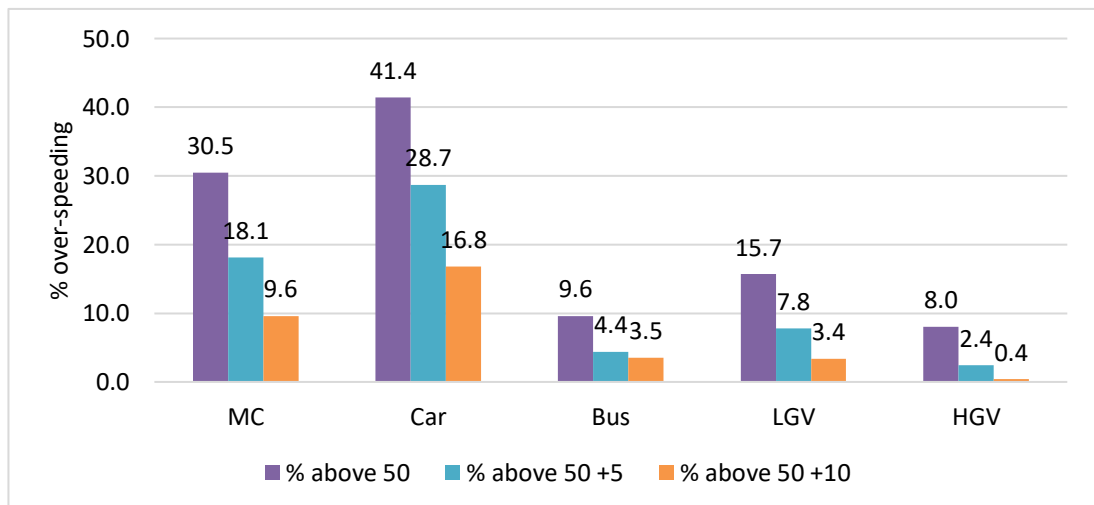
Figure 37: Proportion of vehicles exceeding the 50 km/h speed limit for each type of vehicle

Figure 36 shows that on the 50 km/h roads sites, cars were the fastest vehicle observed, although the travel speed of motorcycles was not considerably different. The 85th percentile

speed for cars and motorcycle was higher than 55 km/h; 16.8% of the cars were travelling at 60 km/h, which is 10 km/h higher than the speed limit.

In addition, Figure 37 shows that 41.4% of cars and 30.5% of motorcycles were recorded as travelling at speeds above the limit, with 18.1% of motorcycles and 28.7% of cars moving faster than 55 km/h. Furthermore, 16.8% of cars and 9.6% of motorcycles were logged as travelling over 10 km/h above the speed limit. HGVs and buses had the lowest proportion of vehicles exceeding the speed limit.
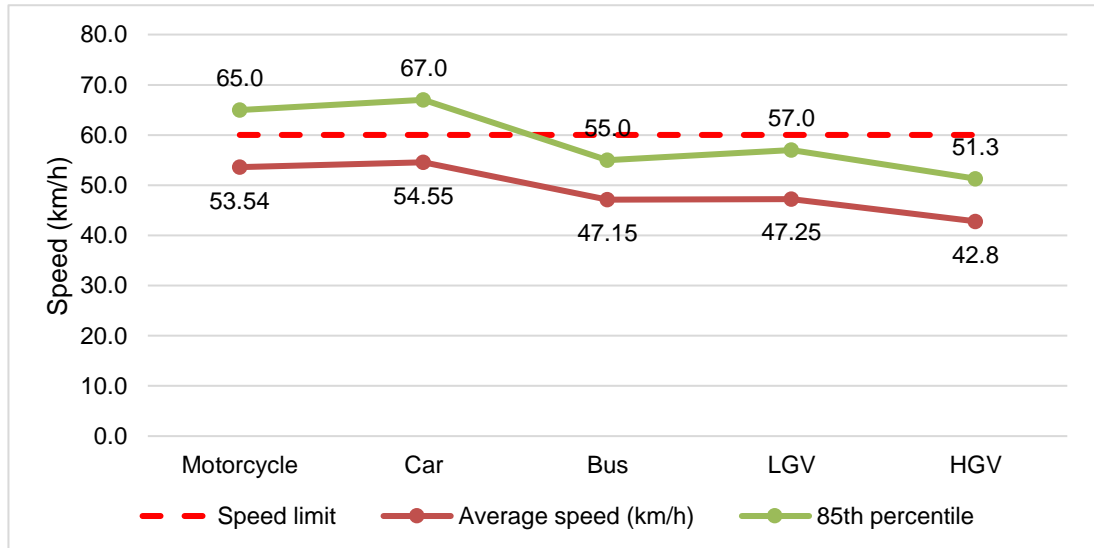
Figure 38: Average speed (red line) and the 85th percentile speed (green line)
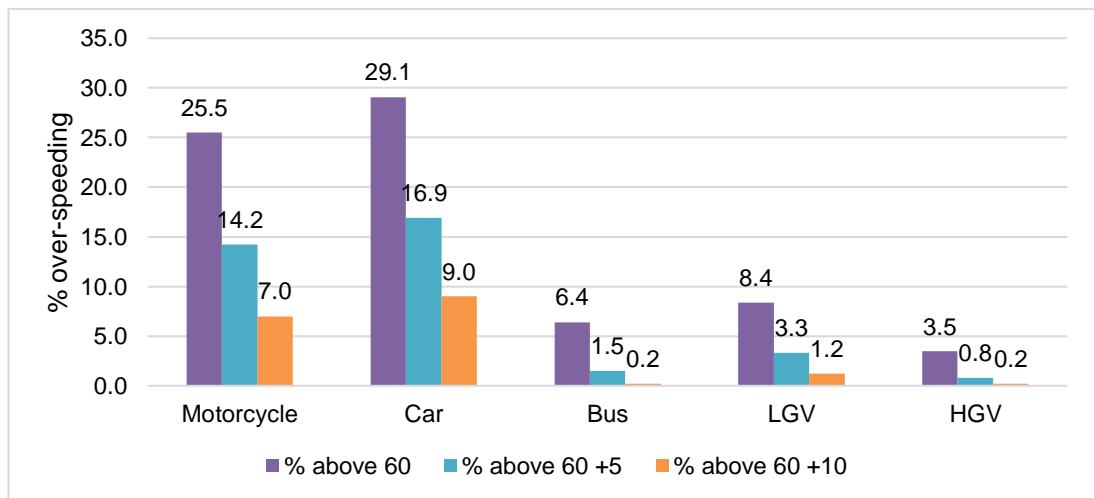
Figure 39: The proportion of vehicles exceeding 60 km/h speed limit for each type of vehicle

Similar results were also noticed on 60 km/h roads where the 85th percentile speed for cars and motorcycles was higher than the speed limit, as shown in Figure 38. Moreover, Figure 39 shows that 29.05% of cars and 25.50% of motorcycles were observed as travelling above the speed limit. Among those cars, 16.9% of drivers travelled above 65 km/h, and 9% of cars exceeded 70 km/h. Meanwhile, the proportion of motorcycles who exceed 65 km/h and 70

km/h was 14.2% and 7%, respectively. HGVs were the slowest-moving vehicles. The distributions of speed for each vehicle type are important to consider, because this data helped to reveal which type of vehicle was actually the most potentially investigated further, especially based on the large proportion of violations in each study site. Therefore, a motorcycle and cars were large in speeding proportion, the researcher was urged to undertake further analysis to understand the comparisons between motorcycles and cars' speed characteristics.
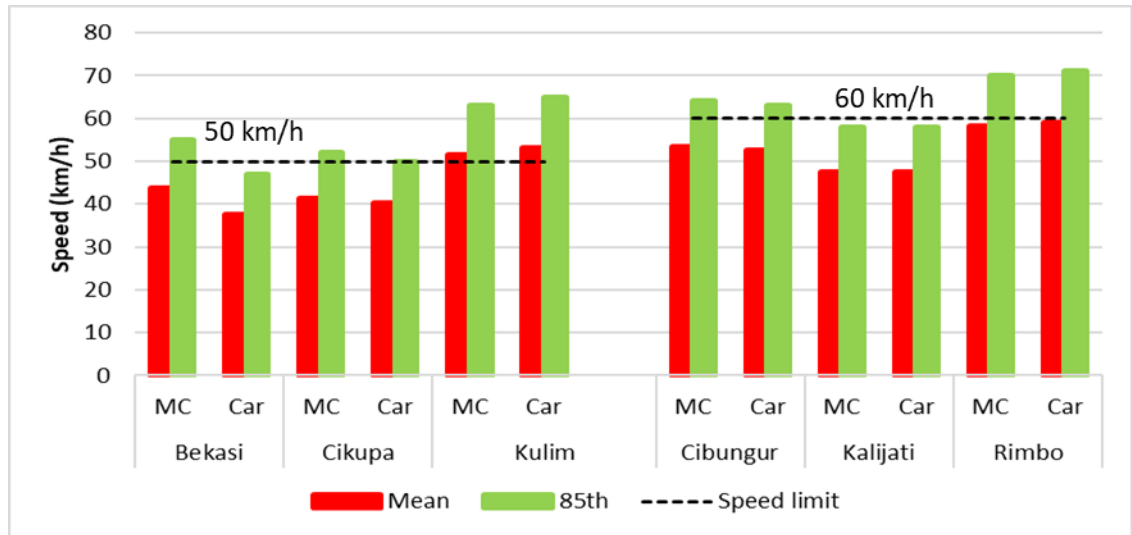
Figure 40: Motorcycles and cars' speed characteristics by survey locations

Figure 40 shows that motorcycles and cars' 85th percentiles in Bekasi, Kulim, Cibungur and Rimbo were recorded above the speed limit. However, only in Kulim and Rimbo motorcycles and cars' mean speed were observed close to speed limit.
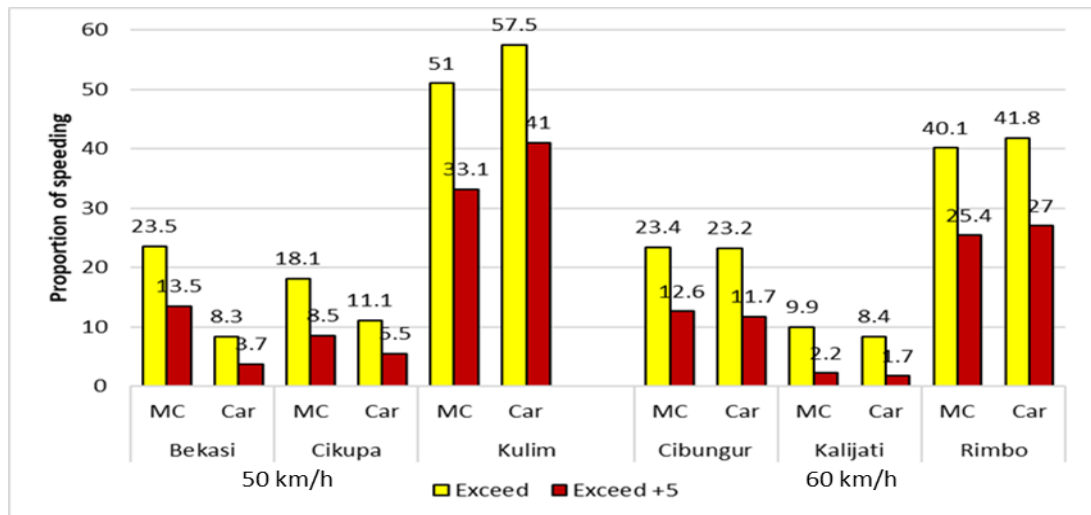
Figure 41: Proportion of motorcycles and cars exceeding the speed limit by survey location

Here, in Figure 41, the proportion were used to determine the difference of speeding proportion between cars and motorcycles in all survey locations. The number of cars and

motorcycles that exceeding the speed limit is roughly equal in Kulim and Rimbo at 51% and 57% and, further, 40.1% and 41.8%, respectively, for exceeding 5 km/h above the speed limit. In other locations, motorcycles' speeding varied between 9.9% and 24%, while cars' speeding varied between 8% and 23.2%. Overall, on the 50 km/h road, 30.50% of motorcycles and 40% of cars were observed to go over the legal speed, whereas on the 60 km/h road, 25.50% of motorcycles and 29.1% of cars exceeded the speed limit.

In conclusion, drivers all types of vehicles violate the speed limit, but it is clear that cars and motorcycles dominate speed limit violations in all locations considered in this research. There is a similar chance of speeding for both types of vehicle. Although, the number of motorcycles found to be speeding was higher than the number of cars, suggesting that cars have less of chance to speed due to traffic density where motorcycles can pierce through traffic density and cars cannot. Kulim and Rimbo are the locations with the highest proportion of violations. The higher the proportion of speeding violations, the easier it is to observe the effects of any intervention.

5.6.3 Speed based on road category: single vs dual carriageway

Furthermore, it is necessary to analyse vehicle speed characteristics in relation to road category, i.e. a single or a dual carriageway. Figure 42 shows the average speed for vehicles on single and dual carriageways.
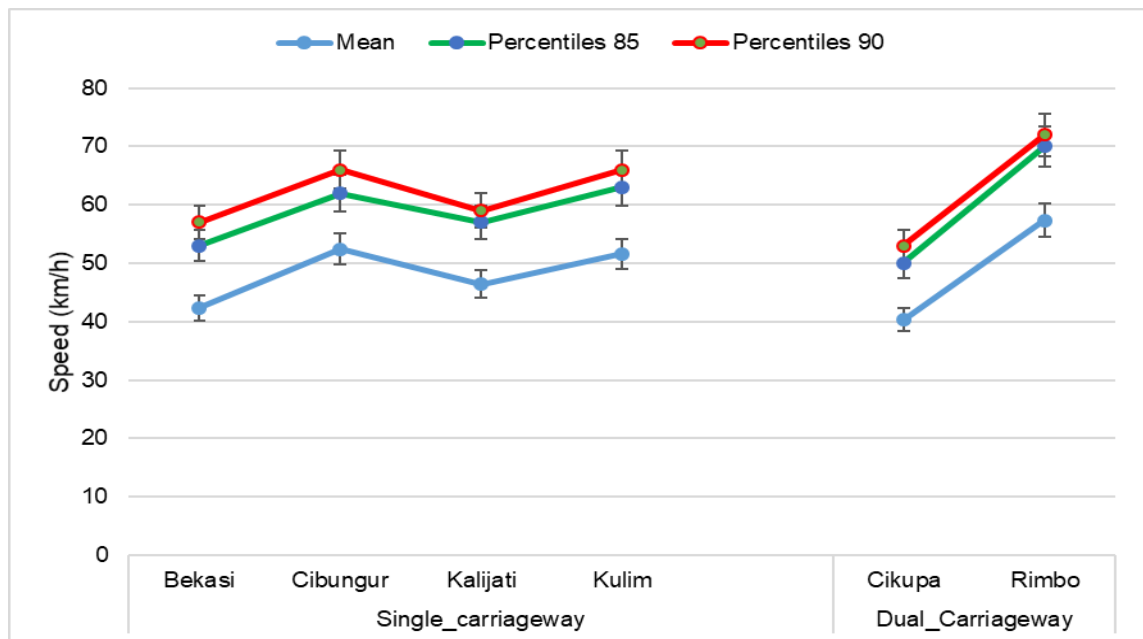
Figure 42: Mean speed, 85th and 90th percentile speeds on single and dual carriageways
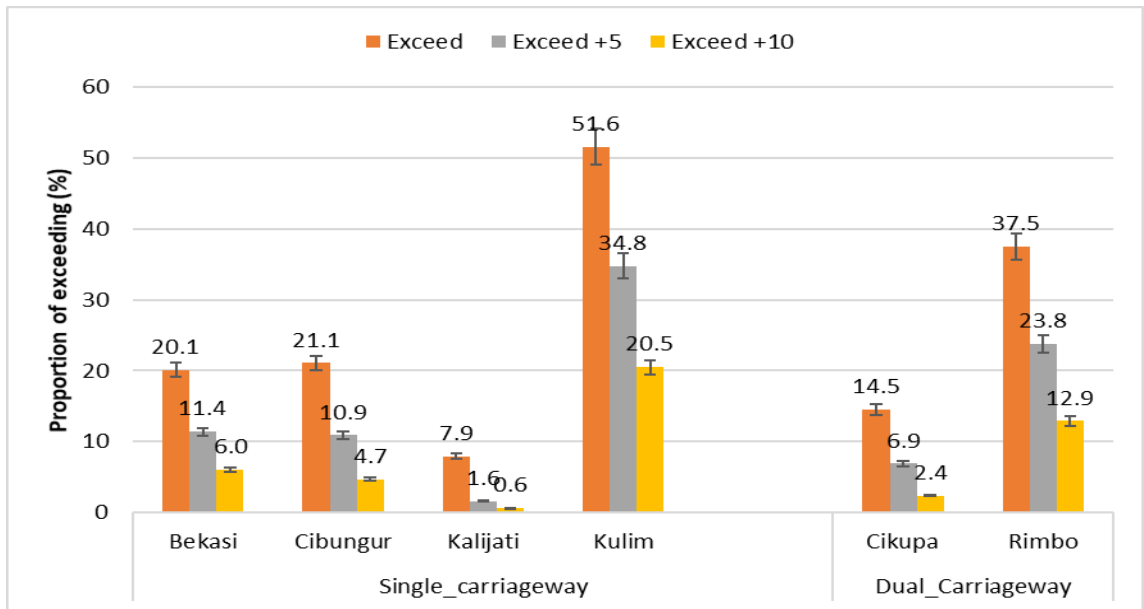
Figure 43: Average proportion of vehicles exceeding the speed limit

Similar to the results of the previous section, for the single carriageway category, as shown in Figure 43, Kulim has the highest proportion of speeding vehicles, while for the dual carriageway category, Rimbo came out on top. This result, once again, adds confidence that Kulim and Rimbo are locations that suffer intensely from the speeding problem compared to other sites, and therefore that they together provide a glimpse of problematic situations in both a single and a dual carriageway road category.

5.6.4 Speed based on day and time of travel
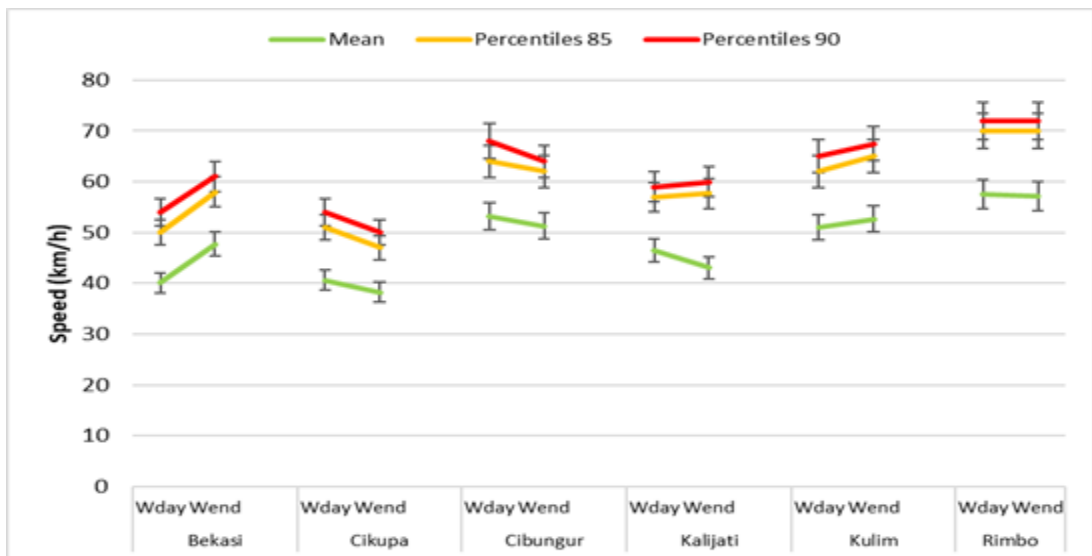
Figure 44: Average speed, 85th and 90th percentile speeds on weekdays and weekends

Another important factor that influences motorists' choice of speed is the day of the week and the time that the journey is being undertaken. It is acknowledged in traffic studies that vehicle

speed patterns are observed to be different between weekdays and weekends and between peak and off-peak hours.

Figure 44 shows that regardless of whether it is a weekday or weekend, the average speed at Rimbo was the highest compared to speeds at the other survey sites, as were the 85th and 90th percentile speeds. There were similar mean speeds observed between weekdays and weekends in Rimbo, but at other survey locations such a difference was observed.
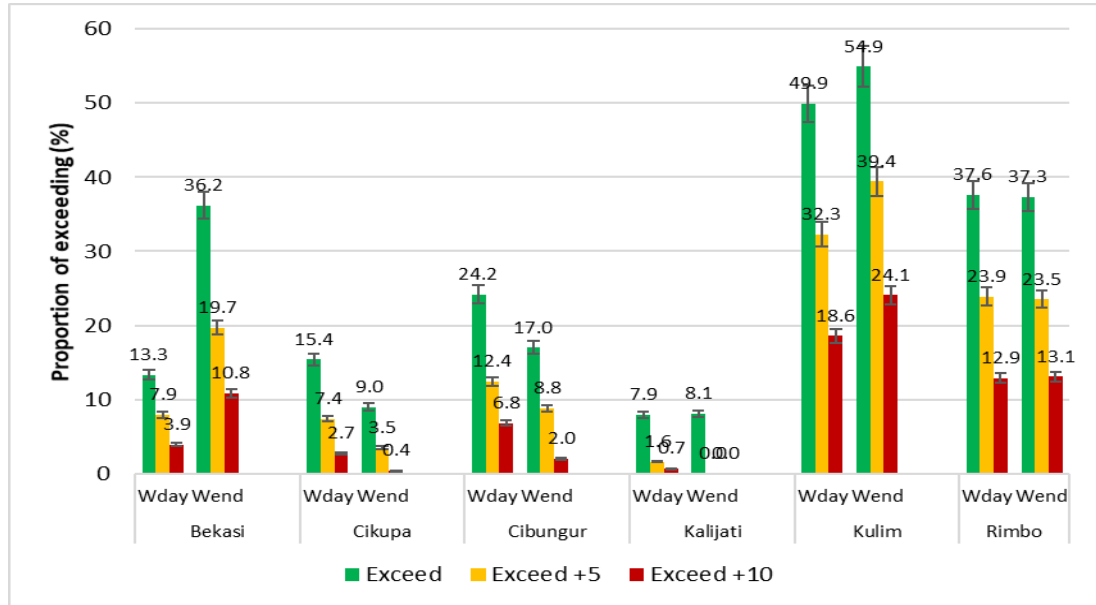
Figure 45: Proportion of vehicles exceeding the speed limit on weekdays and weekends

Figure 45 shows that the highest proportion of vehicles exceeding the speed limit was observed in Kulim, at approximately 49.90% of vehicles on weekdays and 54.09% on weekends. The 5% increase in the proportion of vehicles exceeding the speed limit during the weekend corresponded to an increase in traffic speed of 1.66 km/h.

Similarly, in Bekasi, there was a significant increase in the proportion of speeding vehicles on weekends: the proportion of vehicles exceeding the speed limit reached as high as 22.9%, which corresponded to an increased speed from 40.1 km/h to 47.7 km/h. In contrast, the average vehicle speed was found to decrease during the weekend in Cikupa, Cibungur, and Kalijati, which was also followed by a decreased proportion of vehicles speeding. Only in Kalijati did the proportion of vehicles speeding remain consistent across both weekdays and weekends. For further analysis, the survey results were plotted by the time of the survey, i.e. whether the vehicles were observed during a peak or an off-peak period. The speed variation across different times of day are presented in Figure 46 below:
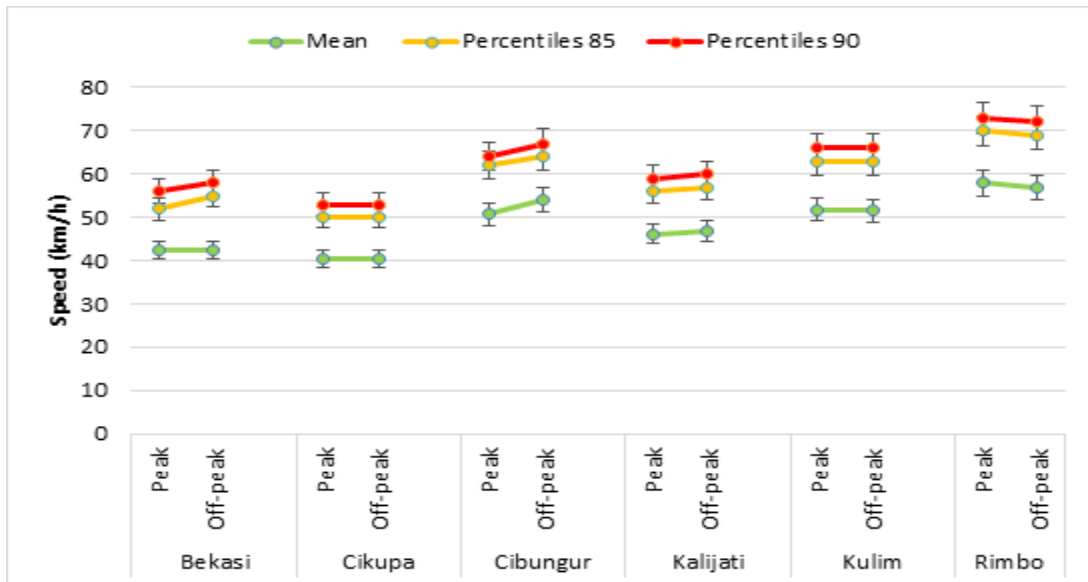
Figure 46: Average speed, 85th and 90th percentile speeds during peak and off-peak hours
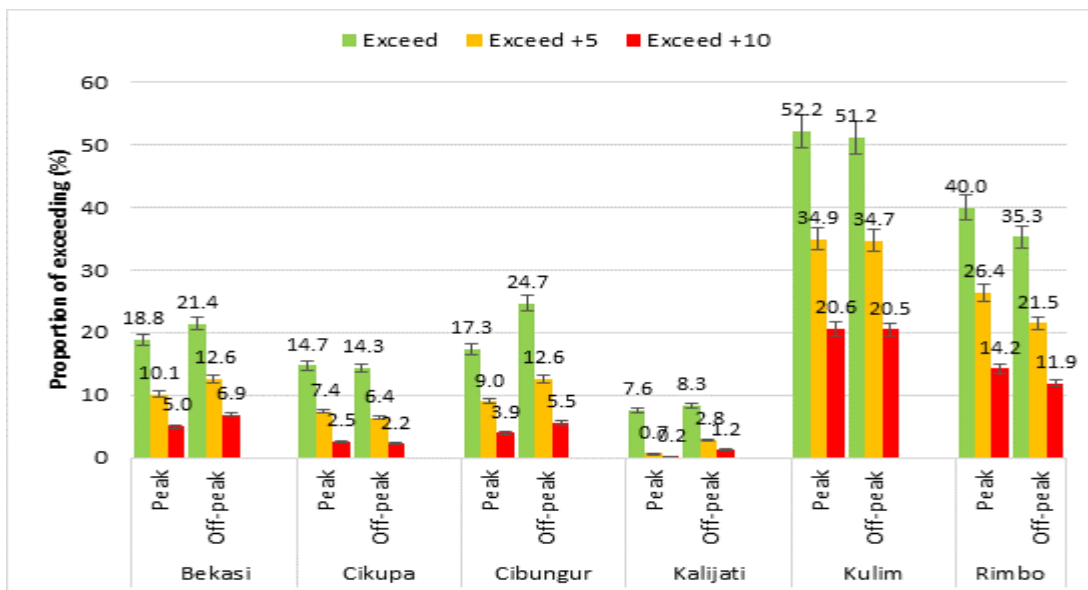
Figure 47: Proportion of vehicles exceeding speed limit during peak and off-peak hours

Figure 47 shows that, once again, Kulim had the highest proportion of vehicles exceeding the speed limit that reached above 50% of total recorded speed at both peak and off-peak times. Similarly, Rimbo has 40% of vehicles exceeding the speed limit at peak times and 35% at off-peak times. The variation in the proportion of vehicles speeding at peak versus off-peak times was less than 1% in Cikupa, Kalijati, and Kulim, while in Cibungur the proportion increased by 7.48% during the off-peak period, and in Rimbo it decreased by 4.77% during the off-peak period.

Overall, there was no substantial variation observed in average speed between peak and off-peak hours in most survey locations. Bekasi, Cikupa, Kalijati, and Kulim were observed to have less than a 1 km/h mean speed difference between peak and off-peak hours. However, a

substantial difference was detected in both Cibungur and Rimbo: during the weekend, Cibungur experienced increased mean speed and Rimbo encountered decreased mean speed.

5.7 The relationship between speed and flow (density)

Traffic speed, flow or volume, and density are all related to each other(Kononov et al., 2012; Hussain et al., 2011; Aarts and Van Schagen, 2006). Hence, another important characteristic of traffic flow is traffic density, which indicates the number of vehicles per unit length of the road. Under free-flow conditions, speed, density, and flow are all related by the following equation:

$$k = \frac{q}{v}$$

Where

k = Density (vehicles/mile, vehicles/kilometer)

q = Flow (vehicles/hour)

v = Speed (miles/hour, kilometers/hour)

Density is inversely proportional to the volume of traffic (Kononov et al., 2012). If the density increases, the speed will decrease, which then will be followed by a decrease in the volume of traffic, and vice versa. The chances of observing speeding are less in a higher density of traffic. Traffic density results for all of the survey sites are presented in Figure 48 and Figure 49.
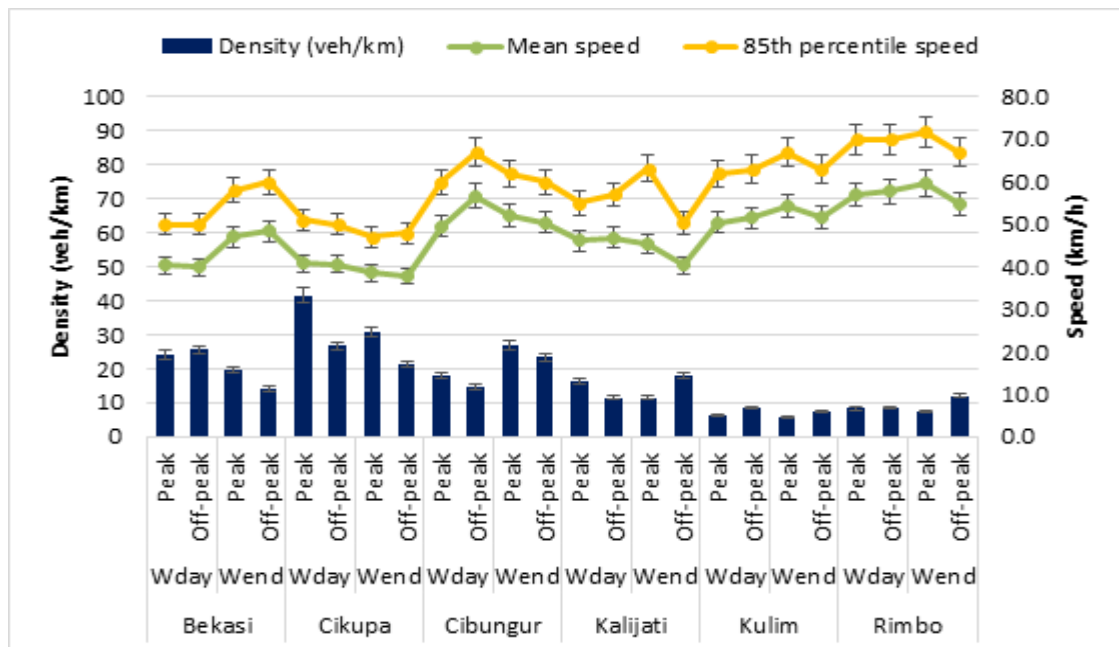
Figure 48: Traffic density and speed at all survey locations

Figure 48 shows that the traffic density for the Cikupa site, at 41.6 veh/km during peak hours on weekdays, was the highest among all locations, whereas the Kulim site had the lowest density at 5.6 veh/km during peak hours on weekends. High traffic density also occurred in Bekasi and Cibungur. The general trend was that traffic density was higher on weekdays than

on weekends, with Cibungur being the only exception. In Kulim and Rimbo, the traffic density was less than 10 veh/km for all survey days and times.
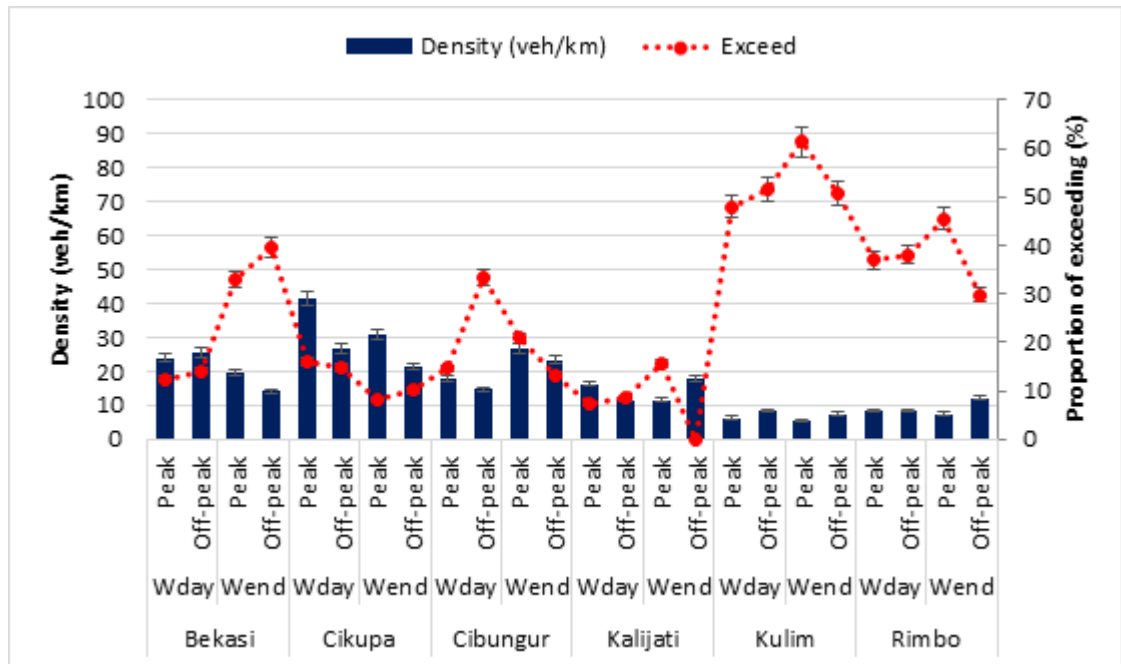
Figure 49: Traffic density and exceeding proportion at all survey locations

Figure 49 shows that there is a correlation between the proportion of vehicles exceeding the speed limit and the traffic density. The survey results revealed that at locations with higher traffic density locations, the proportion of vehicles travelling over the speed limit is small, as observed in locations Bekasi, Cikupa, Cibungur and Kalijati. Therefore, the highest proportion of speeding occurred concurrently with the lowest traffic density in Kulim and Rimbo.

5.8   Decision on study site

The purpose of this survey was to provide information that could be used to select appropriate study sites and vehicle types, and to suggest the optimal time and day for data collection, in order to provide us with the greatest opportunity to observe the effects of interventions applied in this study. Wherever possible, a study site should represent the diversity of problems related to speeding. Therefore, after assessing the survey results, the conclusions are as follows:

1. Analysis of collected traffic accident data suggested six survey locations. Based on their experience, police investigators recommended them as the accident spots related to speed factors.

2. All selected sites are major roads, with both urban and rural areas and single and dual carriageways represented, along with two different speed limits (50 km/h and 60 km/h), and good road surfaces throughout.

3. The highest traffic volume (PCU/hour) was recorded in Cikupa, while the lowest was in Kulim. Both extreme volumes occurred on weekday mornings. The highest number of vehicles per hour was observed in Bekasi to be 2412 vehicles. Since lower traffic volumes would provide a greater opportunity for free traffic flow, which is a requirement of this study, the sites at Rimbo and Kulim were determined to be the most favourable locations according to this criterion.

4. Motorcycles and cars dominated the traffic, at 92% of the total traffic volume. The average proportion of motorcycles in all six locations was 68%, while cars made up 24% of vehicles. Buses, LGVs, and HGVs made up 2%, 5%, and 1%, respectively.

5. The mean speed was observed to be below the speed limit in most locations, except in Kulim, where the average speed was recorded as being 1.6 km/h higher than the speed limit.

6. All 85th percentile speeds were found to be higher than the speed limit, except in Cikupa. A larger difference between the mean and 85th percentile speeds was found in Kulim (a difference of about 13 km/h), followed by Rimbo (a 10 km/h difference).

7. Cars' and motorcycles' mean speeds were observed to be higher than other vehicles' speeds. In addition, the proportion of motorcycles and cars travelling above the speed limit was higher than that of other vehicle types.

8. The 85th percentile speed of cars and motorcycles was higher than the speed limit, whether the speed limit was 50 km/h or 60 km/h.

9. For single carriageway roads, Kulim had the largest proportion of vehicles travelling above the speed limit, while for dual carriageway roads, the largest proportion of speeding vehicles was observed in Rimbo.

10. The percentage of vehicles exceeding the speed limit on 50 km/h urban roads was 16%, and on 60 km/h urban roads the percentage was 37%.

11. There was a difference in mean speed between weekdays and weekends at all survey sites except Rimbo.

12. The highest proportion of vehicles exceeding the speed limit was observed in Kulim, on both weekdays and weekends, and during both peak and off-peak times.

13. The lowest traffic density was found at the Kulim site, followed by the Rimbo site.

Based on these results, Rimbo and Kulim were selected as the most suitable sites to conduct speed enforcement studies. These sites have a greater chance of allowing the measurement of free flow speed; when traffic flows freely, the situation provides the opportunity for motorists to determine their own choice of speed unconstrained by external factors. The proximity of other vehicles (i.e., traffic density) in the other locations prevents motorists from driving at the

speed of their own choice. Also, the Rimbo and Kulim locations have a high proportion of speed limit violations, which allowed for a closer observation of the effects of interventions implemented in the present study.

The locations chosen showed similar patterns of speeding behaviour on both weekdays and weekends, and at both peak and off-peak times; this state supports the efficiency of the study by removing time constraints for study arrangement, although in actual observation, care was taken to run the experiment in higher chance of free-flowing traffic. The two locations also represent the diversity of factors to be examined: Rimbo and Kulim have different speed limits, different road categories (single and dual carriageway), and different locales (urban and rural).

The data indicates that all types of vehicles exceed the speed limit, but motorcycles and cars were considered more suitable for this study due to their high proportion of speed violations compared to other vehicles. This choice is not only related to the fact that there were a high number of both types of vehicles in the traffic, but also to the fact that that they were involved in speeding with a proportion higher than that of other vehicles.

5.9 Further development of method: test routes design and pilot test

Figure 50: Two test drive routes located in Pekanbaru, Indonesia

Based on the survey result, two routes were selected as study location to test the interventions. These routes are Rimbo and Kulim. The first route, Rimbo was characterised as a dual carriageway with a 60 km/h speed limit, while second route, Kulim, was characterised as single carriageway with a 50 km/h speed limit (Figure 50). Then, these routes were labelled as **Dual carriageway route (DC60)** and **Single carriageway route (SC50),** respectively**,** to symbolise their location and characteristics.

5.9.1 Ultimate design: virtual division of test routes

Two selected routes were prepared for the test drive. They are located in Pekanbaru City, Indonesia. Both routes consist of urban and rural roads with 13 reference points in each route. The urban section started from the research field office and ended at the city's periphery or vice versa and was considered to be the first (outbound) and the last segment (inbound). Participants would travel on the urban free phase in both segments. The routes continued with the main part of test route, which consisted of two parts, the control road and the treatment road, which are located opposite to each other and parallel. However, before switching from the control road to the treatment road, the participants would have to go through a free driving phase on a rural road and make a U-turn at a predetermined point. In total, 13 segments were constructed in this arrangement, as described in Table 10.

Table 10: Test drive route arrangement

Segment			Area	Dual carriageway route	Single carriageway route
No	Reference point	Label		Distance (m)	Distance (m)
1	Research field office	Start line	Segment 1	Urban	20000	16000
2	Start line	Parallel to billboard 3	Segment 2	Rural	4700	3500
3	Parallel to billboard 4	Parallel to police checkpoint	Segment 3	Rural	650	750
4	Parallel to police checkpoint	Parallel to police sign	Segment 4	Rural	275	400
5	Parallel to police sign	Parallel to billboard 2	Segment 5	Rural	360	350
6	Parallel to billboard 2	Parallel to billboard 1	Segment 6	Rural	670	500
7	Parallel to billboard 1	Billboard 1	Segment 7	Rural	11000	6000
8	Billboard 1	Billboard 2	Segment 8	Rural	670	500
9	Billboard 2	Enforcement sign	Segment 9	Rural	360	350
10	Enforcement sign	Police checkpoint	Segment 10	Rural	270	400
11	Police checkpoint	Billboard 3	Segment 11	Rural	650	750
12	Billboard 3	Finish line	Segment 12	Rural	4700	3500
13	Finish line	Research field office	Segment 13	Urban	20000	16000

With regard to reference points, they have been adapted to the design of interventions as follows: each control and treatment road was divided into five smaller segments, which were

positioned parallel to ultimately facilitate the comparison of test results between the control road and the treatment road; for example, segment 2 and segment 8 were placed parallel but facing in opposite directions.

Therefore, a completed participant's test track would consist of 13 segments. Segment 1 was dedicated for travelling from field office to starting line of test route. Then, the route continued with segments 2, 3, 4, 5, and 6 that were designated as control roads. Participants must make a U-turn at a specific point in segment 7, before they continued to segment 8, 9, 10, 11, and 12, which were set as treatment roads. After passing the finish line, participants returned to field office using segment 13. With regards to free-flow traffic requirement, segment 1, segment 7, and segment 13 were dedicated as free phases. Travel in these free phases was anticipated to exhibit non-free-flow characteristics, which consequently would not reflect drivers' free choice of speed. Free-flow was merely expected on the control and treatment road, both were also called main test segments in a later section of this report.

5.9.2 Establishment of roadside billboards on the test drive route

According to the experimental design, three billboards have been established on the test drive route. They were positioned sequentially along a series of designated points. Billboards 1 (segment 8) and 2 (segment 9) were placed before the police checkpoint, while billboard 3 (segment 12) was placed after the checkpoint. They were constructed after stage 1 of the experiment had completed.
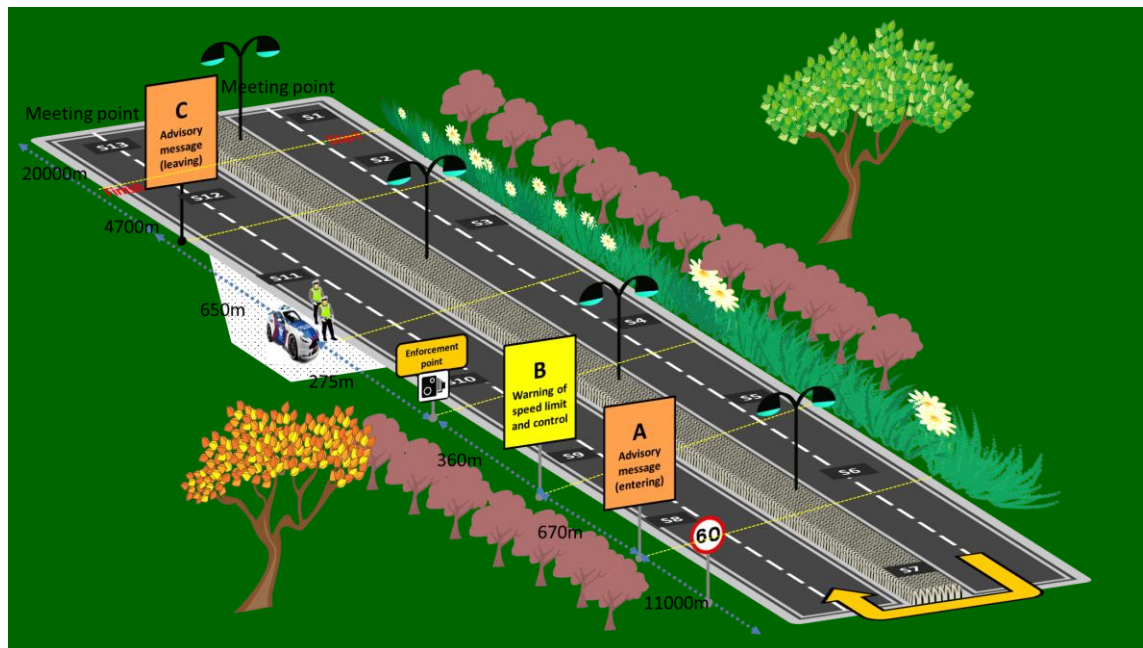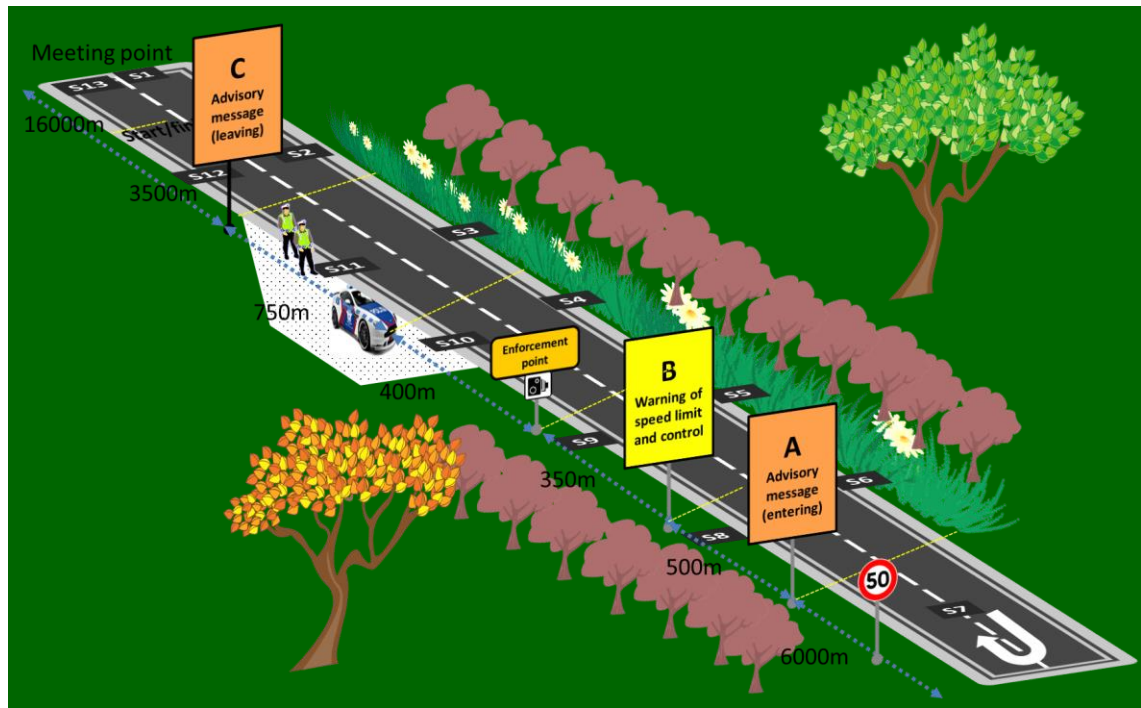
Figure 51: Billboard and police checkpoint location on test routes for dual carriageway (above) and single carriageway (below) routes.

However, due to geographical and environmental constraints, the distances between billboards in dual carriageway route and single carriageway route were to some extent different as described in Figure 51. The intention was to put the publicity in easily-spotted places, thus allowing the motorists to see the messages from a distance. Locations where visibility was obstructed, or the sites were found to be too close to manoeuvring points were avoided.

5.9.3 Deployment of police team on test routes

Police teams were required to be present on the route while the tests were being run. When they arrived at the designated checkpoint, police parked a marked vehicle in a position that allowed road users to observe the police's actions. Police would place a portable sign (segment 10) that notified the road users about their upcoming presence and activity on the site (segment 11). The assigned officer would aim the handheld speed gun toward the traffic stream. The other officer would write down the speed that was recorded by the speed gun.

However, police were not allowed to stop any vehicle other than the dummy vehicle, which was driven by an actor. There would be an interaction between police and the actor on the roadside so as to allow another road user to perceive a demonstration of real speed enforcement that was set up on the site. They must not chase or pursue the speed offender, though they may report another type of traffic violation or crime to the operation room at HQ. All standard operation procedures with regard to general policing, officers' safety, and the

contingency plan was normally applied. Several agreed circumstances must be reported to research field offices if they arose, such as the presence of another police team, a traffic jam, or adverse weather. Police would leave the checkpoint after all participants had finished the test drive. Please refer to Appendix A.5.

5.9.4   Experimental run order

The complete procedure for the experimental run is presented in Table 11.

Table 11: Route, group, treatment, and stage of the experiment

Route	Group	Intervention	Pattern	Training (T)	Police (P)	Publicity (R)	Stage
Dual carriage way 60 km/h	1	No intervention	*NI*	Absence	Absence	Absence	I
	2	Training only	*T*	Presence	Absence	Absence	I
	3	Police only	*P*	Absence	Presence	Absence	I
	4	Training and police	*TP*	Presence	Presence	Absence	I
	5	Police and publicity	*PR*	Absence	Presence	Presence	II
	6	Training, police, and publicity	*TPR*	Presence	Presence	Presence	II
	7	Publicity only	*R*	Absence	Absence	Presence	II
	8	Training and publicity	*TR*	Presence	Absence	Presence	II
Single carriage way 50 km/h	1	No intervention	*NI*	Absence	Absence	Absence	I
	2	Training only	*T*	Presence	Absence	Absence	I
	3	Police only	*P*	Absence	Presence	Absence	I
	4	Training and police	*TP*	Presence	Presence	Absence	I
	5	Police and publicity	*PR*	Absence	Presence	Presence	II
	6	Training, police, and publicity	*TPR*	Presence	Presence	Presence	II
	7	Publicity only	*R*	Absence	Absence	Presence	II
	8	Training and publicity	*TR*	Presence	Absence	Presence	II

The experiment was run in two stages for each route. The first stage consisted of four types of treatment where publicity was excluded (for groups 1, 2, 3, and 4), whilst in the second stage publicity remained present (for groups 5, 6, 7, and 8). For ease of police team deployment, the police presence was maintained continuously between stage 1 and stage 2 (groups 3, 4, 5, and

6). The test drive on single carriageway route was performed after the completion of experimental runs on dual carriageway route. To conclude, this experimental design employed strong control and made for a smooth and efficient experiment run.

Group assignment

This study applied random selection and random assignment of participants to groups in order to ensure that there was no systematic bias in assigning the individuals to the experimental groups. Furthermore, this procedure eliminated the possibility of systematic differences between participants' characteristics that could affect the outcomes, so that any differences in outcomes could be attributed to the experimental treatment.

To conduct this procedure, every participant pulled out a number from the prepared box that contained eight numbers corresponding to the experimental group (1, 2, 3, 4, 5, 6, 7, and 8). The first 120 participants were assigned to dual carriageway and the second 120 to single carriageway.

As the table shows, two test drive routes were prepared. Each route needed eight groups, labelled as Group 1 to 8. Every group of participants was exposed to a specific treatment. Group 1 was assigned as no-intervention, while group 2, 3, and, 7 were exposed to the single type of intervention. The rest of group were exposed to two or three combined intervention. All treatment that been conducted in the first route, dual carriageway, were repeated in the second route, single carriageway.

Participants' tasks

Every participant took part in the experiment individually and voluntarily. Once a participant arrived at the research field office, the opening information provided described the study to them as seeking to determine "the choice of speed during driving or riding as they [participants] do in their daily activity;" then, participants were requested to read the study information sheet and were asked if they would like more information about the study and their involvement. Once they had fully agreed to take part in the study, the participant then signed the consent form. A participant who was not assigned for training would be ready to start the test immediately, whereas those who were selected to attend the training would be directed to a classroom to attend a 45-minute training session that was conducted in discussion and consultation style. After training had finished, participants were asked to come back to the field office to be ready for the test drive.

As part of the next stage, the route was explained to the participant on a printed map that included the length of the test drive route and any points of interest. The participant would be

addressed few alternatives routes to reach the experimental starting point and informed that the traffic conditions on the road were reported as being free-flow. The participant was required to demonstrate a clear understanding of the route before further instruction continued. Furthermore, the participant was instructed not to make unnecessary stops during the test, such as taking breaks, refuelling, or making or receiving a phone call or text. The participant was suggested to take available food and drink, to save their phone and other valuable things in a provided locker, and to use the toilet prior to the test drive. If there were no further questions asked, participants were asked to make themselves ready in their vehicle.

It was compulsory that participants wear a seat belt or helmet and jacket throughout the experimental run. A GPS to record their speed was mounted in a clear, open sky position, and participants were instructed not do anything to the GPS such as switching it off, moving it to another place, or keeping it in a pocket or bag. As soon as the GPS beeped, meaning it had connected to the satellites, there would be no further instruction given to participants except to drive normally as they usually do. The participant then departed and formally started the test drive.

A test drive would take approximately 50—60 km or 60—90 minutes of driving, depending on the speed and route chosen. As soon as a participant was back to the meeting point, the GPS device would be switched off and dismounted from the vehicle. It must be connected directly to a computer so that the data log could be read and the data could be projected onto a Google Earth Pro map to see whether the route was observed and no breach of test rules occurred.

After each participant had completed the test drive, a short debriefing was conducted which mainly asked what happened during the test drive, whether the police were a presence on the road or not, whether they were able to see the road safety campaign billboards on the roadside, etc. If the result showed that the driver had completed a valid test route, the participant would receive a certificate of participation and money to compensate their time and effort in the test drive. However, the participant was considered failed if one or more breach of test rules found during the test based on their GPS data. There would not be any compensation, though they might request to take a re-test drive.

5.9.5   Pilot test

Prior to the experiment, pilot tests were conducted. The purpose of the pilot test was to examine the feasibility of the study design. At the outset, the pilot test was focused on assessing the quality of GPS devices' signal connection and data log, and secondly, to gather

information and opinions about the proposed experiment procedures and the proposed location of the intervention in order to improve the quality and efficiency of the primary study. The following subjects were tested in the pilot study:

1. Instructions being given to participants, police officers, and field office staff (investigators)

2. The correct installation and operation of GPS including the downloading of data from devices

3. Speed enforcement techniques and procedures (using a laser speed gun operated by police officers)

4. The participant's tasks and procedures before, during, and after the experiment

5. The validity of results (GPS data log analysis)

6. Information involved in the intervention, including a contact number of the police officer involved, speed limit, messages, symbols and figures on the billboard, training facility, and training material

7. The alternative routes for reaching the main test routes from the research's field office

8. The alternative police checkpoint and billboard locations

9. The field office arrangement, including parking, toilet facilities, waiting room, prayer room, and storage for research apparatus

The pilot study was very productive, thus providing valuable information on the development of proposed procedures for the main study, that include GPS data processing.

5.9.6   GPS data processing and analysis

Techniques for processing, exploring and analysing data with context of factorial experimental designs with a GPS data series response in each cell is challenging. The complexity of the data offers the following tasks:

1. Managing a large data set. The experiment generated approximately 1,152,000 GPS data points for 2 routes, 8 groups, 15 participants, a 1 hour and 20-minute trip, logged at 1Hz (about 4,800 data points), each of which features a time stamp, location identifier (latitude-longitude), elevation, length of trip leg, speed, etc., for each response variable. These 1,152,000 data points must be summarized in an understandable and informative way to aid pattern or model building.

2. The response in each cell consisting of 15 data series. Possible trends or other structures over time and distance must be explored in order to build an appropriate empirical model.

3. Measuring the effects of the factors requires definition and quantification of the difference between two response series in order to describe the effect. This definition depends on the structure of the data.

4. The author's interest was not only the main effects but also in the interaction effects among the factors. Defining interactions when the response in each cell is a data series requires close exploration of the data.

Therefore, the first step in doing analysis is to prepare the GPS data that record the participants' response during the test, then to present the speed profile that allows for the investigation of possible trends over time for this type of data through exploratory techniques. This step was followed by a statistical test. The presentation of results and analysis in several sections can be mixed with both works.

GPS data processing and data preparation for analysis

All collected data were prepared for analysis. This data preparation stage consisted of several steps that were included, but not limited to, the process of downloading, coding (anonymization), and storage, map matching through GPS track visualization, data cleaning to remove errors or invalid data points, smoothing, exporting and importing data, and converting data to the proper file formats. The aim was to make the GPS data ready to use in a suitable format and to optimize the validity and reliability of data prior to the analysis stage.

Data downloading, anonymization, and storage
After the test drive, GPS devices were connected to a personal PC, which was installed with vendor software to read the data log from the devices. The GPS data is anonymous data; a pseudonym was assigned to participants' personal information to ensure the confidentiality of each participant. Data was stored in a secure M drive on the University of Leeds' servers and has also been backed up on a personal laptop, in both cases being password protected and encrypted. A list of participants' assignments to route and group is presented in Appendix A.

Map matching for driving track validation
GPS data need to be validated in the first step by visual validation after being projected onto a mapping application. This is the initial step of validation, where each driving track and each participants' speed profile was mapped by the Google Earth Pro application, as presented in Figure 52 to assess whether the participant followed the right test route or not.

Figure 52: Visualization of GPS track and speed profile using GEP application

At the same time, the speed profile is showed on bottom screen that corresponds to participants' travel speed. The simple graph on the bottom of GEP helped the research team to recognize in early steps unusual speeds or invalid track points, i.e., points being anomalously high (spiky), inconsistency, signal jumping, and disruption of free-flow traffic during the test drive. Only correct driving tracks were marked as valid, while unusual speed profiles were noted and verified further in data cleaning steps.

Data cleaning for errors and invalid track points

Unfortunately, data obtained from a GPS receiver might contain errors in measurement. Although careful preparation has helped to minimize errors, a number of reasons that could not be eliminated affected the integrity, e.g. the scrambling movement while the vehicle was standing still. Furthermore, in many studies, as well as in this study, GPS tracks that recorded data in a travelling vehicle probably need very little filtering anyway, unless there were a lot of stops that may have produced GPS wandering.

Data cleaning consists of a filtering and smoothing process. Filtering takes care of systematic errors, while smoothing minimises the effect of random errors. Apparently, conducting cleaning for error track point is laborious. Therefore, a GPS track editor application was used to conduct an automatic filtering, which assumed the following points:

1. No movement was recorded (stationary) based on speed is zero and/or leg time (time between two points) was greater than 5 seconds (only applied to control and treatment road).

2. An unmanageable movement where speed is higher than 120 km/h.

3. An impracticable movement where acceleration is greater than ± 7 m/s^2 (the average rate of acceleration of all ordinary vehicles is between 3–4 m/s^2.

4. Less than 0.000005° change in either latitude or longitude (Stopher et al., 2005; Tsui and Shalaby, 2006).

5. Heading was zero or unchanged direction, except for the first recording at the beginning of each period of no movement (Stopher et al., 2005; Tsui and Shalaby, 2006).

6. At least 3 meters' leg distance away from the preceding valid position (distance between two points) (Flamm and Kaufmann, 2007).

7. Have altitude more than 100 meters above sea level for dual carriageway route and 300 meters for single carriageway route (refer to local topography data of Pekanbaru city) (Schüssler and Axhausen, 2009).

Furthermore, invalid track points that were found after GPS data were exported (in CSV format) and cleaned manually in Excel or SPSS. An example of this work is presented in Figure 53.
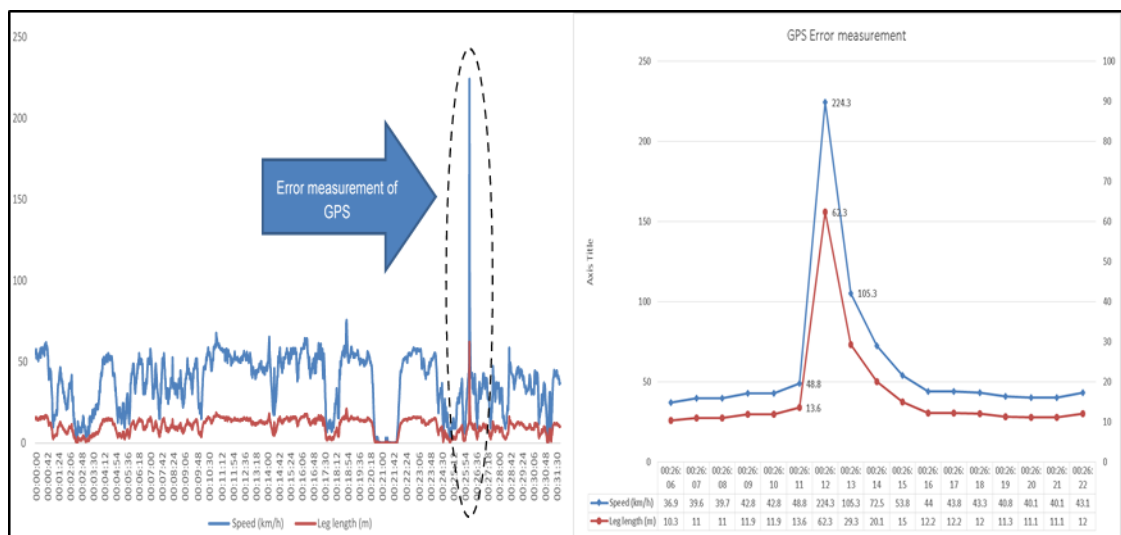
Figure 53: Invalid track point showed in speed graph

Meanwhile, after the data filtering process was completed, the data preparation was continued with data smoothing using the SPSS Smoothing (T4253H) function. SPSS Smoothing (T4253H) produces new series by applying a compound data smoother to the original series. The smoother starts with a running median of 4, which is centred by a running median of 2. It then re-smooths these values by applying a running median of 5, a running median of 3, and then hanning (running weighted averages).

Residuals are computed by subtracting the smoothed series from the original series. This whole process is then repeated on the computed residuals. The smoothed residuals are added to the smoothed values obtained the first time through the first process. Finally, the endpoints are smoothed by extrapolation and are not system-missing.
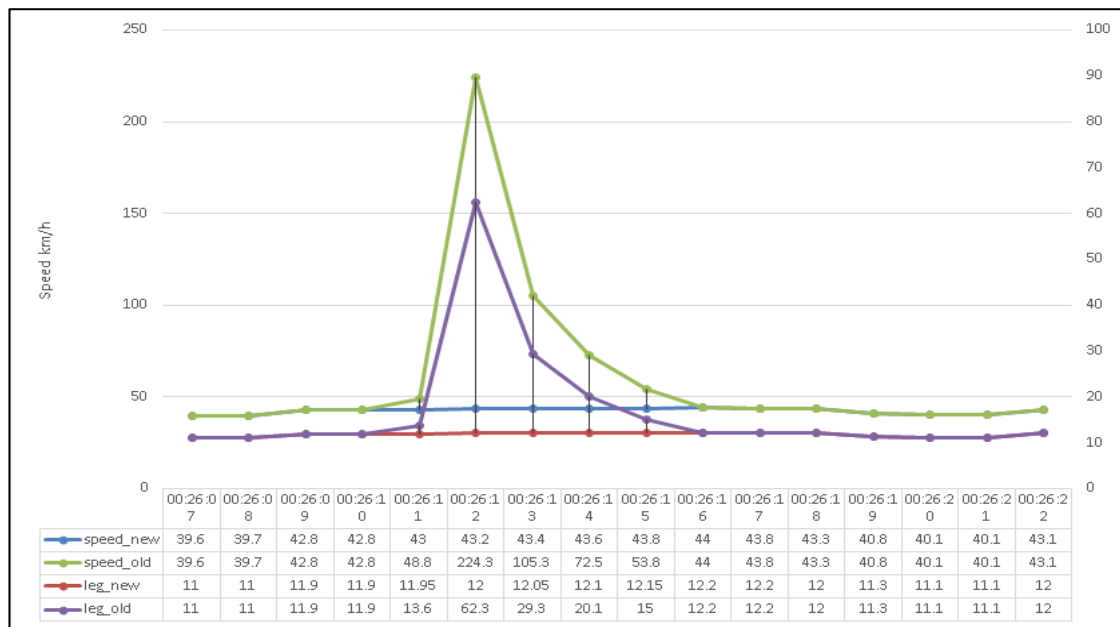
Figure 54: Speed filtering results: a comparison of errors and deleted track points

Nevertheless, the primary objective of data cleaning is to eliminate unrealistic data from the speed profiles. The results of the filtering and smoothing process must be examined to determine the effects of the quality of the smoothed data because they might result in different speeds, distances covered, and acceleration profiles as presented in Figure 54. Examination of the filtered and smoothed speed and acceleration was conducted statistically and visually by comparison to the original GPS-recorded speeds and accelerations.

GPS track editing and exporting

A completed test drive track consists of 13 segments that are related to the reference point as described in and marked with a flag on the map. The Garmin Basecamp application's split feature was utilized to divide the track into 13 segments. This activity was conducted manually by choosing the closest track points to the reference flag as presented in Figure 55 and the points were then displayed by varying the colour in Figure 56. After editing was finished, each segment was exported in CSV format and stored using same pseudonyms. GPS data was now ready to be opened in MS Excel or IBM SPSS for analysis.
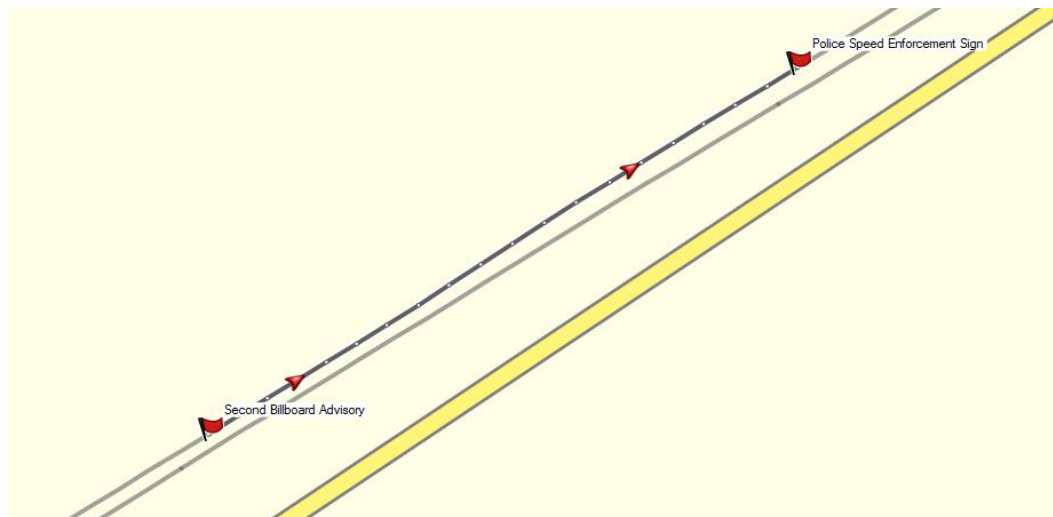
Figure 55: Track segment between two reference points
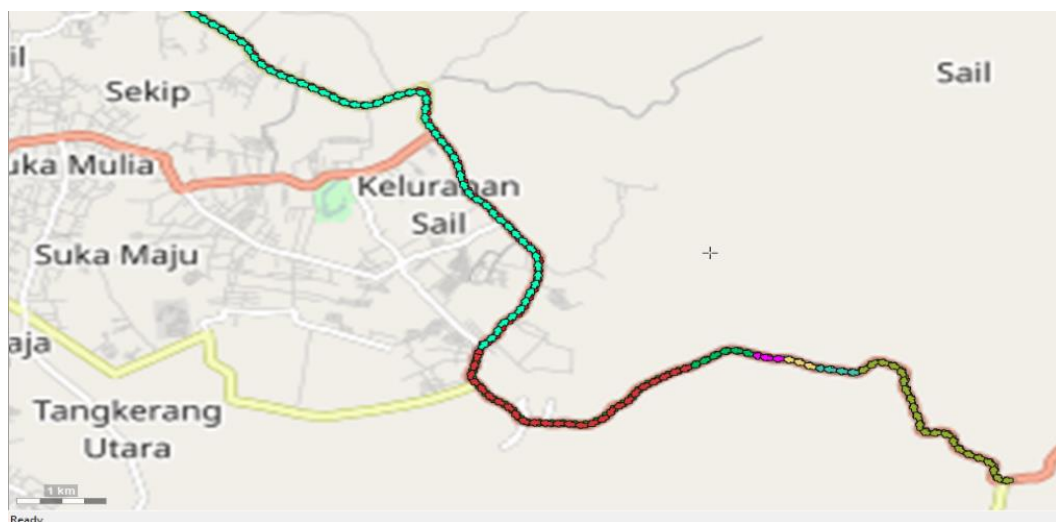
Figure 56: Segment varies by colour for rich visualization

Adding key variables to GPS data

The Microsoft Excel macro command program was used to add some key variables to GPS track data. Simultaneously, the Excel program would insert a few new variables in separate columns. These variables are the route, group, participant ID, segment ID, case record ID, training attended, police presence, publicity presence, whether a continuous distance from start point was observed, elapsed time, and acceleration (m/s^2).

Variable setup for statistical analysis

Data collected in this experiment were participants' choice of speed along the test drive route. Therefore, in the data setup, speed was labelled as "speedkmh." The treatments in this experiment were motorists' training in the section labelled "training," the presence of stationary and visible police on test drive route in the section labelled "police," and the presence of billboards on the roadside in the section labelled "publicity".

The segments of test drive routes were labelled as "segment_s," followed by the assigned number in accordance with intervention (or lack of intervention) that took place at these reference points. Segments 2, 3, 4, 5, and 6 were categorized as control roads, while segment 8, 9, 10, 11, and 12 were designated as treatment road.

Every statistical analysis would require a particular data setup, though the key variables that contain independent and dependent variable and participants' demographic data have remained unchanged.

5.10 Conclusion

This chapter describe the preliminary study of speed enforcement in Indonesia. The data related to speed, speeding, and accidents are key to the development of method of this study. Therefore, road and traffic survey were conducted in six nominated locations. Survey consist of road condition survey, traffic count and spot speed survey, included accident data extraction for these survey locations.

The result shows that two potential locations, namely Rimbo and Kulim, was selected as a study sites. Rimbo is a dual carriageway road, with 60 km/h speed limit, while Kulim is a single carriageway road with 50 km/h. The proportion of exceeding the speed limit on both locations was recorded higher than other locations, which also supported by low density of traffic for weekdays and weekend. The chance of observing free-flow traffic and motorists' actual or true choice of speed is high.

The survey result was used to enhance and develop the experimental study method, particularly for test route design, which include roadside publicity and police checkpoint locations, and followed by arrangement of intervention group. A pilot test was conducted to examine the feasibility of the study design, which was found very productive. A guideline for GPS data processing and analysis was developed to ensure the speed profile and statistical analysis used only valid and reliable data.

Chapter 6

Surveys of: motorists' attitudes and police job satisfaction

6.1 Introduction

Public attitudes toward speed, speeding, and police enforcement are an important aspect of speed enforcement (Cao et al., 1998; Musselwhite et al., 2010). Correspondingly, police, as the main body responsible for speed enforcement, must realise that a better policing approach is necessary in order to improve compliance, understanding, and acceptance of safer speeds (Homel, 1997; Williams and Stahl, 2008).

This study aims to develop more effective speed enforcement; therefore, it is important to understand current public attitudes—particularly those of motorists—towards traffic safety, speed, and speed limits, as well as public views on speed enforcement. Similarly, it is also critical to understand police officers' satisfaction with existing procedures of speed enforcement, as well as their knowledge and awareness of current operative speed enforcement strategies (Bono et al., 2001; Johnson, 2012; Dantzker, 1994; Boke and Nalla, 2009).

Two self-completion questionnaires have been utilised to capture 1) the public's attitude toward speed, safety, and enforcement, and 2) police officers' job satisfaction.

6.2 Survey method

The public attitude toward safety, speed, and speed enforcement, as well as police officers' satisfaction with the job they are currently doing with speed enforcement, are revealed through the following research questions:

1. What is the current public attitude toward safety, speed, speeding and speed enforcement?

2. How satisfied are traffic police officers with the current speed enforcement procedures?

The first question is answered through a public attitude questionnaire, while the second question is answered by a police job satisfaction questionnaire. In this report, public attitude questionnaire is abbreviated as PAQ and police job satisfaction questionnaire is called PSQ. Both surveys use descriptive research methods, which are a type of inquiry that aim to gather

information about or to observe certain phenomena, typically at a single point in time. PAQ is developed based on a similar questionnaire used by road safety organizations in Australia and New Zealand. Over the last 10 years, the public attitude questionnaire has been used to explore public attitudes toward road safety and its related factors, including speed and law enforcement in Australia and New Zealand (Land Transport Safety Authority, 2004; Petroulias, 2011; Petroulias, 2013). Nevertheless, not all questions were adopted, only the questions related to speed and speed enforcement were selected.

PSQ is based on Zeitz et al. (1997) organizational culture index in Boke & Nalla (2009). Based on an extensive literature review, Zeitz et al. (1997) developed ten priori dimensions of organizational culture and a factor analysis, which indicated five essential dimensions of organizational culture. The instruments developed by Zeitz et al. have been utilized in various studies and, "the scales have very acceptable psychometric properties in measuring culture attributes".

6.2.1   Questionnaire validation and pilot study

Prior to the pilot study, the content of the two questionnaires was validated. Inquiry into content validity was undertaken to ascertain whether the content of the questionnaires was appropriate and relevant to the study purpose; the study team wanted to ensure that the content reflected the broad scope of the aspects of the study, (DeVon et al., 2007).

To assess the content validity of PAQ, the researchers outlined the theoretical frameworks around safety, speed, speeding, and speed enforcement by undertaking a thorough literature review and seeking expert opinion. Similarly, PSQ was developed based on the theoretical frameworks around speed enforcement, road policing, police organisation, and police management.

Five experts and professionals in the areas of road safety, speed, drivers' behaviour, and police enforcement were asked to review the draft of questionnaires (28-item in PAQ and 27-item in PSQ) to ensure that the drafts were consistent with the conceptual framework. Each reviewer individually rated the relevance of each item on the questionnaires to the conceptual framework using a 4-point Likert scale (1=not relevant, 2=slightly relevant, 3=relevant, 4=very relevant).

Finally, both the questionnaires and the research information sheet, which was translated into the Indonesian language, have been tested through a pilot sample carried out with the target population. This process allowed for an evaluation of the appearance of the questionnaire regarding readability, consistency of style and formatting, practicability, and the clarity of the language used (Kelley et al., 2003; DeVon et al., 2007). Twenty drivers and five police officers

were invited to participate in the pilot test. The pilot study participants identified whether the instructions and the questions were understandable, the wording was clear, and the meaning of questions was the same for all respondents. Respondents were also asked for their opinion regarding the layout and style and whether the target individual would be able to answer the questions. When conducting the pilot study, the same procedures were used as in the main survey.

6.2.2 Participants

There are two types of participants in this study. The first type of participant is drivers or riders of the selected mode of vehicle (i.e. car drivers and motorcyclists), and the second type is traffic police officers. The characteristics for the motorists are as follows: male and female, age 16 years old and over, holding a valid driving licence, and travelling in free-flowing traffic. Participants were selected randomly, and their participation was voluntary. Participants' ages were observed to range from 16 to 72 years old, with an average age of 30.64 years old (*SD* = 10.47).

The next group of participants were traffic police officers from the enforcement division. The characteristics are as follows: active-duty police officers, male and female, age 19 years and over, and assigned to the traffic enforcement division or unit. Police participants in this study were selected randomly, and they were not under an obligation to take part if they choose not to do so.

6.2.3 Measurement tool and methods

Two sets of pencil-and-paper-based questionnaires, PAQ and PSQ, were prepared for this study. PAQ consists of twenty-eight questions, divided into six constructs, as well as a request for participant demographic information. These six constructs were general perceived road safety, perception of road safety factors, attitude toward speeding, perception of the speed limit, perceptions related to speeding and licensing, and perceptions around being caught by police. Constructs, themes, dimensions, and questions used in these questionnaires are discussed in the questionnaire result section.

Both questionnaires were designed to take no more than 10 minutes to complete. The questionnaires were approximately three pages of A4 paper with 28 and 27 closed ended questions. In both questionnaires, positively and negatively worded questions were utilized to prevent response bias. Response bias refers to answer patterns on questionnaires that do not reflect the respondents' actual state or opinion., but rather a favourable or the easiest answer and it can pose a serious threat to the validity of self-reporting instruments

As this study took place in Indonesia, the information sheets and questionnaires were available both in English and in the Indonesian (Bahasa Indonesia) language format. The police satisfaction questionnaire is presented in Appendix A.1, and the public attitude questionnaire is provided in Appendix A.2. Each questionnaire has been supplemented with a research information sheet.

The public survey took place on the roadside and involved stopping and questioning drivers there, a safe location away from traffic was provided, and safety arrangements for stopping, parking, and leaving the survey site were made. As a result, the police force was an integral part of this study, for only a uniformed police officer has the appropriate powers under the Indonesian Traffic Act 22/2009 to regulate and direct traffic.

Consultation took place during pre-study visits to the sites to enable any necessary agreements to be reached, particularly around the issue of participant safety. In order to set up a study site on the roadside, the Indonesian Police manual for "stop and check on the road" was used as initial guidance. In addition, Design Manual for Road and Bridges (DMRB) volume 5, section 1, Part 4- TA 11/09, Traffic Surveys by Roadside Interview, are also respected and confirmed. The final selection of study sites included detailed planning of the placement of traffic signs, enforcement signs, traffic cones, and police staffing, as illustrated in Figure 57. The design process also took into account that any obstructions to visibility must be diminished.
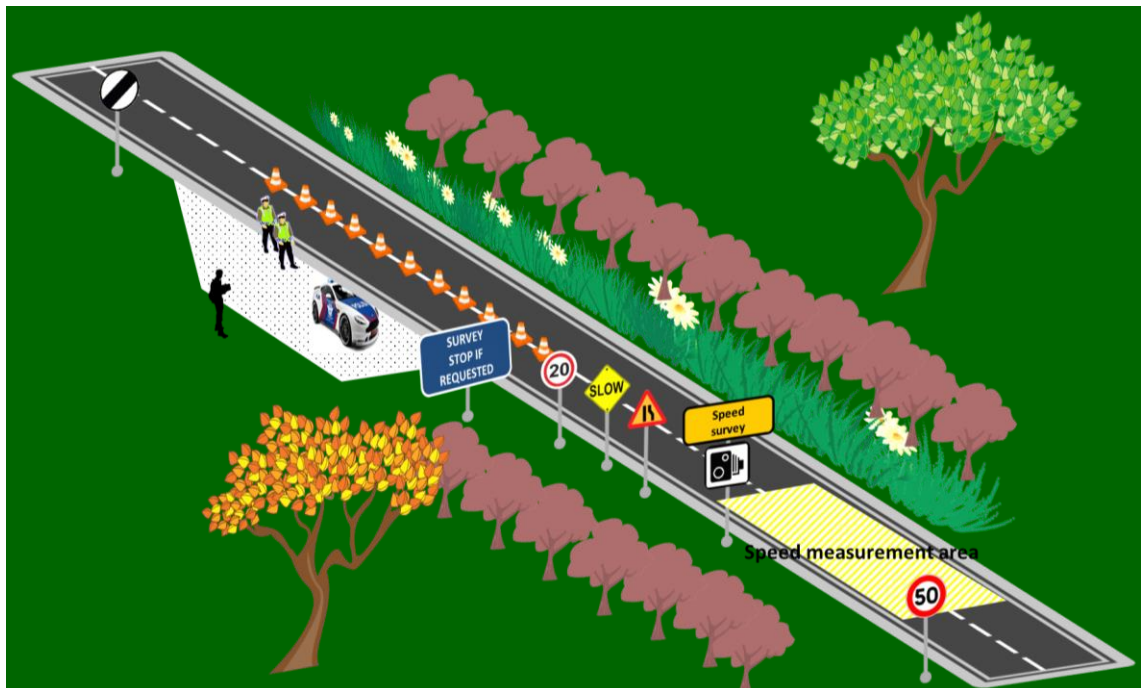
Figure 57: Refuge area set up as study site for motorist survey

Currently, police do not have the record of speeding offences, therefore the participants were selected among drivers who observed exceed the posted speed limit. As portrayed, a LIDAR speed gun and stopwatch were used as part of the participant selection process, along with a

traffic cone, portable traffic signs, and survey signs to mark the refuge area where the questionnaire administration took place. A personal computer and laptop were used to store the data in the field office.

6.2.4   Procedures

Motorist survey procedure

In order to select motorists to participate in the survey, police conducted speed enforcement on the road network around the site using a speed gun. When police spotted a vehicle that was travelling above the speed limit during free flow conditions (i.e. that had a 3-second minimum separation from the leading vehicle), a police officer requested the motorist to stop and explained the speed limit and the inappropriateness of the participant's chosen speed as shown in Figure 58. Only speed offenders were selected because they were considered to be related to speed enforcement procedures that were going to be tested in this study.

Figure 58: Police observed the motorist that travel above the limit and request them to stop

In each case, the police officer then introduced the research team and, at the same time, offered the drivers the opportunity to participate in the study by explaining the background and purpose of the study. Prospective participants were invited to read the research information sheet and were asked questions prior to deciding to participate in this study. Participants were not under any obligation to participate if they chose not to do so. When they fully agreed to take part in the study, participants signed the consent form and then were handed the questionnaires to complete on the site, as the questionnaires were designed to take no more than 10 minutes to complete.

At the end of the survey, the researchers explained that the questionnaire contained a final section where participants were invited to provide contact details (email, telephone, or mobile

number) if they thought that they would be interested in taking part in the later stage of the study.

Police officer survey procedure

The researcher collaborated with the Indonesian National Police Traffic Corps (INPTC) and the Regional Traffic Police Unit, particularly the head of the enforcement division -, in order to identify police officer participants. It was a very smooth process: the head of the enforcement unit agreed to provide a list of police officers who met the required participation characteristics. Subsequently, the selected officers were contacted and invited to participate in the present study. If they requested further details about the survey, they were encouraged to read the research information sheet.

Once again, with the help of an administrative officer, participants who agreed to take part were contacted by phone or email to arrange a meeting or to have the questionnaire delivered to them. They were offered the opportunity to ask more detailed questions prior to deciding whether to participate. The researcher explained clearly that their information would be completely anonymous, and that it could not be linked with their status and job in any way.

Ethical considerations pertaining to stopping motorists on the roadside

Before the study was carried out, there was a concern that motorist respondents might feel under pressure due to being stopped by the police. However, from the time when the police and the motorists began to interact, a brief opening statement was used to clarify to the motorists that the police speed check was conducted only for the free flow speed survey and not for proof of traffic violation or any enforcement purposes.

The researcher and the police manager closely observed the interactions and ensured that the duty to treat the participants ethically and respectfully was be observed by the police officers at all the times during the survey.

6.2.5   Questionnaire data analysis

Data was analysed using statistical application IBM SPSS 23, with negatively worded items being reverse scored to allow for consistent comparisons with positively worded items. A graph was produced to represent the percentage of participants' response for each question, using the following legend:

Strongly not agree	Not agree	Neutral	Agree	Strongly agree

Figure 59: Response label and colour

The percentage labels in Figure 59 were inserted in the graph, include for neutral response because they were participants' opinion or thought about that particular issue, neither agree

nor disagree. Therefore, the placement of the neutral category is at the midpoint of the scale. For other response, the higher the percentage, the wider the bar chart proportion.

Descriptive statistics

Descriptive statistics were used as an exploratory method to examine the variables of interest prior to conducting inferential statistical data on them. The data of interest includes the frequency, the average score of a scale variable, and the standard deviation (SD), which is the spread of the data around the mean of a scale variable. In terms of measures of the data, the median shows the likeliest response, the inter-quartile range (IQR) shows whether the responses are clustered together or scattered across the range of possible responses. Furthermore, the composites scores, a single overall score computed from multiple questions within the same construct (Laerd Statistics, 2015a). The scores were calculated by taking the sum of the items or the included in each construct. The composite shows one score that makes it easier to assess overall quality for attitude to speeding.

Once the composite score calculated, the analysis moved forward with conducting a reliability analysis to assess how well the items work together to assess the variable of interest. The Cronbach's alpha was used to evaluate the reliability of the items comprising a composite score.

Reliability test with Cronbach's alpha

Cronbach's alpha coefficient (α), also referred to as internal consistency or inter-item reliability, was used to measure the reliability of the results (Laerd Statistics, 2015a). The purpose of the reliability test is to determine if a group of questions all measure the same idea, as well as to assess the consistency of responses among a group of questions. The Cronbach reliability test assumes that the items being tested measure a single construct (i.e., that the construct is unidimensional) and that observations are independent of each other. The reliability test for the motorist attitude survey is presented in Table 12 and the test for the police job satisfaction survey is in Table 13.

Table 12: Reliability analysis result for public attitude questionnaire

Questions	No. of Items	Cronbach's alpha
General road safety	4	0.75
Key approaches to road safety	5	0.652
Attitude to speeding	7	0.694
Speed limit	5	0.344
Loss of license	3	0.655
Risk of apprehension	4	0.812

Table 13: Reliability analysis result for police job satisfaction questionnaire

Questions	No. of Items	Cronbach's alpha
Job satisfaction	4	0.72
Management support	8	0.82
Job challenge	5	0.52
Loyalty	3	0.78
Citizens' cooperation	3	0.74
Social cohesion	4	0.58

The guideline was applied for evaluating α values: > .9 excellent, > .8 good, > .7 acceptable, > .6 questionable, > .5 poor, ≤ .5 unacceptable (George and Mallery, 2011). Schmitt (1996) provides a further guideline that the smaller is the number of items available in the composite scores, the lower the alpha level is going to be. Since several constructs measure has only three items in the composite score, it was decided that .61 would be suitable to draw the cut-off line.

Statistical tests

To determine how much of the variation in the dependent variable is explained by the independent variables, a multiple regression analysis was used. Multiple linear regression is a commonly used statistical technique in the behavioural sciences. In its simplest form it allows the linear relationships between several independent variables (IV, or predictor variables) and a single dependent variable (DV, or predicted variable) to be quantified (Hankins et al., 2000).

Justification of and details about the regression test employed are explained in the statistical analysis of results' sections. Prior to running statistical tests, the basic requirements and assumptions were checked and tested, for example when the normality and homogeneity of variance were violated, non-parametric statistical tests could be used.

6.3   Result and analysis of public attitude survey toward speed, speed enforcement, and safety

In November and December of 2015, the questionnaire-based survey was conducted in the city of Pekanbaru, Indonesia. The survey attempted to determine what motorists perceive and feel regarding the current speed enforcement situation. A copy of this survey can be found in Appendix A.

6.3.1   Overview of survey participants (motorists)

Frequencies and percentages of participation are presented in Figure 60. The recruitment process resulted in a vast number of participants. Around 1200 motorists were identified and invited to take part, and a total of 764 motorists completing the survey, i.e. the overall response rate was 63%. Those who did not want to take part were mixed, either car drivers or

motorcyclists. Nevertheless, the number of female participants that agree to take part in survey was found less than male driver.
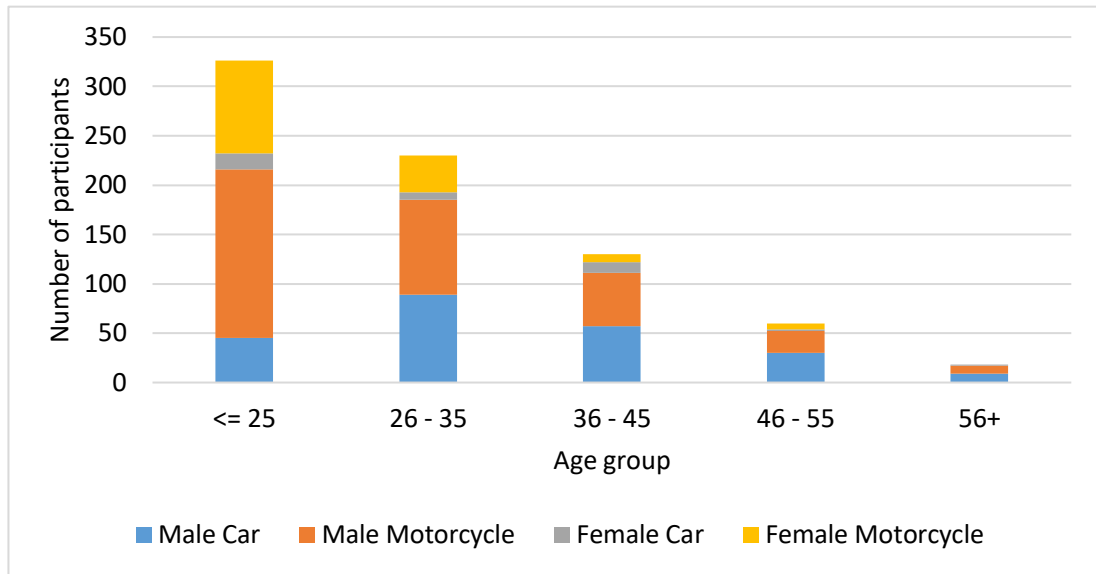
Figure 60: Participants' demographic data (gender, age-group, and vehicle)

The demographic proportions in each category reflect the demographics of general road users and traffic distribution in Indonesia, particularly in Pekanbaru. For example, the gender category, where men accounted for 76% of participants, reflects Indonesia's male-dominated traffic. Similarly, the proportion of motorcycles is almost double the proportion of cars. Based on vehicle registration data, the proportion of motorcycles is 70% of the total number of vehicles registered.

6.3.2 Perception of general road safety
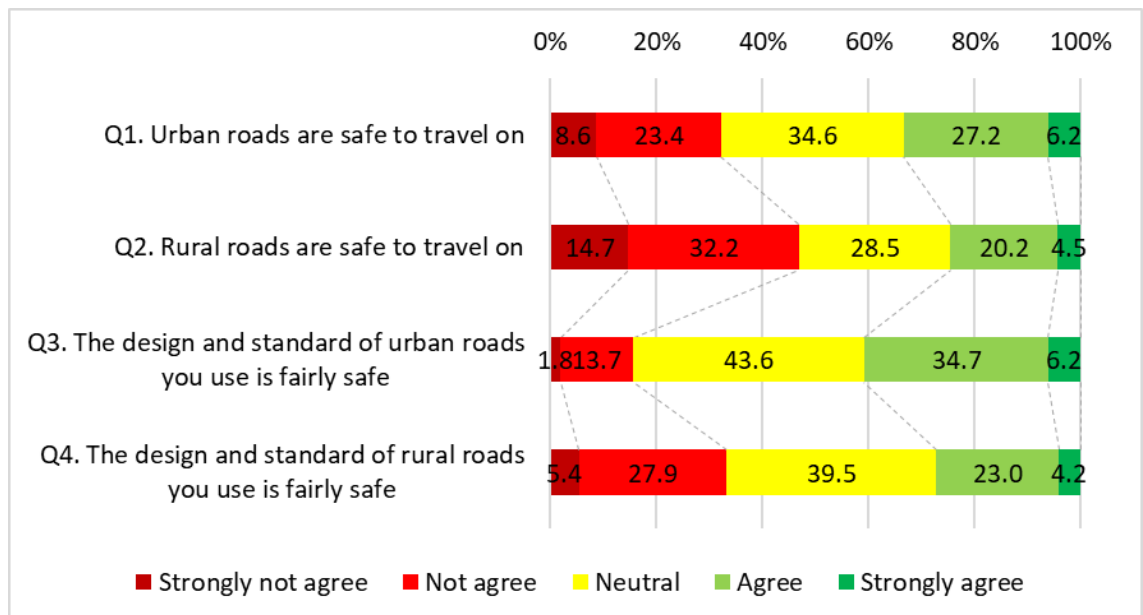
Figure 61: Motorist's perception of general road safety

The first four questions in the questionnaire explored drivers' perceptions about traffic safety in general, which seem to be related to the road they travel daily, including its design and standards, as presented in Figure 61.

The first and second questions about general safety on urban and rural roads get a notably different response. The public perception of safety on urban roads was split in two nearly equal proportions. On the other hand, rural roads outside the built-up area were considered to be more dangerous. A similar response pattern can also be seen between the third and fourth questions. Although the design and standard of the urban road were perceived as being fairly safe by the motorists, the design of rural roads was perceived as being less safe. The average composite score was 11.89 (SD = 2.981) out of a maximum score of 20.

It is evident that participant perception of both urban and rural road was less safe. Participants perceived that rural roads were more dangerous than their urban counterparts. This finding is not only because of the higher traffic speed on rural roads, but it may also be linked with the road environment condition (Tjahjono, 2003; Hidayati et al., 2012). There are far more hazards on rural roads than on urban roads, given the environment of rural roads, which are narrow in nature, with blind bends, dips, and other distractions, which can lead to loss of vehicle control.

Many segments of rural roads in Indonesia contains potholes, floods and puddles, slippery surfaces, and unpaved or uneven road shoulders. Based on researcher observations, there are still many road sections without signs, markings, or corners, as well as intersection designs with too many points of conflict, and additionally a low-discipline driving culture. In addition, the mixing of inter-city (regional) traffic and local traffic creates significant variations in traffic speed.

Nevertheless, the perception that rural roads are more dangerous than urban roads does not exist only in Indonesia: in other countries, e.g. the UK, the facts show that more people die on rural roads than on urban roads (GOV.UK, 2016). The number of accidents in the city may be higher, but the possibility of fatality from traffic accidents is greater on a rural road. The primary factors involved in rural accidents are a loss of control and travelling too fast for the conditions. Accidents have mainly been influenced by roads' curving characteristics, slopes, and other hazards. As a result, the cause of numerous fatal accidents on rural roads has been recorded by police as speeding (Collins and Stradling, 2008; Clarke et al., 2010; Tjahjono, 2010).

6.3.3 Perception of the key approaches to road safety

The second theme in the questionnaire looking for participants' perceptions regarding several key activities undertaken toward road safety improvement. The questions concerned road

engineering, enforcement and penalties applied, publicity, advertisement, and training for motorists related to road safety. These factors were chosen among many approaches that aimed to improve traffic safety and related to the main focus of study.
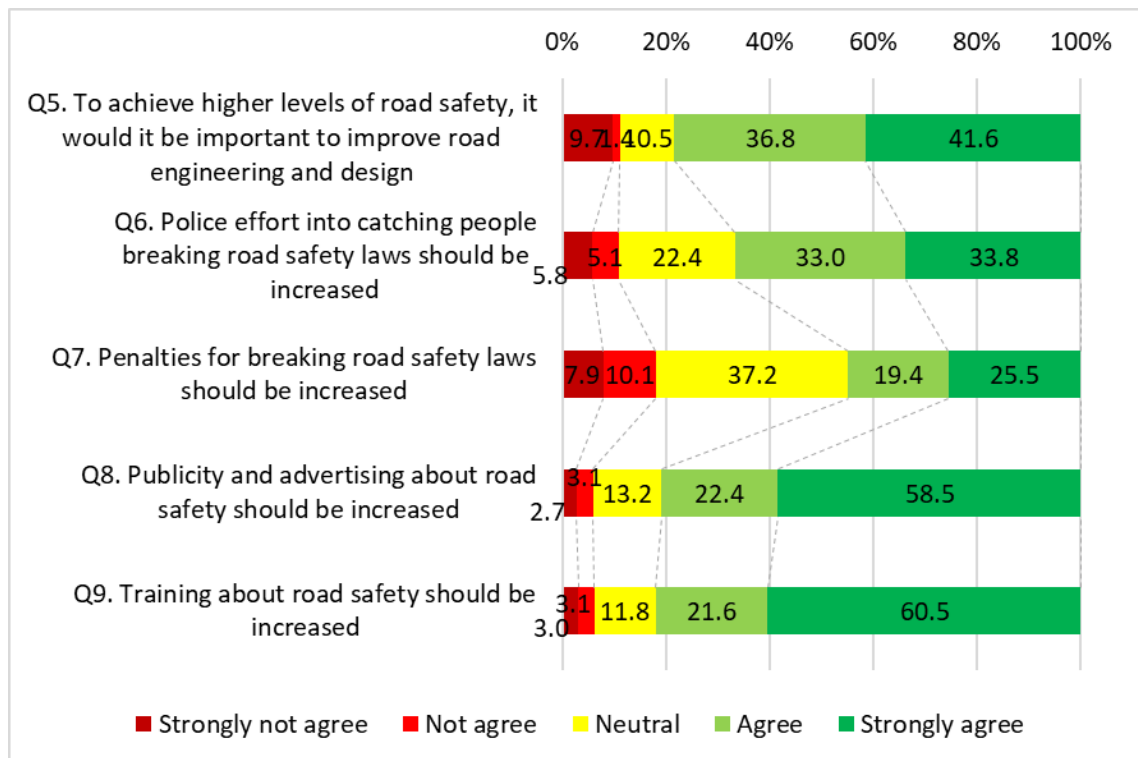
Figure 62: Motorist perceptions about the main road safety approaches

The average response to the first and second questions were 3.99 and 3.84 out of 5, respectively, which means that participants are in favour of the statement. Both IQR's score were 1, which indicates that the responses are clustered together. However, when participants were probed regarding the increase of penalties, the likeliest response was "neutral," i.e. neither agree nor disagree. There was strong support for increasing publicity and training about road safety. Overall, participants were in favour of improving of these key approaches to road safety.

Several factors contribute to traffic accidents, but speed is at the centre of the road safety problem. Many actions can be taken to reduce the number of traffic accidents, and the most popular approach is the 3 E's approach described in Chapter 3 - Engineering, Enforcement and Education. This approach can also be enhanced with publicity and campaigns. Regarding these approaches, survey results show that more than 80% of motorists prefer a "softer" approach, i.e. an approach through training and publicity. In fact, it turned out that the increase of penalty was perceived as the least desirable approach by the motorists.

The results show that the public feels the strongest support for publicity and advertisements that warn drivers about the speed limit and the consequences of speeding, as well as training

for motorists that increased their knowledge, skills, and experience. Police efforts and increased penalties seem to have little favour, since these approaches pose a great threat to the road users.

Nevertheless, there is an agreement that police must improve their presence to provide better protection and service to the community. On the one hand, people need police presence to provide a sense of safety and security on the road, but on the contrary, they are nervous when driving through police checkpoints (Ullman, 2013). Some people even felt worried with severe punishment when they were caught making a traffic violation. This result is in line with Zaal (1994), who concluded in his review that for enforcement to be successful it must present a meaningful deterrent threat to road users.

In many countries, when motorists are aware of police activities on a certain segment of the road, they switch their route. Various reasons causing this behaviour are as follows: the motorist does not want to pass in front of the police, they may be under the influence of alcohol or drugs, they may not have a valid driving license, or the vehicle registration may have expired. Further, the vehicle being operated may have some defects or problems such as dead light bulbs or specific equipment that does not function or is not standard (Engel and Calnon, 2004). Despite this public fear, based on the researcher's own experience as a policeman, many motorists who stopped and spoke with the officers found in the end that the interaction with the police was painless and sometimes even very helpful and informative.

On this issue, Corbett (2000) found that many drivers consider a traffic violation to be different from other crimes; even when people break the traffic law, they do not want to be compared to or punished as criminals, despite the fact that the consequences of such acts may result in the loss of someone's life.

Based on this allegation, any road safety approach applied, including police enforcement on the road and the associated penalties, requires effective social communication and publicity in order to improve the community's knowledge and understanding of enforcement efforts. Many reports have shown that the effects of publicity and campaigns alone are small, but that they have continuously increased a positive response (Rothengatter et al., 1989).

6.3.4 Attitude toward speed, speeding, and speed enforcement

The third section in this survey aimed to explore participants' attitudes toward speeding. Though placed in the third place on the questionnaire paper, this construct was designated as a dependent variable. It was preceded by two general constructs that asked for perceptions about traffic safety and the key approaches to improving road safety; hence, it was assumed

that the participants would be more focused in providing relevant responses to the questions about speeding and enforcement.
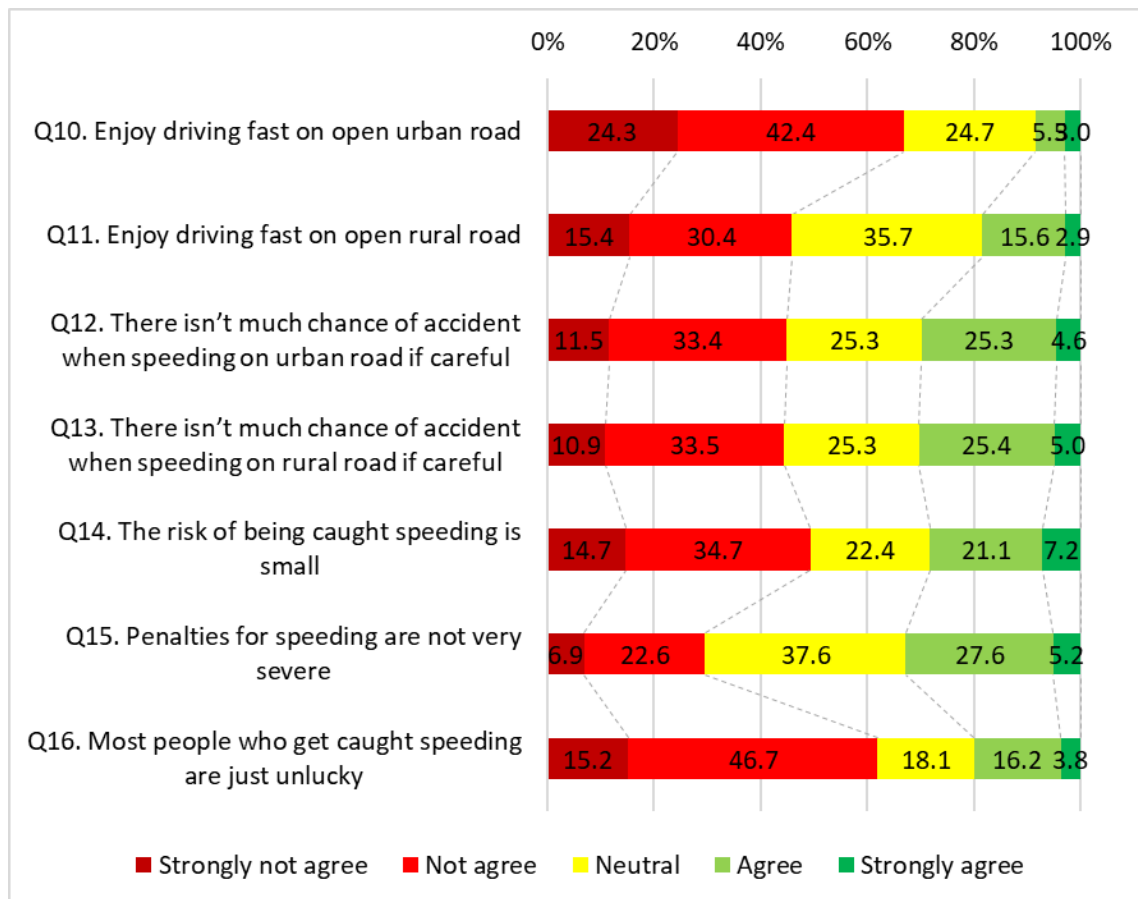
Figure 63: Motorist's attitude to speeding

Participants were asked whether they enjoy driving quickly on the road and how they perceive the risk of speeding and the speed enforcement conducted by police. These questions are critical to understanding the rationale and the decision-making surrounding Indonesian motorists' choice of speed.

The survey shows that the proportion of people who enjoy driving fast on rural roads is approximately twice the proportion of motorists who enjoy driving fast in urban areas. Nearly half of participants disagreed when asked if they enjoy driving quickly on urban roads. Furthermore, when asked whether the chance of an accident on urban vs rural roads is high if speeding, participants gave nearly similar proportions and range of response and were likely divided in their decision.

The current condition in Indonesia is that automatic speed enforcement does not exist. Speed enforcement is sporadic, rare, and always conducted manually by the police. Participant attitudes toward the idea of being caught by police are small (e.g. and divided. However, many people perceived that the chance of being caught speeding is not small.

A similar response was given by the respondents when asked whether the penalties for speeding are severe. The mean, median, and mode were 3 or "neutral," while the IQR shows a split attitude among the participants. However, when probed whether the ones who get caught speeding are just unlucky, the results of the IQR are 1 (Q1st= 2 and Q3rd = 3), most respondents indicated agreement with the idea that someone who gets caught for speeding is not just experiencing a misfortune.

Also, a composite score for attitudes to speeding was calculated as the sum of numerical responses to these seven questions. The mean of the composite score is 18.58, which indicates that the attitude to speeding tends to be negative. The IQR of the composite score was Q1st is 16 and Q3rd is 21.

This result shows that respondents consider speeding to be dangerous, and that they see it as linked with an increased risk of accident, although when probed about the effects of different road types, the response for whether participants enjoy driving fast on rural roads tends to increase. Participants have mixed views regarding the severe penalties for speeding: for some people, enforcement and severe penalties appear to be the most effective method to reduce speeding within a short period, but to others, the method is not comprehensive enough to tackle the speeding problem.

It is also evident that motorists appreciate the consequences of speeding and know that someone who is apprehended for speeding is not just unfortunate. This result is in line with what was mentioned in the ITERATE report, i.e. that most motorists essentially understand the risks of speeding and intend to keep their speed less than the posted speed limit (Tate and Carsten, 2008; Jamson, 2008). Nevertheless, due to various reasons, speeding motorists have failed to maintain compliance with posted speed limits. Unintentional speed violations are an important characteristic of drivers' choice of speed. More effective speed enforcement is required to deal with these circumstances. The factors and motives which may influence speed choice at an individual level, are situation-dependent to develop better speed management, more effective speed enforcement, and safer travel on the road.

6.3.5   Perceptions of speed limit

The fourth theme explored participant perceptions of the speed limit. This section started with questions on speed enforcement, which were followed by questions on whether the current speed limits on urban or rural roads travelled by the surveyed motorists are perceived as being too high. The last two questions probe whether motorists think that the current speed limit should be raised.
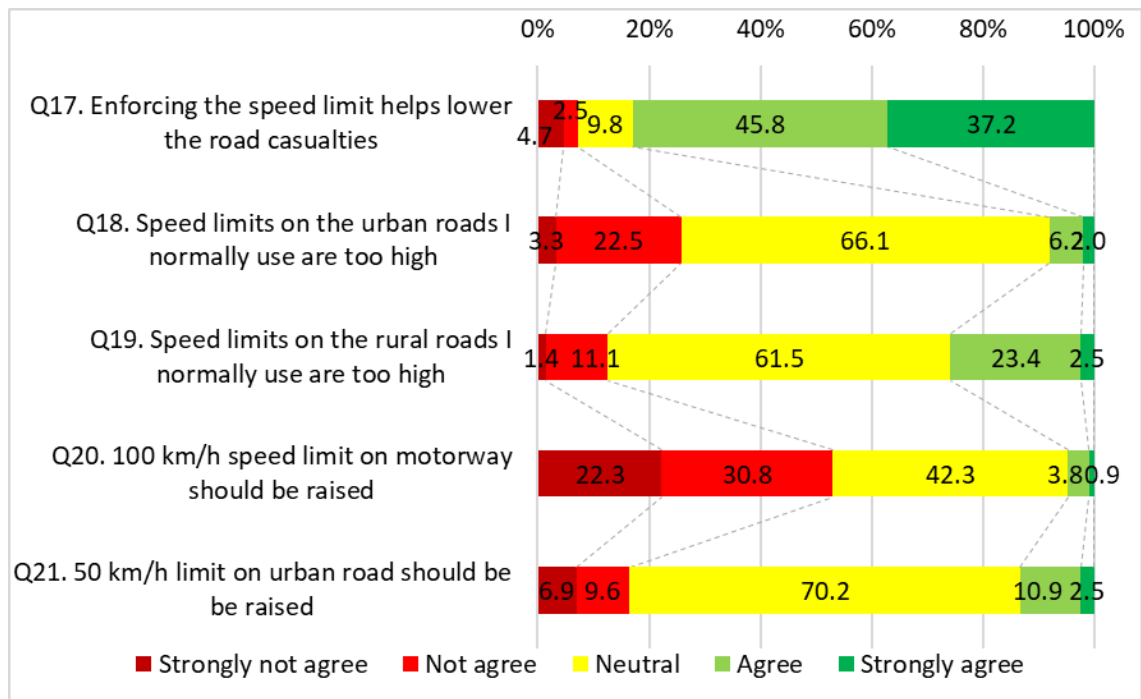
Figure 64: Motorist's perception on current speed limit

The results show that 83% of participants agree that enforcing the speed limit helps to lower accident casualties. However, 7.2% of respondents reject this idea. Furthermore, participants tend to disagree that the speed limits on urban roads is too high, instead agreeing that the speed limits on rural roads is too high. A similar (negative) response was recorded when raising the speed by more than 100 km/h on the motorway was proposed, while raising speeds above 50 km/h in urban road received a neutral response.

The speed limit is one of the most important tools in managing traffic speed. Many discussions on speed limit have taken place around speed limits' purpose, credibility, and appropriateness. This survey revealed one important discovery: despite a lack of posted speed limits in Indonesia, people believe that the presence and the enforcement of speed limits would lower the number of road casualties. These results are consistent with the argument proposed by Tarko (2009) that speed enforcement, as well as the risk of accidents, are considered to be speed deterrents.

Despite these views around speed, many road users occasionally travel over the speed limit for various reasons. One common reason, often admitted to by motorcyclists, was a lack of attention paid to the speedometer or a failure to correctly recognise the speed limit of a given road. Hence, drivers travelled at speeds that corresponded to individual perception only (Tarko, 2009). This result is in line with other research findings indicating that many motorists consider the existing speed limit to be appropriate for the road characteristics and traffic situation, and that they also consider the speeds that they have chosen to be within the safety limits (DaCoTA, 2012). Therefore, Indonesian road authorities must consider carefully looking

at the speed limits on every single road, so that the posted speed limit truly reflects acceptable travelling speeds.

Furthermore, the results show that the current speed limits on urban roads may be perceived as being too low, even though motorists do not agree that it should be raised. In Indonesia, many urban roads are overcrowded for most of the day. Even though the speed limit is set at 50 km/h, the speed that is usually experienced in traffic is below 40 km/h. After congested conditions pass, motorists tend to exceed the speed limit to compensate for lost time.

Based on the results in this section, it can be concluded there is both opposition and support for increasing speed limits on urban roads. In contrast, hardly any people agreed that the speed limit should be raised to over 100 km/h. Based on researchers' observations, this outcome is reasonable because, except on highways and toll roads, almost no roads in Indonesia are comfortably travelable at speeds over 100 km/h due to their geometry, layout, and road environment.

6.3.6 Perception of loss of license due to speeding

This section inquiries into the public acceptability of the speed enforcement measures that are currently under consideration in Indonesia. Police and judicial authorities have never applied the measure of automatic loss of licence for traffic violations. Rather, these three questions were designed to evaluate drivers' perceptions of extreme scenarios: the participant would have to foresee the situation, the violation, and the consequences.
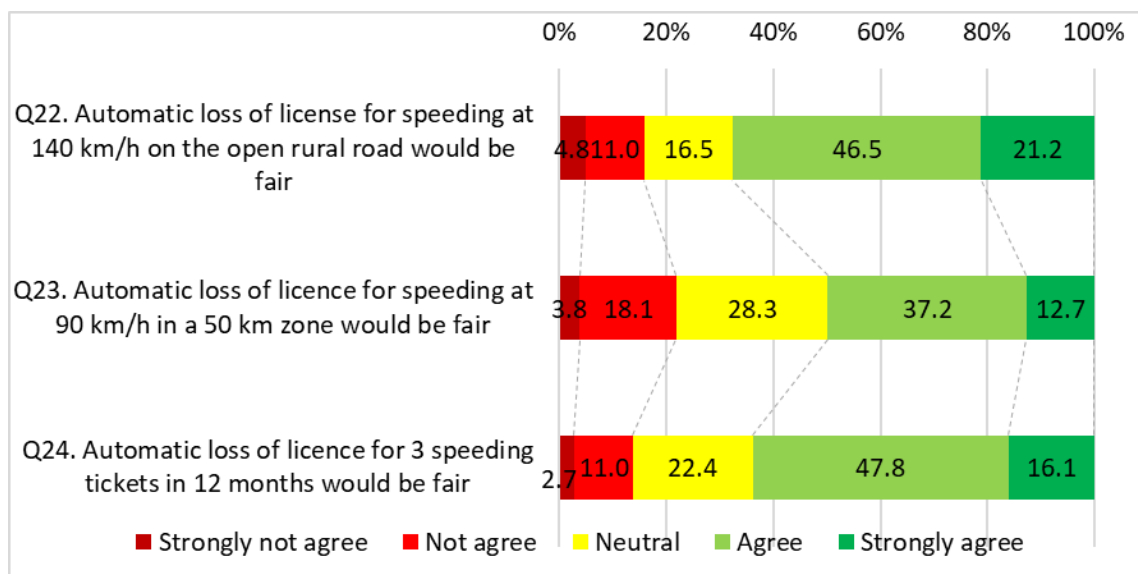
Figure 65: Motorists' perception of loss of licence due to speeding

The results show that automatic loss of licence for speeding at 140 km/h on a rural road and 90 km/h on urban road, was perceived acceptable, supported by an average score of 3.68 and 3.34, respectively. A similar positive response was seen for the question asking about loss of

license for speeding when the offender is a repeat offender; for this question, the average score is 3.63.

The results show that automatic loss of licence for speeding at 140 km/h on a rural road, where the speed limit varies between 60—100 km/h, was considered to be acceptable. Loss of license as a consequence for exceeding the speed limit, either in the form of accumulated demerit points or being directly summoned to court, has been adopted in various countries (Zaidel, 2002a; Mäkinen et al., 2003). In the UK, for example, the Association of Chief of Police Officers, replaced by the National Police Chiefs' Council (NPCC) suggests that when a driver exceeds the speed limit by a particular margin, which is usually 10% over the speed limit plus 2 mph, it would be appropriate to issue a fixed penalty notice, for the driver to attend a speed awareness course, as well as to issue a summons. Police usually offer the course as alternatives which means by attending the course means that offenders do not have to pay the Fixed Penalty Notice and they do not get penalty points on their licence. These are only guidelines, and a police officer has the discretion to act outside of them providing they act fairly, consistently, and proportionately.

In Indonesia, a comparable system, called the demerit point system (DPS) for traffic offenders, has been included in the Indonesian Traffic Act 2009. Unfortunately, the DPS clause has not been entirely implemented. Consequently, many people are not aware that traffic violations, in particular violations of the speed limit, not only can be fined, but also cause a person to lose the right to drive, or even to be imprisoned. Several factors were assumed to cause the delay in implementation and public awareness of this matter.

The results of this survey could serve as valuable information for police and other law enforcement agencies. At a certain level, the results of this survey show that people support enforcement against the drivers whose speed far exceeded the speed limit on the road. These results suggest that it may now be the right time for police and other authorities to clamp down on this type of driving before it results in more devastating accidents, as discussed earlier in Chapter 2 on the Indonesian context.

6.3.7 Perception of risk of apprehension by police

The questions in the last section in the survey asked participants how they perceived the chance of receiving a speeding ticket or being caught by the police for a general traffic offence. As an example, currently in Indonesia, automatic speeding tickets are not issued. No fixed penalty notice is issued without an interaction between police and motorists. Therefore, in the case of traffic violations caught by the police, the driver must be stopped, checked, and interrogated before being given a speeding ticket.
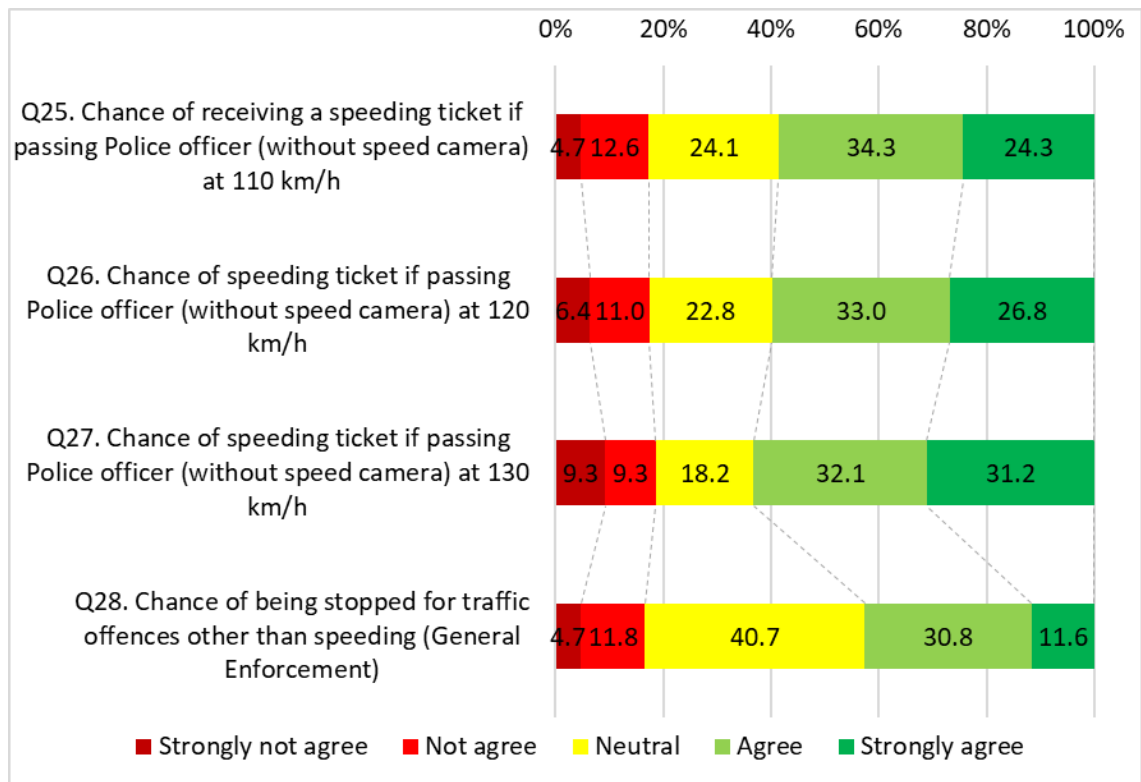
Figure 66: Motorists' perception of risk of apprehension by police

The result shows that a similar response, approximately 60%, was common to the first three questions. However, the higher the speed involved in the question, the stronger the support for the statement was observed to be, even if the difference among the mean scores for the different questions is small.

Nevertheless, for the last question that asked participants about the chance of being stopped by police for traffic offences other than speeding, the result shows a neutral response. However, the proportion of respondents recorded to be in opposition to this statement also should not be disregarded. There were more than 15% of participants believed that the possibility of apprehension for violations of general traffic offences, is low.

Motorist perceptions of the risk of apprehension is one of the most challenging debates in road safety research literatures. Several reports have argued that the apprehension of offenders is a key component of increasing speed limit compliance and maximising the effectiveness of speed enforcement (Elvik and Christensen, 2007). Additionally, the risk of apprehension depends on the individual's information set, the level of police presence, and the apprehension rate. Furthermore, increasing the apprehension rates should not be perceived as a means of raising revenue, but rather as a way to decrease the number of accidents and accident casualties (Tay, 2010).

Most of the police in Indonesia have not been using radar or laser speed guns to detect vehicle speed. Instead, police use visual detection by comparing the speed of the offender with that of

other vehicles or with general traffic speed, as well as by observing the speedometer while chasing the offenders. Offenders are usually intercepted by another unit at a point that does not allow the high speed. When a chase is conducted the risk is huge, both for the perpetrator and for other road users, as well as the police, and such a pursuit would also attract interest. For all these reasons, these methods are rarely conducted.

This result demonstrates that the perception of the probability of apprehension for speeding is reasonably high. This perception could indicate that people are aware of and familiar with police capacity to deal with speed offenders. Some participants may have the opportunity to witness and/or experience how the police act when detecting a speeding vehicle on the road. As an outcome of this section, it could be argued that a higher apprehension rate for certain traffic offences does not imply the reduction of accidents and casualties. A small number of apprehensions for a specific violation could better determine the public perception of risk of apprehension.

6.3.8   Determining attitudes toward speeding, enforcement, and road safety

It is important to understand the contribution of each independent variable towards the dependent variable - motorists' attitudes toward speed, speeding, and speed enforcement. Therefore, a multiple regression has been utilized to reveal how much of the variation in the dependent variable can be explained by all of the independent variables.

The dependent variable in this survey was an on additive scale, combining the seven variables of attitudes towards speeding into one dependent variable. A similar procedure was applied to all independent variables (see method). The additive scale was assumed to be continuous; it is the basic rationale of using regression analysis in this study. All of the selected predictors were included in the multiple regression model.

Prior to the statistics test, the study's justification and assumptions were assessed based on the methods recommended by Cohen et al., (2003). There was independence of residuals, as evidenced by a Durbin—Watson statistic of 1.900. The independent variables collectively were linearly related to the dependent variable as shown by the scatter dot plot. A linear relationship was noticeable between the dependent variable and each of the independent variables, as assessed by the partial regression plots. There was homoscedasticity, as determined by a visual inspection of a plot of studentized residuals versus unstandardized predicted values. The points appear to be randomly distributed with a mean of zero and no apparent curvature.

To examine the multicollinear correlation, the coefficients and tolerance/VIF values were inspected. Multicollinearity occurs when two or more independent variables re highly

correlated with each other (Laerd Statistics, 2015c). This leads to problems with understanding which variable contributes to the variance explained and technical issues in calculating a multiple regression model. The test result shows that none of the independent variables have correlations greater than 0.7, which indicated that no independent variables were highly correlated with each other. No tolerance/VIF value was found to less than 0.1, which indicated no collinearity problem in the data set.
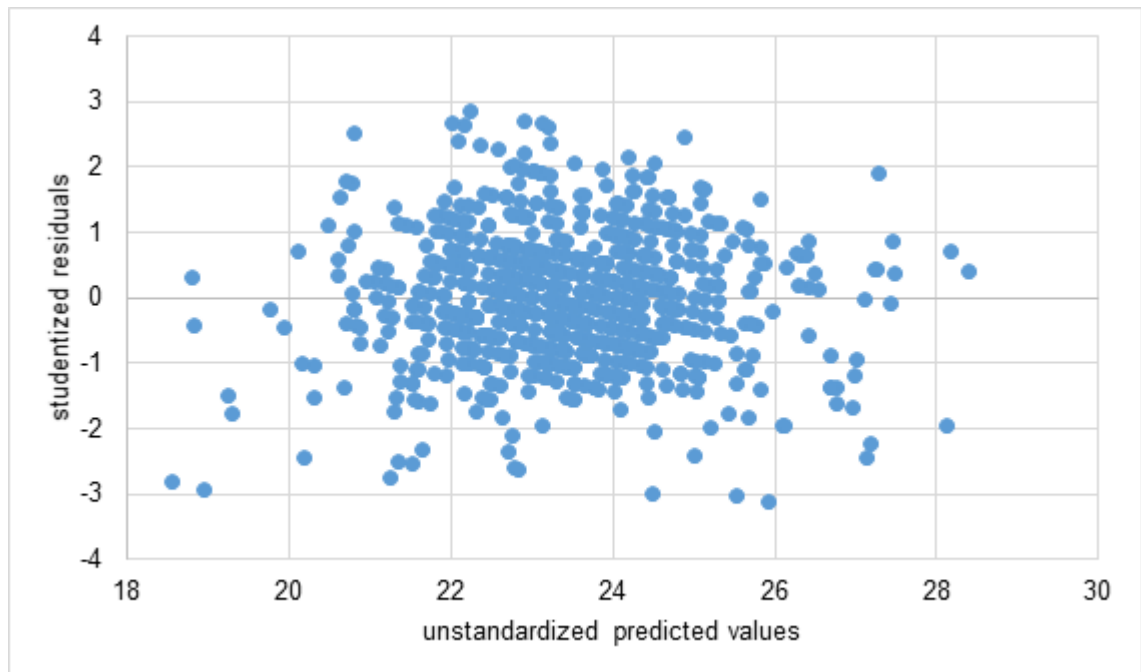
Figure 67: Example of residual plot for perception on the construct of being caught by police

There were three outlying cases in dataset which were found to have values greater than ±3 standard deviations from the mean. To determine if they should be removed, the cases were investigated. The decision was made to keep them in the analysis since there were no errors or mistakes in the data entry, but the outlying data were noted in case they had a large leverage value and/or influence on the mean or other measures; all the measures have to be considered together. Finally, the leverage value was checked for the data, and no value was found to be greater than 0.2. This result is considered to exhibit high leverage and therefore to be risky.

Furthermore, the Cook's Distance values for each case was assessed. Cook's Distance is a measure of influence; if there are Cook's Distance values above 1, they should be investigated. It was found that in the present results there are no Cook's Distance values above 1 (Cook and Weisberg, 1982).

A histogram with a normal curve and a P-P plot were both produced to for the assumption of normality of the residuals. The histogram shows that the standardized residuals appear to be

approximately normally distributed. The P-P plot confirm the normality of the findings; the data points for the residuals were aligned along the diagonal line.

The results of the linear regression model were significant: $F(5,755) = 13.53$ and $p < .0001$ and $R^2 = 0.125$, indicating that approximately 12.5% of the variance in public attitudes toward speeding is explainable by the independent variable, age, gender, vehicle type, perceptions of general road safety, perceptions of main road safety approaches, perceptions of speed limits, perceptions of loss of license related to speeding, and perceptions of risk of apprehension by police. Regression coefficients and standard errors can be found in Table 14.

Table 14: Summary of multiple regression analysis

Variable	B	SE$_B$	Beta	t	Sig.
Intercept	25.488	1.740		14.651	0.000
Perception of general road safety	-0.288	0.051	-0.196	-5.648	0.000
Perception of main road safety approach	0.139	0.044	0.113	3.140	0.002
Perception of speed limit	-0.402	0.073	-0.195	-5.491	0.000
Perception of loss of license	0.145	0.066	0.078	2.187	0.029
Perception on apprehension by police.	0.100	0.042	0.084	2.363	0.018
Age	0.50	0.15	0.12	3.27	0.001
Gender	-0.44	0.36	-0.04	-1.21	0.226
Vehicle	0.80	0.33	0.09	2.42	0.016

Perceptions of general road safety significantly predicted attitude toward speeding: $B = -0.29$, $t(755) = -5.65$, and $p < .001$. The beta on average is as follows: every one-unit increase of general road safety perception result in a 0.29-unit decrease in attitude to speeding. Similarly, perceptions of the main road safety approach significantly predict attitudes toward speeding: $B = 0.14$, $t(755) = 3.14$, and $p < .05$. This result indicates that on average, every one-unit increase of perception of main road safety approach result in a 0.14-unit increase in attitude to speeding. Perception of speed limit appropriateness significantly predicted attitude to speeding: $B = -0.40$, $t(755) = -5.49$, and $p < 0.001$. This result indicates that on average, every one-unit increase of perception of speed limit appropriateness result in a 0.4 unit decrease in attitude to speeding.

Perception of loss of license significantly predicted attitude to speeding: $B = -0.145$ $t(755) = 2.36$, and $p < .05$. This result indicates that on average, every one-unit increase of loss of license perception result in a 0.15-unit increase in attitude to speeding. Finally, perception of police apprehension significantly predicted attitude to speeding: $B = 0.10$, $t(755) = 236$, and $p < .05$. This indicates that on average, every one-unit increase of perception of apprehension by police result in a 0.1-unit change in attitude toward speeding.

It is expected that the R-squared values is not high since the attempts to predict human behaviour, such as perception, belief and attitude, typically has R-squared values lower than

50%. Motorists as the individual are hard to predict and their attitude to speeding and enforcement are influenced by multi-factor which at the same time has a complex relationship among these factors (SWOV, 2012; Allan Quimby, Maycock, Palmer and Buttress, 1999; Allan Quimby, Maycock, Palmer and Grayson, 1999).

In conclusion, all five variables of perceptions predicted attitude to speeding with statistical significance, and demographic factors age and vehicle type as well, but gender was not statistically significant.

6.3.9   Conclusion: public survey results

Speed has been recognised as a key aspect of road safety, although road safety stakeholders have found it difficult to motivate road users to comply with the speed limit or to observe safer and more appropriate speeds in their travels. One of the objectives of this study is to determine the attitude of motorists in Indonesia toward speed and speed enforcement where speed enforcement is currently rare, sporadic, and manually conducted. Therefore, this section centres upon the analysis of the questionnaire data that focuses on the first research questions, which asked the current public attitude toward safety, speed, speeding and speed enforcement.

The results show that questions about perceptions of general safety on urban and rural roads lead to different responses. It evident that people perceive rural roads as being more dangerous than urban roads. Several reports have argued that road condition and road environment play a major role in Indonesian road safety (Tjahjono, 2003; Hidayati et al., 2012). Rural roads feature damages and deficiencies, lack of signs and markings, and unstandardized curves and intersection design. The result of the current study is in line with several reports in other countries, e.g. the UK, where rural roads have higher KSI rates, thus noticed being more dangerous. The possibility of fatalities is greater on rural roads due to the higher speeds operated by the motorist, as well as the other aforementioned dangerous factors.

The questionnaire items were designed to present several approaches to participants, including the most popular approach, the 3E's: engineering, enforcement and education, enhanced with encouragement through publicity campaigns and training. The results show that a sympathetic approach was preferred over penalties or apprehension. It is evident that the idea of increased penalties has little favour, since this idea poses a great threat to the public. Yet, many people recognise that, in order to be successful, law enforcement must pose a deterrent, as shown by Zaal (2004). This perception was discussed by Corbet (2000), who stated that people do not consider speeding to be a crime, although the consequences of such acts may endanger lives. Thus, speed enforcement must not rely only on apprehension and

severe sanctions; these measures should be accompanied by continuous publicity campaigns and education. It seems reasonable that, when a combined approach is applied, the community respond positively to speed enforcement conducted by the police.

However, mixed views are evident when severe penalties for speeding are proposed, although people reflect speeding as dangerous behaviour and know that it is linked to increased risk of an accident. Accordingly, most motorists profess an intention to keep their speed less than the posted speed limit, although due to various reasons, they failed to maintain their compliance. The results of the survey show strong support for the idea that the factors and motives for noncompliance which influence speed choice at an individual level are situation-dependent (Tate and Carsten, 2008; Jamson, 2008). Unintentional speed violations could highlight important characteristics of drivers' choice of speed; to fix the problem, better speed management and a more effective speed enforcement program are required.

Effective speed enforcement has been the topic of much discussion by numerous stakeholders, largely related to the purposes, methods, and results. One significant finding is that despite the lack of posted speed limits in Indonesia, people believe that the presence and enforcement of a speed limit would have lowered the number of road casualties. These results are consistent with the argument proposed by Tarko (2009) that the perceived accident risk and the threat of speed enforcement are considered to be deterrents to speeding. However, many motorists consider that the existing speed limit is not appropriate to road characteristics and traffic situation (DaCoTA, 2012).

The result further shows that the current speed limits on urban roads are perceived as being too low, even though raising the urban speed limit was opposed. A possible explanation for this result is that congestion is experienced almost every day, and in such situations traffic speed is generally far below the speed limit. In contrast, hardly any people agreed to raise the speed limit to over 100 km/h. Roads' geometry, layout, and roadside environment do not make them safe for higher speeds.

One of the most interesting findings of this study is the opinions on the consequences for exceeding the speed limit with loss of license. Although the system has not been fully implemented in Indonesia, these results show that people undeniably dislike motorists who speed excessively.

Nevertheless, automatic speed enforcement and radar or laser speed guns to detect vehicle speed has not been implemented by Indonesian police. To catch a speed offender, police applied safe pursuit and interception. The risk of this method is enormous, and it attracts people interest on police pursuit safety issue. However, this might have helped police to make

people aware of the police ability in dealing with speed offender. The small number of apprehensions of speed offender could determine the people perception of risk of apprehension.

Finally, the contribution of each independent variable towards the dependent variable was found significant, 10.7% of total variation in attitude to speeding is explainable by the public perceptions to safety, speeding and enforcement. There are still a lot of factor need to be uncover that cause variability of motorists' attitude to speeding, enforcement and safety.

6.4 Result and analysis of police satisfaction with current speed enforcement procedures

Job satisfaction has the connotation of whether someone is satisfied with their current employment situation. In December of 2015, a satisfaction survey was conducted among police officers in Jakarta and Pekanbaru, Indonesia. This survey was intended to determine police officers' satisfaction around current operative speed enforcement strategies. The questionnaire consisted of twenty-seven questions, which were divided into six sections, as well as a request for participant demographic information. These six sections were job satisfaction, management support, job challenge, loyalty, citizen cooperation, and social cohesion. A copy of this questionnaire can be found in Appendix B. There were 273 cases included in the analysis and no cases that were excluded because of missing values.

6.4.1 Overview of survey participants (police officers)

About 300 police officers were invited to participate in the survey, and 273 police officers successfully completed their questionnaire, making for an overall response rate of 91%. Frequencies and percentages of participants' demographic data are presented in Figure 68.
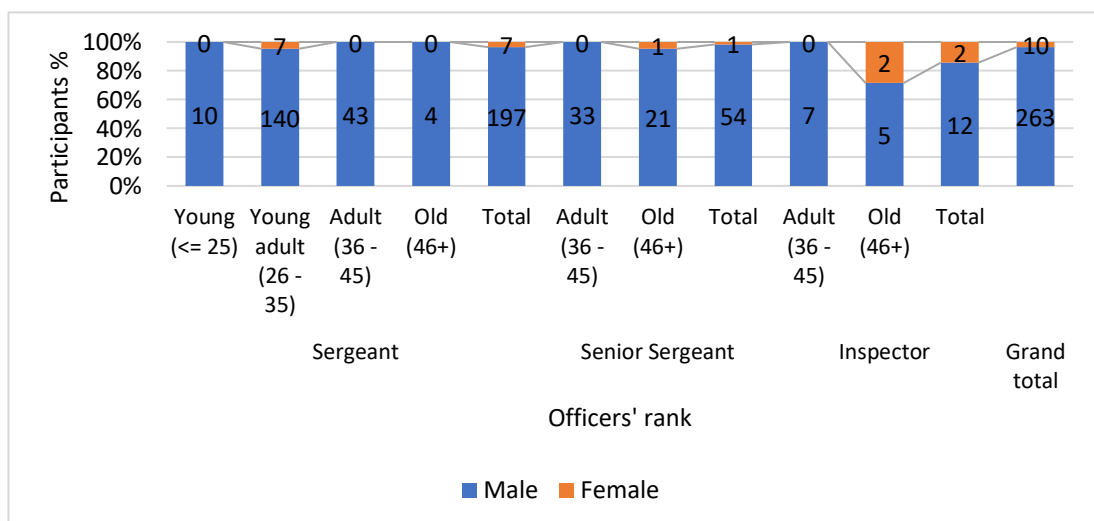
Figure 68: Frequency for participants' gender, age group, and rank

Based on the demographic and individual characteristics of police officers, the largest proportion of age category was young adults in the 26 to 35 age brackets (n = 147, 54%), while by gender category was the most popular category was male (n = 263, 96%). The observation of officers' rank shows that sergeant (n = 204, 75%) was the most frequently observed, while the most frequently observed category for location was Jakarta (n = 145, 53%).

6.4.2 Job satisfaction
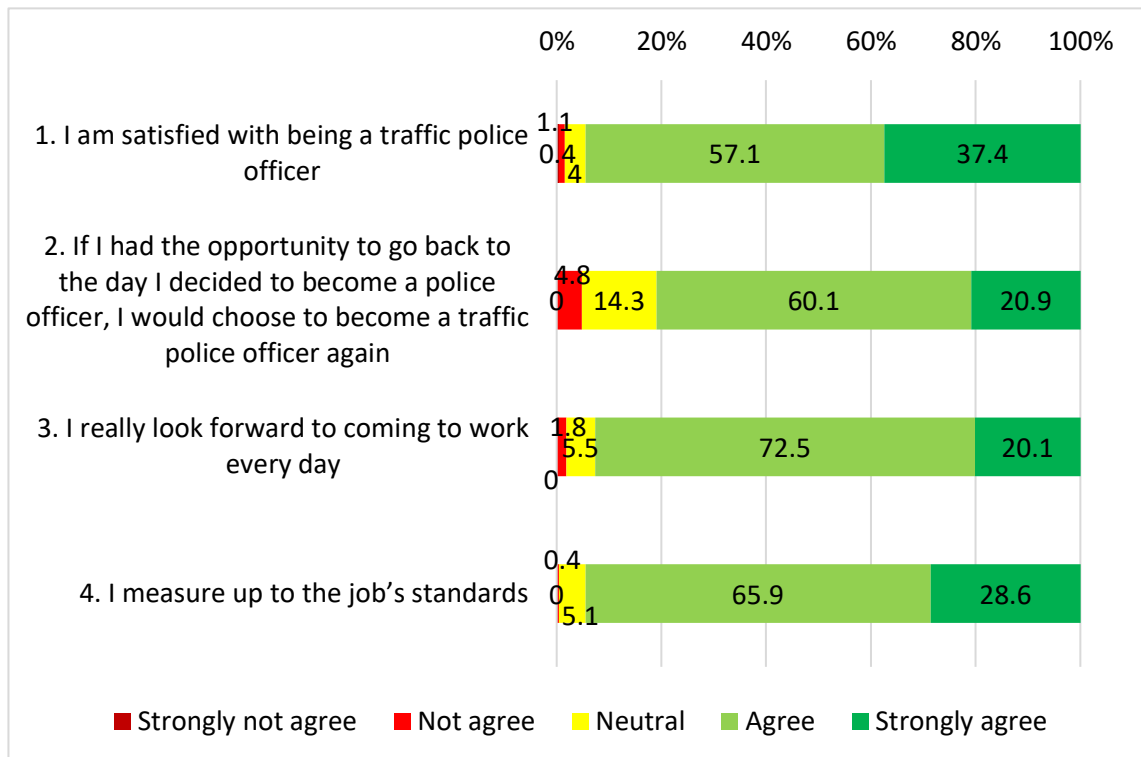
Figure 69: Responses to job satisfaction questions

The first part of this questionnaire was intended to determine the level of job satisfaction of traffic police officers, a level which served as the dependent variable. Job satisfaction questions were created with four items similar to those used by Boke & Nalla (2009), a study which was designed by Zeitz, Russell and Ritchie's (1997) based on an organisational culture index. The questions focus on four dimensions of participants' perception of their job as presented in Figure 69.

As an opening probe, 94.5% of officers reported being satisfied being a traffic police officer. Participants' average score is 4.30, and the IQR shows that the responses are clustered together. About 81% of participants conveyed that if they had the opportunity to go back, they would choose to become traffic police officer again. There is an increasing proportion of officers opposing the idea of becoming a police officer again. Officers were in no doubt that they were looking forward to coming to work every day, with 92.6% reporting positive

responses. Finally, around 94.5% of participants were confident that they fulfil the requirements and standards set out by their job.

The composite scale is arranged so that the higher the value, the higher the assessment of job satisfaction. Participants' responses on the scale ranged from 9.00 to 20.00, with an average of 16.61 (SD=1.85). Cronbach alpha coefficients were calculated: they indicate acceptable reliability with a coefficient of 0.72.

6.4.3 Management support
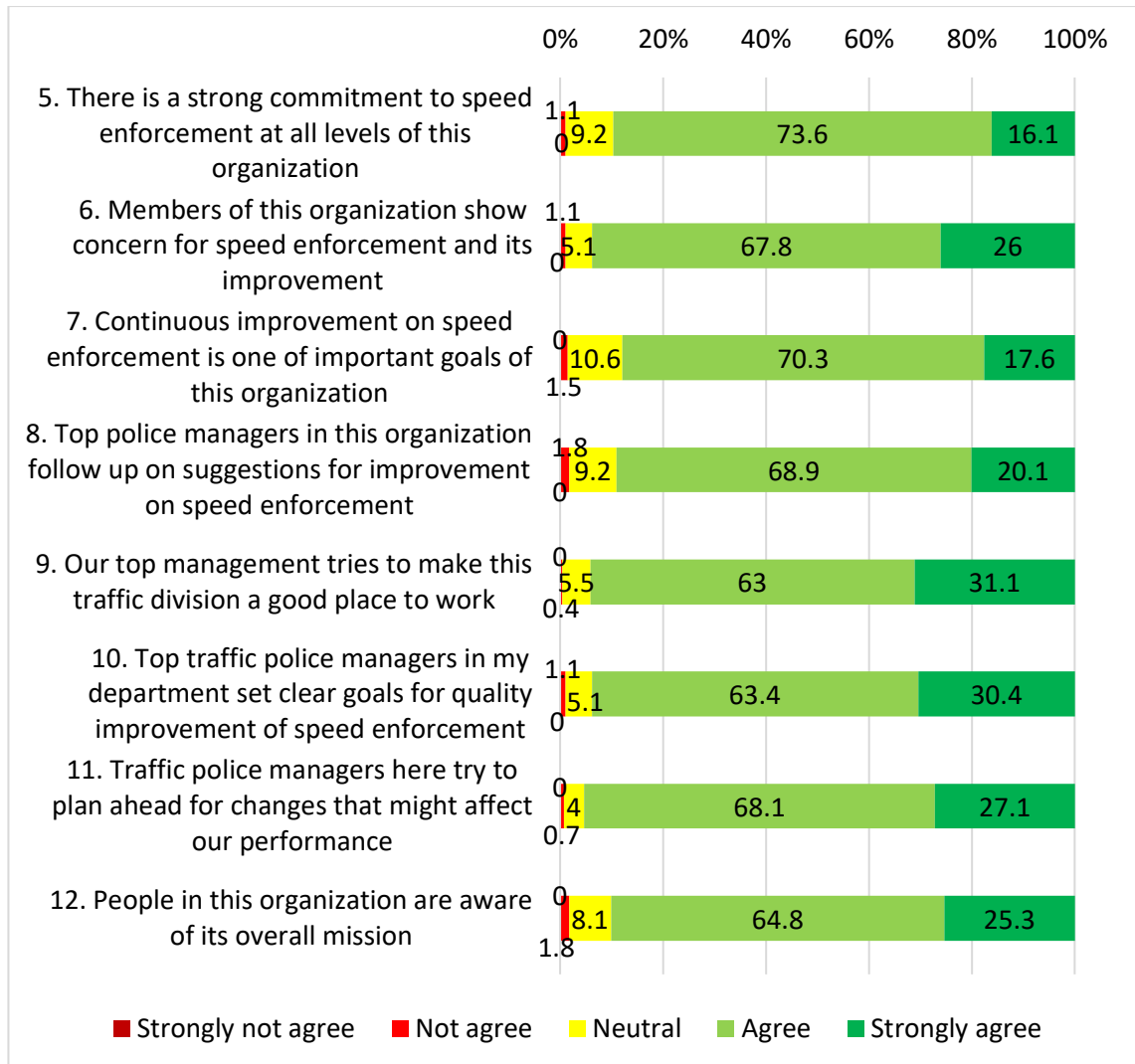
Figure 70: Management support survey results

Previous research has shown a strong positive relationship between individual performance and management support; the higher the management support for the officers, the higher is the overall agency performance (Brough and Williams, 2007). Therefore, the second set of questions evaluate the officers' management support. Questions are presented in Figure 70. The items for management support had a Cronbach's alpha coefficient of 0.82, indicating good reliability.

Overall, officers' perceptions of management support were very positive. A strong police commitment to speed enforcement was approved by 89.7% of officers, while 93.8% reported that people in their police station showed concern for speed enforcement. Furthermore, 87.9% of officers believe that speed enforcement improvement is an important goal in their division. They also feel that top managers each time have followed up their suggestion.

Similarly, 94.4% of officers surveyed believe that the top police manager has tried to make their division a good place to work, and 93.8% of officers also reported that the top police manager had positioned clear goals on how to improve quality of speed enforcement. Police officers also reported that their manager had prepared a plan to counter the effect of changes that happen in the organisation.

Moreover, officers feel confident that people in the police division are aware of their overall mission, which was indicated by 90.1% support for the statement. Finally, the composite score for management support ranged from 20.00 to 40.00, with an average of 33.18 (SD = 3.08), which indicates great satisfaction on management support.

6.4.4 Job challenge
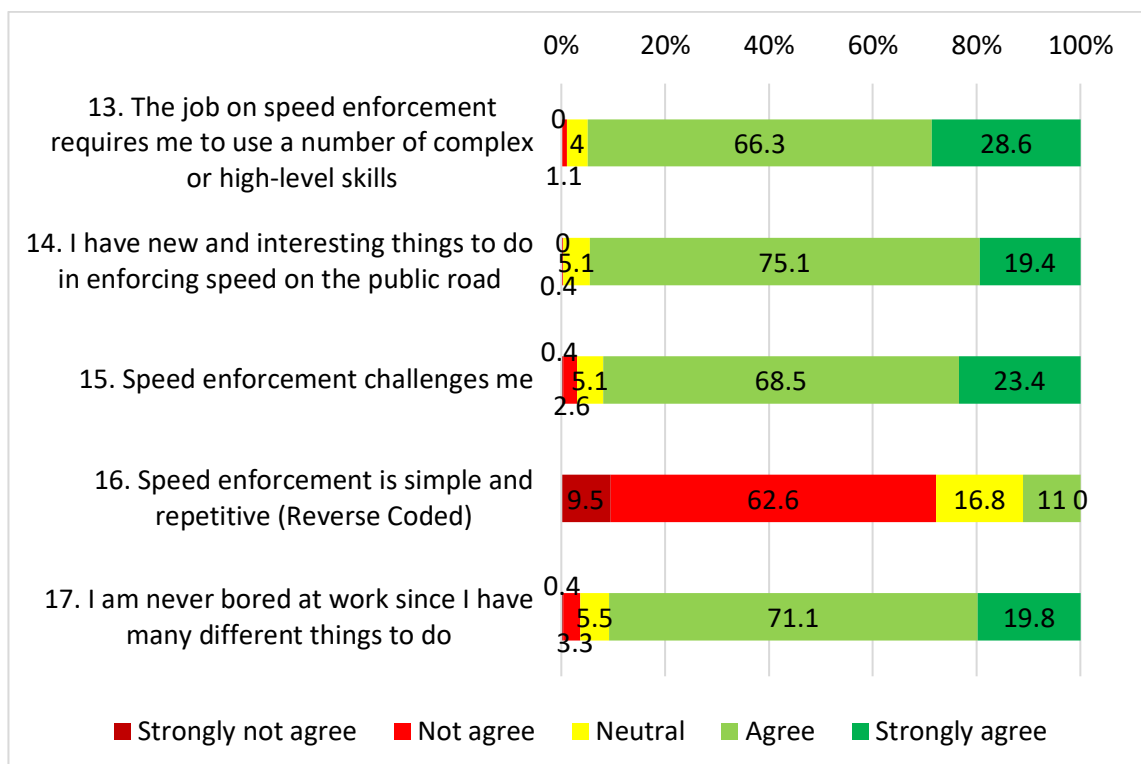
Figure 71: Job challenge survey result

Speed enforcement is rarely carried out by police in Indonesia. It is an unusual action for many police officers in Indonesia, particularly due to the lack of equipment such as speed cameras or speed guns. Some officers never conduct speed enforcement during their career, either by speed gun or by safe pursuit and interception, which often requires a specialized unit. Given

this circumstance, enforcement of speed must be seen as a new challenge for the majority of police officers.

The third question introduced the job challenge concerning speed enforcement as a determinant of officers' job satisfaction. It was comprised of five criteria, which evaluate the following police officers' attitude as presented in Figure 71.

Cronbach alpha coefficients were calculated for job challenges scales: the items had a coefficient of 0.55, indicating low reliability, although the upper alpha obtains 0.63, which is acceptable. This result may be related to officers' lack of knowledge and experience in relation to speed enforcement.

Officers reported that speed enforcement requires them to use a number of complex high-level policing skills, indicated by 94.9% support for that question. Similarly, 94.5% of participants felt that enforcing speed on the public road is interesting although it is new to them. When asked whether speed enforcement challenges them, 91.4% of officers surveyed responded in the affirmative.

To learn more about police attitudes toward speed enforcement, a question was posed concerning speed enforcement as a simple and repetitive task: at this point, 72.1% opposed the statement. Finally, 90.1% of officers reply that they never feel bored as a police officer. The composite score for job challenge has an average of 20.25 (SD = 1.85), which indicates positive responses and support on job challenge.

6.4.5 Loyalty
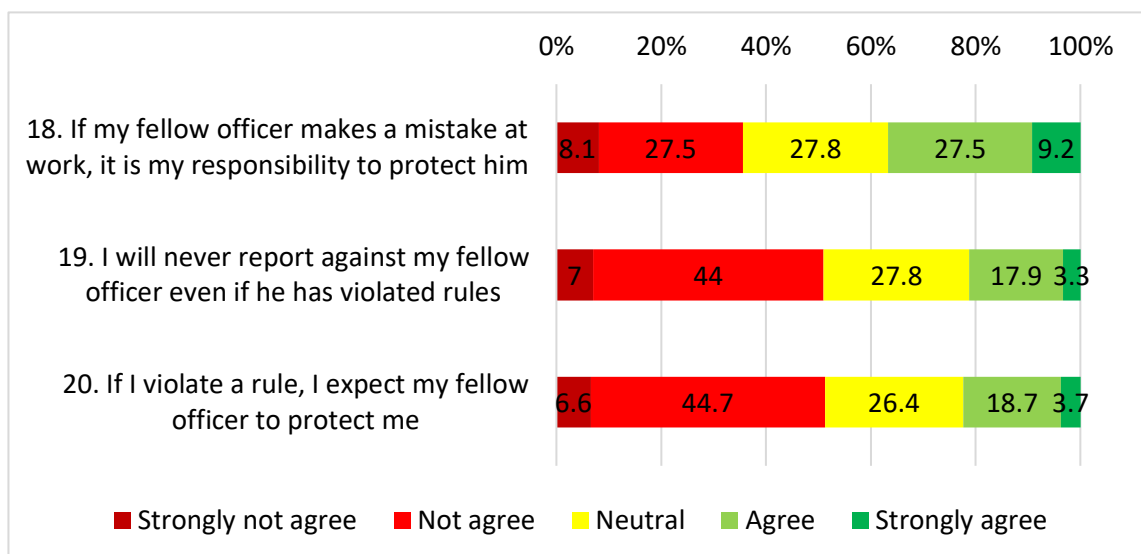
Figure 72: Loyalty survey result

One of the duties of a police officer is loyalty to their organization and its mission and values, to their chief, senior, or superior, to their colleagues or friends, and to their subordinates or

staff. Police officers often have to perform their duties in dangerous situations. Officers have to rely on one another for their safety and security. They have to believe that fellow officers are loyal to them, even in dangerous situations or situations involving risk (Yüksel, 2013; Boke and Nalla, 2009). Loyalty is one important factor in determining the effectiveness of policing duties, as in situations with disloyalty officers would not likely be keen to put themselves in demanding circumstances. The loyalty section had a Cronbach's alpha coefficient of 0.78, indicating acceptable reliability.

The introductory question asked officers whether they would protect their fellow officer who made a mistake at work, which generated split responses in nearly equal proportion. The same reactions were shown by officers when asked whether they would report if their friend made a mistake or whether they would be reported by a friend; 51% backed this idea, and 21% rejected it. The composite score average is 8.37 (SD = 2.55), which indicates an officer tendency to be neutral.

6.4.6 Citizen cooperation
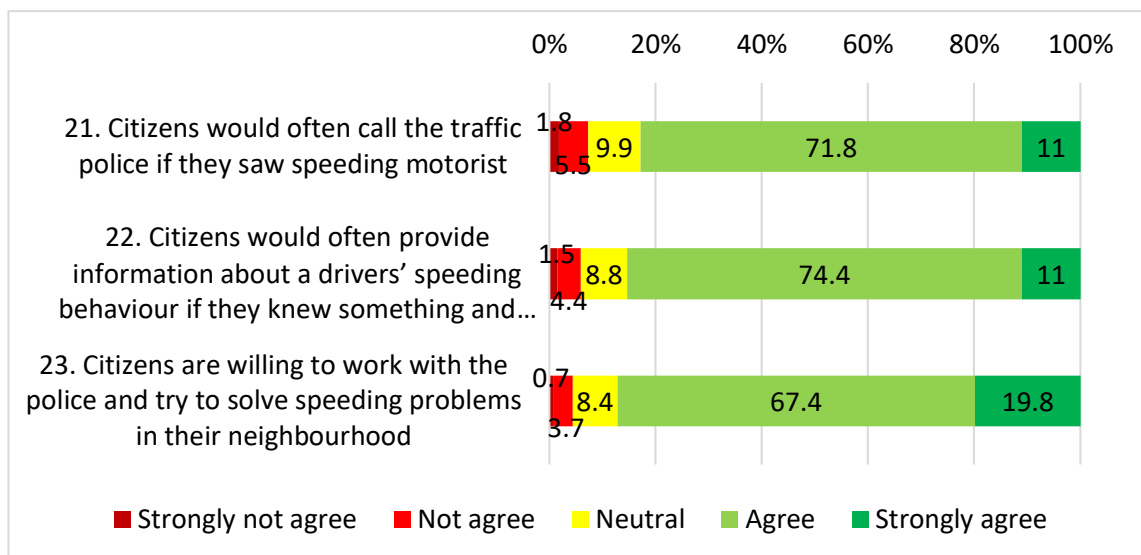
Figure 73: Citizens' cooperation survey result

Police continuously try to improve the collaboration between citizens and the police to increase citizens' trust in the police and to tackle growing crime and other problems. This collaboration is based on the philosophy that security cannot be produced by either the police or the community acting alone; it requires cooperation (Rice et al., 2010). The following questions try to assess officers' perception on citizens' cooperation in relation to speeding problems within their jurisdiction.

The results show that 82.8% of officers' report that citizens would call them when they saw a speeding motorist. Moreover, 85.1% of officers believed that citizens would provide information about the offender. They also have confidence that citizens are willing to work

with them to solve the neighbourhood speeding problem, with 87.2% giving a positive response to this statement. The composite score for citizen cooperation ranged from 5.00 to 15.00, with an average of 11.75 (SD = 1.76), which indicates that officers believe cooperation between citizens and the police to be great. Cronbach's alpha 0.74, indicating good reliability.

6.4.7 Social cohesion (independent variable 5)
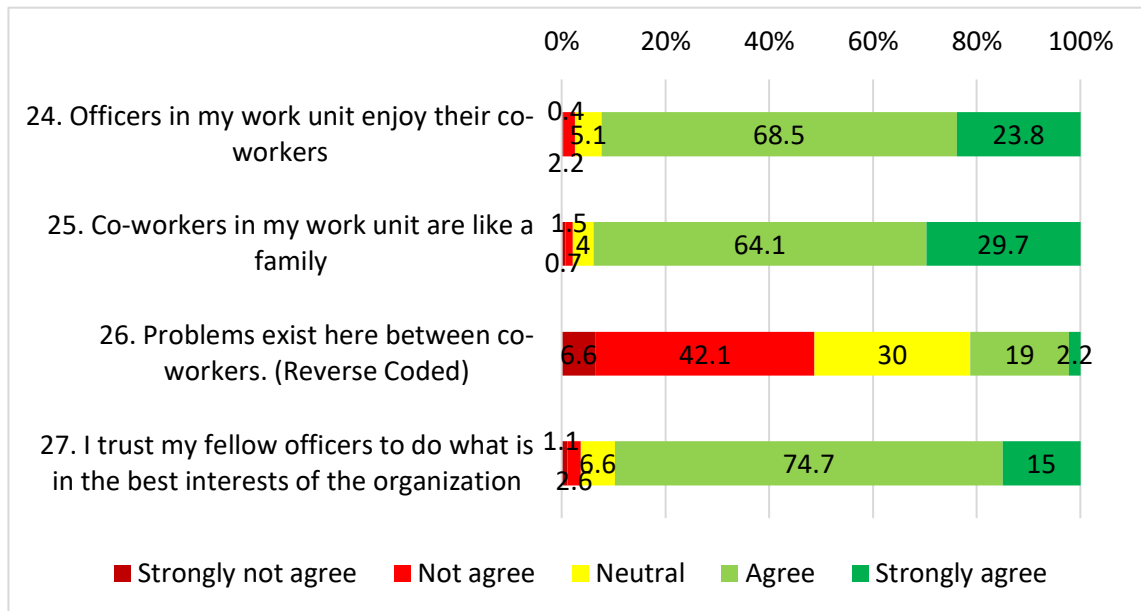
Figure 74: Social cohesion survey result

The final section presented to the participants concerns social cohesion among police officers. Social cohesion within a police division is about creating healthier relationships between police officers with diverse individual characteristics (Boke and Nalla, 2009). Social cohesion is what must happen in all police organizations to enable different groups of people to get on well together.

The first two questions officers expressed an approval of 92.3% and 93.8%, respectively, that their unit was pleasant and that co-workers were like family. Moreover, officers tend to oppose the idea that there is a problem among them by 48.7%, although 20% do believe that such a problem does exist. Finally, officers show a high degree of trust in their fellow officers: 89.7% agreement to that statement was observed. The composite mean score for this construct was 15.66 (SD = 1.925), indicating that police officers' social cohesion is strong.

6.4.8 Statistical tests for determining job satisfaction

It is important to utilize proper statistical tools in order to better understand results. The dependent variable in the current study was on an additive scale, combining the five dependent variables of job satisfaction into one dependent variable. We assume the additive scale is continuous, which is the basic rationale of using regression analysis in this study.

A linear regression analysis was conducted to assess whether management support, job challenge, loyalty, citizen cooperation and social cohesion significantly predicted job satisfaction. All the selected predictors were included as variables for the linear regression model. The assumption of normality was assessed by plotting the quantiles of the model residuals against the quantiles of a Chi-square distribution, also called a Q-Q scatterplot (DeCarlo, 1997). Based on this Q-Q scatterplot of the model residuals, the normality assumption is met.

The assumption of homoscedasticity was assessed by plotting the model residuals against the predicted model values (Osborne and Waters, 2002). The assumption is met since the points appear to be randomly distributed with a mean of zero and no apparent curvature.

Table 15: *Variance Inflation Factors*

Variable	*VIF*
MS	1.59
JC	1.43
LO	1.09
CC	1.24
SC	1.30

In addition, Variance Inflation Factors (VIFs) were calculated to detect the presence of multicollinearity between predictors. High VIFs indicate increased effects of multicollinearity in the model. Variance Inflation Factors greater than 5 are cause for concern, whereas VIFs of 10 should be considered the maximum upper limit (Menard, 2009). All predictors in the regression model have VIFs less than 10 as presented in Table 15.

The results of the linear regression model were significant, as presented in Table 16 and highlighted in yellow, $F(5,257) = 18.00$, $p < .001$, and $R^2 = 0.26$—results indicating that approximately 26% of the variance in job satisfaction is explainable by management support, job challenge, citizen cooperation and social cohesion.

Table 16: Results for linear regression predicting job satisfaction

Variable	*B*	*SE*	β	*t*	*p*
(Intercept)	5.03	1.35	0.00	3.71	< .001
MS	0.22	0.04	0.39	5.80	< .001
JC	0.20	0.06	0.20	3.11	.002
LO	0.11	0.04	0.16	2.89	.004
CC	-0.10	0.07	-0.09	-1.53	.128
SC	0.03	0.07	0.03	0.49	.628

Note. $F(5,257) = 18.00$, $p < .001$, $R^2 = 0.26$

Management support significantly predicted job satisfaction: $B = 0.22$, $t(257) = 5.80$, and $p < .001$. This result indicates that on average, every one-unit increase of management support result in a 0.22 unit increase in job satisfaction. Furthermore, job challenge significantly

predicted job satisfaction: $B = 0.20$, $t(257) = 3.11$, and $p = .002$. This result indicates that every one-unit increase of job challenge result in a 0.20 unit increase in officers' satisfaction. Loyalty significantly predicted job satisfaction: $B = 0.11$, $t(257) = 2.89$, $p = .004$. This result indicates that on average, one-unit increase of loyalty result in a 0.11 unit increase in job satisfaction.

Nonetheless, citizen cooperation and social cohesion were not the significant predictor of job satisfaction: $B = -0.10$, $t(257) = -1.53$, and $p = .128$. and $B = 0.03$, $t(257) = 0.49$, $p = .628$. for citizen cooperation and social cohesion, respectively. Therefore, on this sample, an increase of citizen cooperation and social cohesion did not have a significant effect on job satisfaction.

6.4.9 Conclusion: police survey results

Various studies have been carried out on the impact of job satisfaction on job performance. Job satisfaction represents one of the most widely-studied subjects in occupational psychology. Job satisfaction has most often been specified as a pleasant or positive emotional state resulting from the perception of work, feelings and judgements of the work environment, work experience, and the perception of all elements of the work and workplace (Tomaževič et al., 2014). Locke (1976) argued that job satisfaction results from the difference between the expectation of the job and the reality of the job.

Based on this proposition, the job satisfaction of traffic police officers must be explored. There is a gap between, on the one hand, the traffic police officers' expectations of being able to implement speed enforcement measures, with, on the other hand, the reality of speed enforcement being rare and unusual. This study tries to reveal whether and to what extent different elements of current speed enforcement procedures contribute to the overall job satisfaction of traffic police officers. These results, in turn, provide insight into what aspects of the speed enforcement implementation process are important to be developed and improved.

The findings of this study show that the traffic police officers surveyed were largely satisfied with their job. Officers feel confident that support from organizations and management were satisfactory. These results highlight the importance of management's responsibility as a basis of job satisfaction, and further suggest that police officers like to work in an environment where they enjoy considerable support from the organization and from all top managers. This finding is also consistent with other previous studies on officer satisfaction (Zhao et al., 1999; Johnson, 2012; Wang, 2006).

Similarly, officers reported that the challenges related to speed enforcement are motivating. They realized that law enforcement speeds require complex policing skills. However, since some of the determinants introduced in this survey were new to them, officers were likely to attempt to portray themselves and their organization in a more favourable light.

Nevertheless, the results also show that only 26% of the variance in job satisfaction is explainable by management support, job challenge, citizens' cooperation, and social cohesion. There are still many aspects yet undiscovered which correlate to police officer job satisfaction. This finding is in line with previous studies of police job satisfaction that found approximately 25% of the variance in job satisfaction is explainable by management support, challenge, and loyalty (Johnson, 2012).

It is interesting that citizen cooperation and social cohesion did not significantly predict job satisfaction among police officers. This finding reveals how the officers, in general, are ambivalent about the role of citizens' cooperation on successful police performance. Therefore, it is often difficult to tell if job performance causes job satisfaction, or if job satisfaction causes job performance. Research suggests a moderate positive relationship and that the two variables seem to interact with each other indirectly through individual differences and work-environment characteristics (Bono et al., 2001)

In conclusion, the job satisfaction of Indonesian police officers was determined to be relatively high among the surveyed population. The major determinants for officers' satisfaction was management support, job challenge, and loyalty, whilst citizen cooperation and social cohesion did not have a significant effect on job satisfaction.

Chapter 7

Single intervention effect on motorists' choice of speed

7.1   Introduction

This study focused on the examination of the effectiveness of speed enforcement on drivers' choice of speed. One of the research questions asked about the baseline of drivers' choice of speed in the absence of selected speed enforcement procedures. While the other questioned whether the selected interventions, motorists' training, police presence, or roadside publicity of enforcement, have a significant effect on for drivers' choice of speed, before they were tested in combined intervention.

According to the review of the literatures and general methodology of this study, there were three independent variables (IV) tested, namely speed awareness training, police presence, and roadside publicity of enforcement, on one dependent variable (DV) was motorists' choice of speed. The effect of these interventions was explored independently to answer the proposed research questions. At the outset of analysis, the speed profile graphs were produced and analysed. Finally, several t-tests or a one-way ANOVA was applied to test whether there was a statistically significant difference of mean speed among the groups.

7.2   Experimental method

The baseline of drivers' choice of speed and the effect of each type of intervention speed that consist of police presence, motorist training, and roadside publicity, are addressed through the following research questions:

1.   What is the baseline of drivers' choice of speed in the absence of police intervention?
2.   Does motorists' training, police presence, or roadside publicity of enforcement have a significant effect on for drivers' choice of speed?

The overall experiment method in this study followed between groups design, hence for the single interventions were designed as independent measures design. This design is helpful to determine if there are differences between three or more conditions/treatments where no pre-test measurement taken. Different participants were assigned in each condition of the independent variable. It means that each condition of the experiment included a different

group of participants. The assignment was done by random allocation, which ensures that each participant had an equal chance of being assigned to one group or the other.

7.2.1   Procedure

The single intervention was part of the complete experiment where the factorial experiment was designed, as discussed in sections 4.5 and 5.9.4.

Test routes

This study would carry out the experiment in two routes as described in 5.9.1.

Group assignment

The first 60 participants were assigned to single type of intervention either in dual carriageway or single carriageway route. Detail is as presented in Table 17 corresponds to the experimental group 1, 2, 3, and, 7.

Table 17: Route, group, treatment, and stage of experiment

Route	Group	Participant	Intervention
Dual carriageway 60 km/h	1	15	No intervention
	2	15	Training only
	3	15	Police only
	7	15	Publicity only
Single carriageway 50 km/h	1	15	No intervention
	2	15	Training only
	3	15	Police only
	7	15	Publicity only

7.2.2   Data analysis

According to experimental design, there are three type of intervention that consider as single intervention, namely: training, police and publicity. To investigate each effect of these single-factor intervention, the statistical test was also tailored to the test procedures and route design.

For training effect, the study was designed to determine if there are differences between interventions. Participants are randomly assigned to one of two groups. Each group receives a different intervention, Group 1 received no intervention, known as a 'control', whilst Group B undergo a training procedure. The dependent variable of interest is the mean speed in every segment of test route. Since the dependent variable is not measured before the intervention takes place, this type of study design has followed a 'post-test only' design. It aims to determine if there are differences between the two groups, and therefore, between training and no intervention.

The independent-samples t-test is used to determine if a difference exists between the means of training and no-intervention group on a mean speed of segments. More specifically, the independent t-test was utilized to determine whether the difference between these two groups is statistically significant.

For police and publicity effect, the study was designed to determine if there are mean speed changes over time between two-time points of test route. The two "time points" are: Time Point #1 is control road and Time Point #2 is treated road. At the "control road", the dependent variable for these participants are measured. Then, at the "treated road", the same dependent variable for the same participants are measured for the second time.

In control road, no intervention is applied, while in the treated road, there has been an intervention where the participants were exposed to a treatment or condition, either to police presence or roadside publicity. After the mean speed has been measured at Time Point #1 (the control road) and Time Point 2 (the treated road), the mean speed was compared to detect whether the mean speed for Time Point #2 (the treated road) is higher or lower than for Time Point #1 (the control road).

The paired-samples t-test is used to determine whether the mean speed difference between paired observations, on control and treated road, is statistically significantly different from zero. Descriptive statistics has also helped to identify what the differences are in terms of the mean scores and standard deviations.

7.3   The baseline of motorists' choice of speed

One of the key questions in this study is what the baseline of motorists' choice of speed is in the absence of interventions. The purpose of determining a participant's baseline speed is to provide evidence that can be used to observe and evaluate the effect of treatment during and after completion of the intervention. The baseline of drivers' choice of speed was defined as the choice of speed where intervention was not present on test routes. Therefore, to answer this question, a group was assigned to each route to experience the test route without any established enforcement procedures.

7.3.1   Spot speed survey results

At the beginning of this section, the first spot speed survey results that were described in section 5.6, are restated as presented in Table 18. The initial speed survey result has revealed that the mean speeds were recorded as 57.3 km/h and 51.6 km/h for dual carriageway route and single carriageway route, respectively. The 85th percentile speeds for both routes were

found to be higher than the posted speed limit, 70 km/h on dual carriageway route and 63 km/h on single carriageway route.

Table 18: Speed characteristics of test routes based on spot speed survey in km/h

Statistics	Dual carriageway 60 km/h	Single carriageway 50 km/h
Speed limit	60	50
Mean	57.32	51.61
Median	57	51
Mode	60	48
SD	11.53	10.76
Maximum	104	97
85th percentile	70	63
Exceed	37.5	51.6
Exceed +5	23.8	34.8

The proportion of vehicles travelling above the speed limit was relatively high, 37.5% and 51.6% for dual carriageway route and single carriageway route, respectively. Further analyses showed that 23.8% of vehicles travelled 5 km/h above the limit on dual carriageway route and 34.8% of vehicles on single carriageway route. This result also corresponds with the 90th percentile speed, where 10% of speeds were observed to be higher than 72 km/h on dual carriageway route and 66 km/h on single carriageway route. This means the drivers in question are more than 10 km/h above the posted speed limit on those routes. In a later stage, this survey results are compared to the participants' speed as measured in the experimental study, whether the interventions are absent or present.

7.3.2   Speed choice in the absence of intervention

Fifteen motorists were assigned to a group on each test route that would experience no intervention in the study. The group was called "no intervention." Their test data was expected to provide insight into motorists' baseline speed. The summary of the test results is presented in Table 19.

Table 19: Statistical summary of "no-intervention"

Characteristics		Dual carriageway route		Single carriageway route	
		Control	Treatment	Control	Treatment
Speed km/h	Mean	62.16	62.39	48.48	49.35
	Median	64.02	64.03	48.41	49.74
	Mode	51.64	49.38	33.16	32.65
	SD	10.07	9.56	8.61	7.56
	Variance	101.34	91.45	74.09	57.17
	85th percentile	71.35	69.28	58.01	58.27
PTA[11] (%)	Mean	61.05	70.96	45.85	52.58
PTA +5 (%)	Mean	44.28	46.35	26.85	32.89

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[11] PTA is the "Proportion of Time Above" the speed limit.

It was interesting to find that the 85th percentile speeds on the control and treatment roads for both routes were higher than the posted speed, which indicates that desirable speeds are higher than the posted speed limit. This value also correlates with the proportion of time spent travelling above the speed limit, which exceeded 50% of the total journey time, except on the control segments of single carriageway. To analyse further the speed characteristics of the "no-intervention" group, a speed profile graph was produced, and statistical tests were performed for each route.

Baseline of dual carriageway 60 km/h

A speed profile graph was created to assess the choice of speed on dual carriageway route based on the test results of Group 1 ("no-intervention"). Overall, the mean speeds were 62.2 ± 9.6 km/h with treatment and 62.4 ± 10.1 km/h for the control, respectively; a difference as low as 0.2 km/h was recorded. Correspondingly, most of the segments' mean speeds were observed to be higher than the speed limit. Similar speed patterns were apparent between control and treatment segments. The mean speed on control segments 3, 4, and 5, and treatment segments 9, 10, and 11, were observed stable at approximately 64 km/h to 67 km/h. Consistently, the 85th percentile speed for each segment resembles the pattern of mean speed. Even still, the difference between a middle segment of road (control and treatment) was merely 0.1 km/h. Most of the segments' 85th percentile speeds were >10 km/h above the speed limit, as shown in Figure 75.
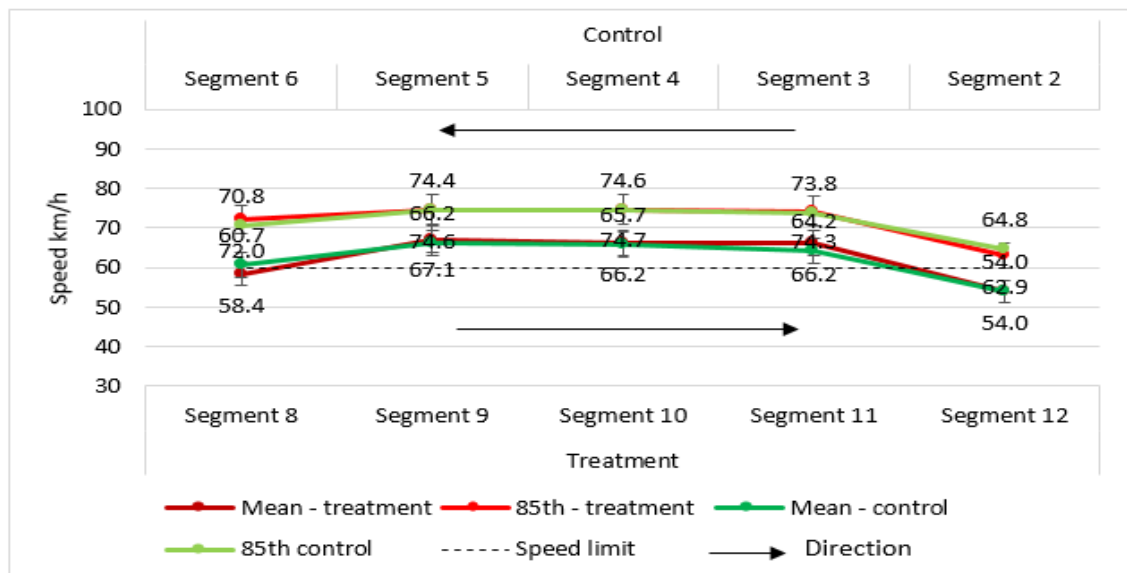
Figure 75: No interventions mean and 85th percentile speed on dual carriageway route

To ensure that the choice of speed on the control and treatment roads can be used as a baseline, first, it must be established whether there was a significant difference between the mean speeds on those segments. There were no factors or interventions that could trigger a

speed difference between control and treatment segments. Hence, the drivers' choice of speed between the segments should not have a significant difference.

The paired-samples t-test was used to determine whether the mean difference between control and treatment is statistically significantly different from zero. The format of data is mean ± standard deviation, unless otherwise stated. The differences between the mean speed on control and treatment roads were normally distributed, as assessed by a visual inspection of a normal Q-Q Plot; as well, the assumption of normality was not violated, as assessed by Shapiro-Wilk's test (dual carriageway route, $p = .124$). One outlier was detected that was more than 1.5 box-lengths from the edge of the box in a boxplot. Nonetheless, inspection of its value did not reveal it to be extreme or a data entry or measurement error, so it was kept in the analysis.

The paired t-test shows that participants travelled faster on treatment road (62.4 ± 8.6 km/h) as opposed to the control road (62.4 ± 6.8 km/h). There was a speed increase of 0.2 km/h (95% CI, -2.6 to 2.6) on treatment road compared to the control road; $t(14) = -0.205$, $p = 0.840$, $d = 0.25$. There was not a statistically significant difference between mean speeds ($p > 0.05$).

Further tests were then conducted to examine the differences between the mean speeds for each pair of segments. The results indicated that participants' choice of speed has no difference for all segments on test dual carriageway route. In conclusion, the test results from participants in the "no-intervention" group, both for the control and the treatment road, reflects the baseline of participants' choice of speed for this test route.

Baseline of single carriageway 50 km/h

A speed profile graph was produced to assess the choice of speed on single carriageway route based on the test result of Group 1 ("no-intervention") test result. Generally, the treatment road's mean speed was 49.3 ± 5.5 km/h and the control's mean speed was 48.5 ± 5.5 km/h. There was a 0.8 km/h mean speed difference recorded. Correspondingly, most of the observed segments' mean speeds were adjacent to the speed limit line. The speed pattern between the control and treatment roads was slightly different, especially for segments 3 to 4 and segments 10 to 11.

The mean speed on the control road varied segment by segment, while the mean speed on the treatment segments 8, 9, and 10 was stable at approximately 49 km/h to 50 km/h. The highest differences among paired/parallel segments were found between segments 3 and 11, about 4.3 km/h, as shown in Figure 76.
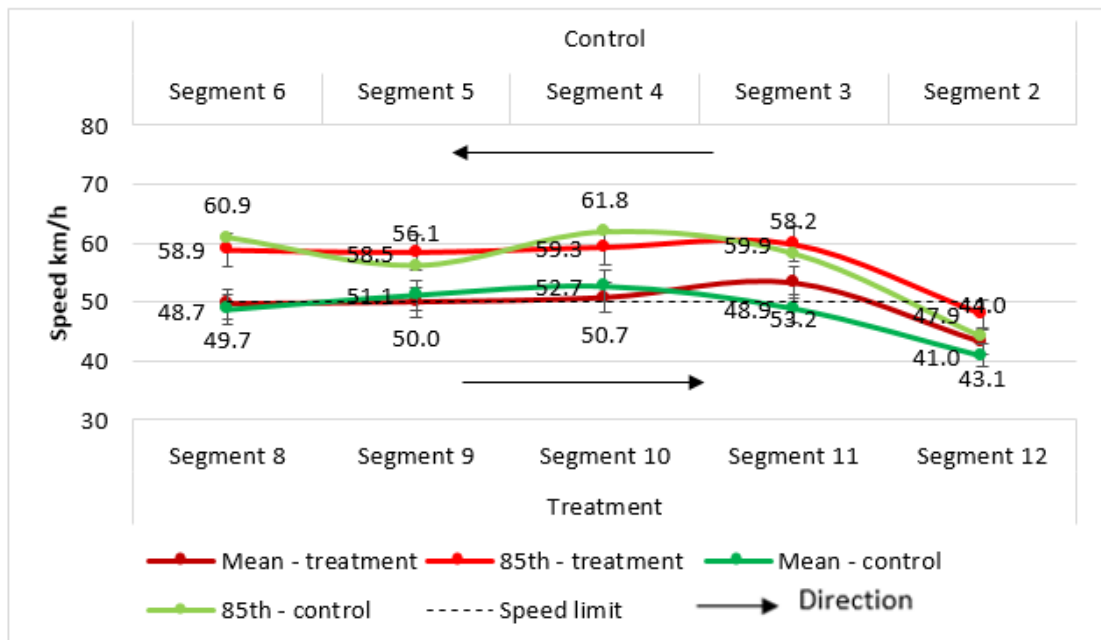
Figure 76: "No-intervention" result on single carriageway 50 km/h

Consistently, the pattern of 85th percentile speed has taken after the pattern of mean speed, except on control segment 5, where a large speed reduction was recorded. Most of the 85th percentile speeds were higher than 55 km/h (or >5 km/h over the posted speed limit).

Further analysis was required to break down the choice of speed on control and treatment roads so that the baseline of participants' choices of speed could be established. The paired-samples t-test was used to determine whether the mean difference between mean speed on the control road and mean speed on the treatment road was different from zero with statistical significance. Data are in the format of mean ± standard deviation, unless otherwise stated.

The differences between the mean speed in control and treatment road were normally distributed, as assessed by visual inspection of a normal Q-Q Plot. One outlier was detected that was more than 1.5 box-lengths from the edge of the box in a boxplot. Nonetheless, inspection of it did not reveal it to be extreme or a data entry or measurement error, so the outlier was kept in the analysis.

The paired t-test shows that participants travelled faster on the control road 49.3 ± 5.5 km/h as compared to the treatment road (48.5 ± 5.5 km/h). There was an decrease in speed of 0.8 km/h (95% CI, -3.04 to 1.35) on the treatment road compared to the control road; $t(14) = -0.857$, $p = 0.406$, $d = 0.15$. There was not a statistically significant difference between mean speeds ($p > 0.05$).

Further tests were then conducted to examine the differences between the mean speeds for each pair of segments. The result of the paired samples t-test for paired segments 3—11, 4—

10, 5—9, and 6—8 were not different from zero with statistical significance. Only paired segments 2—12, i.e. the beginning and the end of the test route, were found to be statistically significantly different from zero.

This result indicates that the participants' choices of speed have no difference for most of the segments on test single carriageway route. In conclusion, the test results from the "no-intervention" test have, on the control and treatment road, reflected the baseline of participants' choice of speed for this test route. A different mean speed at the beginning and at the end of test route was noted.

7.3.3 Comparison of spot speed data and no-intervention speed data

Further investigation was conducted to compare the speed data from two independent results of this study. This procedure calculates the difference between the observed means in two independent samples, namely spot speed and no-intervention data. A significance value (P-value) and 95% Confidence Interval (CI) of the difference was reported. The hypothesis is the difference is 0 (null hypothesis) (Altman, 1991). The significance level, or P-value, is calculated using the t-test, with the result as presented in Table 20.

Table 20: Comparison of means between spot speed and no-intervention groups

Statistics		Spot speed Data	No intervention	
			Control road	Treated road
Dual carriageway	Mean	57.3	62.1	62.3
	SD	11.5	8.6	6.7
	Sample size	4271	15	15
	Difference		4.8	5
	Standard error		2.972	2.971
	95% CI		-1.0 to 10.6	-0.8 to 10.8
	t-statistic		1.615	1.683
	DF		4284	4284
	Significance level (p)		0.1064	0.0925
Single carriageway	Mean	51.6	48.5	49.3
	SD	10.7	5.5	5.4
	Sample size	4540	15	15
	Difference		-3.1	-2.3
	Standard error		2.764	2.764
	95% CI		-8.5 to 2.3	-7.7 to 3.1
	t-statistic		-1.121	-0.832
	DF		4553	4553
	Significance level (p)		0.2621	0.4054

The result shows that the mean speeds of no-intervention groups on dual carriageway were a little over 4.8 in control and 5 km/h in treated road higher than the spot speed. The no-intervention having an average speed of 62.1 km/h in control road and 62.3 km/h in treated

road, while the spot speed having an average of 57.3 km/h. The non-intervention mean speed had the SD of 8.6 km/h in control road and 6.7 km/h in treated road, whereas the spot speed's mean had a SD of 11.5 km/h. The spot speed data having a higher SD describes that the spot speed data was more dispersed or spread out than the no-intervention' data.

Furthermore, the result of comparison shows that there is no significant difference between the mean speed produced by spot speed survey and non-intervention group, either in dual or single carriageway. Therefore, the result of no-intervention groups test in both routes was accepted as a baseline speed for drivers travelling on dual carriageway.

7.4   Single intervention effect on the dual carriageway 60 km/h

7.4.1   Police

The first single intervention investigated is the impact of police presence on motorists' speed. Police were deployed on the test route at a planned checkpoint located on segment 11 of the treated road's. Also, a police warning sign was placed at segment 10 to inform motorists about the speed enforcement activity conducted at the checkpoint. Therefore, the effect of police presence was explored by comparison of speed choice on control road and treated road.

Table 21: Comparison of control and treated road for police intervention

Speed characteristics	Police	
	Control road	Treatment road
Mean (km/h)	60.83	54.81
Std. Deviation (km/h)	14.65	7.47
Variance (km/h)	214.74	55.76
85th Percentiles (km/h)	75.04	61.64
PTA (%)	66.1	68.7
PTA+5 (%)	54.42	58.42

Table 21 shows that participants have travelled faster on control road (60.8 ± 14.7 km/h) as opposed to the treated road (54.8 ± 7.5 km/h). The interventions elicited a decrease of 6.0 km/h in speed in treatment road compared to the control road. Variance of speed was found higher in the control road which indicates that the treatment reduces within-participant speed variability. The desired speed or 85th percentile in the control road was found 4.4 km/h higher than the treated road. Contrastingly, the mean of PTA in the treated road was 2.6% higher than control road, which also followed by PTA+5 or 65 km/h that was surprisingly 4.0% higher.

To understand further, a speed profile graph was produced to assess the effect of the police intervention on participants' choice of speed as presented in Figure 77.

Figure 77: Mean speed on control and treated road

Lower mean speed on treatment road was evident, predominantly on segment 9, 10 and 11, where police enforcement sign and police checkpoint located. Comparison of parallel segments on the control road shows that the deployment of police on the treatment road have influenced the participants. The speed increase between segment 2 and 3 and between segment 8 and 9, as well as the decrease between segment 5 and 6 and between segment 11 and 12 was found related to road layout changes. The paired-samples t-test was used to analyse the difference between mean speed on control and treatment road, whether the mean difference is statistically significantly different from zero, between the pair of mean speed.

The differences between the speed choice in control and treatment road were normally distributed, as assessed by visual inspection of a Normal Q-Q Plot. One outlier in treated road's data was detected that were more than 1.5 box-lengths from the edge of the box in a boxplot. Inspection of their values reveal it to be extreme, so they were excluded from the analysis.

Table 22: The paired samples test between control and treatment road for police intervention

Statistics		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SE	95% CI				
					Lower	Upper			
Pair 1	Control road - Treated road	8.79	7.45	1.99	4.49	13.09	4.41	13.00	0.001

The Paired Samples Test in Table 22 presents the mean difference between the two variables where there was a statistically significant decrease of mean speed in treatment road compared to the control road, $t(13) = 4.41$, $p = 0.001$, $d = 0.25$. A statistically significant difference was confirmed.

It is important to understand whether the size of this mean difference has practical importance because the difference in this analysis also meant a change of speed choice with regard to police presence. The change might be statistically significantly different around the police checkpoint but not in another part of test route. Therefore, the confidence intervals have provided information on the magnitude of the difference, from which it can be concluded that there is a statistically significant decrease of 8.79 (95% CI, 4.49 to 13.09) km/h due to the presence of police.

7.4.2 Training

The second series of analyses examined the impact of training on participant choice of speed. Training was conducted before the test; therefore, the effect was expected to be observed from for all segment. Therefore, it was investigated by comparison of the test result with the baseline or no-intervention condition on both part of test sections, control and treated road.

Overall, training intervention has produced slightly higher mean speed (65.1 ± 7.8 km/h) as opposed to the baseline's mean speed (62.3 ± 7.5 km/h), as correspondingly found to be at control road and treatment road. However, overall variability of speed was found smaller in no-intervention which indicated to the less difference of mean speed being exhibited within no-intervention' participants, as related to the mean. The desired speed or 85th percentile in training was found 4.8 km/h higher than no-intervention. Simple statistics were produced for comparing speed characteristic between training and no-intervention as presented in Table 23.

Table 23: Comparison of Training intervention and No-Intervention (baseline)

Speed characteristics	No intervention			Training		
	Control road	Treated road	Overall	Control road	Treated road	Overall
Mean (km/h)	62.2	62.4	62.3	64.7	65.5	65.1
SD (km/h)	8.7	6.8	7.5	7.7	9.1	7.8
Variance (km/h)	74.9	46.0	55.8	59.3	82.0	61.0
85th Percentiles (km/h)	71.2	71.8	71.2	72.8	76.7	72.3
PTA (%)	61.1	71.0	66.0	66.1	68.7	67.4
PTA+5 (%)	44.3	46.3	45.3	54.4	58.4	56.4

Correspondingly, Table 23 also shows that the PTA in the treated road by no-intervention was 2.3% higher than training, although the overall proportion was found slightly higher in Training by 1.4%. The higher the threshold of the speed limit, the higher the difference. The proportion of travel above the speed limit plus five or 65 km/h was surprisingly 11.1% higher during training intervention. A speed profile graph was created to understand how the means speed of each intervention differs from each other, as shown Figure 78.
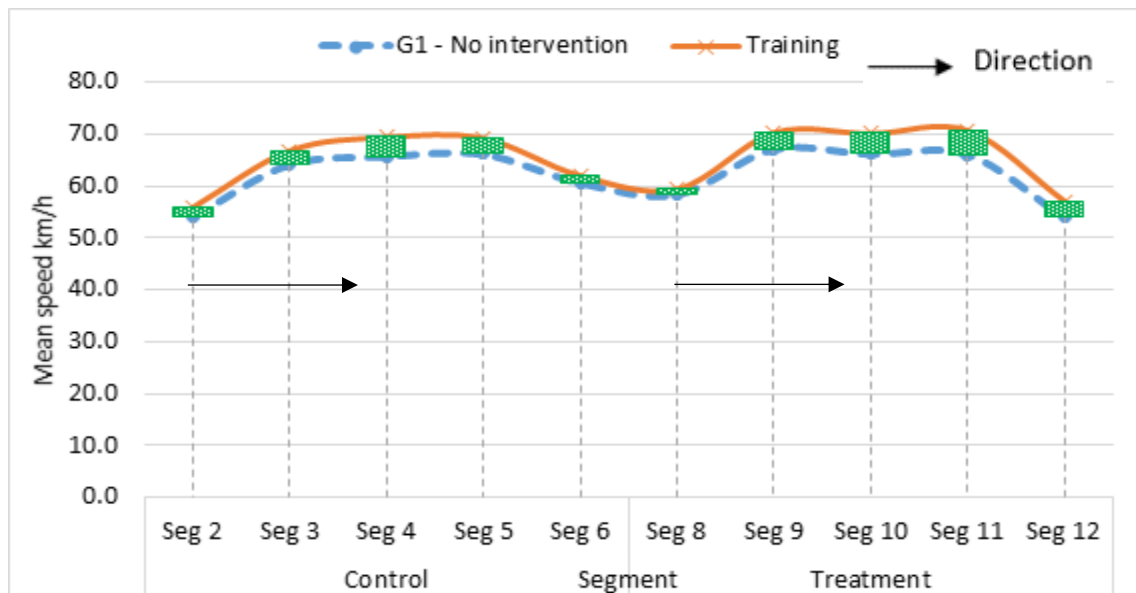
Figure 78: Dual carriageway mean speed plot for training and no-intervention

Analogous speed patterns were observed, although training intervention generated higher mean speed than no-intervention, either on control or treated road. The increase and decrease in mean speed took place in a change of road layout. The speed difference was investigated further by creating a mean differences bar, training effect has higher mean speed compared to baseline speed in all segment, as indicated by the bars that were always in a positive area.

An independent t-test was applied to determine whether there are any statistically significant differences between the training and baseline. The mean speed was normally distributed for training and no intervention as assessed by visual inspection of Normal Q-Q Plots. Two outliers were found in the no-intervention group, and no outlier was found in training. The assumption of homogeneity of variances was met, as assessed by Levene's test for equality of variances ($p > 0.05$).

Table 24: Independent samples t-test for equality of means

Statistics		t	df	Sig. (2-tailed)	Mean Difference	SE Difference	95% CI of the Difference	
							Lower	Upper
Control road	Equal variances assumed	-0.85	28.00	0.40	-2.53	2.99	-8.66	3.60
Treated road		-1.08	28.00	0.29	-3.15	2.92	-9.13	2.83
Overall		-1.02	28.00	0.32	-2.84	2.79	-8.56	2.87

The independent t-test shows that there was not a significant difference in mean speed between training and baseline, for control road t(28) -0.85, p = 0.4, for treated road, t(28) -1.08, p = 0.29, and for overall t(28) -1.02, p = 0.32. To sum up, there was no difference of mean

speed between training and no intervention, whether on the control or the treated road or overall.

7.4.3 Publicity

The last intervention investigated is the impact of roadside publicity on participants' speed. Publicity was placed on the roadside at three locations segment 8, 9, and 12 of the treated road. Detail of the roadside publicity intervention is presented in test route design, section 5.9. The effect of roadside publicity was explored by comparison of speed choice on control road and treated road, as presented in Table 25.

Table 25: Comparison of control and treated road for roadside publicity intervention

Speed characteristics	Publicity	
	Control road	Treatment road
Mean (km/h)	61.93	60.61
Std. Deviation (km/h)	13.28	10.89
Variance (km/h)	176.46	118.57
85th Percentiles (km/h)	80.09	76.96
PTA (%)	39.97	43.56
PTA+5 (%)	30.94	30.17

Table 25 shows that participants have travelled faster on control road (61.93 ± 13.28 km/h) as opposed to the treated road (60.61 ± 10.89 km/h). The interventions elicited a decrease of 1.32 km/h in speed in treatment road compared to the control road. Variability of speed was found higher in control road which indicated to the more difference of mean speed being exhibited within participants' speed on that road section, as related to the mean. The 85th percentile in control road was found 3.13 km/h higher than the treated road. Similarly, mean of PTA in the treated road was 3.59% higher than control road, in contrast, PTA+5 or 65 km/h that was merely 0.77% higher.

To understand further the effect of the roadside publicity presence on participants' speed, a speed profile graph was produced, as presented in Figure 79. Lower mean speed on treatment road was observed on segment 8, 9, and 12, where roadside publicity was placed. Comparison of parallel segments on the control road shows that the establishment of roadside publicity on the treated road has positively influenced the participants. There was a slight mean speed increase between segment 10 and 11 where no publicity on this site, while other mean speed variations was related to road layout.
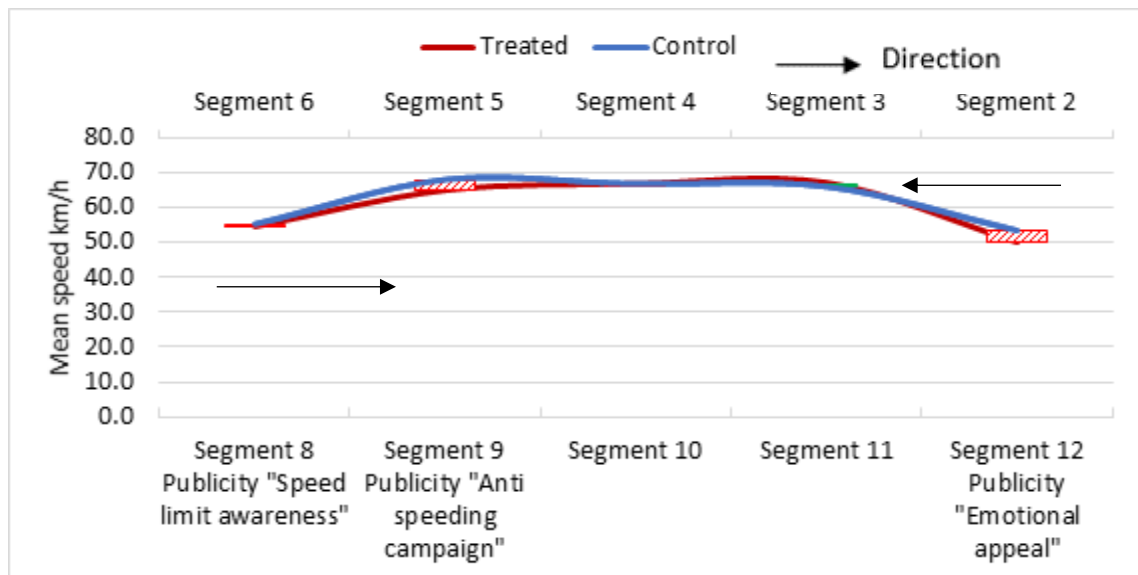
Figure 79: Mean speed on control and treated road

To analyse the difference between mean speed on control and treatment road, whether the mean difference is statistically significantly different from zero, the paired-samples t-test was used. The differences between the speed choice in control and treatment road were normally distributed, as assessed by visual inspection of a Normal Q-Q Plot. Data points' position were detected approximately along the diagonal line in the Normal Q-Q Plot. No outlier was detected that were more than 1.5 box-lengths from the edge of the box in a boxplot.

Table 26: The paired samples test between control and treatment road for roadside publicity

Statistics		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SE	95% CI				
					Lower	Upper			
Pair 1	Control road - Treated road	1.32	6.81	1.76	-2.45	5.09	0.75	14.00	0.47

The Paired Samples Test in Table 26 presents the mean difference between the two variables where there was not a statistically significant change of mean speed in the treatment road as compared to the control road, t(14) = 0.75, p = 0.47 d = 0.25. No difference of mean speed is confirmed.

7.4.4 Comparison of single interventions

Mean speed on each segment was used to compare the speed choice in the treated road. The highest mean speed was recorded with the training only intervention, 65.5 (SD= 12.0) km/h, while the lowest was observed during police presence, 54.8 (9.4) km/h, as presented in Table 27. The variability of speed was ranged from 88.9 in the police to 218.3 in the publicity intervention. However, participants in the no- intervention group committed violation more, 71.0% of their travel time proportions was above the limit.

Table 27: Single intervention result in dual carriageway 60 km/h

Statistics	No intervention	Training	Police	Publicity
Mean (km/h)	62.4	65.5	54.8	60.6
Std. Deviation (km/h)	9.6	12.0	9.4	14.8
Variance (km/h)	91.4	143.7	88.9	218.3
85th Percentiles (km/h)	69.3	77.3	63.2	75.5
PTA (%)	71.0	68.7	32.7	43.6
PTA+5 (%)	46.3	58.4	19.5	30.2

To understand further, how the mean speeds of each intervention differ, a speed profile graph was created, as shown in Figure 80. By using the speed pattern of the 'no-intervention' group as a baseline, the speed difference between the groups experiencing each intervention was investigated further. Along the graph line, the training group's mean speed was above that of the other groups, although speed patterns were similar, except during police presence. The presence of police reduced the speed significantly, especially while approaching segment 10 where the enforcement sign was placed, followed by a slight increase after passing the police unit on segment 11.
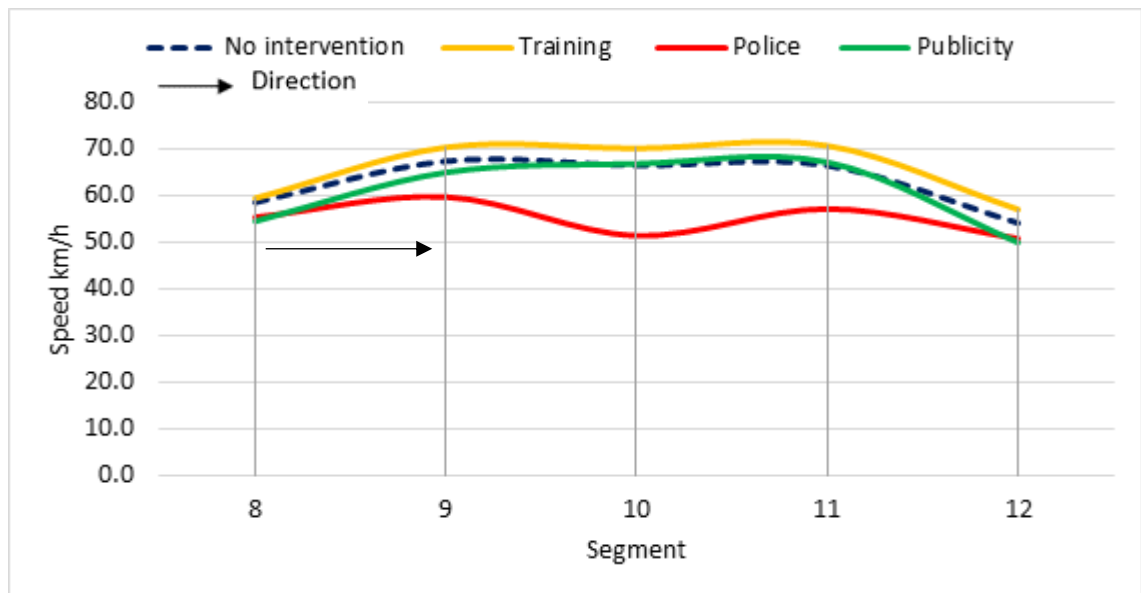
Figure 80: Segment means speed plot based on single intervention on dual carriageway

Furthermore, the publicity intervention effect showed a more varied mean speed. Upon entering the treatment road, where billboards were posted to warn the motorist about the speed limit (segment 8), and participants have adjusted their average speed to be lower than the baseline, as well as at the anti-speeding campaign billboard location (segment 9). In segments 10 and 11, mean speeds have returned to the baseline, before declining again after being exposed to an emotional message about a family waiting at home (segment 12).

To determine whether there were any statistically significant differences between the mean speeds for interventions and baseline, a one-way analysis of variance (ANOVA) were applied.

Mean speed was normally distributed for all single intervention as assessed by visual inspection of the normal Q-Q Plots. One outlier and seven outliers were detected that were more than 1.5 box-lengths from the edge of the box belonging to police and publicity, respectively. However, further inspection of the data did not find the outliers to be extreme, so they were kept in the analysis. The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances ($p < 0.05$), therefore the robust test of equality of means (or Welch's ANOVA) was used.

Welch's ANOVA result shows that the mean speed during the experiment on the dual carriageway route increased from the police intervention to the publicity intervention to the no-intervention to the training intervention, in that order, as presented in Figure 81.
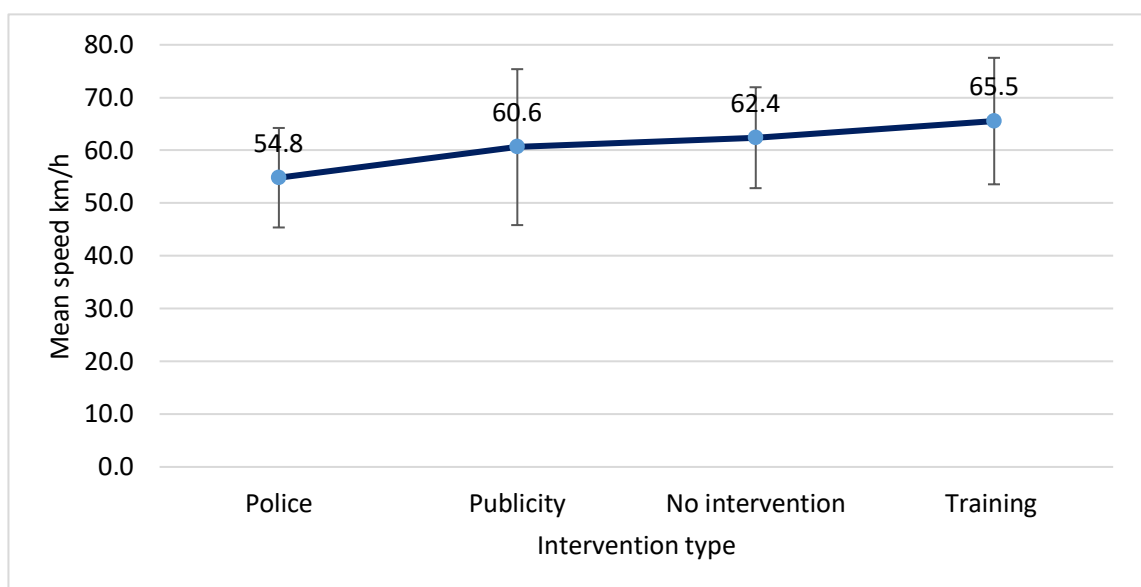
Figure 81: Mean speeds plot for single intervention on dual carriageway

The results shows that there was a statistically significant difference in mean speed between the different of single intervention result $F(3, 162.463) = 14.356$, $p < 0.005$. Further analysis was conducted by way of a post hoc test to reveal the possibility that a specific group might differ from another group, in all possible pairwise comparisons. The Games-Howell post hoc test was applied to compare all possible combinations of group differences when the assumption of homogeneity of variances is violated as presented in Table 28.

Table 28: Post-Hoc (Games-Howell) test for multiple comparisons of intervention

Group (I)	Group (J)	Mean Difference (I-J)	SE	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Police	No intervention	-7.58	1.55	0.000	-11.61	-3.55
Police	Training	-10.73	1.76	0.000	-15.31	-6.16
Police	Publicity	-5.79	2.02	0.025	-11.07	-0.53
Training	No intervention	3.15	1.77	0.287	-1.45	7.76
Training	Publicity	4.94	2.2	0.116	-0.77	10.65
Publicity	No intervention	-1.78	2.03	0.816	-7.08	3.51

Nevertheless, the Games-Howell post hoc test has shown that no intervention mean speed was lower than the training, a difference of 3.15± 1.77 [mean ± standard error] km/h, which was not statistically significant (p = 0.287). However, no intervention mean speed was higher than the police, the difference of 7.58± 1.77 [mean ± standard error] km/h, which was statistically significant (p <0.05). No intervention mean speed was higher than the publicity, the difference of 1.78± 2.03 [mean ± standard error] km/h, but, was not statistically significant (p <0.05).

Besides the significant difference with "no-intervention", the police have significant difference also with the training and the publicity. No other significant difference was found, and all group comparison detail is described in Table 28.

To sum up, the training intervention influenced a higher mean speed compared to other types of intervention, although the pair between training and other intervention were not statistically significant, except the pair of training and police intervention. A statistically significant difference was found to involve police intervention, both with the no intervention or training intervention. Publicity has not affected the lower choice of speed, except the pair of publicity and police intervention. Publicity has no significant difference with other types of intervention.

7.5   Single intervention effect on the single carriageway (50 km/h)

Similar procedures were applied to investigate the effect of each intervention on motorists' choice of speed.

7.5.1   Police

Police was deployed on test route at prearranged checkpoint located on treated road's segment 11. In addition, a police warning sign was placed at segment 10 to inform motorists about the speed enforcement activity conducted at checkpoint. Therefore, the effect of police presence was explored by comparison of speed choice on control road and treated road, as presented in Table 29.

Table 29: Comparison of control and treated road for police intervention

Speed characteristics	Control road	Treatment road
Mean (km/h)	44.76	47.1
Std. Deviation (km/h)	8.89	8.84
Variance (km/h)	79.05	78.13
85th Percentiles (km/h)	57.7	56.55
PTA (%)	26.34	35.93

Table 29 shows that participants have travelled faster on treated road (47.7 ± 8.84 km/h) as opposed to the control road (44.8 ± 8.89 km/h). A decrease of 2.9 km/h of mean speed was

recorded in treated road compared to the control road. Variability of speed was found similar as well as the 85th percentile of mean speed. Contrastingly, mean of PTA in treated road was 9.6% higher than control road, although PTA+5 or greater than 55 km/h was 0.9% higher in treated road.

To understand further, a speed profile graph was produced to assess the effect of the police intervention on participants' choice of speed as presented in Figure 82.
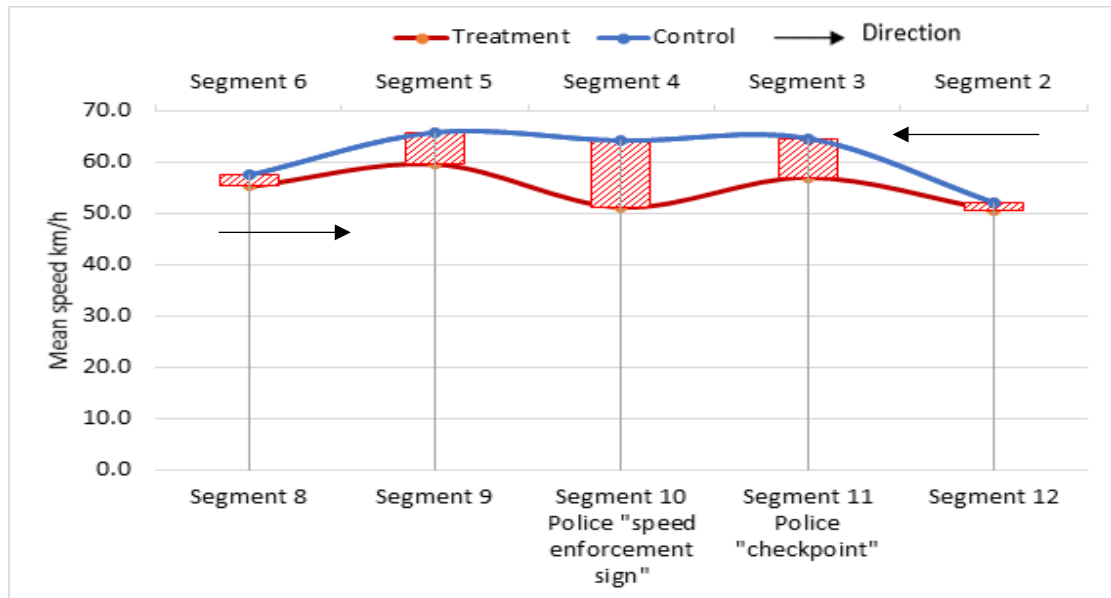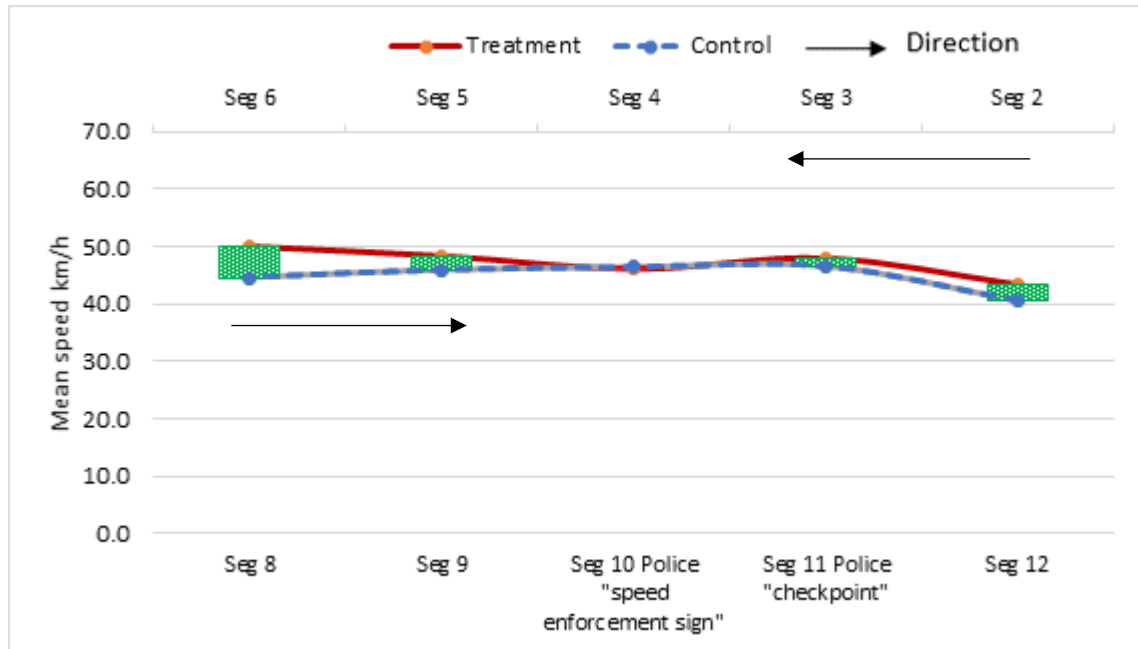

Figure 82: Mean speed on control and treated road

Differences of mean speed between control and treated road was somewhat small. Comparison of parallel segments on the control road shows that the deployment of police on the treatment road have also influenced the participants on control road. The mean speed between segment 4 and 10 was found close to zero.

The paired-samples t-test was used to analyse the difference between mean speed on control and treated road, whether the mean difference is statistically significantly different from zero, between the pair of mean speed.

Prior to the statistical test, the assumption of normality was assessed. The differences between the speed choice in control and treatment road were normally distributed, as assessed by visual inspection of a Normal Q-Q Plot, and Shapiro-Wilk's test (p = 0.086). One outlier data were detected that were more than 1.5 box-lengths from the edge of the box in a boxplot. Inspection of their values reveal it was not to be extreme, so it was kept in the analysis.

Table 30: The paired samples test between control and treatment road for police intervention

Statistics		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SE	95% CI				
					Lower	Upper			
Pair 1	Control road - Treated road	-2.33	4.65	1.20	-4.91	0.24	-1.94	14.00	0.072

The Paired Samples Test presents the mean difference between the two section of test route where there was not a statistically significant decrease of mean speed in treatment road compared to the control road, t(14) = -1.94, p = 0.072, d = 0.25.

The difference in this analysis also meant a change of participants' choice of speed with regard to police presence. The change was not statistically significantly different around the police checkpoint as well as on the other part of test route. It can be concluded that there was no statistically significant change of speed (mean 2.33 km/h, 95% CI, -4.91 to 0.24) due to the presence of police.

7.5.2 Training

On single carriageway, the training intervention resulted in a slightly lower mean speed (47.3 ± 4.8 km/h) as opposed to the non-intervention mean speed (48.9 ± 5.1 km/h), as well as at control and treatment road of single carriageway. However, overall variability of speed was found similar for both condition. The 85th percentile or desirable speed was also observed similar 4.8 km/h.

Table 31: Comparison of Training intervention and No-Intervention (baseline).

Speed Characteristics	Group assignment and intervention					
	No intervention			Training only		
	Control road	Treated road	All	Control road	Treated road	All
Mean (km/h)	48.5	49.3	48.9	46.6	47.9	47.3
Std. Deviation (km/h)	5.5	5.5	5.1	5.5	5.2	4.8
Variance (km/h)	30.5	29.8	26.3	30.8	27.2	23.2
85th Percentiles (km/h)	54.2	55.0	54.0	54.1	55.1	54.1
PTA (%)	45.8	52.6	49.2	40.6	45.6	43.1
PTA+5 (%)	26.8	32.9	29.9	21.0	22.3	21.7

Simple statistics were produced for comparing speed characteristic between training and no-intervention as presented in Table 31. Overall proportion of speeding in no-intervention was higher than training, the higher the speeding threshold, the large the differences of proportion of speeding. No intervention has 8.2% higher proportion of travelling above 55 km/h than training. It was 5.8% in control road, then become double, 10.6% in treated road.

To investigate further the speed along the test route, a speed profile graph was produced, as presented in Figure 83. In most segments, the no-intervention group travel faster than training

group. The average differences were 1.9 and 1.4 km/h for control and treated road, respectively. The increase and decrease of mean speed mainly took place at the beginning and the end of test route or route's section, where participants must stop or made a U-turn.
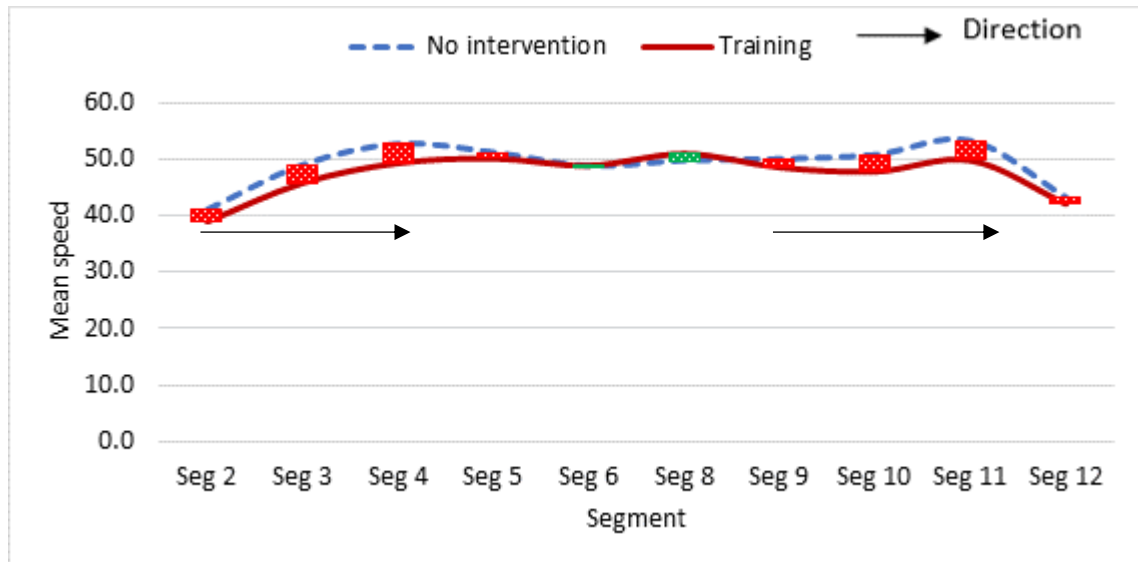
Figure 83: Single carriageway mean speed plot for training and no-intervention

To determine whether there are any statistically significant differences between the training and baseline, an independent t-test was applied. However, assumption and justification were analysed first. The mean speed was normally distributed for training and no intervention as assessed by visual inspection of Normal Q-Q Plots. No outliers were found in no-intervention group and in training. The assumption of homogeneity of variances was met, as assessed by Levene's test for equality of variances ($p > 0.05$).

Table 32: Independent samples t-test for equality of means

Statistics		t	df	Sig. (2-tailed)	Mean Diff	SE Diff	95% CI of the Difference	
							Lower	Upper
Control road	Equal variances assumed	0.91	28.00	0.37	1.83	2.02	-2.31	5.97
Treated road		0.77	28.00	0.45	1.49	1.95	-2.50	5.48
Overall		0.92	28.00	0.37	1.66	1.82	-2.06	5.38

The independent t-test shows that there was not a significant difference in mean speed between training and baseline, for control road t(28) 0.91, p = 0.37, for treated road, t(28) -1.08, p = 0.45, and for overall t(28) 0.92, p = 0.37. To sum up, there was no difference of mean speed between training and no intervention, whether in control and treated road or overall.

7.5.3 Publicity

According to study design, roadside publicity was placed at three locations on treated road's segment 8, 9, and 12. The control road's mean speed is 46.3 ± 6.5 km/h as opposed to the treated road 46 ± 6.3 km/h. The interventions elicited a decrease of 0.3 km/h of mean speed in

treated road compared to the control road. Variance of speed was found to be slightly higher on the control road which indicates that the intervention reduced speed variability. The desired speed or 85th percentile was 2.2 km/h higher in the control road than in the treated road. On the other hand, mean of PTA in the treated road was 3.2% higher than in the control road. By contrast, PTA+5 (above 55 km/h) was 0.02% lower. The result of roadside publicity intervention on control and treated road, is presented in Table 33.

Table 33: Comparison of control and treated road for roadside publicity intervention

Speed characteristics	Publicity		
	Control road	Treated road	All
Mean (km/h)	46.32	45.96	46.14
Std. Deviation (km/h)	6.49	6.27	5.96
Variance (km/h)	42.08	39.36	35.50
85th Percentiles (km/h)	55.97	53.78	54.11
PTA (%)	31.67	34.36	33.01
PTA+5 (%)	20.74	20.72	20.73

A speed profile graph was produced to investigate the effect of the roadside publicity presence, as presented in Figure 84.
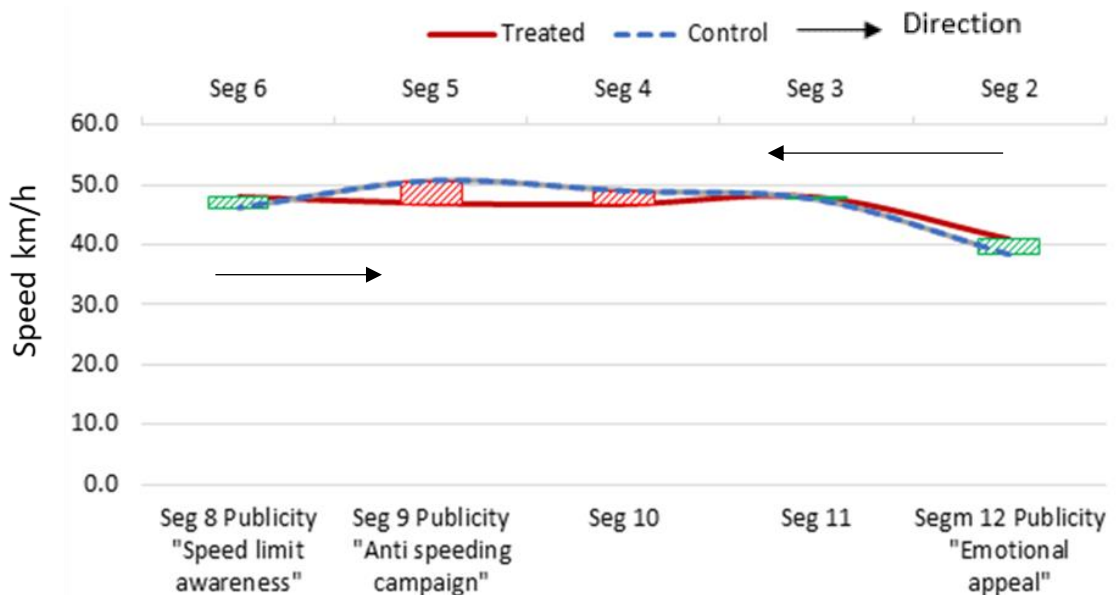
Figure 84: Mean speed on control and treated road during publicity intervention

Lower mean speed on the treatment road was observed on segment 9 and 10, just after the first and the second roadside publicity location. Comparison of parallel segments on the control road shows that the establishment of roadside publicity on the treated road had positively influenced the participants. There was a slight mean speed increase between segments 10 and 11 where there was no publicity on this site, while other changes in mean speed variation seemed to relate to variation in road layout.

To analyse the difference between mean speed on the control and treatment roads, i.e. whether the mean difference is statistically significantly different from zero, the paired-samples t-test was used. However, prior to the statistical test, the assumption of normality was assessed. The differences between the speed choice in control and treatment road were normally distributed, as assessed by visual inspection of a Normal Q-Q Plot. Data points' position were detected approximately along the diagonal line in the Normal Q-Q Plot. No outlier was detected that were more than 1.5 box-lengths from the edge of the box in a boxplot.

Table 34: The paired samples test between control and treatment road for roadside publicity

Statistics		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SE	95% CI				
					Lower	Upper			
Pair 1	Control road - Treated road	0.36	4.6	1.2	-2.8	2.9	0.303	14	0.77

The Paired Samples Test presents the mean difference between the control and treated road where there was not a statistically significant change of mean speed in treatment road compared to the control road, $t(14) = 0.303$, $p = 0.77$ $d = 0.25$. No difference mean speed is confirmed although a decrease of 0.36 (95% CI, -2.8 to 2.9) km/h was observed, as the effect of roadside publicity.

7.5.4 Comparison of single interventions

The result of each single intervention factor on the single carriageway is presented in Table 35 below. The 'no-intervention' result was observed to be higher than any single intervention, 48.9 (SD=8.1) km/h and the police was the lowest by 45.9 (SD= 9.6) km/h.

Table 35: Summary statistics of groups on single carriageway in km/h

Speed	No intervention	Training	Police	Publicity
Mean (km/h)	48.9	47.3	45.9	46.1
Std. Deviation (km/h)	8.1	7.6	9.6	8.1
Variance (km/h)	65.4	58.0	91.4	65.3
85th Percentiles (km/h)	58.2	54.9	56.3	55.2
PTA (%)	49.2	43.1	31.1	33
PTA+5 (%)	29.9	21.7	18.9	20.7

The variance of speed ranged from 58.0 to 91.4 observed during the three interventions. All 85th percentile speeds were found to be higher than the posted speed limit. The lowest 85th percentile was recorded with the training intervention, 54.9 km/h, which is 4.9 km/h higher than the posted speed limit. Participants in the 'no-intervention' committed more speeding offences than other groups, offending for 49.2% of their travel time.

To assess further, how each intervention affected the choice of speed along the test route, a speed profile graph was created, as shown in Figure 85.
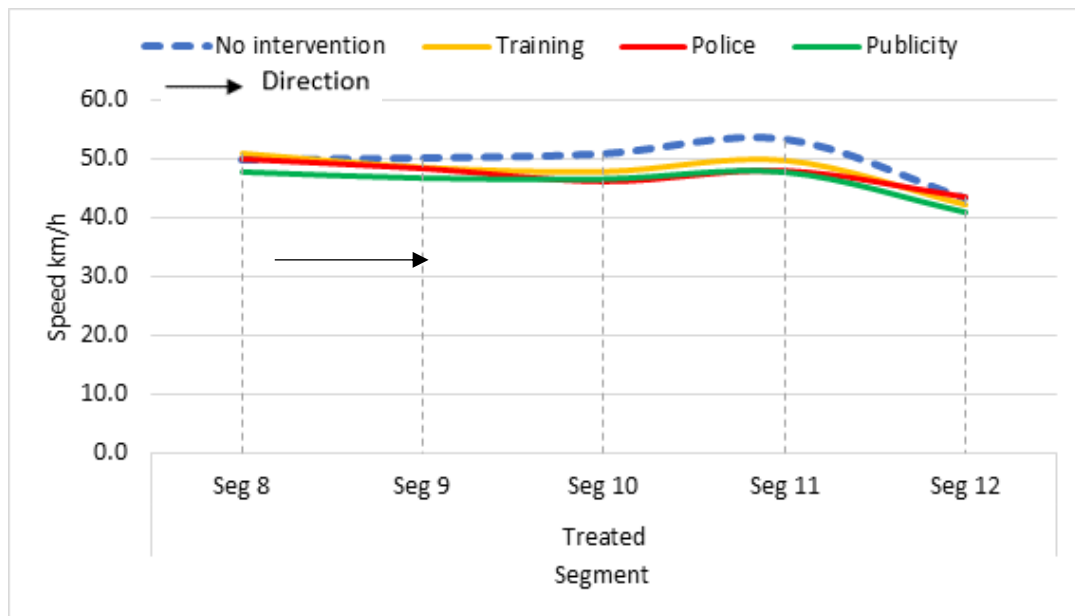
Figure 85: Segments' mean speed plot based on intervention group in single carriageway

The graph shows that the speed patterns were relatively similar. There was a tendency for mean speeds in segment 8, 9 and 10 to gradually decrease while approaching segment 10, except for the baseline where they appeared flat. In segment 11, there was a slight increase of speed for all intervention types, although the training and the no-intervention groups increased speed more. Finally, at the end of test route, a lower mean speed for all types of intervention was logged.

The training intervention tends to produce a steady pace. Since the early segment, the gap (differences) of the training mean speed with the baseline have not changed much, remaining between 1 and 3 km / h. The increase and decrease of speed were observed to be more related to the road layout, i.e. at the time of start, turning point, and at the finish line. The training intervention created more stable performance and shows a lower mean speed compared to the no intervention data. This finding is contrast to training result in the dual carriageway road.

Furthermore, the group that experienced the police presence intervention reacted by reducing speed as they crossed segment 10. It produced the highest difference of mean speed by 10.4 km/h in segment 11. The roadside publicity intervention showed a substantial change in mean speed between segments 8, 9, 10, and 11.

To determine whether there were any statistically significant differences between the mean speeds for single interventions and the baseline, a one-way analysis of variance (ANOVA) was

computed. Prior to the statistical test, assumptions and justifications for the one-way ANOVA must be analysed. The mean speed was normally distributed for all single interventions, as assessed by a visual inspection of the normal Q-Q Plots. The data points' positions were detected to be approximately along the diagonal line in the normal Q-Q Plot.

To assess the outliers for each single intervention's mean speed, a boxplot was utilized. Three outliers were detected that were more than 1.5 box-lengths from the edge of the box that belonged to the police intervention group. However, further inspection of the data did not find the outliers to be extreme, so they were kept in the analysis.

The ANOVA result shows that the mean speed during the experiment increased from the publicity (45.9 ± 7.4 km/h) to the police (47.1 ± 9.6 km/h) to training (47.9 ± 7.2 km/h) to "no-intervention" (49.3 ± 7.6 km/h), in that order, as described in Figure 86.

The assumption of homogeneity of variances was not violated, as assessed by Levene's test for equality of variances ($p > 0.05$); therefore, a standard ANOVA result was used. The findings reveal that overall there were not a statistically significant effect on mean speed across all the single intervention results; $F_{(3, 296)} = 2.366$, $p = 0.071$ or $p > 0.05$.
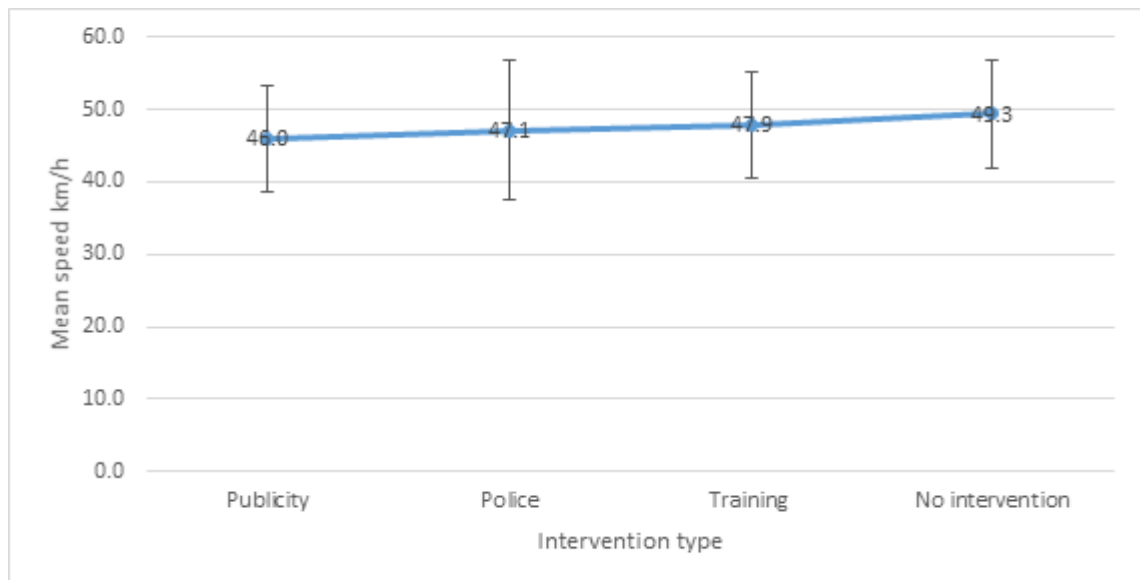
Figure 86: Mean speeds plot for single intervention on single carriageway

To sum up, although the training intervention, the police presence and the publicity presence on the roadside have influenced a lower mean speed to compare to the baseline, but there was not statistically significant.

7.6 Comparison of car and motorcycle speed for single intervention test

There were 89 motorcycle riders and 31 car drivers assigned to single or no-intervention condition. For dual carriageway route, 40 motorcycles and 20 cars, while for single carriageway

49 motorcycles and 11 cars. Only the treatment road is used in comparison of speed. The result is presented in Figure 87.
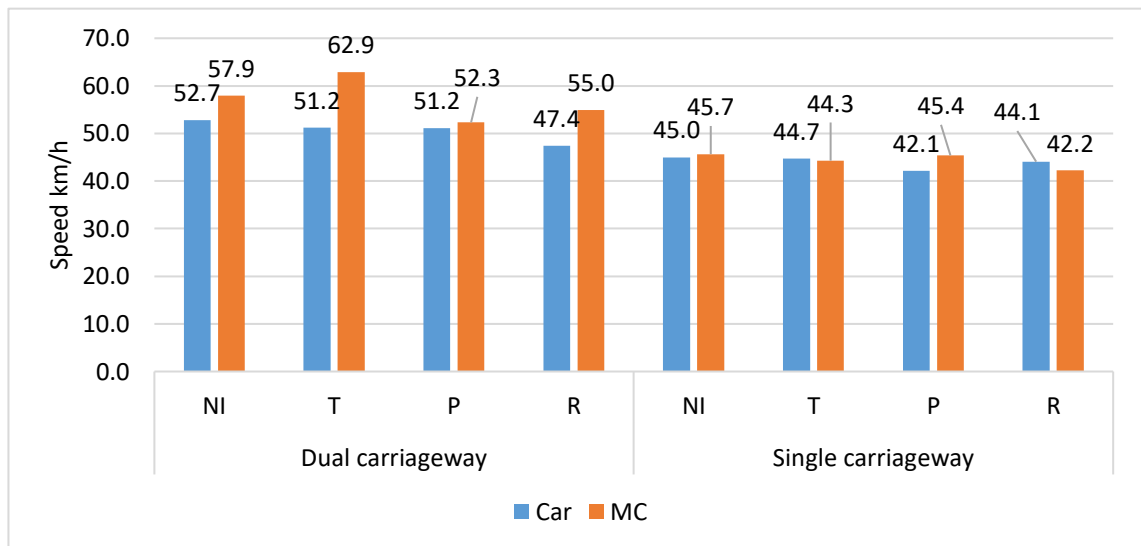
Figure 87: Mean speed of car and motorcycle for single intervention group

In dual carriageway route, motorcycles' speeds were found higher in all group, while in single carriageway route cars' and motorcycles' speeds were found similar to each other. In dual carriageway, the highest speed difference was 11.7 km/h in training only intervention, while on single carriageway the largest speed difference is 3.4 km/h, took place in police only intervention.

To assess the difference of car and motorcycle mean speed, whether it is statistically significant or not, an independent t- the test has been performed. Assumption and justification for independent sample t-test were analysed before the statistical test. The result is presented in Table 36.

Table 36: Independent t-test result of car and motorcycle speed for single intervention

		Levene's Test		t-test for Equality of Means						
							Mean	SE	95% CI of the Diff	
Route	Intervention	F	Sig.	t	df	Sig. (2-tailed)	Diff	Diff	Lower	Upper
DC60	No intervention	4.595	0.052	-1.524	13	0.151	-5.19	3.41	-12.55	2.17
	Training	0.027	0.871	-2.864	13	0.013	-11.68	4.08	-20.50	-2.87
	Police	2.300	0.153	-0.271	13	0.791	-1.15	4.26	-10.36	8.06
	Publicity	2.062	0.175	-2.007	13	0.066	-7.54	3.75	-15.64	0.57
SC50	No intervention	2.868	0.114	-0.184	13	0.857	-0.68	3.68	-8.62	7.27
	Training	2.361	0.144	0.109	13	0.915	0.42	3.82	-7.84	8.68
	Police	0.315	0.584	-0.693	13	0.500	-3.26	4.71	-13.43	6.91
	Publicity	2.517	0.137	0.681	13	0.508	1.85	2.71	-4.01	7.71

The independent t-test shows that there was only one significant difference in mean speed between car and motorcycle speed, for training intervention in dual carriageway road, t(13) -

2.864, p = 0.013. There was no difference of mean speed between car and motorcycle speed, in other single intervention in dual and single carriageway.

7.7 Conclusion

The evidence from the single intervention experiment suggests that there is a difference in the speed pattern depending on the type of intervention applied. On dual carriageway, the training intervention has been found to create a slightly higher mean speed during the test, although it has not produced a statistically significant difference with the baseline mean speed. There is a tendency that trained participants drive faster than the baseline speed on dual carriageway segments, while on single carriageway segments, the trained participants were observed to drive slower than the baseline, although the training intervention still produced a higher proportion of speeding compared to the other groups.

In contrast, the police presence intervention strongly influenced participants to decrease their speed on both routes. However, on single carriageway segments, there was clear evidence that the participants reacted to the presence of the police despite their being on the opposite side, which did not occur on dual carriageway segments. A decrease in mean speed was also observed between "no-intervention" and the publicity intervention, although it was not statistically significant. In addition, comparison of car and motorcycle mean speed, shows only the training group in dual carriageway route was significantly different.

The analysis of participants' choice of speed based on the single interventions is interesting. Three runs were used to estimate each effect. They were a straightforward procedure in determining whether a particular intervention had an effect on speed choice compared to other interventions. However, the interaction between the factors cannot be estimated for this design and analysis. Therefore, the factorial design in this study has allowed further analysis by combining the three factors into one analysis, which is usually called factorial ANOVA or three-way ANOVA, and are presented in the next chapter.

Chapter 8

The effect of interventions in combination on motorists' choice of speed

8.1 Introduction

One of the aims of this study is to investigate the effect of combined interventions that include police presence, training, and publicity, on drivers' choice of speed, and thus to assess whether training and publicity should be added to police enforcement in order to enhance the effectiveness of that enforcement. It was expected that field observation in the present study would provide accurate data for studying drivers' choice of speed. Hence, this chapter presents the result of the experiment conducted.

There is one dependent variable, namely, "choice of speed", that was measured continuously. There are three independent variables (i.e., training, police, and publicity) where each independent variable consists of two categorical (absence and presence), independent groups. Hence, per design of factors and levels, there were eight independent groups in this experiment. The absence of intervention is treated as low level and the presence as high level. A different way of presenting cell of design is by using (-) to represent the low and (+) for high levels of the factors.

The factorial experiment in this study has allowed for an effective and efficient investigation of drivers' choice of speed on pre-designed enforcement corridors or test routes. 240 participants, who were voluntarily involved in a study that combined training, police presence, and publicity in a single experiment, accomplished the test. The number of observations per cell is 15, which is equal to the number of participants assigned. Each observation is a sequence of driving from control road to treatment.

8.2 Experimental method

This section begins with a restatement of the research questions in order to guide the data collection and analysis. The effectiveness of speed enforcement that combined three-factors, motorist training, police presence, and roadside publicity, are addressed through the following research questions:

1. Are there significant mean differences for the drivers' choice of speed depending on which interventions were applied, between training, police presence, and roadside publicity?

2. Are there significant interactions between training, police presence, and roadside publicity?

3. What is the estimated impact of changes in motorists' speed choice on accident and casualty risk?

To answer these research questions, this study followed three-factor independent group design or factorial design, where the influence of a specific treatment of a particular group was compared with the effects of a different treatment on other groups. It is the ultimate design of choice whenever the study aims to examine treatment variations, because of this design's efficiency; it is the most effective way to examine the interaction effects of two or more factors and levels.

8.2.1 Experimental design: 2^3 factorial design

One of the objectives of this study is to determine if there is an interaction effect between training, police presence, and roadside publicity on motorists' choice of speed. It was hypothesised that the motorists' choice of speed is affected by these factors, particularly the presence of police on the road, as discussed in the literature review section.

Fixed factors of experiment

Police enforcement is influenced by many factors, such as drivers' perception of the risk of apprehension and visual information regarding speed limit and speeding risk (Hauer et al., 1982; Wegman and Goldenbeld, 2006; Hijar et al., 2003; McInerney et al., 2001; Goldenbeld, 1995). However, variables in this study were designed to be fixed factors. There is no intention to represent all police strategies or tactics in the domain of speed enforcement (as described in the literature reviews); this study is intended to investigate "stationary and visible" police presence only (see Figure 88). This consideration is also applicable to other factors, such as motorists' training and roadside publicity (using billboard as the media). The motorists' training is not randomly selected from all types of training available, just as roadside publicity is not chosen from numerous types of publicity that used by the police. Hence, all factors in this study are fixed and are hence expected to produce fixed effects.

As such, this study is conducted to determine if these interaction effects exist between the level of police presence, motorists' prior involvement in training, and roadside publicity, in order to justify the effectiveness of police speed enforcement procedures.

Figure 88: Police unit and warning sign deployed on the checkpoint

The cells of design

The primary dependent variable in the present study is choice of speed (in km/h), which is collected from participants during the test drive on the predesigned routes. The experimental design employed three independent variables as the factors—training, stationary and visible police presence, and publicity of enforcement—into one study. Each of these treatments has two levels, the absence and the presence of the treatment; thus, a 2 x 2 x 2 or 2^3 factorial design is called for. Furthermore, the labels used for the present study are 'Y' for test result, 'T' for training, 'P' for police presence, 'R' for roadside publicity, (-) for the absence and (+) for the presence of intervention; then t, p, and r were used to represent the presence of factors in cell of design. A careful design of each variable or factor and level is presented in Table 37.

Table 37: Variables and factors

Variables	Factors	Levels
Independent (IV)	Training (T)	Absence (-)
		Presence (+)
	Police (P)	Absence (-)
		Presence (+)
	Roadside publicity (R)	Absence (-)
		Presence (+)
Dependent (DV)	Drivers' choice of speed (Y in km/h)	

All of the unique combinations of the groups of the three independent variables have created eight cells of the table, or 8 cells in the study design. These independent variables are diagrammatically presented in Table 38.

Table 38: The cells of design: combinations of factors and levels

Factors and levels		Roadside publicity (R)			
		Absence		Presence	
		Police (P)		Police (P)	
		Absence	Presence	Absence	Presence
Training (T)	Absence	*i*	*p*	*r*	*pr*
	Presence	*t*	*tp*	*tr*	*tpr*

Afterwards, two test drive routes were prepared in accordance with the first survey results. Each route required eight groups, where every group of participants would be exposed to a different treatment. Although it was not a replication of the first route, all treatment that been conducted in the first route were repeated in the second route.

Furthermore, to promote efficiency in this experiment and to avoid a reversal effect of manipulations, the experiment was carried out in two stages. All experiments that required publicity were run at the second stage since it is considered to be high cost and ineffective if employed randomly. Once the billboards were constructed, the effect would not be able to be manipulated in a short period. The messages would be quickly spread out among the drivers. Details of the experimental groups and stages of the experiment are discussed in section 8.2.4.

8.2.2   Participants

Overall, 240 participants completed the test drive on one of two designated routes (so 120 per route), dual carriageway (60 km/h speed limit) and single carriageway (50 km/h limit). Each route has 8 groups of drivers; each group was independent and underwent one configuration of experimental treatments. Hence, 15 participants were assigned to every configuration of treatments (See section 5.9.4).

Among the 120 participants assigned to the dual carriageway (60 km/h), 81 were male, and 39 were female, whilst on single carriageway route, 91 participants were male and 29 were female. In total, the male participants totalled to 172 people, and the female participants totalled to 68 people. Furthermore, for both routes, motorcycle users made up 176 people, while there were 64 car users. The average age was 29 years old. It was interesting to see that more than half of the participant was under 25 years old and hence would be categorized as young and novice motorists.

8.2.3   Procedure

The following procedures were approved by the University of Leeds ethical board before this research was carried out. It was accurately what has been conducted, which described in sufficient detail to allow for replication of findings.

Test routes

This study would carry out the experiment in two routes as described in 5.9.1.

Group assignment

Each route needed eight groups, labelled as Group 1, 2, 3, 4, 5, 6, 7 and 8. Detail of group assignment was discussed in Section 5.9.4.

Participants' tasks

Participants were asked to drive normally as they drive in their daily activity. Detail of task was discussed in Section 5.9.4.

8.2.4   Data analysis

Data exploration techniques for creating speed profiles in factorial design based on combined intervention effect

It was a challenging task to describe how the participants' speed profiles were drawn, since the factors and levels were distributed across the groups as combinations of interventions. However, in a factorial design, the effect of one factor is the difference between the high and the low level of that factor (Montgomery, 2013; Anderson and Whitcomb, 2000). The effect for each factor is a contrast of *high level* and *low level* of that factor (Matsumura and Tucker, 1996).

For the purpose of analysis, five segments on treatment road, *s*, were extracted from each participants' mean speed. For example, let T be the effect of training, as determined from the difference of training presence (+) and training absence (-). The aggregation of data was conducted using the sum function; therefore, the contrast for factor is defined as:

$$d_s = \frac{1}{n}\left(\sum_{i \in T+} y_{is} - \sum_{j \in T-} y_{js}\right), s = 1, 2, 3, 4, 5$$

where n's refers to the number of data points collected at each level. The contrast series is expressed as the series of 5 segment-by-segment speed choices on treated road. Contrast series can be formally equated as follow:

Let $y_{is}, s = 1, 2, 3, 4, 5$ denote the choice of speed at segment s in cell $\boldsymbol{i}$.

Let $T(+)$ denote the set of cells' labels in which the level of the design variable T is (+), then $T(+) = (t, tp, tr, tpr)$

Let $T-$ denote the set of cell numbers in which the level of the design variable T is (−), then $T(-) = (i, p, r, pr)$.

Therefore, for contrast T, difference of mean speed is:

$$difference\ T = \frac{1}{4}\ (Sum\ of\ T(+) - Sum\ of\ T(-))$$

$$= \frac{1}{4}\left((t + tp + tr + tpr) - \left((i) + p + r + pr\right)\right)$$

All series of differences are as follows:

- $Training\ (+)$: 4 series (from cell $t, tp, tr\ and\ tpr$)
- $Training\ (-)$: 4 series (from cell $i, p, r\ and\ pr$)
- $Police\ (+)$: 4 series (from cell $p, tp, pr\ and\ tpr$)
- $Police\ (-)$: 4 series (from cell $i, t, r, and\ tr$)
- $Publicity\ (+)$: 4 series (from cell r, tr, pr, tpr)
- $Publicity\ (-)$: 4 series (from cell $i, t, p\ and\ tp$)

Then, the contrast series for police, P, and roadside publicity, R, were defined exactly the same way.

The next step is to investigate further possible speed choice changes over time. A cumulative sum (CuSum) of the contrast series was plotted. Suppose that during a period of time the values are all below average. The amounts added to the cumulative sum will be negative and the sum will steadily decrease. However, a segment with a downward slope indicates a period of time where the values tend to be below the average. Likewise a segment with an upward slope indicates a period where the values tend to be above average (Hawkins and Olwell, 1998).

The sth CuSum in this analysis is the cumulative sum of the s values in a contrast series. Supposed $\{d_s, s = 1, 2, 3, 4, 5\}$ is a contrast series. Then the sth CuSum, S_s, for the contrast series is:

$$S_s = \sum_{i=s}^{s} d_s$$

Therefore, the CuSum series A is formally equated as

$$CuSum = Cumulative\ Sum\ (difference\ T)$$

where the cumulative sums of the different segments' sequence $\{d_1,\ d_2, d_3, d_4, d_5\}$, are $ds1, ds1 + ds2, ds1 + ds2 + ds3, \ldots$

Then, CuSum for police, P, and roadside publicity, R, were defined exactly the same.

The next task is about creating a speed profile for the interaction effect, either a two-way or a three-way interaction. Very often, the result of the interaction effect is a breakthrough improvement in a system (Montgomery, 2013). The main principle of factorial analysis recognizes that an interaction effect occurs when the effect of one factor depends on the level of another factor.

A two-factor interaction is defined as the difference on the average effect of a factor when the level of another factor changes (Montgomery, 2013). For example, let TP be the interaction of training and police factors; then the interaction is defined as the average effect of training when the police level changes from absence (-) to presence (+). By convention, one-half of this difference is called the *AB* interaction. Therefore, the mean speed for contrast series formally equated as follow:

Let y_{is}'$s = 1, 2, 3, 4, 5$ denote the choice of speed at segment s in cell i.

Let $TP(+)$ denote the set of cell numbers of average T when the level of the design variable P is $(+)$, then $TP (+) = (i, r, tp, tpr)$

Let $TP -$ denote the set of cell numbers of average T when the level of the design variable P is $(-)$, then $TP (-) = (t, tr, p, pr)$

$$TP = \frac{1}{4} \left((i + r + tp + tpr) - (t + tr + p + pr) \right)$$

The quantities in the bracket are contrasts in the treatment combination. Then, using similar logic, the TR and PR interactions are:

$$TR = \frac{1}{4} \left((i + p + tr + tpr) - (t + tp + pr + r) \right)$$

and

$$PR = \frac{1}{4} \left((i + t + pr + tpr) - (p + tp + r + tr) \right)$$

The cells that contain these factors are taken and arranged in a two-factor interaction table, as shown in Table 39:

Table 39: Two-factor interaction matrix

Cell	T	P	TP		Cell	T	R	TR		Cell	P	R	PR
i, r	(-)	(-)	(+)		i, p	(-)	(-)	(+)		i, t	(-)	(-)	(+)
t, tr	(+)	(-)	(-)		t, tp	(+)	(-)	(-)		p, tp	(+)	(-)	(-)
p, pr	(-)	(+)	(-)		r, pr	(-)	(+)	(-)		pr, tpr	(+)	(+)	(+)
tp, tpr	(+)	(+)	(+)		tr, tpr	(+)	(+)	(+)		r, tr	(-)	(+)	(-)
Contrast TP = (+) − (−)					Contrast TR = (+) − (−)					Contrast PR = (+) − (−)			

Table 39 above shows that all the two-way interaction effects are defined by the contrasts main factors. The product of any two contrasts gives the other contrast in that matrix. It is defined that the contrast TP is the product of the T and P contrasts, the contrast TR is the product of the T and R contrasts, and the contrast PR is the product of the P and R contrasts.

Furthermore, the TPR interaction is defined as the average difference between the TP interactions at two different levels of R (Montgomery, 2013; Anderson and Whitcomb, 2007). Thus,

$$TPR = \frac{1}{4}\left((t + p + tpr + r) - (i + tp + pr + tr)\right)$$

The cells that hold these factors are taken and arranged in a three-factor interaction as shown in the following table:

Table 40: Three-factor interaction matrix

Cell	T	P	R	TPR
i	(-)	(-)	(-)	-
t	(+)	(-)	(-)	+
p	(-)	(+)	(-)	+
tp	(+)	(+)	(-)	-
pr	(-)	(+)	(+)	-
tpr	(+)	(+)	(+)	+
r	(-)	(-)	(+)	+
tr	(+)	(-)	(+)	-
$Contrast\ TPR\ =\ (+) - (-)$				

Then, CuSum, the cumulative sum of the different segments' sequence $\{d_1,\ d_2, d_3,\ d_4, d_5\}$, are (for each instance) $ds1, ds1 + ds2, ds1 + ds2 + ds3, \dots$ and two-factor and three-factor contrast were defined exactly the same as for a situation with a single factor.

To sum up, the main effect is defined as T, P and R, the two-way interaction effects are TP, TR and PR; additionally, the three-way interaction effect is TPR. The sign (+) represent the high level or the presence of a factor, while (-) represent the low level or the absence of factor. These terms are interchangeable.

Furthermore, a speed profile graph was set up to analyse whether the contrast series of the main effect and the interaction effect were suggestively differenced from zero, and a factorial ANOVA test was performed to determine if there was a significant interaction effect between the three independent variables when speed was a continuous dependent variable.

Statistical test

Several research questions and hypotheses were proposed in this study. Respectively, these were answered and tested using proper and justified statistical tests. For example, the mean difference between two groups was tested by a paired t-test or an independent t-test, while differences between groups involving more than two independent variables used factorial ANOVA.

Factorial ANOVA is also referred to more generally as a three-way ANOVA or more specifically as a three-way between-subjects' ANOVA. The primary goal of running a three-way ANOVA is to determine whether there is a three-way interaction between three independent variables applied in this study.

Combined intervention effect

To determine if there are differences between three or more intervention tested, the mean scores were compared between the intervention factors using a factorial ANOVA. Since the three independent variables were employed in this study, the factorial ANOVA, which also called three-way ANOVA, is used to determine if there is an interaction effect or three-way interaction exists.

Four steps were applied in order to interpret the results for three-way ANOVA result (Laerd Statistics, 2015d) as follows:

1. Determining whether a three-way interaction was statistically significant,
2. Determining any statistically significant two-way interactions,
3. If there are one or more statistically significant simple two-way interactions, a follow up with simple-simple main effects[12] was applied to compute any statistically significant main effects, and
4. Determining any statistically significant comparisons or pairwise comparisons.

Justification and detail of each statistical test employed are explained in statistical analysis sections. Furthermore, prior to running a statistical test, basic requirements and assumptions were checked and tested. Each statistical test involved different requirements and assumptions. The requirements to be confirmed were, for example, (1) the dependent variable was measured in a continuous or scale variable, (2) the independent variables were categorical, and (3) the observation of participants was independent, which means that participants were randomly assigned to each experimental group and involved only in one group. Meanwhile, for the assumptions of normality, detecting outliers, homogeneity of variance, linearity of relationship between variables, etc., the details of these requirements and assumptions tested are explained in statistical analysis sections.

8.3 Initial analysis of speed choice

The purpose of the preliminary analysis is to investigate whether there is a difference of speed choice on test route due to test route division between control and treated road. According to the experimental design, the training intervention was conducted before the participants started driving on either road, while the other interventions were placed on the treated road

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[12] A statistically significant simple two-way interaction can be followed up with simple simple main effects. This is similar/analogous to how to follow up a statistically significant two-way interaction in a two-way ANOVA with simple main effects. However, the same naming convention applies here as it did with the simple two-way interactions, with the simple main effects of the simple two-way interaction referred to as simple-simple main effects (Laerd Statistics, 2015d).

only. The complexity of this design has required care in analysis to avoid redundant data being included. Therefore, to determine whether there are any statistically significant differences between the means of eight independent groups on control and treated road, a one-way analysis of variance (ANOVA) was applied.

Table 41: One-way ANOVA for mean speed on control and treated road

Test route			Sum of Squares	df	Mean Square	F	Sig.
Dual carriageway	Control road	Between Groups	780.2	7	111.5	1.14	0.34
		Within Groups	10940.1	112	97.7		
		Total	11720.3	119			
	Treated road	Between Groups	3092.1	7	441.7	6.25	0.00
		Within Groups	7911.6	112	70.6		
		Total	11003.7	119			
Single carriageway	Control road	Between Groups	208.5	7	29.8	0.73	0.64
		Within Groups	4543.6	112	40.6		
		Total	4752.1	119			
	Treated road	Between Groups	157.3	7	22.5	0.62	0.74
		Within Groups	4087.1	112	36.5		
		Total	4244.4	119			

The result of one-way ANOVA shows that on the control road, the group mean speeds were not statistically significant, $F_{(7, 112)} = 1.14$, $p = 0.34$ and $F_{(7, 112)} = 0.73$, $p = 0.64$, for the dual and single carriageway, respectively. On the dual carriageway's treated road, the group mean speeds were statistically significantly different $F_{(7, 112)} = 6.25$, $p < 0.05$, whilst on the single carriageway treated road the group mean speed were not statistically significantly different $F_{(7, 112)} = 0.62$, $p = 0.74$.

The result has corresponded with the experimental procedure and route design that due to the absence of enforcement procedures on the control road, except for training, participants should not have different speed choice. Therefore, only the treated road that consists of five segments was been included which expected to produce stronger statistical analysis. The means speed of each segment of treated road was used to calculate the main effects and interactions effect of the intervention.

8.4   Dual carriageway 60 km/h route

120 participants successfully conducted a test drive/ride on the dual carriageway route. The overall observed mean speed for each type of intervention is of interest. The mean speed of all the participants on the control route was 57.1 km/h (SD = 12.2). The highest mean speed

recorded was 65.5 km/h (SD = 12.0 with the training intervention, while the lowest was observed with the police intervention, 54.8 km/h (SD = 9.4). A simple description of the test result is reported in Table 42.

Table 42: Descriptive statistic result for dual carriageway route

Training (T)	Police (P)	Publicity (R)	Mean	SD
Absence	Absence	Absence	62.3	9.6
		Presence	61.3	14.8
	Presence	Absence	57.8	9.4
		Presence	58.0	11.5
Presence	Absence	Absence	65.1	12
		Presence	53.8	9.3
	Presence	Absence	59.4	13.8
		Presence	53.6	7
Total			57.1	12.2

If sorted from the highest to the lowest mean speed, then the graph is as follows.
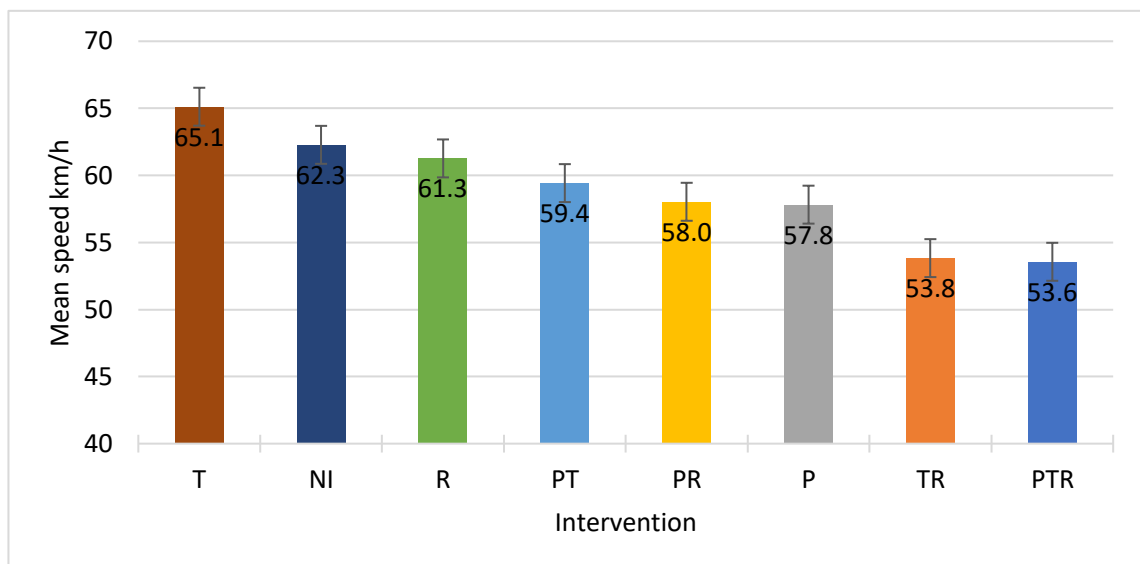
Figure 89: Mean speed of each intervention on dual carriageway

Figure 89 shows that training only group (T) was higher than no-intervention (NI). The roadside publicity (R) produced lower mean speed compared to no-intervention (NI), then followed by combination of police and training (PT), police and publicity (PR), and police only (P) interventions. The combination of training and roadside publicity (TR), can surprisingly elicit lower mean speed than any combination of two factors where police where presence. Ultimately, the combination of three type of intervention, training, police and roadside publicity (PTR) together, has generated the lowest mean speed compared to other type combination or single intervention. The largest variability of mean speed took place during

publicity (R) intervention, whilst the combined intervention of training, police and publicity (PTR) has made the smallest variability.

8.4.1 Main effect speed profile

The speed profile graphs were produced to assess the effect of the intervention on participants' choice of speed on each segment. The means speed plot and the contrast series of main effects for dual carriageway route is presented in Figure 90 below.

Police
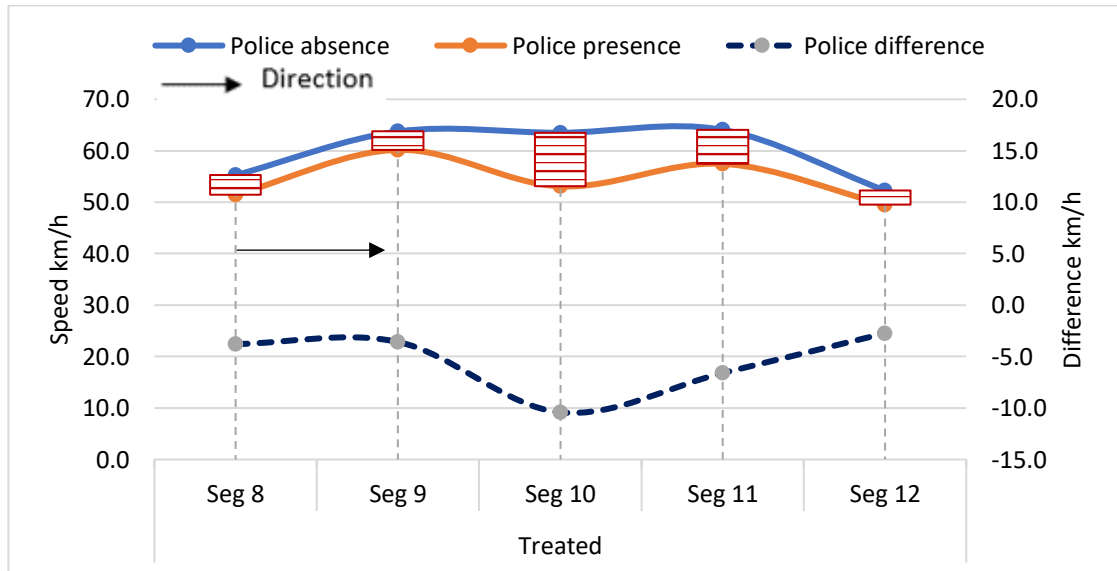
Figure 90: Speed profile for contrast series for Police intervention on dual carriageway

Most values of the contrast series for the police intervention lie below zero as presented in Figure 90. The means difference was found to be scattered about a fixed mean, and even more there was a sharp decrease of mean speeds between segments 9 and 10, before bouncing back after segment 11. This result suggests that when the level of a factor is changed, there may be a meaningful change in the mean response, and this change may be a function of time or distance with respect to the location of police checkpoint.

Training

The training speed profiles in Figure 91 shows that most of the values for the training intervention contrast series are below zero and fluctuate about a fixed mean (0 and -5 km/h). This result showed that training in overall group has influenced the participants to drive more slowly compared to untrained participants. The overall difference of mean speed between trained and untrained driver is 2.6 km/h.
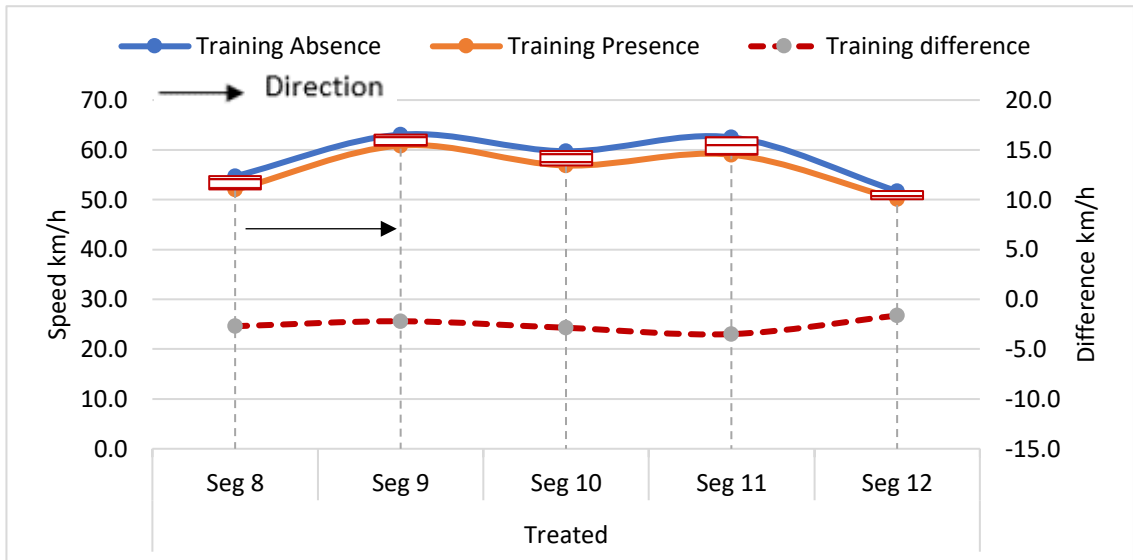
Figure 91: Contrast series of Training intervention on dual carriageway

Publicity
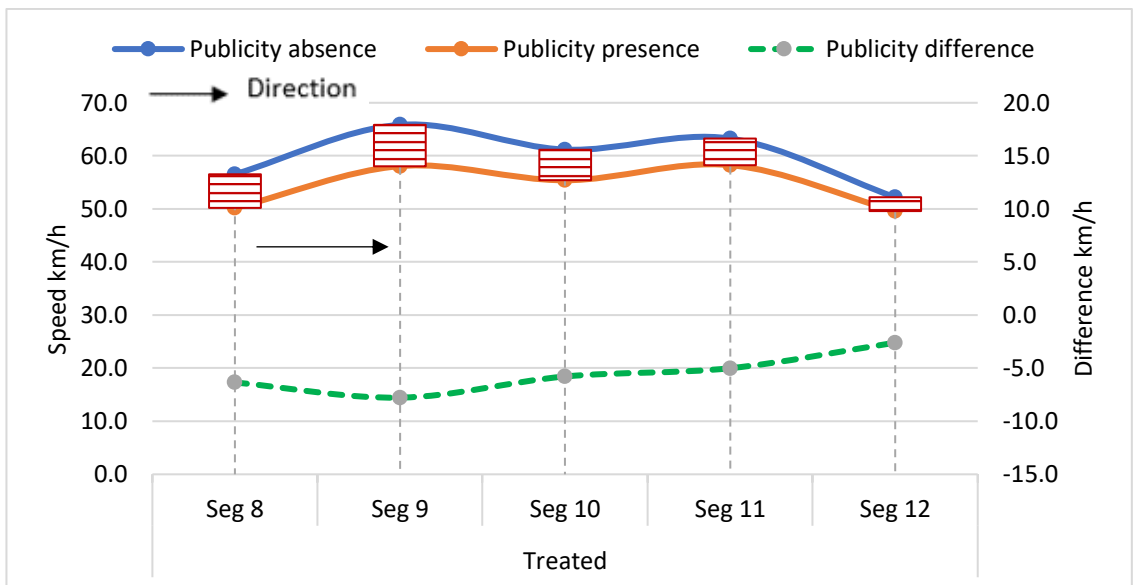
Figure 92: Contrast series for Roadside publicity intervention on dual carriageway

Meanwhile, Figure 92 shows that the contrast series for the publicity intervention also lies below zero, although the points are not scattered about a fixed mean; rather, they tend to maintain a smaller gap with the fixed mean. The largest difference was observed between segments 8 and 9. The difference reduces over the test route.

Cumulative sum of difference

Furthermore, to detect the change in each series, the cumulative sum control chart was generated, as shown in Figure 93. A visual assessment functioned to detect both increases and decreases. The CuSum graph depicts the participants' choice of speed as it decreases with the

progression of interventions. This information reveals that the influence of a given intervention against time (routes segments) was profound.

Police and publicity produced a similar large influence although different pattern was observed in segments 8 and 9, while the smaller effect was caused by training intervention. The CuSum of publicity reveals the benefit of the communication displayed along segment 8, which was then reinforced in segment 9 by the anti-speeding campaign. Although these interventions have not produced a large decrease in speed, their effect lingers for a longer period of the test than that of the other interventions. Meanwhile, the police presence intervention caused a large variation between segments 10 and 11, which demonstrates the enormous influence of police presence. However, the police effect tended to be wiped out as soon as the participants passed the police checkpoint.
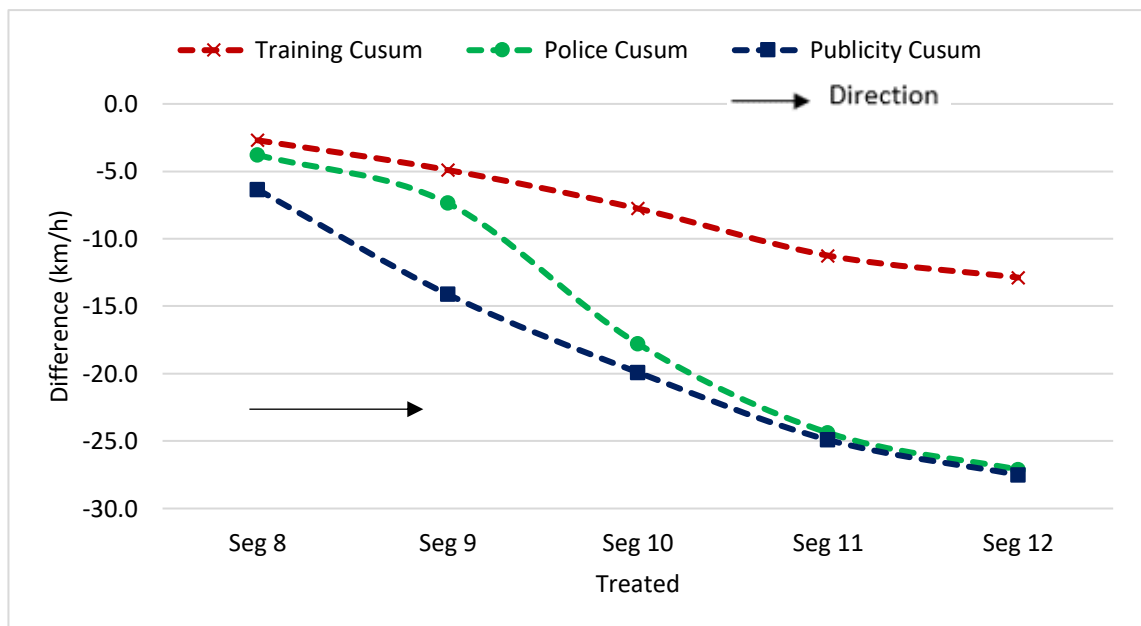
Figure 93: CuSum of difference of the main effect on dual carriageway 60 km/h

8.4.2 Interaction effect speed profile

Police and training

The plots of mean speed and mean speed differences for two-factor interactions are presented in following figures. Figure 94 reveals that the differences between high and low levels of training + police (TP) factors were small. The means speed contrast was fluctuated around zero, which indicated that negative and positive values had equal chances of occurring. Only between segment 9 and segment 11 was $TP(+)$ observed to be higher than $TP(-)$ before finally declining in segment 12 near the end of the test route.
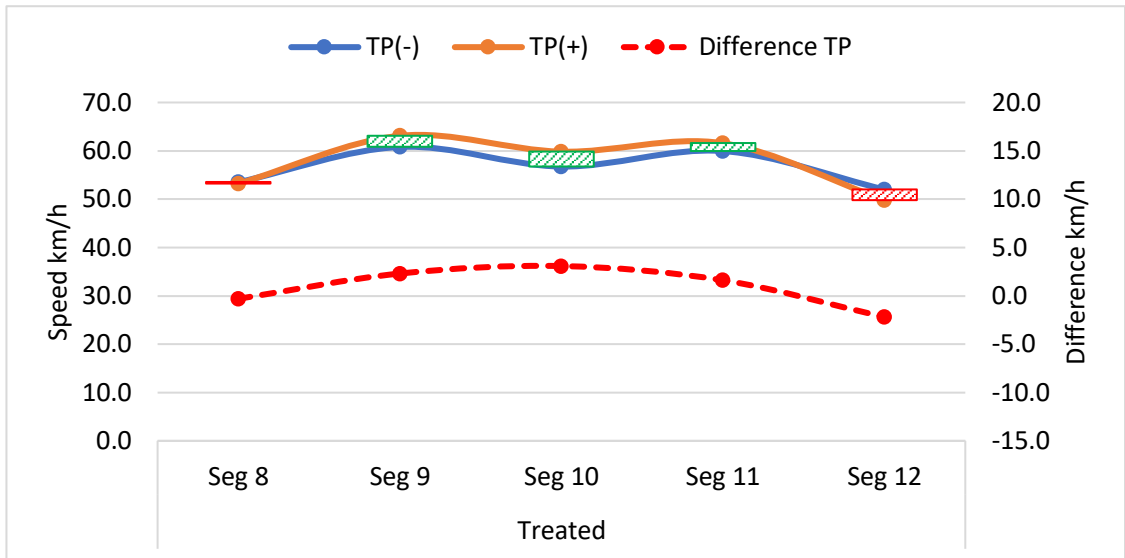
Figure 94: Contrast series of interaction effect of two factors on dual carriageway

Training and publicity

A different trend was visible in Figure 95 below where the training and publicity interventions interacted. It was seen that $TR(+)$ is always lower than $TR(-)$, which is indicated by differences below zero along the route. It appears that the existence of publicity adds to the usefulness of the training.
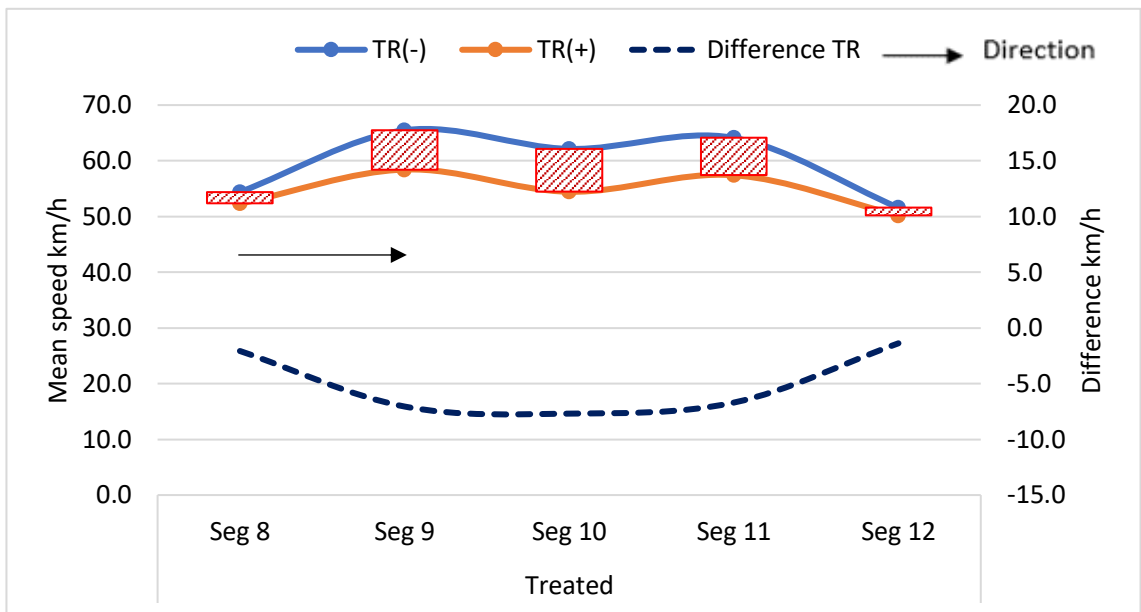
Figure 95: Contrast series of interaction effect of training and roadside publicity

Police and publicity

In contrast, the presence of publicity $PR(+)$ added to the police intervention was found to increase the participants' choice of speed as depicted in Figure 96. Although the differences were found close to zero in the beginning of treated road. $PR(+)$'s mean speeds were found higher than $PR(-)$'s mean speeds in all segment, with nearly identical size of differences.
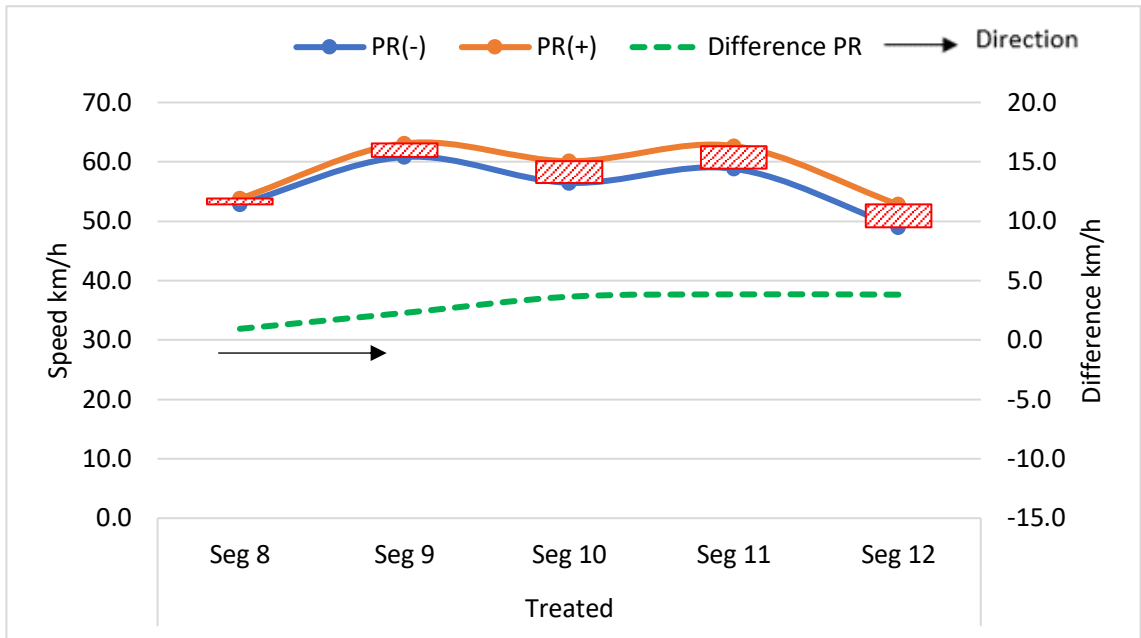
Figure 96: Contrast series of interaction effect of police and roadside publicity

Cumulative sum of difference for two factors' combinations
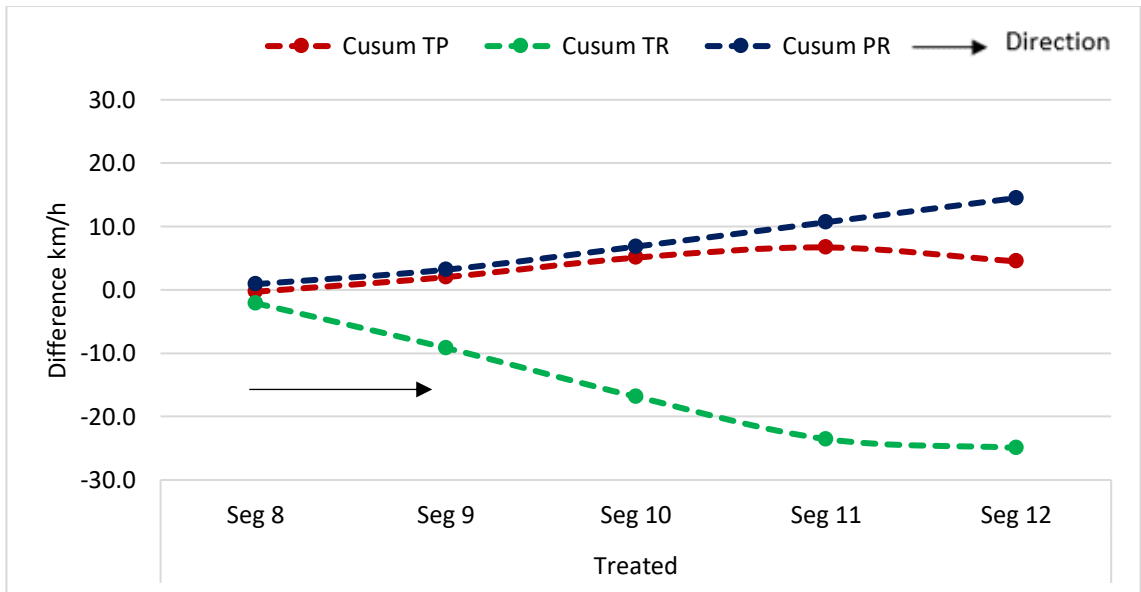
Figure 97: Cusum of mean differences of all two factors' interaction

Furthermore, a CuSum graph was produced to detect the change in three series of combined intervention as presented in Figure 97. The combined intervention of training and police was observed to produce a steady positive change, although it leans towards the zero in the last segment.

The interaction between training and publicity $(TR\ (+) - TR\ (-))$ was able to promote a consistent lower speed on the test route, although the difference tends to vanish in the last segment. The effect of the interaction was observed from the first segment, but the large

differences took place in segments 9, 10, and 11, which indicated steady differences or lower mean speed for the presence of publicity $TR(+)$.

Finally, the interaction between police and roadside publicity $(PR(+) - PR(-))$ thought-provoking. Instead of decreasing speed, the presence of publicity leads to even higher speeds. The differences were constantly increasing on each segment of the treated road.

Police, training and publicity and Cusum of difference for three factors' combinations

The last speed profile produced was the three-factor interaction as presented in Figure 98, including difference and CuSum of mean speed. The mean speeds differences between high and low levels of training + police + publicity (TPR) factors were found to be small. They wavered around zero, which indicated that the differences between $TPR(+)$ and $TPR(-)$ were just little. Only at segments 10 and 11, the decreased of speed and the relatively large differences were observed.
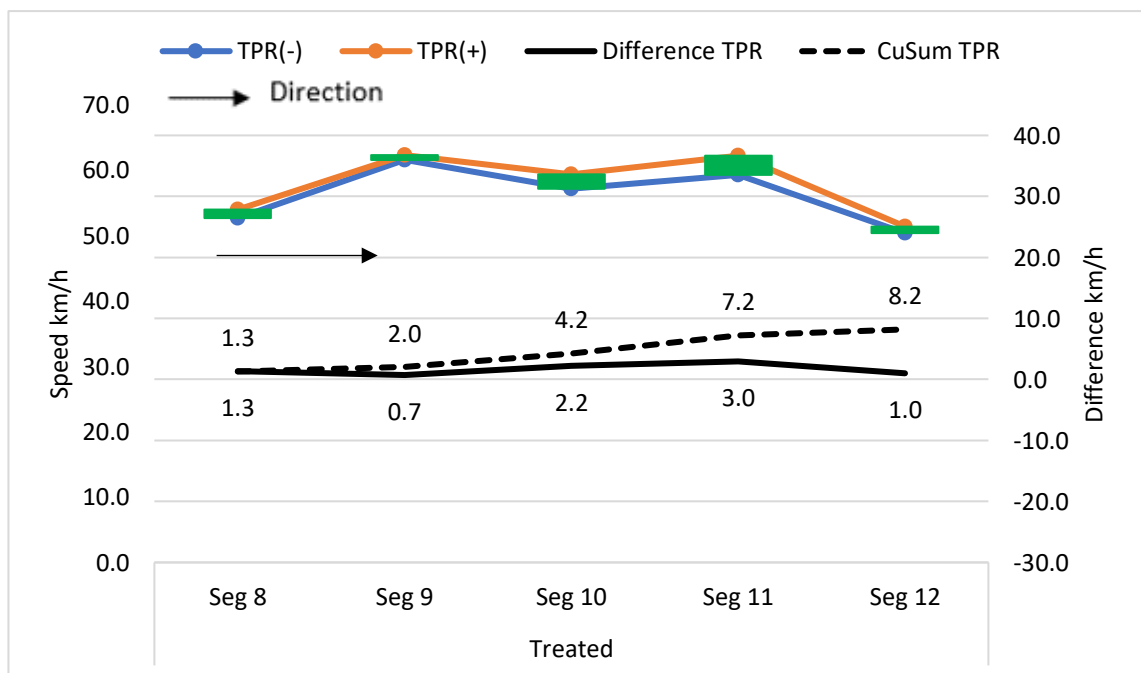
Figure 98: Contrast series and CuSum of interaction effect of three factors

The mean difference that occurred in segment 11 was the largest among the segments. The difference finally reverted back to zero at the end of the test route. Moreover, the CuSum of differences shows that the trend appears to ascend in the middle but flat at the end.

8.4.3   Statistical test for intervention effect on the dual carriageway route

A statistical test was conducted to analyse the difference of mean speeds on treatment segments for all participant speed data. A factorial ANOVA was used to determine whether there is an interaction effect between three independent variables on a continuous dependent variable. The format of data is mean ± standard deviation, unless otherwise stated.

Requirement and assumption for three-way ANOVA

Prior to the statistical test, requirement and assumptions for the factorial ANOVA must be assessed. The dependent variable, mean speed in each treated segment, is measured at the continuous level. Three independent variables or factors are the training, the police and the publicity. Each factor consists of two categories or levels, the absence and the presence of the variables. There is no relationship between the observations in each group, which means that the observations were independence.

The mean speed was normally distributed for each cell of design (i.e., each combination of the three independent variables), as assessed by a visual inspection of the normal Q-Q Plots. The data points' positions were approximately along the diagonal line in the normal Q-Q Plot.

To assess the outliers, a boxplot was utilized. Several outliers were found in each cell of design (as well as in each segment) as presented in Appendix B. However, further inspection of data did not find the outliers to be extreme, so they were kept in the analysis. The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances, $p < 0.05$. However, since group sample sizes are equal, the three-way ANOVA was run anyway, because ANOVA is somewhat robust to heterogeneity of variance in these circumstances.

Determining a statistically significant three-way interaction

After running the three-way ANOVA procedure using SPSS Statistics, a number of tables and graphs were generated that assist with interpretation. First, tests of between-subjects' effects table, as highlighted in Table 43.

Table 43: Tests of between-subject effects

Statistics	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18168.7	10	1816.9	15.0	0.000
Intercept	81611.1	1	81611.1	675.3	0.000
Age-group	687.9	1	687.9	5.7	0.017
Gender	1803.3	1	1803.3	14.9	0.000
Vehicle	662.6	1	662.6	5.5	0.020
Training	752.7	1	752.7	6.2	0.013
Police	3852.8	1	3852.8	31.9	0.000
Publicity	4113.4	1	4113.4	34.0	0.000
Training * Police	63.6	1	63.6	0.5	0.469
Training * Publicity	4062.0	1	4062.0	33.6	0.000
Police * Publicity	1246.2	1	1246.2	10.3	0.001
Training * Police * Publicity	532.8	1	532.8	4.4	0.036
Error	71183.8	589	120.9		
Total	2042318.6	600			
Corrected Total	89352.6	599			

The result shows that there was statistically significant three-way interaction between training, police and publicity (TPR), $F(1, 589) = 4.40, p = 0.036$. Then, the two-way interactions section in the results was consulted. There was not a statistically significant training + police (TP) interaction; $F(1, 589) = 0.12, p = 0.733 \ or \ p > 0.05$. In contrast, there were statistically significant interactions between training + publicity (TR) $(F(1, 589) = 33.6, p = 0.000 \ or \ p < 0.05)$, and police + publicity $(PR)(F(1, 589) = 10.3, p = 0.00 \ or \ p < 0.05)$.

The effect of training (T) was statistically significant; $F(1, 589) = 6.2, p = 0.01 \ or \ p < 0.05$. As well, the main effect of police (P) was statistically significant; $F(1, 589) = 31.9, p = 0.000 \ or \ p < 0.05$. Finally, the main effect of roadside publicity (R) was statistically significant $F(1, 589) = 34.0, p = 0.000 \ or \ p < 0.05$. The interaction effect is best visualized with a line graph, as shown in the following figures.
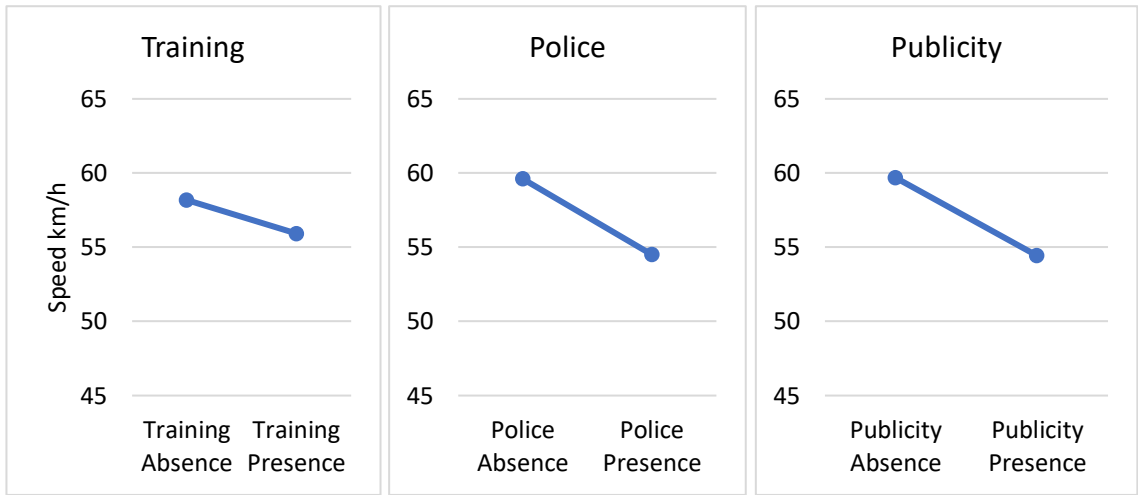
Figure 99: Main factors means' speed graph on dual carriageway
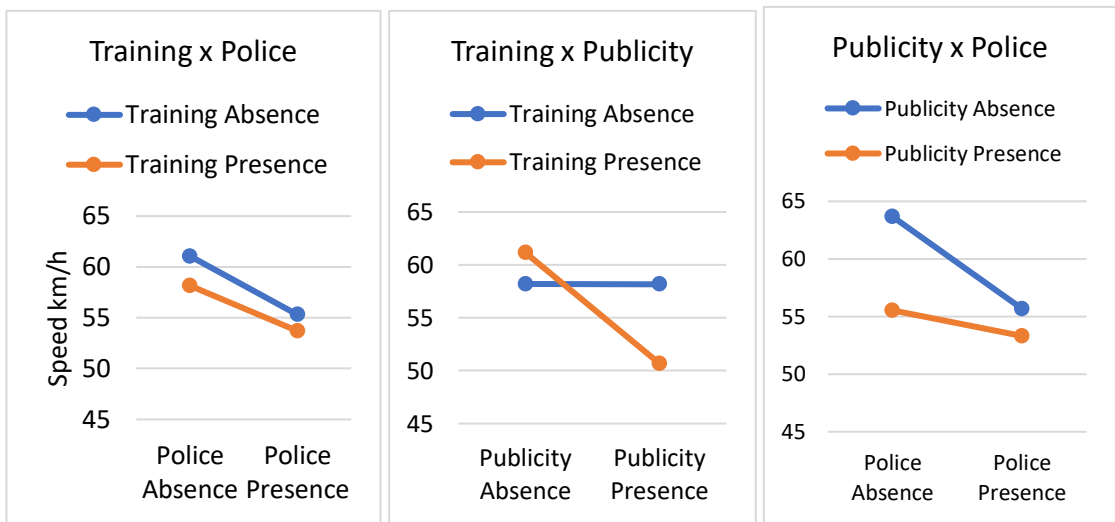
Figure 100: Two-way interaction graphs on dual carriageway 60 km/h
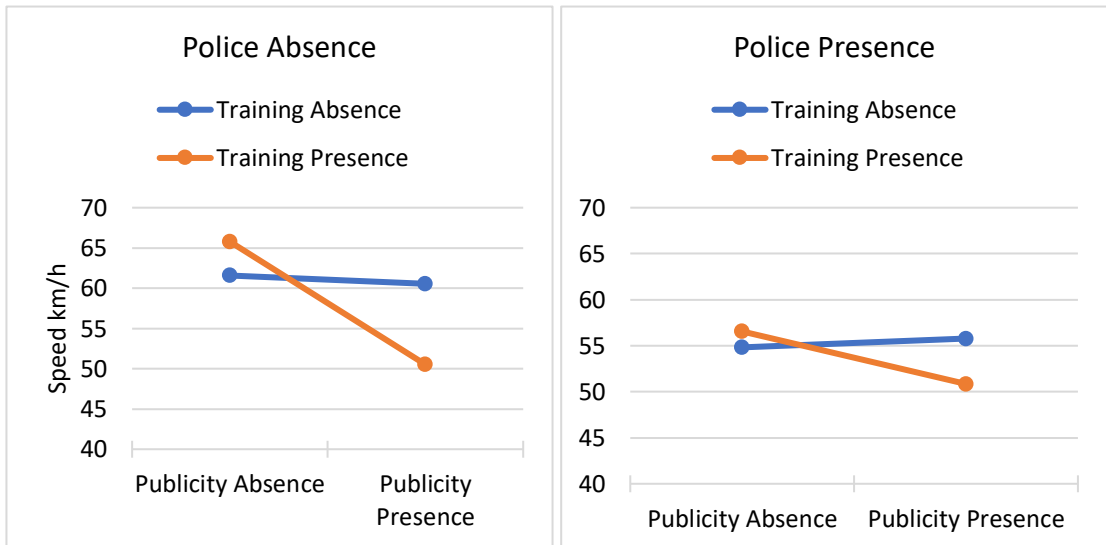
Figure 101: Three-way interaction graph on dual carriageway 60 km/h

Figure 101 shows that there appears to be a simple two-way training and publicity interaction either for the police absence or police presence because the lines do not appear to be parallel. That is, the effect of training on mean speed has appeared to be different depending on whether the roadside publicity is at absence or presence, whether it took place in police absence or police presence conditions.

Determining statistically significant simple two-way interactions

The result established a statistically significant three-way interaction effect, combined intervention the training, the police and the publicity. The significant three-way interaction indicated that the simple two-way of combined training and publicity interactions were different for both "absence" and "presence" of the police. In this term, a simple two-way interaction is a two-way interaction occurring at a specific level of a third independent variable. The mean speed during the absence of police is 59.8 (SD = 12.1) km/h, while the mean speed during the presence of police is 54.3 (SD = 11.7) km/h.

Therefore, to determine which, or all, of the simple two-way interactions are statistically significant, a follow up of statistical test with simple two-way interactions at all levels of the third independent variable were calculated.

Table 44: Summary of test for the simple two-way training and police interactions

Police	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Contrast	3500.227	1	3500.227	28.962	.000
	Error	71183.83	589	120.855		
Presence	Contrast	832.587	1	832.587	6.889	.009
	Error	71183.83	589	120.855		

There was a statistically significant simple two-way interaction between the training and the publicity interventions, either for the police absence, $F(1, 589) = 28.96$, $p < 0.000$, or the police presence, $F(1,589) = 6.89$, $p = 0.009$. Complete result of simple two-way interactions is available in Appendix B.

As contrast is a linear combination of training and publicity, that allowing comparison of several different treatments, the interpretation for the statistically significant results indicated that the effect of the training intervention on motorists' mean speed depends on the information provided by the roadside publicity. In other words, the publicity results moderated the effect of the training intervention's level on motorists' choice of speed, in the absence or presence of the police.

Determining statistically significant simple-simple main effects

Further investigation is needed to reveal the contributing components to statistically significant result of simple two-way interactions. Therefore, a statistically significant simple two-way interaction was followed up with simple-simple main effects. Simple-simple main

effect are differences among particular cell means within the design. More precisely, it is a further breakdown of simple effect where the effect of one independent variable within one level of a second independent variable. The simple-simple-main effect was calculated as presented Table 45.

Table 45: Simple-simple main effect

Police	Publicity	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Absence	Contrast	563.49	1	563.49	4.66	.031
		Error	71183.83	589	120.86		
	Presence	Contrast	3810.34	1	3810.34	31.53	.000
		Error	71183.83	589	120.86		
Presence	Absence	Contrast	122.98	1	122.98	1.02	.314
		Error	71183.83	589	120.86		
	Presence	Contrast	909.41	1	909.41	7.52	.006
		Error	71183.83	589	120.86		

Firstly, the result shows no statistically significant difference of training in the presence of police without publicity presence. To interpret this, a simple main effect contrast is the difference between marginal means, where the levels of the training are joint, therefore, whether the motorists attended the training or not, did not have an effect on mean speed in the presence of police without publicity (publicity absence). In other words, the mean speed for trained and untrained motorist, all of whom were experienced the presence of police, but without publicity, was not statistically significantly different.

Secondly, there were two statistically significant simple-simple main effects of training for the absence of police, either at the presence or absence of publicity. As well as, a statistically significant simple-simple main effect of training for the presence of presence of police and publicity.

The interpretation of the statistically significant result is, in comparison to the presence of police without the publicity (publicity absence), level of training taken has a statistically significant effect on mean speed during police presence with the publicity (publicity presence). In other words, the mean speed of trained motorists and untrained motorist, all of whom were experienced the presence of police with the publicity (publicity presence), was statistically significantly different.

Furthermore, in the absence of police, with and without the publicity (publicity presence and absence), level of training taken has a statistically significant effect on mean speed. In other words, the mean speed of trained motorists and untrained motorist, all of whom were experienced no police, either with or without the publicity (publicity presence and absence), was statistically significantly different. Therefore, the presence of publicity on the test route

has added to effectiveness of enforcement, whether police presence or not in their checkpoint.

Since one or more statistically significant simple simple main effects were recorded, it must be followed up with simple simple comparisons.

Determining statistically significant simple-simple comparisons

The statistically significant interactions were further investigated by conducting simple-simple comparisons. This test is useful because it not only provides the statistical significance level for each pairwise comparison, but also provides confidence intervals (i.e., simultaneous confidence intervals) for the mean difference for each comparison. Therefore, a simple-simple pairwise comparisons were run for police intervention at different level of roadside publicity with a Bonferroni adjustment applied, as presented in Table 46.

Table 46: Pairwise comparison of mean speed for training, police and publicity

Police	Publicity	Training (I)	Training (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
							Lower Bound	Upper Bound
Absence	Absence	Presence	Absence	4.205	1.828	0.022	0.616	7.795
	Presence	Presence	Absence	-10.025	1.795	0.000	-13.552	-6.499
Presence	Absence	Presence	Absence	1.729	1.795	0.336	-1.797	5.255
	Presence	Presence	Absence	-4.935	1.795	0.006	-8.461	-1.408

Three pairwise comparisons were recorded statistically significant different, they are:

When police were absence and the publicity was absence, there was statistically significant difference between the mean speed of motorist who took and did not took the training at 4.2 km/h (95% CI, 0.62 to 7.8), p =0.022, a significantly **higher mean speed**.

When the police intervention was absence, but the publicity was presence, there was a significant mean speed difference between the level of training intervention, -10.02 km/h (95% CI, -13.5 to -6.5), p < 0.05, a significantly **lower mean speed**.

When the police were presence, but the publicity was presence, there was statistically significant difference between the mean speed of motorist who attended and unattended the training at -4.9 km/h (95% CI, -8.5 to -1.4), p = 0.006, a statistically significantly **lower mean speed**.

And a pair that was not statistically significant, took place:

When the police were presence and the publicity was absence, there was no statistically significant difference between the motorists who attended and did not attended the training by 1.7 km/h (95% CI, -1.8 to 5.3), p = 0.336.

To sum up all the investigation of combined intervention, a three-way ANOVA was conducted in order to determine the combined effects of the police, the publicity and the training on motorists' choice of speed. There was a statistically significant three-way interaction, statistical significance was accepted at the $p < 0.05$. There was a statistically significant simple two-way interaction between the police and the roadside publicity for the motorist who attended and did not attended the training. Nevertheless, during the presence of the police, but the publicity was absence, the difference of the training intervention level has no statistically significant mean speed difference.

Further follow up by pairwise comparison shows that three combined interventions were significant, except for the presence of police without the publicity which produced no significant mean difference for the level of training intervention. Besides the three-way, the two-way combination of police and publicity and training and publicity, were found statistically significant, but not statistically significant for training and police combination. All main factors' effect was all statistically significant.

8.5   Single carriageway 50 km/h route

For single carriageway route, 120 participants have successfully completed the test. The initial analyses in section 8.3 has indicated that there is no difference of speed choice between the groups on single carriageway route. Thus, analysis based on the types of intervention becomes very interesting to analyse in detail.

The observed means speed on the entire type of intervention were very interesting. Mean speed of all participants for the treated road was recorded 46.7 (SD = 8.0) km/h. The highest mean speed recorded was 48.9 (SD = 8.09) km/h during no-intervention, while the lowest were observed during police intervention, 44.6 (SD = 7.55) km/h. A descriptive of the test result is reported in Table 47.

Table 47: Descriptive statistic result for dual carriageway route

Training (T)	Police (P)	Publicity (R)	Mean (km/h)	SD
Absence	Absence	Absence	48.9	8.09
		Presence	46.1	8.08
	Presence	Absence	45.9	9.56
		Presence	47.2	8.11
Presence	Absence	Absence	47.3	7.62
		Presence	46.5	7.49
	Presence	Absence	44.6	7.55
		Presence	47.1	7.17
Total			46.7	8

The mean speed was sorted from the lowest to the highest, as shown in Figure 102.
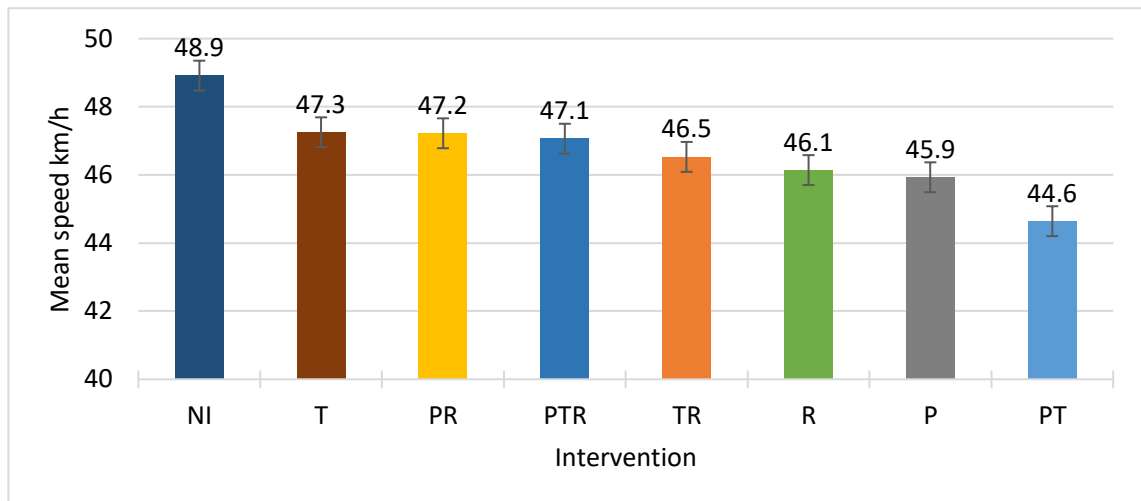
Figure 102: Mean speed of each intervention on single carriageway

The graph shows that the training (T) was able to produce lower mean speed compared to no-intervention (NI), then followed by combination of police and publicity (PR), police, training and publicity (PTR), training and publicity (TR), publicity only (R) and police only (P). Ultimately, the combination of police and training (PT) has generated the lowest mean speed compared to other type intervention. The largest variability of mean speed took place during the police intervention, whilst the combined intervention of training and publicity has made the smallest variability.

8.5.1   Main effect speed profile

The plots of contrast and CuSum series of main effects were generated. The means speed plot and the contrast series of main effects for single carriageway route is presented below:

Police
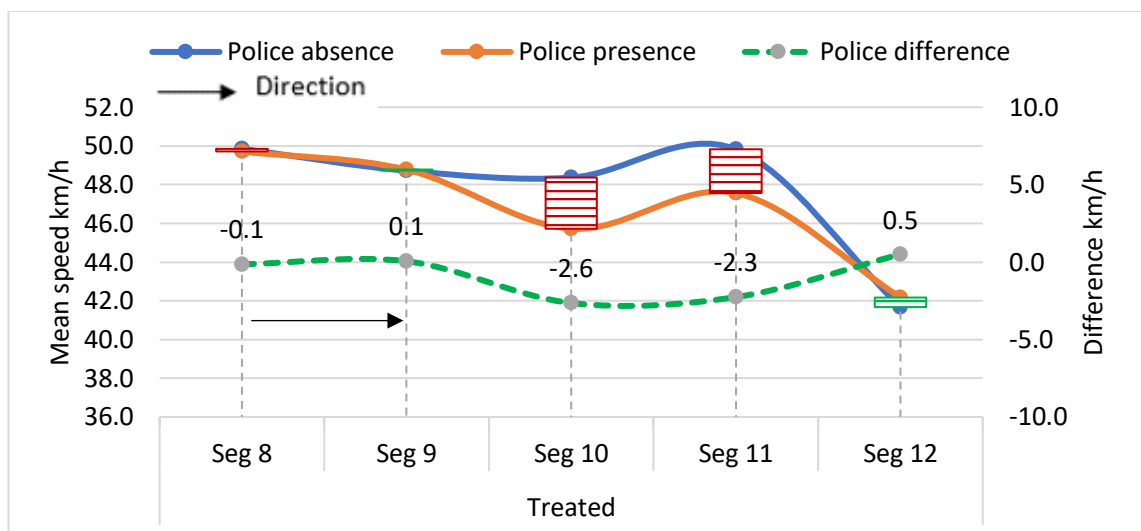
Figure 103: Contrast series of police intervention on single carriageway

Figure 103 shows that three segments', segment 8, 9 and 12, of the contrast series for police (P) appeared to have differences scattered around zero. At segment 10 and 11 where speed enforcement sign and police unit were positioned, mean speeds during the police presence $(P(+))$ were found to be sharply decreased, compared to the police absence $(P(-))$'s mean speed. Thus, large differences were observed in segments 10, and 11. This pattern suggests that change may be a function of time that interacts with the location of the police checkpoint.
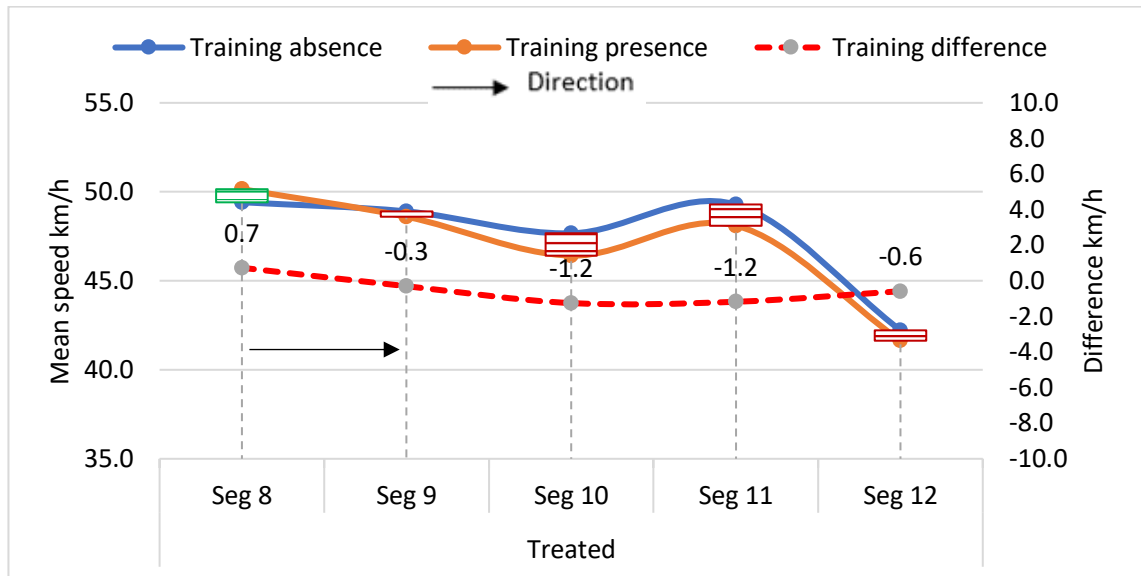
Training

Figure 104: Contrast series of the training intervention on single carriageway

Figure 104 shows that most of the values for the training contrast series fluctuated around the fixed mean (zero difference). Only the difference on segment 8 was found to be positive. The mean speed with the presence of training $(T(+))$ was mostly observed lower than the speed with the absence $(T(-))$ of it, thus, producing a negative mean difference. Upon entering the treated road, the mean speed of the two main factors is fairly high, then decreased gradually to the lowest point at segment 10. Correspondingly, the mean speed differences were growing larger. Heading for segment 11, the mean speed increased once more, and the mean speed difference remain large, before finally declining sharply toward the end.

Publicity

Furthermore, the contrast series for roadside publicity (R) was found to fluctuate around zero as described in Figure 105. Initially, the mean speeds were high, then smoothly decreased until reached at segment 10. The mean speeds differences occurred alternately between positive and negative, and close the zero line. A flat pattern of mean speed differences continues until segment 12, at which point there is almost no difference in mean speed values between the presence and the absence of roadside publicity.
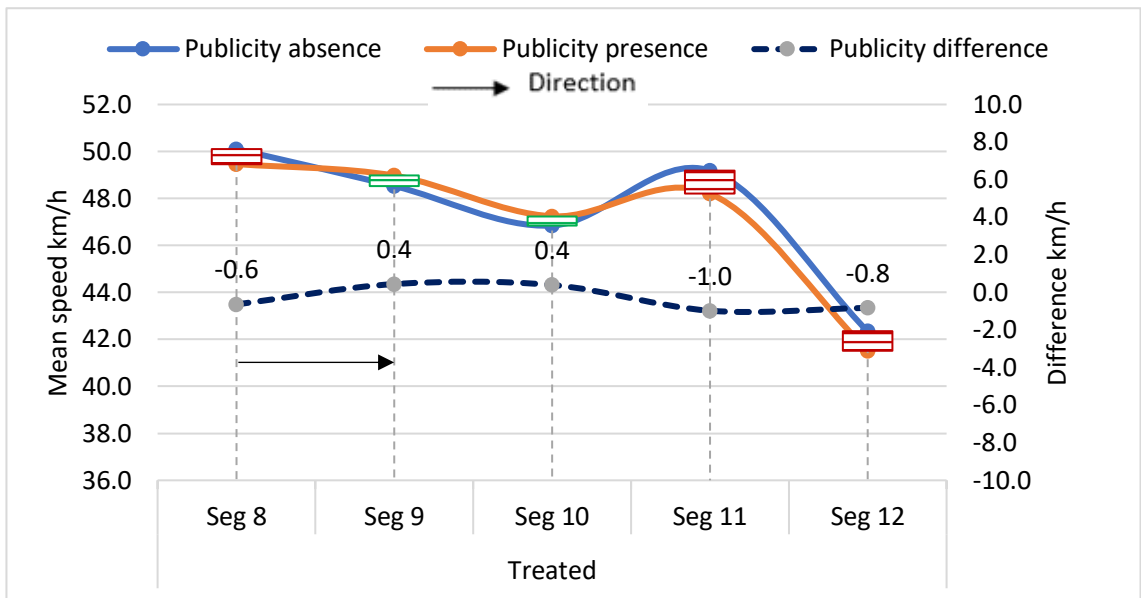
Figure 105: Contrast series of publicity intervention on single carriageway

Cumulative sum of difference for two factors' combinations

To distinguish between variations for each series, the cumulative sum control chart was generated, as shown in Figure 106. The CuSum graph depicts that the influence of the police intervention was the largest compared to the training and publicity interventions. There are observable declining points, on segments 10 and 11, which are quite large, thus bringing the police's CuSum line to the lowest of the series. The training intervention caused a slight decrease in the CuSum of the mean speed difference. Meanwhile, the CuSum of publicity did not show that the effect of the message was great for the entire segment. The CuSum line steadily steps around zero.
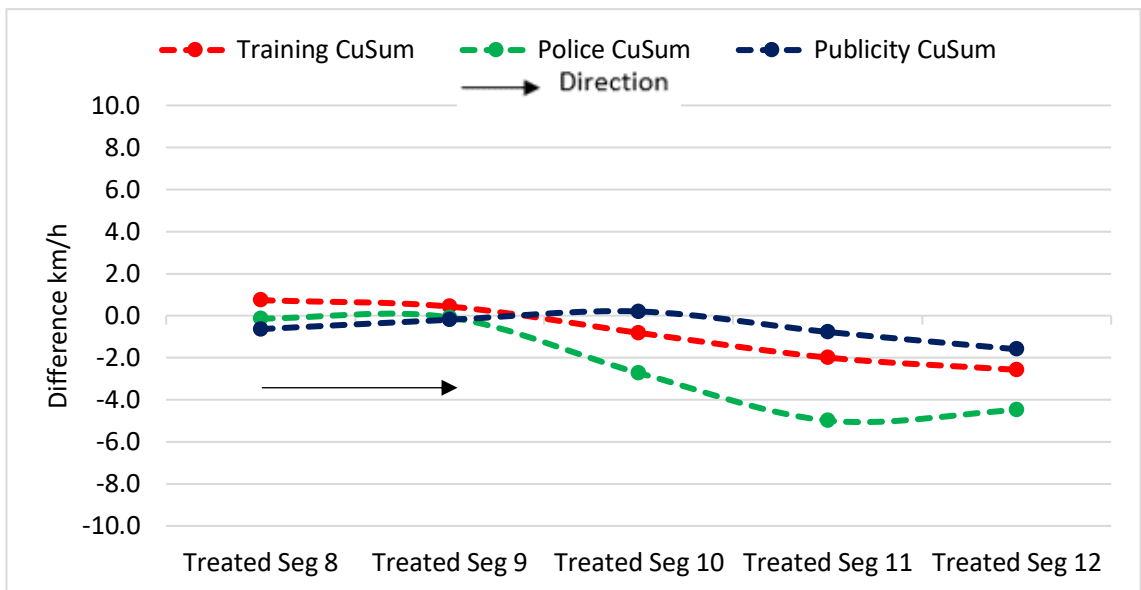
Figure 106: CuSum of difference of the main effect on single carriageway route

8.5.2   Interaction effect speed profile

The plots of mean speed and mean speed differences for two-factor interactions are presented in following graphs.

Police and training

Figure 107 shows that a parallel pattern of speed choice was obvious for combined intervention of police and training.
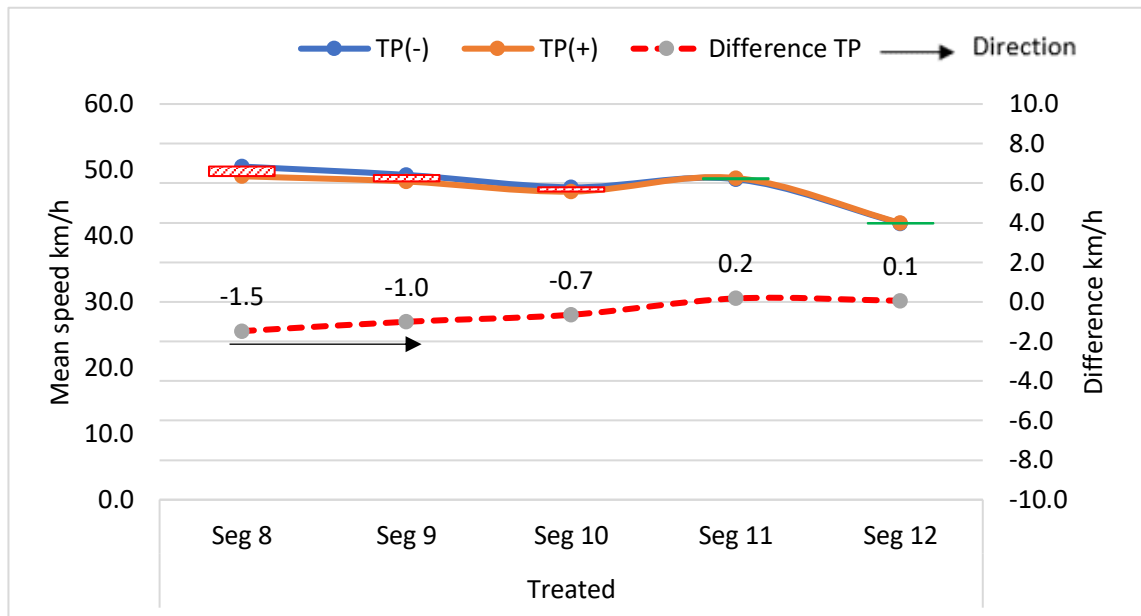
Figure 107: Contrast series of training and police on single carriageway

The average speed of TP $(+)$ and TP $(-)$ has almost the same value. This indicate the combination of the training and the police intervention, either low or high, generated the same speed choice. Hence, the contrast was noticed as flat line and the difference is merely progressing close to the zero line.

Training and publicity

Similarly, Figure 108 shows that the pattern of mean speeds for combined intervention of the training and the publicity was observed parallel. The combination of training with high level of publicity has produced slightly higher mean speed than the low level. The differences $(TR(+) - TR(-))$ shows a gradual rise until segment 10, then moving downward again before the finish line.
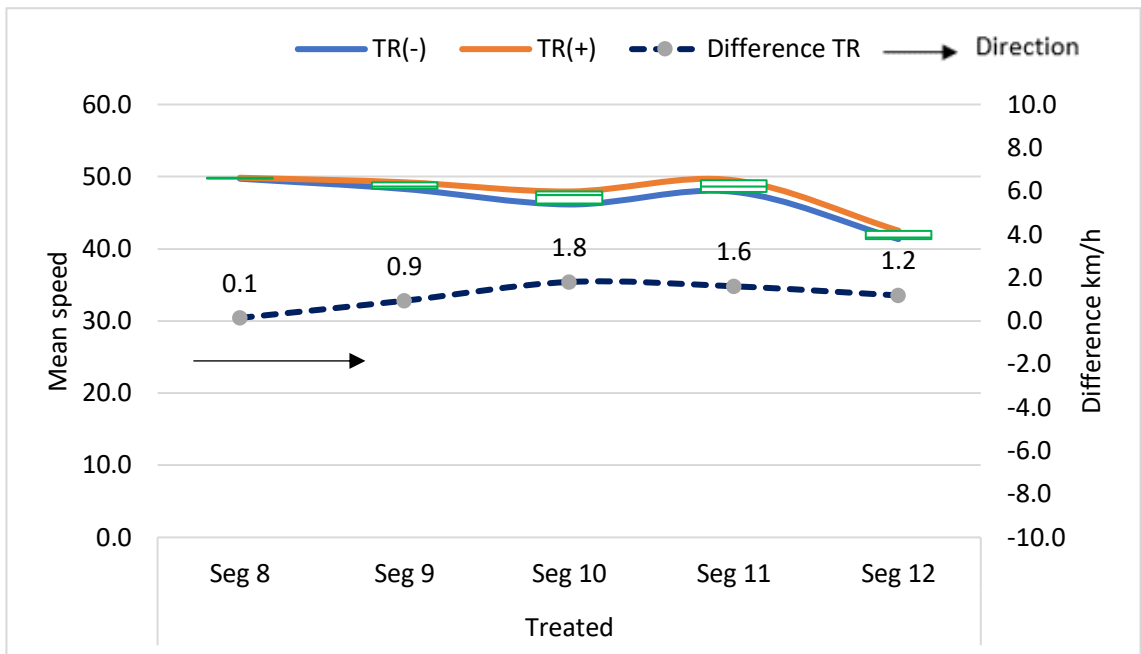
Figure 108: Contrast series of training and publicity on single carriageway

Police and publicity

Finally, the effect of combined the police and the publicity interventions, as shown by Figure 109. The pattern of contrast $(PR(+) - PR(-))$ shows that the mean differences were always positive. This result gives the idea that the presence of roadside publicity, $R(+)$, has maintained the average police effect. Or, seen another way, the presence of police $P(+)$ has maintained the average effect of publicity. The high level of combination $PR(+)$, made a little gap with the low level $PR(-)$, ranging between 0.3 to 2.4 km/h differences, and always positive.
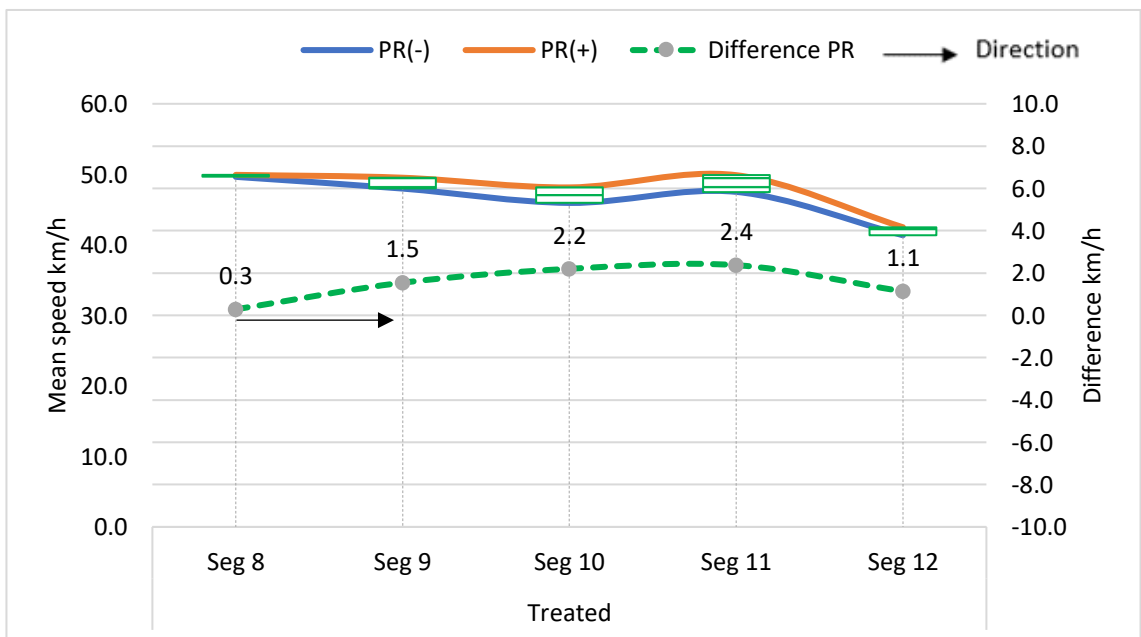
Figure 109: Speed profile for contrast series of police and publicity on single carriageway

Cumulative sum of difference for two factors' combinations

To analyse the trend of mean speed' change along the treated road, the chart of cumulative sum series was produced, as presented in Figure 110.
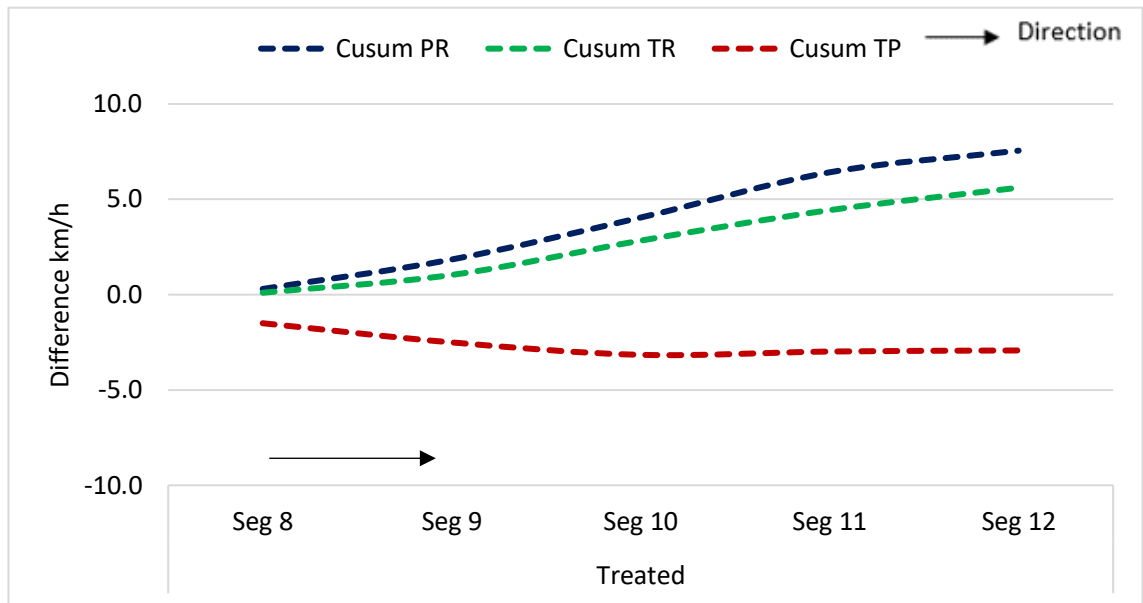
Figure 110: CuSum of two factors' interaction on single carriageway

Among three series of two-factor interaction effects, TP, TR and PR, only the combination of the training and the police was able to develop a lower speed on the test route, although the graphs tended to be flat and close zero. The CuSum series of TR and PR were observed to be gradually increase in the entire treated road. There is no fluctuation observed in mean speed differences, the movement were likely to be steady.

Police, training and publicity, and Cusum of difference for three factors' combinations
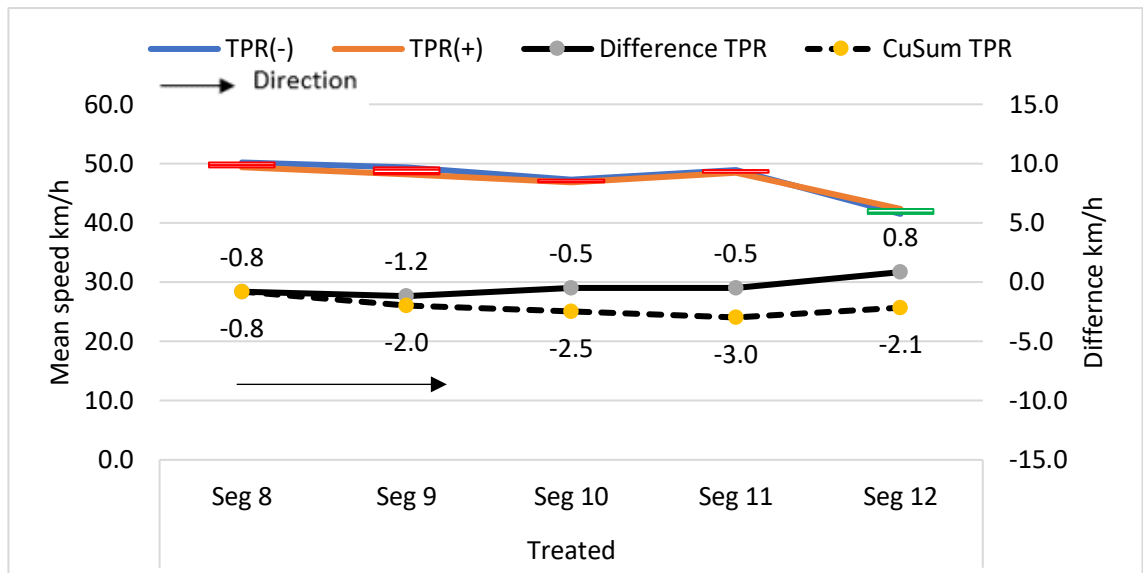
Figure 111: Contrast series and CuSum of three factors' interaction in single carriageway route

Furthermore, the speed profile for the three-factor interaction, including difference of mean speed and the CuSum, is presented in Figure 111. The differences between high and low levels of training + police + publicity (TPR) factors were observed to be mostly negative. However, along the entire route, mean speed differences were noticeable around zero, which indicated that the differences between $TPR(+) \; and \; TPR(-)$ were small. On segment 9, there was a moderate mean difference found. It was the largest among the segments. The difference was finally pulled back to positive at the end of the test route.

The negative mean speed difference produced during the application three-factor combination indicated that the addition of a third factor has brought the mean speed down. Therefore, the effects that occur as a result of interventions in this experiment were calculated and tested statistically by three-way ANOVA.

8.5.3   Statistical tests for intervention effect on single carriageway 50 km/h

Requirement and assumption for three-way ANOVA

Similar analytical procedures were applied for the results on the single carriageway 50 km/h. However, prior to the statistical test, assumptions and justifications for the factorial ANOVA must be assessed. The mean speed in each cell of design was found to be normally distributed, as assessed by a visual inspection of the normal Q-Q Plots.

A boxplot was employed to assess the data outliers. Five outliers were found in all cell of design, as presented in Appendix B. However, further inspection of the outliers did not find them to be extreme, so they were kept in the analysis.

The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances, p = 0.004, but the three-way ANOVA was run anyway because ANOVA is robust to the heterogeneity of variance when the sample size is equal across the groups (Laerd Statistics, 2015d). To assure this decision, the ratio of the largest group variance and the smallest group variance was checked. The ratio was less than 3.0, and therefore, the assumption was not sufficiently violated.

Determining a statistically significant three-way interaction

After running the three-way ANOVA, SPSS Statistics have generated tables and graphs that provide the results. First step is to determine whether a statistically significant three-way interaction exists.

Tests of between-subject effects Table 48 shows that there was no statistically significant three-way interaction between training, police, and publicity $(TPR); F(1, 589) = 0.4, p = 0516$. Therefore, two-way interactions were assessed immediately.

Table 48: Tests of between-subject effects on single carriageway 50 km/h

Statistics	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1505.8	10	150.6	2.6	0.004
Intercept	33489.8	1	33489.8	585.9	0.000
Age-group	665.4	1	665.4	11.6	0.001
Gender	138.9	1	138.9	2.4	0.120
Vehicle	1.4	1	1.4	0.0	0.876
Training	1.6	1	1.6	0.0	0.869
Police	80.1	1	80.1	1.4	0.237
Publicity	2.4	1	2.4	0.0	0.839
Training * Police	0.1	1	0.1	0.0	0.968
Training * Publicity	256.1	1	256.1	4.5	0.035
Police * Publicity	269.4	1	269.4	4.7	0.030
Training * Police * Publicity	24.1	1	24.1	0.4	0.516
Error	33664.9	589	57.2		
Total	1374132.3	600			
Corrected Total	35170.6	599			

The result shows that there was not a statistically significant effect of combined intervention of training and police (TP) interaction; $F(1, 589) = 0.0, p = 0.968 \ or \ p > 0.05$. In contrast, there was a statistically significant differences in combined intervention of training and publicity (TR) interaction $(F(1, 589) = 4.5, p = 0.035 \ or \ p < 0.05)$ and police and publicity (PR) interaction $(F(1, 589) = 4.7, p = 0.030 \ or \ p < 0.05)$.

Determining simple main effect

The three-way interaction was not statistically significant, while two combined interventions, training and publicity (TR) and police and publicity (PR), were found statistically significant. To follow up these statistically significant two-way interactions, simple main effect analysis must be conducted.

Table 49: Simple main effect of training and publicity

Training	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Contrast	151.314	1	151.314	2.647	0.104
	Error	33664.885	589	57.156		
Presence	Contrast	98.915	1	98.915	1.731	0.189
	Error	33664.885	589	57.156		

Table 49 shows the simple effects of the publicity within each level combination of the training effects shown. There is no significant simple main found for combined intervention of training and publicity.

Table 50: Simple main effect of police and publicity

Publicity	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Contrast	322.866	1	322.866	5.649	0.018
	Error	33664.885	589	57.156		
Presence	Contrast	27.952	1	27.952	0.489	0.485
	Error	33664.885	589	57.156		

Table 50 shows the simple effects of the police within each level combination of the publicity effects shown. The combined intervention of police and publicity was found statistically significant when publicity was absence, $(F(1, 589) = 5.649, p = 0.018 \ or \ p < 0.05)$.

Determining simple comparisons

The significant result of combined intervention of police and publicity must be followed up by pairwise comparison. The result of pairwise comparison is presented in Table 51.

Table 51: Pairwise comparison of publicity and police on single carriageway

Publicity	Police (I)	Police (J)	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Absence	Presence	Absence	-2.088*	0.879	0.018	-3.814	-0.363
Presence	Presence	Absence	0.617	0.882	0.485	-1.115	2.348

Table 51 shows that the difference in mean speed is statistically significant (p = 0.018) with a difference in mean speed of -2.088 km/h (the "Mean Difference (I-J)" column) with 95% confidence interval of -3.814 to -0.363 km/h (the "Lower Bound" and "Upper Bound" columns, respectively).

The significant difference, which took place when the publicity was absence, indicated that the police presence was significantly bring down the mean speed as much as 2.09 km/h without the roadside publicity. In other word, the roadside publicity did not add effectiveness of police intervention in single carriageway.

The pairwise comparison investigated further by exchanging the publicity and police arrangement, as presented in Table 52.

Table 52: Pairwise comparison of Police and Publicity on single carriageway

Police	Publicity (I)	Publicity (J)	Mean Difference (I-J)	SE	Sig	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Absence	Presence	Absence	-1.483	0.906	0.102	-3.263	0.297
Presence	Presence	Absence	1.222	0.882	0.167	-0.511	2.955

Table 52 shows that there is no statistically significant comparison, either in the absence or presence of police, the difference in mean speed between the presence and absence of publicity was no difference with zero.

To sum up the test result on single carriageway, there was no significant three-way interaction effect observed. The combined intervention of training and publicity was statistically significant, but further investigation of the simple main effect found no statistically significant simple main effect. The combined intervention of the police and the publicity was statistically significant and the pairwise comparison found that the police intervention during the absence of publicity has caused the lower mean speed. Finally, there is no main effect of interventions was found statistically significant. The main effect and interaction effect are best visualized with a line graph, as shown in the following figures.
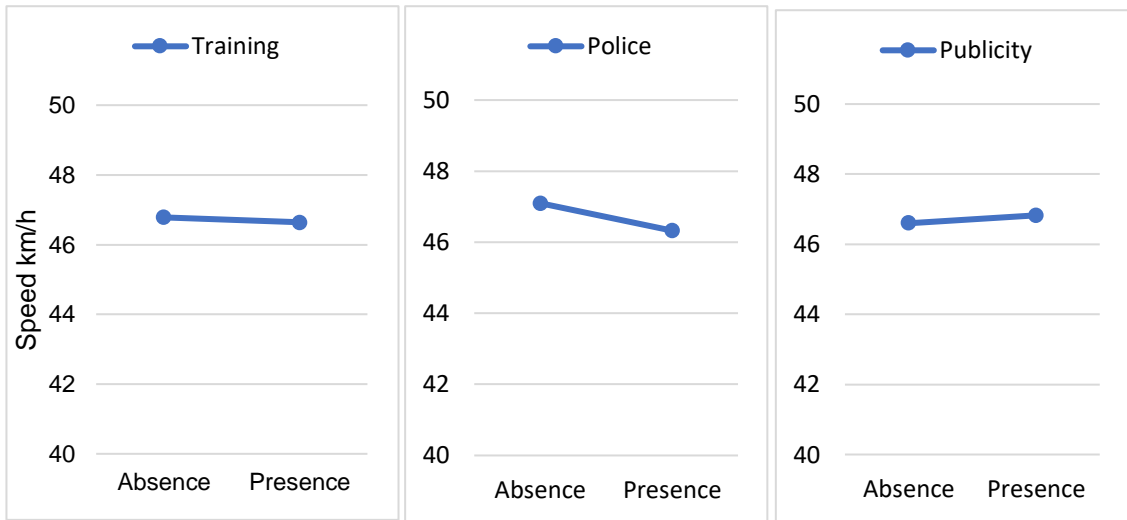
Figure 112: Main effect of three factors on single carriageway route
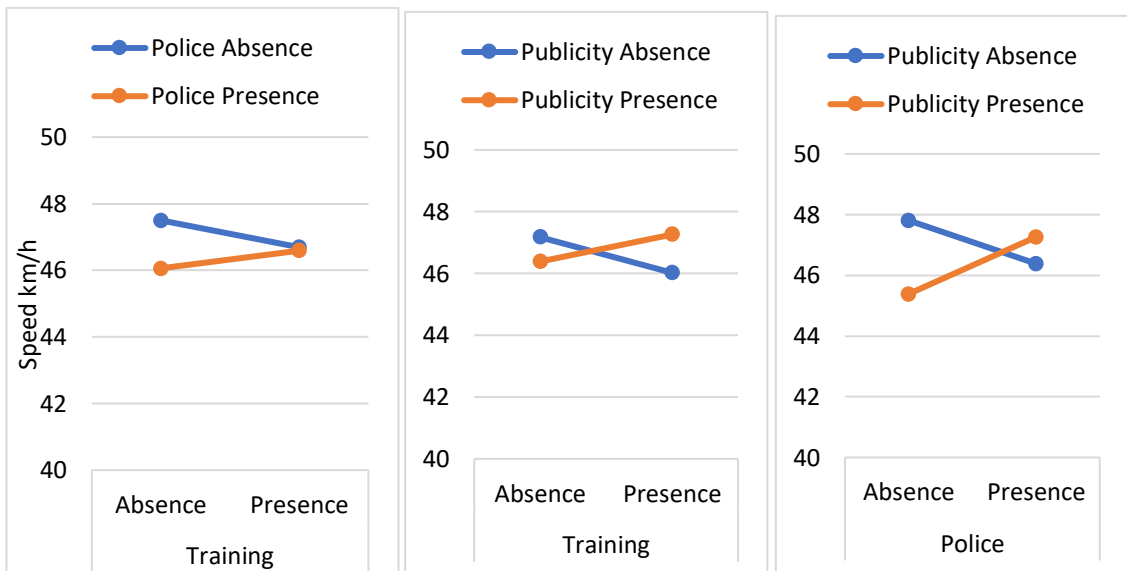
Figure 113: Two-way interactions for single carriageway route
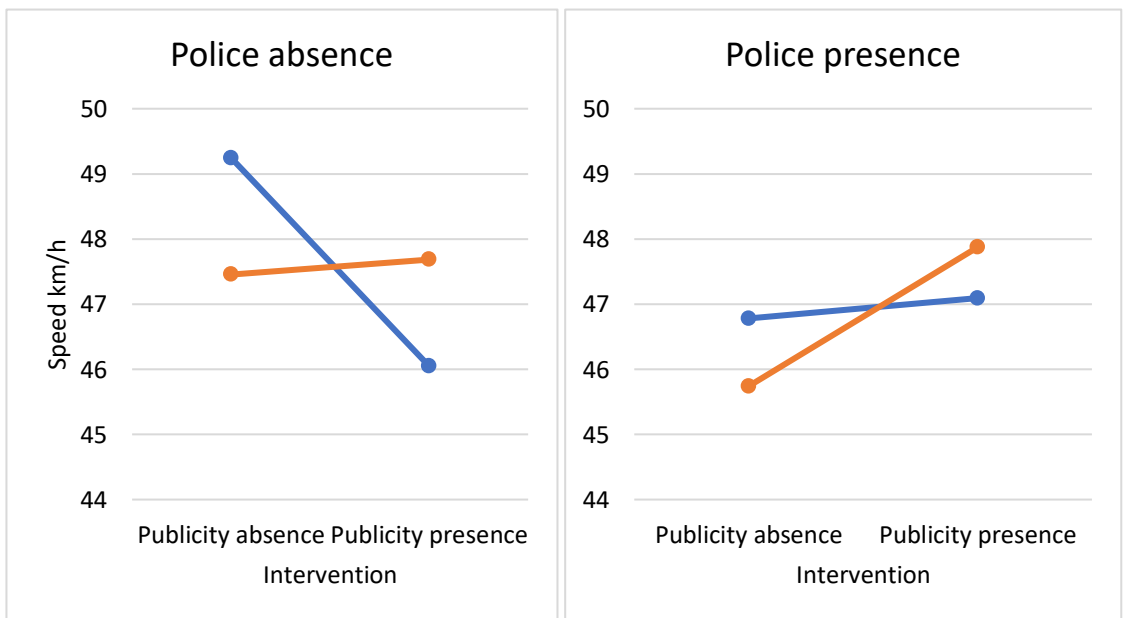
Figure 114: Three-way interaction graph for single carriageway 50 km/h

8.6 Comparison of car and motorcycle speed for combined intervention test

Among 120 participants assigned to each route, there were 80 motorcycle riders and 40 car drivers, for dual carriageway route, while for single carriageway route, motorcyclists were 96 people and were 24 car users. The result is presented in Figure 115.
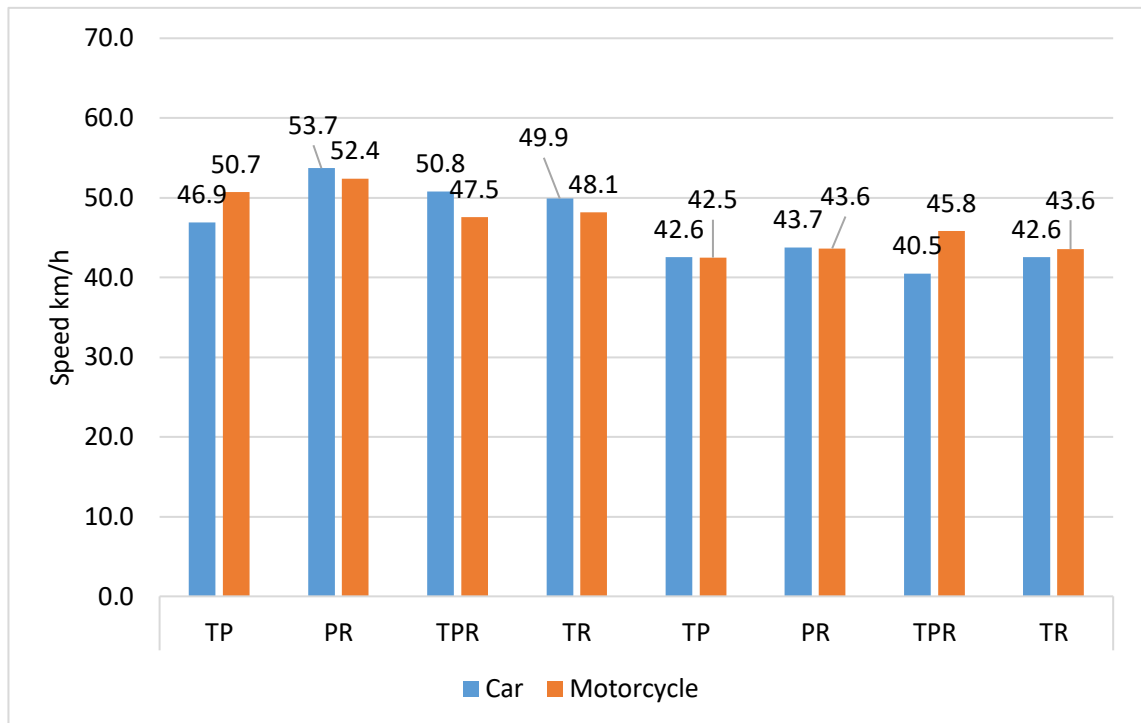
Figure 115: Mean speed of car and motorcycle for combined intervention group

The chart shows only group that experienced two or three factors intervention. In dual carriageway route, cars' mean speed were found higher than motorcycles' mean speed in group Police and publicity (PR), training and publicity (TR) and training, police and publicity (TPR), except for group training and police (TP). In single carriageway, cars and motorcycles mean speed were find close to equal, except for group TPR where motorcycles' mean speed was higher than car. The highest mean speed difference is 3.8 km/h in TP group and 5.3 km/h in TPR group, in dual and single carriageway respectively, where motorcycle travel faster than car.

To assess the difference of car and motorcycle mean speed, whether it is statistically significant or not, an independent t- the test has been performed. Assumption and justification for independent sample t-test were analysed before the statistical test. The result is presented in Table 53.

Table 53: Independent t-test result of car and motorcycle speed for combined intervention

Route	Intervention	Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	SE Diff	95% CI of the Diff	
									Lower	Upper
DC60	Training and police	0.510	0.488	-0.971	13	0.349	-3.8	3.9	-12.1	4.6
	Police and publicity	2.855	0.115	0.458	13	0.654	1.3	2.8	-4.8	7.4
	Training, police and publicity	1.563	0.233	1.623	13	0.129	3.2	2.0	-1.1	7.5
	Training and publicity	2.550	0.134	0.496	13	0.628	1.7	3.5	-5.8	9.3
SC50	Training and police	0.690	0.421	0.028	13	0.978	0.1	3.3	-7.1	7.3
	Police and publicity	5.016	0.043	0.038	13	0.970	0.1	2.9	-6.1	6.3
	Training, police and publicity	1.896	0.192	-1.482	13	0.162	-5.3	3.6	-13.1	2.4
	Training and publicity	0.105	0.751	-0.302	13	0.767	-1.0	3.3	-8.1	6.1

The independent t-test shows that there was no significant difference in mean speed between car and motorcycle in all combined intervention group, either on dual or single carriageway.

8.7 Comparison of proportion of travelling above the speed limit

The proportion of exceeding the posted speed limit provide insight into the speeds at which drivers choose to travel and their compliance with speed limits under free-flow conditions (DFT, 2016). It is important to understand the relationship between the interventions applied and the proportion of travel above the speed limit as another way to investigate the choice of speed. Therefore, another test was conducted to determine how much the proportion of travel above the speed limit changed when different speed enforcement procedures were applied. In this analysis, only the proportion of travelling above the speed limit on the treatment road, where intervention was applied, was used.

8.7.1 Dual carriageway 60 km/h route

The variation between the type of intervention and the proportion of travelling above the speed limit on a dual carriageway is presented in Figure 116.
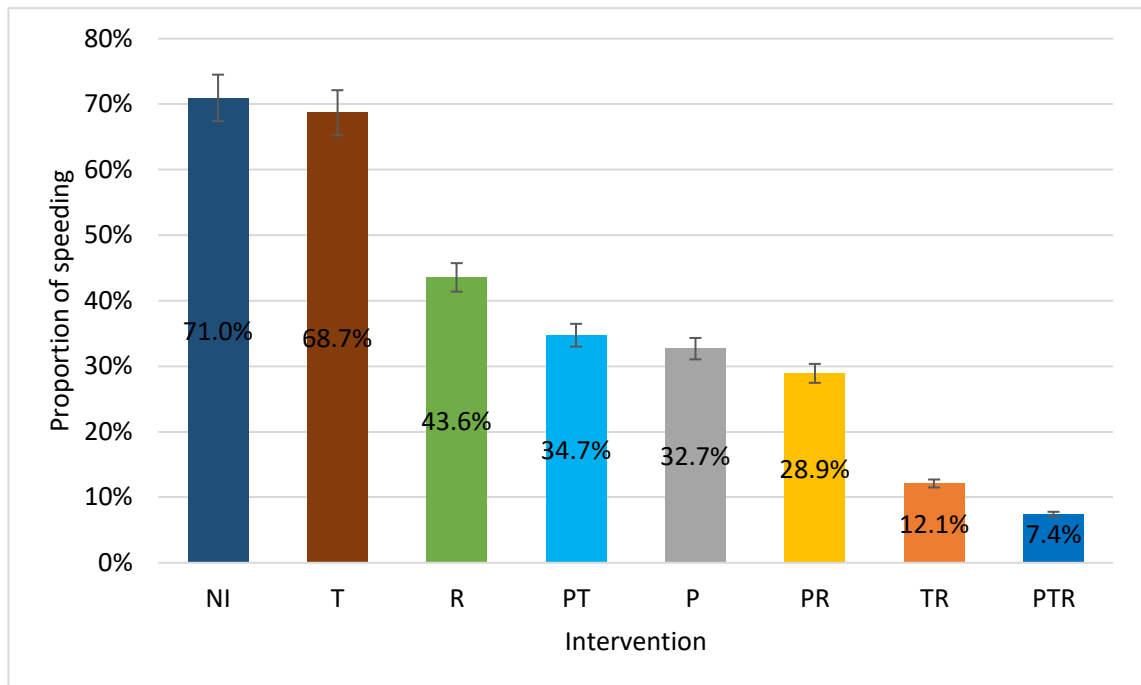
Figure 116: Proportion of speeding on dual carriageway based on intervention

No-intervention condition produced the highest proportion of speeding by 71%, then followed by the training only intervention at 68.7%. The lowest proportion of speeding occurred during the three factors combination, police, training and publicity. The combined intervention of training and publicity produced a slightly higher proportion of speeding than the combined three-factors, although this proportion is still far below the results of other intervention. To understand further the difference between these proportions, a statistical test was conducted.

Determining a statistically significant three-way interaction

The three-way ANOVA was conducted, and the result shows that no significant three-way was found. The combined intervention between police, training and publicity is:

$$(PTR); F(1, 589) = 0.47, p = 0.49.$$

Therefore, the two-way interaction was investigated further. The combined intervention of police and publicity and training and publicity were found statistically significant, combination of police and publicity $(PR); F(1, 589) = 20.04, p = 0.00 \ or \ p < 0.05$, and combination between training and publicity $(TR) (F(1, 589) = 22.31, p = 0.00 \ or \ p < 0.05)$. The interaction between police and training (PT) was not significant $F(1, 589) = 1.05, p = 0.31$.

The interpretation of this result is that that there is no different effect in the addition of the third factor, which suggests that publicity does not affect the interactions between police and training.

Determining simple main effect

To follow up these statistically significant two-way interactions, simple main effect analysis must be conducted.

Table 54: Simple main effect for combination police and publicity

Police	Publicity	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Absence	Absence	69.1	2.9	63.3	74.8
	Presence	27.9	2.9	22.2	33.6
Presence	Absence	33.9	2.9	28.2	39.6
	Presence	18.7	2.9	12.9	24.4

This result explains that the mean of the proportion of speeding during the absence police and publicity is 69.1%. The presence of publicity helped to reduce the proportion of speeding to 27.9%. The presence of police also affected the proportion of speeding, took it down to 33.9%. Moreover, the combination of police and publicity both brought down further the speeding proportion to 18.7%.

Table 55: Univariate test result for police and publicity

Police	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Contrast	126821.525	1	126821.525	100.343	.000
	Error	744424.183	589	1263.878		
Presence	Contrast	17256.600	1	17256.600	13.654	.000
	Error	744424.183	589	1263.878		

Table 55 shows the significantly different mean of speeding proportion in contrast to publicity. Therefore, the simple pairwise comparison was investigated further. However, the significant result of training and publicity are discussed first.

Table 56: Simple main effect for combination training and publicity

Training	Publicity	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Absence	Absence	50.9	2.9	45.1	56.7
	Presence	36.5	2.9	30.8	42.2
Presence	Absence	52.1	2.9	46.3	57.8
	Presence	10.1	2.9	4.4	15.8

Table 56 describes that the mean of speeding proportion if the training and publicity were absence was 50.9%. The presence of publicity helped to reduce the proportion of speeding to 36.5%. The training, surprisingly, increased the proportion of speeding, up to 52.1%, 1.2% over the non-attendance of training. However, the combination of training and publicity both brought extremely low the speeding proportion to 10.1%. It was the lowest proportion of combined intervention result in speeding proportion in the dual carriageway.

Table 57: Univariate test for training and publicity

Training	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Contrast	15385.801	1	15385.801	12.173	.001
	Error	744424.183	589	1263.878		
Presence	Contrast	132042.840	1	132042.840	104.474	.000
	Error	744424.183	589	1263.878		

The result shows that the difference of the mean of speeding proportion due to a combination of training and publicity were statistically significant. The result is followed up by simple comparison.

Determining simple comparisons

First pairwise comparison depicted the mean difference of combined intervention of police and publicity.

Table 58: Pairwise comparison of police and publicity

Police	Publicity (I)	Publicity (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Absence	Presence	Absence	-41.2	4.111	.000	-49.256	-33.108
Presence	Presence	Absence	-15.2	4.116	.000	-23.292	-7.125

Table 58 shows that the establishment of roadside publicity was statistically significant, as well as reduce the speeding proportion by 41.2% compared to the absence of both publicity and police. Accordingly, the combination of police and publicity was able to elicit the reduction of 15.2% proportion of speeding. Both mean differences are statistically significant.

The second comparison shows the mean difference of combined intervention of training and publicity.

Table 59: Pairwise comparison of training and publicity

Training	Publicity (I)	Publicity (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Absence	Presence	Absence	-14.4	4.136	.001	-22.555	-6.308
Presence	Presence	Absence	-42.0	4.105	.000	-50.022	-33.897

This comparison states that, for motorists who did not take the training, the mean of speeding proportion in the presence of publicity is 14.4% lower than the intervention without publicity. While, for motorists who take the training, the mean of speeding proportion in the presence of publicity is 42.0% lower than the intervention without publicity. Both mean differences are statistically significant.

To sum up, the combination of three factors, police, training and roadside publicity, was not statistically significant. Besides, the two-factor combination of police and publicity and training

and publicity were statistically significant. The interpretation of this finding is the addition of the third factor into intervention did not produce significant difference with two factors intervention. The third factor, therefore, did not add to the effectiveness of enforcement. The significant differences were found to involve publicity. The presence of publicity was able to reduce the proportion of speeding as high as 42% when combined with training. Publicity adds to the effectiveness of both police presence and motorists' training.

8.7.2   Single carriageway 50 km/h route

A similar procedure was applied to determine the change in the proportion of participants travelling above the speed limit when a speed enforcement procedure is applied on single carriageway route.
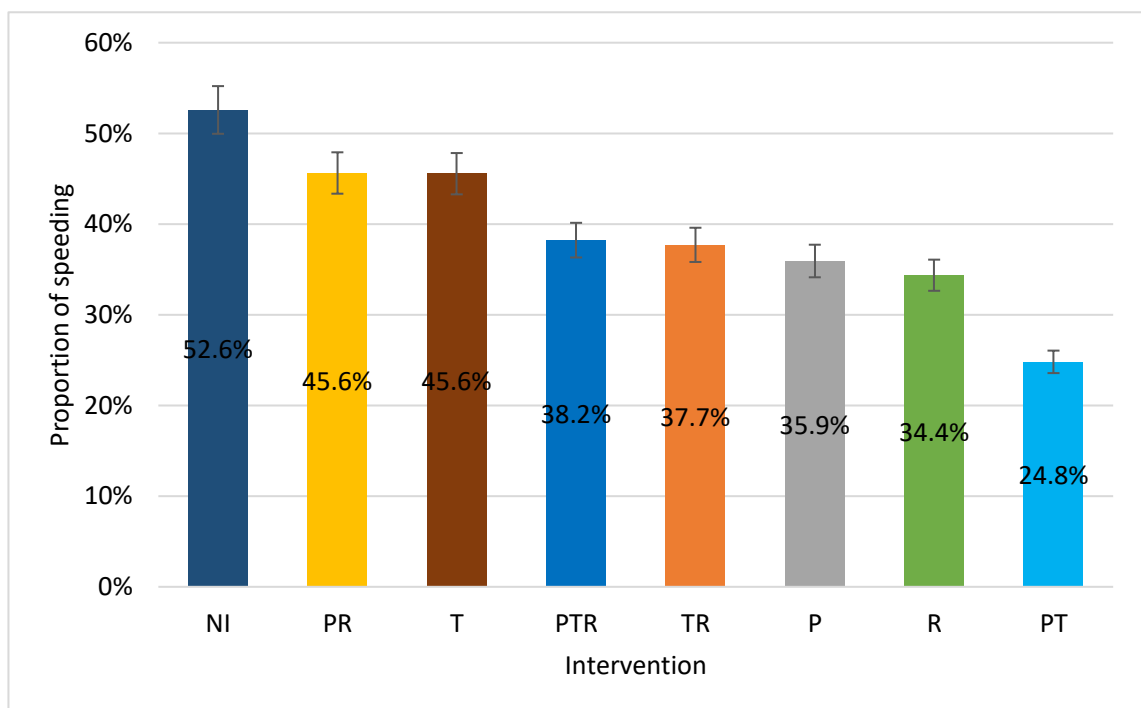
Figure 117: Proportion of speeding on dual carriageway based on intervention

Figure 117 shows that the no-intervention (NI) condition produced 52.6% of the proportion of travelling above the speed limit. The combined intervention of three factors, police, training and publicity (PTR), also generated 38.2%. The lowest proportion occurred when police combined with training (PT), at 24.8%. Surprisingly, publicity (R) alone could produce 34% of the proportion of speeding, just about 10% higher than the lowest result, the combined intervention of police and training. To understand further the difference between these proportions, a statistical test was conducted.

Determining a statistically significant three-way interaction

Assumptions were assessed before statistical tests. The statistical test shows that there was no statistical significance of three-way interaction. The combined intervention between police,

training and publicity is (PTR); $F(1, 589) = 0.224, p = 0.64 \ or \ p > 0.05$. Therefore, the two-way interaction was investigated further. The combined intervention of police and training, (PT) $(F(1, 589) = 0.26, p = 0.61$, and training and publicity, (TR) $(F(1, 589) = 1.88, p = 0.17 \ or \ p > 0.05)$, were found not statistically significant, while combination of police and publicity was statistically significant (PR); $F(1, 589) = 15.7, p = 0.00 \ or \ p < 0.05$.

To explain this result, essentially, a three-way interaction tests whether the simple two-way police and training interactions differ between the presence and the absence of publicity. Thus, there was no difference mean of speeding proportion by the addition of the third factor into the experiment. However, the two-factor combination of police and publicity was found significant, and therefore need to be investigated further.

Determining simple main effect

To follow up these statistically significant two-way interactions, between police and publicity, simple main effect analysis was conducted.

Table 60: Simple main effect for combination police and publicity on single carriageway

Publicity	Police	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Absence	Absence	48.5	3.0	42.6	54.4
	Presence	31.0	3.0	25.1	36.9
Presence	Absence	35.8	3.1	29.8	41.8
	Presence	42.1	3.0	36.2	48.0

Table 60 describes that the mean of the proportion of speeding during the absence police and publicity is 48.5%. The presence of publicity helped to reduce the proportion of speeding to 35.8%. The presence of police also reduced the proportion of speeding down to 31.0% in the absence of roadside publicity. Surprisingly, the combination of police and publicity both increased the proportion to 42.1%, although it is not statistically significant.

Table 61: Univariate test of police and publicity

Publicity	Source	Sum of Squares	df	Mean Square	F	Sig.
Absence	Contrast	22685.8	1	22685.8	17.021	0.000
	Error	785031.2	589	1332.8		
Presence	Contrast	2949.7	1	2949.7	2.213	0.137
	Error	785031.2	589	1332.8		

The result shows a significantly different mean of speeding proportion occurred only during the absence of publicity. Therefore, the simple pairwise comparison was investigated further.

Determining simple comparisons

Table 62: Pairwise comparison of police and publicity

Publicity	Police (I)	Police (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Absence	Presence	Absence	-17.507	4.243	.000	-25.840	-9.173

This comparison states that the mean of speeding proportion in the presence of police is 17.5% lower than the intervention without police. No other statistically significant combination found in the comparison.

To sum up, the combination of three factors, police, training and roadside publicity, was not statistically significant in the single carriageway. The interpretation of this finding is the addition of the third factor, for instance, training, into intervention did not produce significant difference with two factors intervention. The third factor, therefore, did not add to the effectiveness of enforcement.

The two-factor combination of police and publicity was found statistically significant. However, further investigation by simple comparison found that the significant difference of the mean of speeding proportion took place in the presence of police only, while the publicity was not established on the roadside. The presence of police was able to reduce the proportion of speeding as high as 17.5%. Publicity and training did not add to the effectiveness of police presence in single carriageway route.

8.8 Estimated changes in number of accidents, casualties and crash risk

In Indonesia, police continuously strive for preventing traffic accidents and violations on the road. A particular program is often operated in order to show the seriousness of the police in addressing traffic safety problems. However, the facts show that the quality of traffic safety is still at a low level.

8.8.1 Dual carriageway

Different procedures of speed enforcement have proved to produce a different choice of speed, thus different mean speed. Nilsson (1981, 2004) proposed power relationships connecting the changes in traffic speed with the changes in a road accident at various levels of injury severity (Cameron, 2010). The model was summarised by into six formulas, as discussed in section 3.2. Elvik et al. (1997) evaluated the power model and provided the supported result that the overall power estimates for the fatal accident are close to 4, as predicted by Nilsson's power model.

Therefore, in estimating the implications of the different combination of speed enforcement procedures, the Nilsson power model was used to show the potential reduction of accident and casualty. The following are graphs for the number of fatal accidents and fatal casualties, the number of fatal and serious injuries accidents and its casualties, as well as the number of accidents resulting in all type injury and its casualties, based on dual carriageway data.

In the graph, the number of accidents is denoted by Y, and accident victims by Z. Furthermore, a 0 subscript denotes the values observed mean speed baseline, and a *one* subscript denotes the values observed after a change in mean speed after intervention. While, F, FS and I are indicating fatal, fatal and serious, and injury, respectively. No-intervention's result is placed in the beginning of line graph, then followed by the intervention result sorted from highest to lowest.
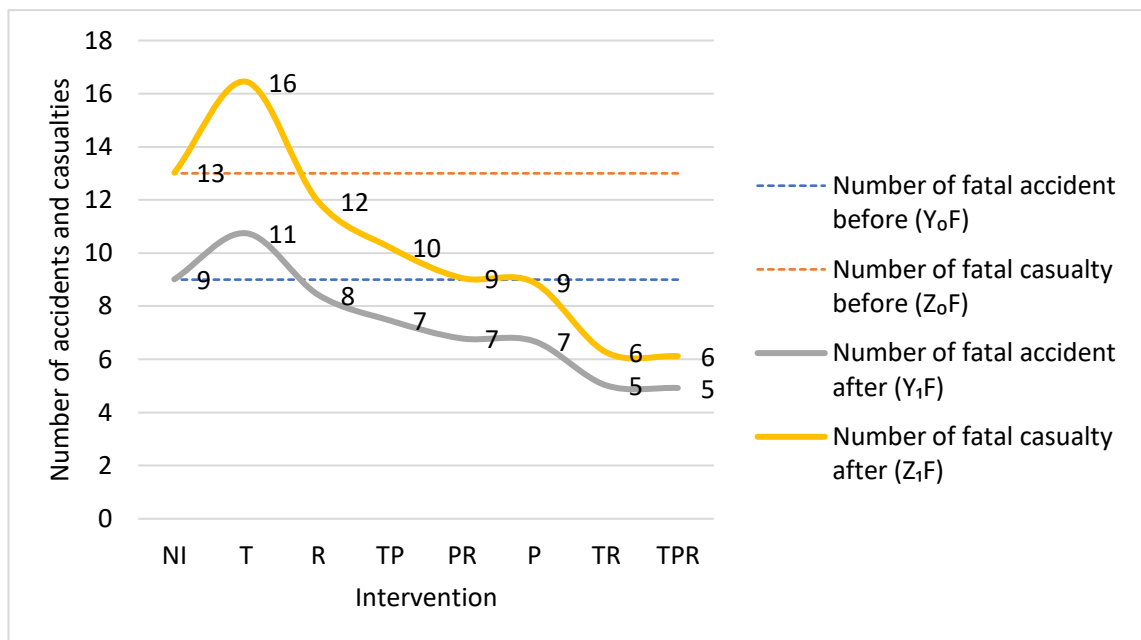
Figure 118: The number of fatal accidents and casualties on dual carriageway

Figure 118 shows that a number of the accident was 9 and it has resulted in 13 people deaths, this situation occurred when no-intervention has been conducted. This data is an actual situation based on police accident data. The lowest result of some accident and casualties occurred when it was intervened by the combinations of police, training and publicity; it predicted to have 6 deaths from 5 accidents.

Meanwhile, the highest number of accident and casualty has been resulted by training only intervention. Further, there are a consecutive declining trend began with the intervention by publicity only, it was 8 accident that caused 12 people deaths followed by two-factor combinations of intervention between the police and training, which resulted in 10 deaths from 7 accidents. Finally, both intervention by the police and publicity or police only

intervention have resulted a similar number of total accident and casualties, which involved 7 accidents and caused 9 people deaths.

Furthermore, this figure also shows that any intervention has been taken creates a lower number of accident and casualties except training only intervention. The effect of training has been discussed in the previous chapter that this kind of intervention has impact on psychological effect toward a more confident in driving a vehicle. For example, the intervention by the police, training and publicity has resulted the lowering number of accident and casualties, from 9 to 5 accident and save 7 peoples.
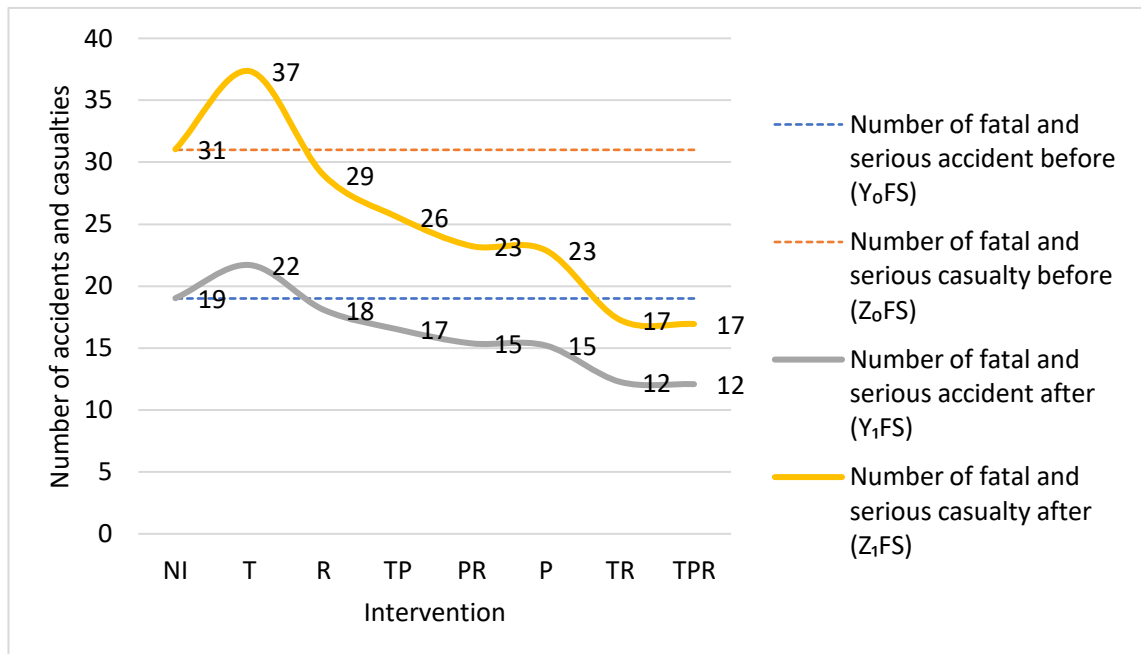
Figure 119: The number of fatal and serious accidents and casualties on dual carriageway

Figure 119 reflects a similar trend that there are a fewer number of accident, fatalities, and seriously injured as an effect three intervention of police, training and publicity. This combination of intervention has resulted reduction of the number of accident from 19 to 12 and save 14 peoples.

This figure also shows that similar pattern between the combination of three intervention of police, training and publicity and two combinations of training and publicity, both resulted 12 accidents with 17 number of casualties. Further, there is also a similar pattern that produced by two combinations of police and publicity and police only, it showed that from 15 accident there were 23 casualties.

Figure 120 shows that there is a decreasing trend in the number of accidents and total injured people. The intervention by police, training, and publicity has reduced the number of accidents from 25 to 18 and has saved the lives of 21 people.
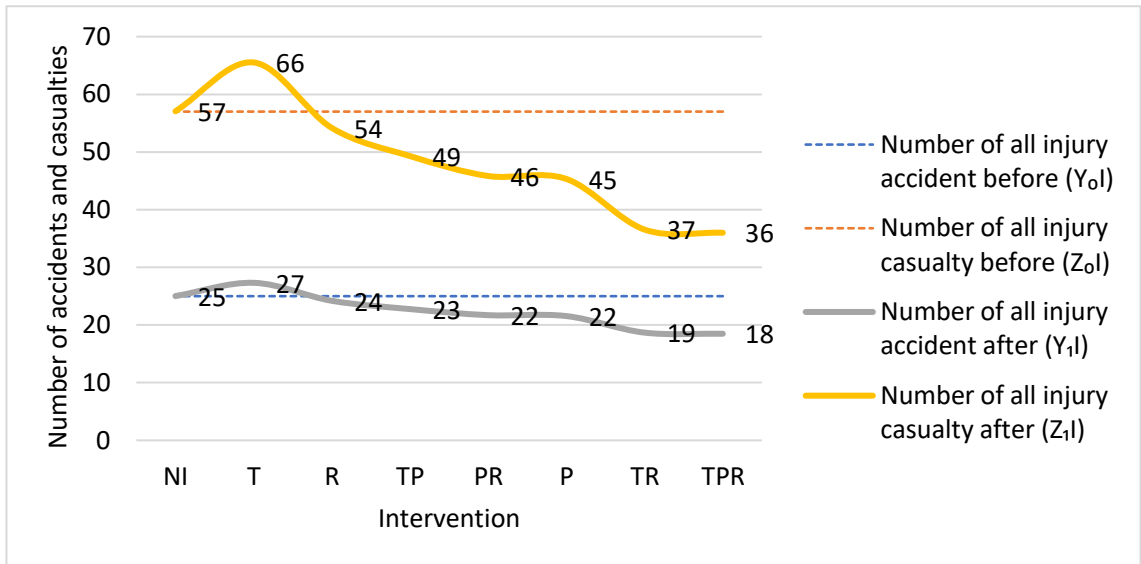
Figure 120: The number of all injury accidents and casualties on dual carriageway

There is a slight different line in Figure 120: The number of all injury accidents and casualties on dual carriageway compared with the previous Figure 119, where TR and TPR have same effect on number of accident and casualties. The combined intervention of police, training and publicity was able to reduce further one accident and save one people compared to the combination of training and publicity.
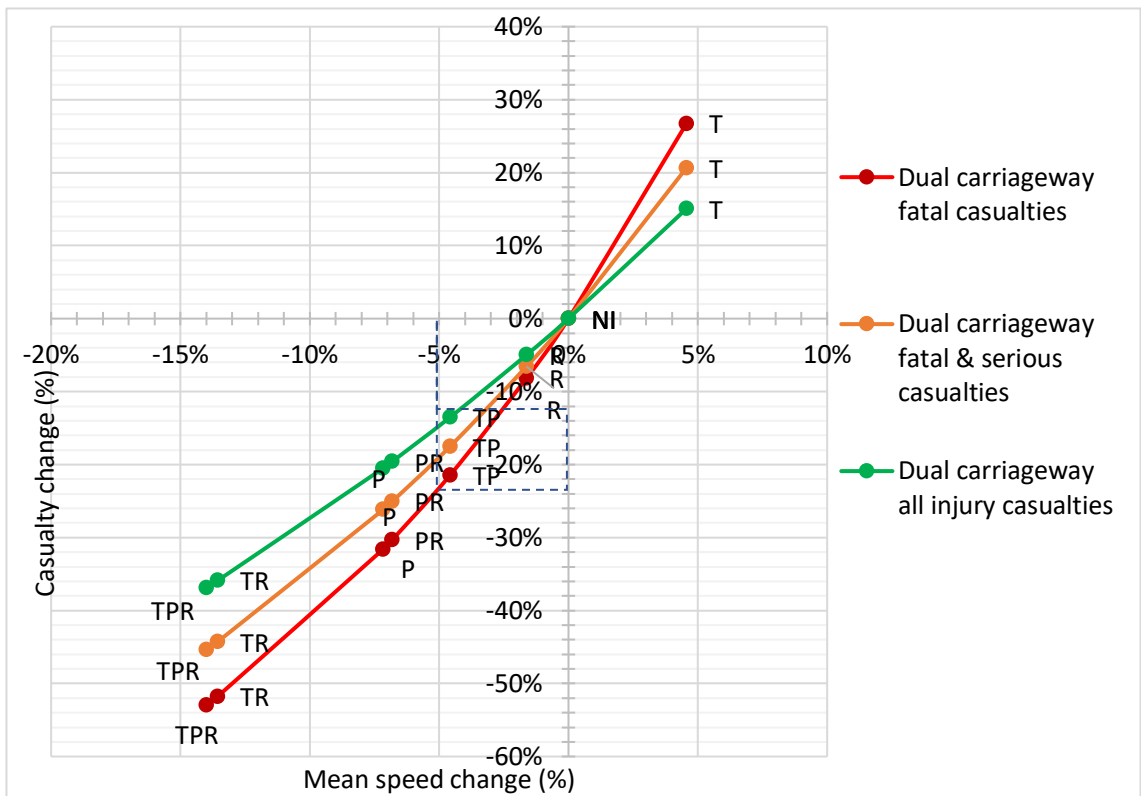
Figure 121: Estimated change of casualty on dual carriageway related to interventions applied

Furthermore, to describe the relationship between mean speed changes and the estimated casualty changes for each combined intervention, a crash risk graph was created. Figure 121

shows that the lowest percentage of decreasing number fatal casualties were 52% when the mean speed was reduced up to 14% in three-factor combination of police, training and publicity. The same mean speed reduction is estimated to decrease up to 45% fatal and serious casualties and 36% all injury casualties. In contrast, when the mean speed was increased by 5%, fatal casualties is estimated to increased up to 27%, fatal and serious casualties up to 21 % and all injury casualties estimation increased by 15%.

In conclusion, there is a potential improvement of safety by combining the training and publicity into speed enforcement conducted by police. The largest estimated reduction of accidents and casualties was generated by a combination of police, training and publicity. However, the estimated reduction by two factors combination of training and publicity was found also large, similar to three factors combination of police, training and publicity, except for all injury category. Furthermore, the estimated reduction graphs suggest that the intervention factor with three factors is very nearly saturated, which also called the ceiling effect. The ceiling effect in this study means that the level at which an addition of factor (independent variable) has only produced very small effect on motorists' choice of speed (dependent variable). For instance, four-factor combination may not significantly reduce further the number of accidents and casualties.

8.8.2 Single carriageway
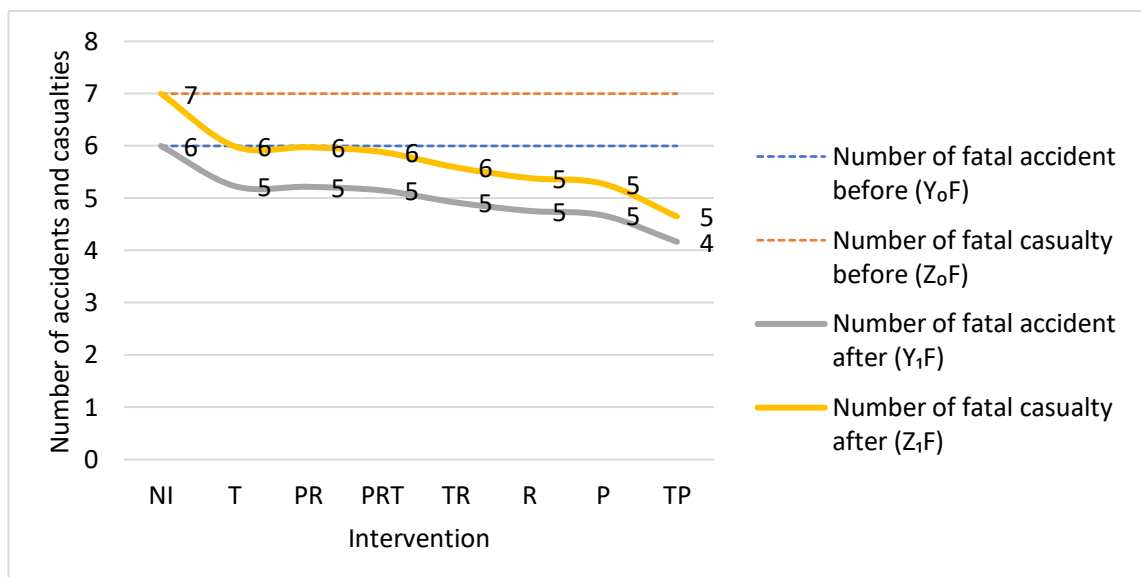
Figure 122: The number of fatal accidents and casualties on single carriageway

Figure 122 shows that there is a difference of choice of speed in response to interventions applied single carriageway. In the absence of intervention, fatal accident and its casualties was 6 and 7, respectively. This is an actual number based on police accident data, which also served as baseline of accident data. There are a slightly lower estimated number when the

intervention applied on the road. The lowest result of number of accident and casualties occurred when it was intervened by the combinations of police and training, it predicted to have 4 deaths from 5 fatal accidents. Compared to the baseline, the combination of police and training is estimated to save three lives in every five accidents.
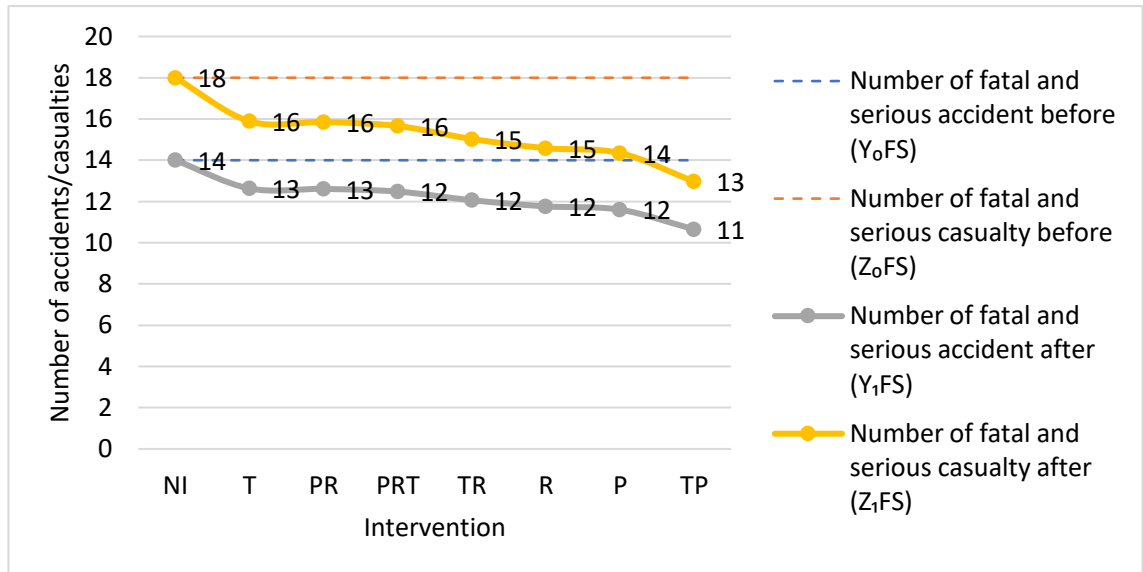
Figure 123: The number of fatal and serious accidents and casualties on single carriageway

Figure 123 also shows that there is a decrease in the number of accidents and casualties as a result of the intervention. This figure also shows a similar estimated number between the several types of intervention. Nevertheless, the combination of police and training has brought down the number of accident and its casualties to 11 and 13, respectively.
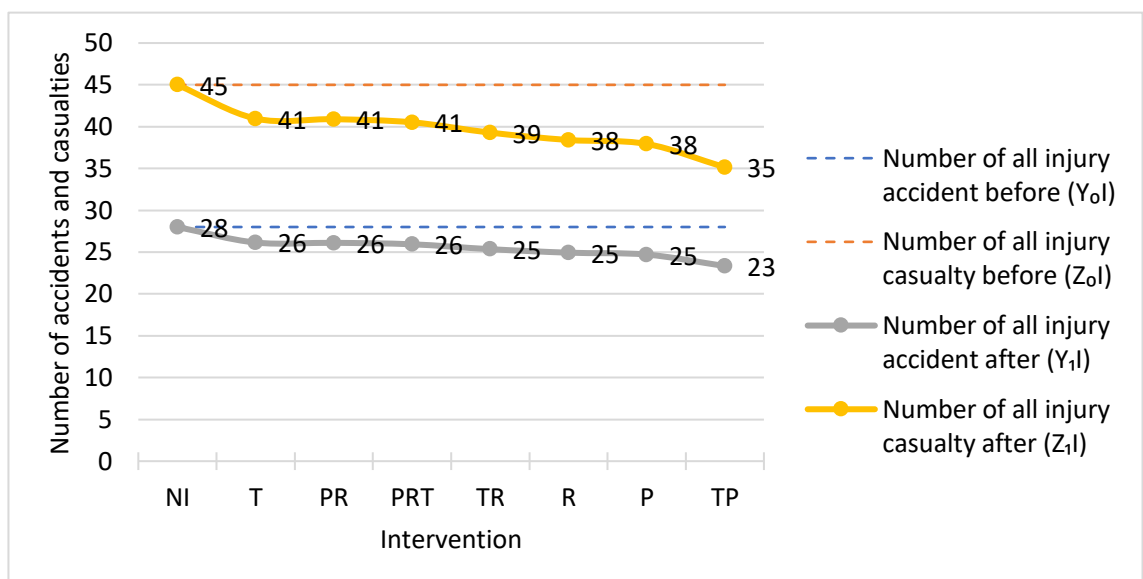
Figure 124: The number of all injury accidents and casualties on dual carriageway

Finally, the number of all injury accident and its casualties is presented in Figure 124. The combination of police and training has estimated to reduce the number of accident to 23, which is 5 accidents less than the actual accident data, and save 10 people from injury.

To investigate further the different trend in single carriageway, the changes of mean speed and casualty for each injury category was plotted, as presented in Figure 125.
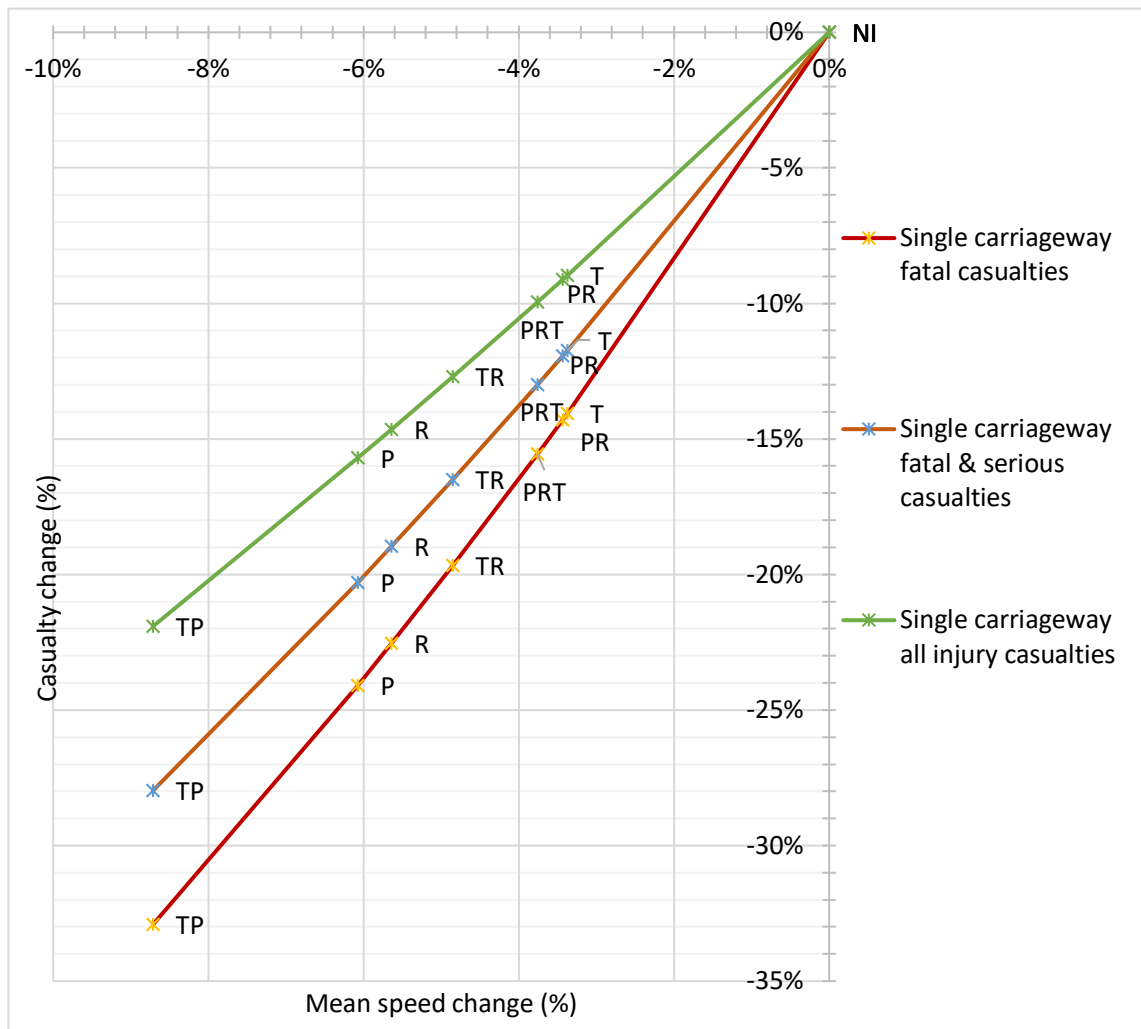
Figure 125: Estimated change of casualty on single carriageway related to interventions applied

Figure 125 shows that the lowest estimated number of casualties, 33% in casualty reduction, occurred when the speed was decreased by 10% as a result of the effect of combined intervention of police and training. The number of fatal and serious casualties was estimated to decrease by 30% the lowest level as result of the same intervention, as well as 20% reduction for all injury casualties.

To sum up, the finding in single carriageway shows that all interventions estimated to produce the similar quantities of reduction, except for the combination of police and training. This result corresponds to statistical test result where the combination of police and training has a statistically significant difference effect. The figure also shows that there was no data for estimating the increased of mean speed. The comparison of estimated changes in crash risk.

8.9   Conclusion

The exact relationship between speed and safety is complex and depends on a wide range of specific factors. However, in general it can be said that the faster the speed, the greater the chance of a crash and the more severe the injuries in a crash. Therefore, the combined intervention was tested in this study to learn the effectiveness of speed enforcement that supported by training and roadside publicity on motorists' choice of speed.

The effect of the intervention on participants' choice of speed was first explored by speed profile graphs. On the dual carriageway route, the police presence created large speed variations that speak to the enormous influence of their presence on the road. However, the effect was only observed around the police enforcement spot, then disappearing as soon as the motorists had passed the checkpoint. The effect of the roadside publicity intervention produced the largest and longest influence on motorists' choice of speed, while training effect increase the mean speed slightly.

The speed profile graph for combined interventions on the dual carriageway presented different effects route, among two-factor combinations, the interaction between training and publicity influenced a reliably lower speed on the treatment road, whereas the interaction between training and police, and police and roadside publicity, simply fluctuated around a fixed mean. Moreover, the speed profile graph for the three-way interaction has indicated identical opportunity for negative and positive results (decrease and increase of speed).

The statistical test for dual carriageway data has shown that three-factor combination was generated statistically significant difference of mean speed. In other words, the combination of three factors together was found to be more effective than any two-factor intervention. Further investigation of simple two-way interaction found that significant difference between the police factor, presence or absence, was also significant. The interpretation to this finding is the effect of the training intervention on motorists' mean speed depends on the information provided by the roadside publicity, wither police absence or presence on the checkpoint. In other words, the publicity results moderated the effect of the training intervention's level on motorists' choice of speed, in the absence or presence of the police. Further investigation by simple-simple comparisons reveals that combination between training and publicity was able to elicit 10 km/h lower mean speed compared to the absence of all intervention. Surprisingly, when the police joined with the training and publicity, the three factors only able to reduce 5 km/h overall mean speed across the intervention groups. The results have indicated that if the publicity was involved, the effect of the combined intervention would generate a statistically

significant mean difference in mean speed. Roadside publicity adds to the effectiveness of motorists' training and police presence.

Furthermore, speed profile graph on the single carriageway route showed that the main effect of police generated the largest effect compared to training and publicity. There are two observable declining points along the route that correspond with the police checkpoint. In contrast to training result on dual carriageway, there was a decrease of mean speed as a result of training. The training and publicity have not caused a large effect; mainly, the contrast line steadily stepped around zero.

The speed profile graphs for the combined interventions of two factors on the single carriageway show that the slight changes in mean speed took place mostly around the police checkpoint location (segment 10 and 11). The presence and the absence of factors have a very little effect of speed changes. Similarly, the combined three-factor intervention's speed profile graph has mean speed differences that floated around zero, which indicated small differences between the presence and the absence of the third factor.

The statistical test show that the three-factor combination was found to be not statistically significant. A statistically significant interaction for combined intervention were found between training and publicity, as well as between police and publicity. Accordingly, the statistical test indicates no statistically significant difference of mean speed observed between the presence and the absence of the main effect of police, training and publicity.

The relationship between mean speed changes due to intervention and the changes of casualty number was evaluated by applying the result of Nilsson power model (Nilsson, 2004) into a graph that was introduced by Elvik et.al. (2004) based on a meta-analysis of studies that provide estimates of how changes in speed affect the number of road accidents and the number and severity of injuries to road users. On dual carriageway, the highest accident reduction estimated to reach 53% of fatal casualties, 45% of fatal and serious casualties and 36% of all injury casualty, which resulted from the combination of police, training and publicity together. Whereas in single carriageway, the largest reduction of casualty was estimated to reach 33% of fatal casualties, 28% of fatal and serious casualties, and 22% of all injury casualties, which was achieved by a combination of training and police presence.

Chapter 9

Halo effect on police presence

9.1   Introduction

The effect of visible and stationary policing on driving speeds is an interesting topic in speed enforcement research, particularly with regard to the length of the effect of enforcement t after the driver passed an enforcement site. This study aimed to determine the relative effectiveness of interventions designed to increase compliance with the speed limit. These interventions including: training, police presence, and roadside publicity. Put more precisely, the present investigation aimed to determine if and when participants who started driving above the speed limit changed their speed when the police were present on their checkpoint, either on the near or far side.

Participants were observed before and after the interventions took place. A successful result would be one where participants did not drive above the speed limit after the intervention. The longer the distance it took after the intervention before participants started to drive above the speed limit, the more effective the intervention. Therefore, the Kaplan-Meier survival method was used to answer two questions:

1.   Is there a statistically significant difference between the survival distributions of the group of interventions where police were present, and

2.   Which specific interventions differed from each other (differences between the survival distributions)?

In the sample of this study, there were four groups of between-subjects factor intervention: police only; police and training; police and roadside publicity; and police, training, and roadside publicity. The intervention without the police variable (training only, publicity only and the combination of training and publicity) was not included in Halo effect observation. The survival distributions illustrate how survival distances differed between the groups over time, which were tested by the Kaplan-Meier method.

Kaplan Meier test for survival analysis

The Kaplan-Meier method (Kaplan & Meier, 1958) is a nonparametric method used to estimate the probability of survival past given time points (i.e., it calculates a survival distribution). This

test is used to calculate the probability that a motorist drive above the speed limit after passing the enforcement point, which is called Halo effect. Furthermore, the survival distributions of two or more groups of a between-subjects factor can be compared for equality (Kishore et al., 2010; Layton, 2013; Laerd Statistics, 2015b).

The Kaplan-Meier method is utilized to understand the Halo effect (based on distance until driving above the speed limit) for participants who experience the presence of police. The survival variable would be "distance to travel above the speed limit" and the between-subjects factor would be the intervention groups (with police presence) and then compare the survival distributions (experiences) between the groups to determine if they are equal. A critical part of the process involves checking to make sure that the data meet the assumptions of this tests.

9.2 Halo effect on dual carriageway 60 km/h route

To start understanding and interpreting the results, the cumulative survival functions for the different intervention groups were plotted. Figure 126 presents various intervention group that made on dual carriage 60 km/h route, a combined intervention by training and police has a proportion of 0.29. Meanwhile, intervention by police and publicity results in a lower proportion, it was 0.27. Meanwhile, the police only intervention reached quite a large effect, it was 0.48. However, the highest proportion is resulted by three combination intervention, those are, training, police and publicity at 0.72.
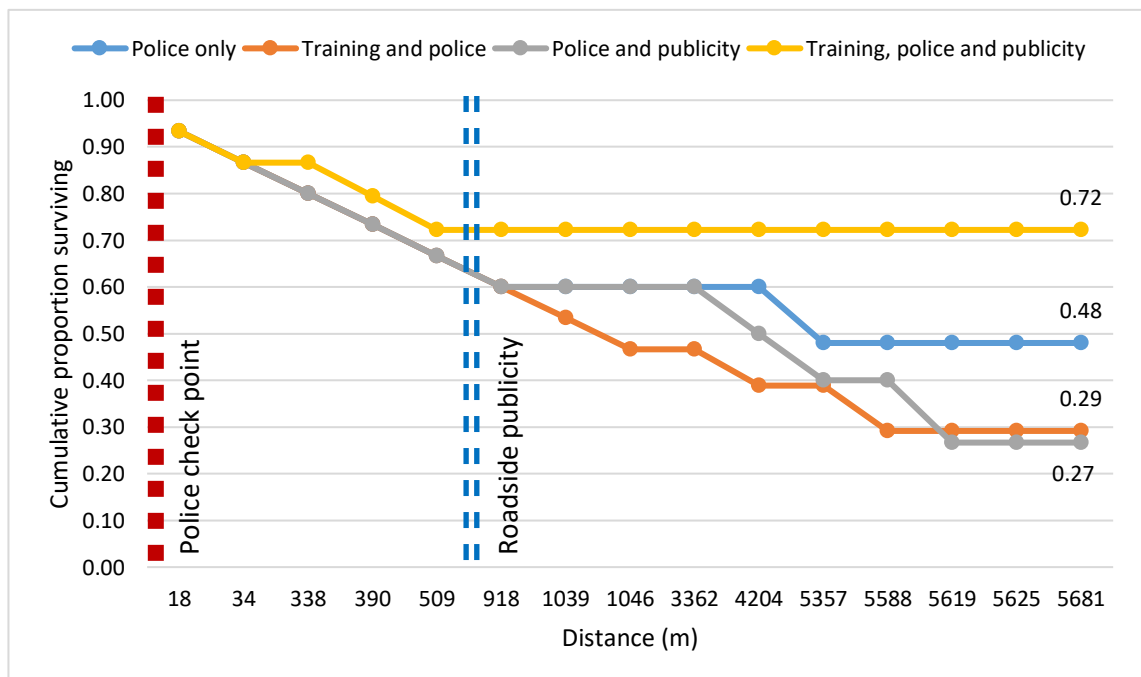
Figure 126: Survival functions for the different intervention on dual carriageway 60 km/h

This distribution is considered to demonstrate an advantageous effect of training and publicity that add to effectiveness of police intervention. It would appear that the combination of three

interventions significantly prolongs the distance taken until participants started driving above the speed limit compared to the other interventions.

In order to clarify the distance until participants began speeding again, the mean and median for the survival table are produced. Table 63 displays the mean and median survival time, and associated statistics, for each intervention where the police were present. These figures seem to confirm that the combination of training, police, and publicity was more successful at keeping participants from speeding for longer than the other three group interventions.

Table 63: Means for survival model in dual carriageway route

Intervention	Mean			
	Estimate	Std. error	95% confidence interval	
			Lower bound	Upper bound
Police only	2947.8	730.3	1516.4	4379.1
Training and police	1933.4	659.4	641.0	3225.8
Police and publicity	2254.5	669.1	943.0	3566.0
Training, police and publicity	4171.3	643.6	2909.7	5432.8
Overall	2867.5	359.7	2162.6	3572.5

The support of training and publicity to police intervention has prolonged the survival distance up to 4.2 km, until participants started driving above the speed limit. At the same time, the combined treatment also prevented more than 70% of participants from breaking the speed limit again. Overall, in the presence of the police on dual carriageway 60 km/h road, participants started driving above the limit after 2.9 ± 0.4 km on average, while 95% CI shows between 2.2 and 3.6 km.

The large participants in training, police and publicity group who were able to finish the test without breaking the speed limit can be explained as a deterrent effect of police enforcement. Similarly, the extended distance of survival in the same group was also influenced by deterrence effect. Deterrence concept has been the dominant paradigm underpinning attempts at behavioural control in road safety around the world (Elliott, 2008).

This outcome shows how participants experienced a general deterrence effect. Thus, the driving behaviour, particularly the compliance to speed limit, was arising from the motorists' perception that speed limit was enforced and hence that there is a risk of detection and punishment if they violate the speed limit. Perhaps, the knowledge they gained from training and provision of information through roadside publicity reinforced the decision to maintain the travel speed below the speed limit.

At the same time, a specific deterrence resulted from participants' actual experiences with detection emerged when they saw the police using the speed gun pointing at the approaching

vehicle. The presence of police on the roadside using speed gun imposed on motorists could prevent them from committing the offence.

9.3 Halo effect in single carriageway 50 km/h route

A similar procedure was conducted for the results collected on the single carriageway 50 km/h. A survival graph was produced to assess the Halo effect of police presence. The cumulative survival functions were plotted, as shown in Figure 127. Figure 127 shows that the police only intervention has a proportion of 0.10. However, this result is very close with the combinations of intervention, training and police, reached up to 0.11. Meanwhile, the survival proportion for the combination of police and publicity was 0.24; the highest proportion is the combination of the training, police and publicity, this combination made up to 0.33 compliance proportion until the end of the test.
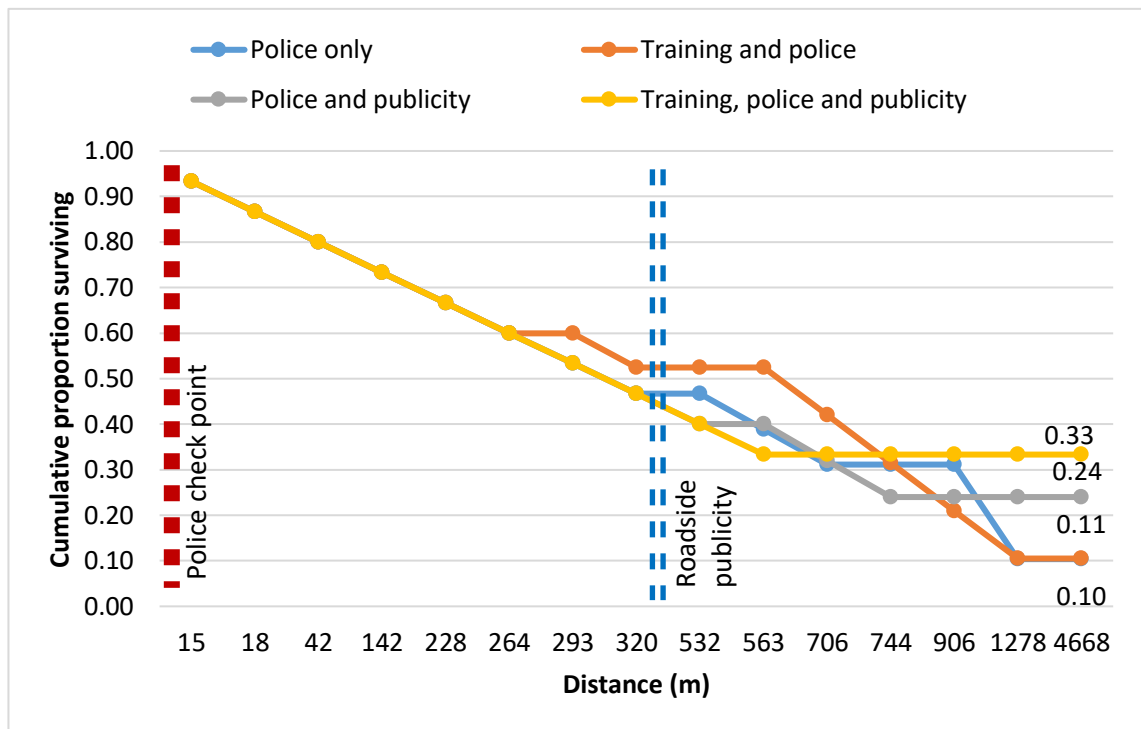
Figure 127: Survival functions for the different interventions on single carriageway 50 km/h

As the graph indicates, the line for training, police, and publicity interventions, combined together, was on top of the other interventions' lines, which indicates that for the combined interventions a higher proportion of participants maintained their speed without breaking the speed limit. Again, this distribution demonstrates the effectiveness of the combined intervention. The combination of three interventions prolongs the distance before participants started driving above the speed limit again.

In order to clarify the distance until participants began to speed again, the means and medians for the survival table are shown in Table 64. The table displays the mean and median survival

time, and associated statistics, for each of interventions where the police were present. These figures seem to confirm that the combination of training, police, and publicity was more successful at keeping participants from speeding for longer than the other three group interventions.

Table 64: Means for survival model in single carriageway route

Intervention	Mean			
	Estimate	Std. error	95% confidence interval	
			Lower bound	Upper bound
Police only	989.9	340.5	322.6	1657.3
Training and police	943.1	407.7	143.9	1742.2
Police and publicity	1228.1	522.0	205.1	2251.2
Training, police, and publicity	1591.6	562.7	488.8	2694.4
Overall	1209.6	251.2	717.3	1701.9

The support of training and publicity on police enforcement together prolonged the distance up to 1.6 ± 0.6 km until participants started driving above the speed limit. At the same time, this combined treatment also prevented 33% of participants from breaking the speed limit. Overall, in the presence of the police on a single carriageway 50 km/h road, participants started driving above the limit after 1.2 ± 0.3 km on average, while 95% CI shows between 0.7 and 1.7 km.

The highest survival rate and extended distance in training, police and publicity group were related to deterrent effect of police enforcement, either specific or general deterrence.

9.4   Conclusion

A Halo effect was observed in this study. There is a different distance outcome as the Halo effect occurs on both routes. On dual carriageway 60 km/h road, the presence of the police was able to prolong the motorist compliance on average 2.9 ± 0.4 km, while in the average effect on the single carriageway 50 km/h road was 1.2 ± 0.3 km. Nevertheless, for both routes, the most effective combination of intervention consists of the police, training and publicity, together. This combined treatment also prevented 72% and 33% of participants from speeding, on dual and single carriageway respectively. The survival rate and extended distance where motorists were able to maintain their travel without breaking the speed limit, was supposed to be influenced by the deterrent effect of enforcement.

Chapter 10

General Discussion and Conclusion

The purpose of this chapter is to bring together separate findings that have been presented in different chapters, then to interpret and describe the significance of these findings into one unified explanation. The discussion in this chapter connects to the introduction by way of the research questions or hypotheses, and the literature reviewed, as well as remain consistent with the arguments and findings that have been revealed in earlier chapters.

The main objective of this study is to develop a more effective speed enforcement procedure. The first section of this chapter discusses the challenges in the methods of study, followed by motorists' attitude toward speeding, enforcement and safety, and police officers' job satisfaction. The public survey was initially intended to aid in the development of the main experimental study procedure. Nevertheless, the outcomes are also used to understand the choice of speed in response to interventions applied in the experiment. Hence, they support the development of more effective speed enforcement.

The subsequent section discusses the result of the experiment, precisely the effect of single and combined intervention on motorists' choice of speed, which includes the deterrence effect that prevents motorists from driving above the speed limit. Finally, the last section discusses the Halo effect of speed enforcement.

10.1 Challenges in study design

This study was designed to examine the effects of three factors: police; training; and roadside publicity, whether as a single or combined factor. The research employed various methods to achieve the objectives, such as survey and field experiments. Both methods required careful design to allow for efficiency and effectivity. The use of methods employed in this study and the topic investigated is novel in comparison to other studies conducted in Indonesia or somewhere else, but the risks encountered and the probability of failure has made this study unique and different from other studies.

Studies that investigate multi-factor experiments that implement quasi-experiments, with 2x2x2 factorial designs, are widely practised in industrialized research or lab experimental or clinical trials. However, the experiments that involve police presence combined with roadside

billboards and driver training in a real-world setting are a handful. It was challenging to run a three-factor intervention, particularly when they were combined, into one experiment in a real situation.

Special arrangement was made with local police and road authority to allow the deployment of the police unit and the establishment of roadside publicity. If it were not for the support of these parties and the team's persistence in overcoming the challenges during the course of this research, this research might never be successful.

As the factors and levels (categories) to consider in this experimental design increase, the complexity of this study also increases substantially. Some challenges faced include:

1. Experiments with police and roadside publicity were unable to be randomized.
2. Training intervention was conducted in the classroom prior to test-drive, while the other intervention was conducted on the road.
3. The route design did not allow the same distance used for every segment due to road layout and permit from the landowner.
4. Potential sequence effects and equivalent groups' problems.
5. The delivery of the experiment under optimal conditions given the constraints of available resources.
6. Budget support was provided for only one trial on each route, so if something went wrong or fails, it can thwart all the research plans, to the last stage.

Nevertheless, the success in completing this research, with all its challenges, has made this study contribute substantially to similar studies in the future.

10.2 Potential improvement of speed enforcement effectiveness

10.2.1 Understanding public and police views on speeding and enforcement

Every road has a speed limit, often referred to as the national speed limit in the absence of speed limit signs, and every motorist must obey the speed limit when they drive on the road. These are some critical articles in the Indonesian Traffic Act 22/2009. Nevertheless, the traffic survey result shows that the 85th percentile speeds in those locations were found to be higher than the speed limit. It is typical that motorists do not observe the speed limit in Indonesia, due to the absence of speed limit signs in most of the rural roads and small number signs installed in the urban road.

A similar conclusion was reported where motorists consider the speeds that they have chosen to be within the safety limits (DaCoTA, 2012). Tarko (2009) described that one common reason, often admitted to by motorcyclists, was a lack of attention paid to the speedometer or

a failure to correctly recognise the speed limit of a given road. Hence, drivers travelled at speeds that corresponded to individual perception only (Tarko, 2009). These results are likely to be related to the other findings where the majority of police officers think that speed enforcement is a new challenge for them. Most of the officers perceived that speed enforcement requires complex and high policing competency. It is not only because of lack technology to support the speed enforcement and a lack of signage, but also the low public acceptance of police enforcement.

One of the most apparent findings to emerge from the analysis of motorist surveys is that people perceived rural road as more dangerous than the urban road. This perception may be due to many segments of rural roads in Indonesia containing potholes, floods and puddles, slippery surfaces, and unpaved or uneven road shoulders. Tjahjono (2003) and Hidayati et al., (2012) have described the rural roads infrastructure and environmental conditions in Indonesia and linked them with road safety situations. Furthermore, based on road conditions and traffic surveys, there are still many road sections without signs, markings, or corners, as well as intersection designs with too many points of conflict, and additionally a low-discipline driving culture. Furthermore, the mixing of inter-city (regional) traffic and local traffic creates significant variations in traffic speed.

The result is also in line with a report in the UK, where rural roads are also perceived as being more dangerous because of poor quality roads which are also supported by the higher accident risk as the complexity of road increases (Taylor et al., 2000). There are fewer casualties on rural roads but a higher proportion of people that are killed and the majority of people seriously injured are involved in accidents on roads in non-built-up areas (Collins and Stradling, 2008).

Unexpectedly, even though motorists asserted a dangerous rural road, their desire to drive fast on the rural road is higher than the urban road. The possible explanation for this view is linked to the low risk of being caught by the police. Police speed enforcement on rural roads is effectively non-existent, except for specific target in specific police operations. Thomas, A. et al., (2001) have stated that one of the leading factors causing drivers to choose high speeds is the low perceived likelihood of being detected and the desire to test themselves in this challenging road environment. Nevertheless, when it comes to the risk of being caught by the police in general and not solely on rural roads, the probability of apprehension for speeding was perceived as reasonably high. This finding is in contrast with the game theory model which assumes that drivers prefer to speed when there is no police enforcement, and when there is police enforcement on the road, drivers prefer not to speed (Bjørnskau and Elvik, 1992).

Speeding is seen as an interaction between drivers and the police in this theory, where the police would prefer to enforce rules when there are reports of speeding. However, in a real police operation, in Indonesia for example, the police always need to perform enforcement, even when there is no speeding reported. Police are deployed at least two times a day (morning and evening peak hour) to monitor and control traffic flow, which includes enforcing the traffic law. They would respond immediately to any traffic offence, such as red light running, violations of stopping line, unlicensed/untaxed vehicles and many other traffic violations. Besides, people are aware of a speeding offender, mainly those who drive far above the limit, and have to deal with the police, often in a hostile situation.

Based on this researcher's knowledge, the current procedure for a motorist who is apprehended for speeding includes being held for up to 24 hours for questioning before police have to charge with a crime or release the driver. The police may decide to release the driver without charge or give him a warning. If charges are brought against the driver, he then has to appear in court. This idea may affect the motorists' perception of being caught for speed limit violations, although the speed enforcement is rare and sporadic. In other words, although police rarely act against speed violations, once they take steps against speeding, the methods that they use are often relatively upsetting for offenders, that is using pursuit, intercept, and arrest.

The majority of respondents immensely disliked drivers whose speed far exceeded the speed limit. They support the idea where the offender could lose the right to drive. People understood that speeding is linked with an increased risk of accident, particularly with respect to the severity of an injury. Nevertheless, the motorists preferred thoughtful approaches in dealing with speeding, such as publicity, advertising and education or training. This finding is in line with the concept where the driver mostly believed that they drive slower than average traffic speeds and safer in comparison to others (Evans, 1991).

On the one hand the motorists agree with severe penalties against offenders, but on the other hand, they prefer a moderate approach. One possible explanation for this is because most people see themselves as safe and compliant drivers who sometimes drive above the speed limit. Despite thinking this, however, those surveyed stated that their speeding offences did not make them a "criminal" (Corbett, 2000a; Wells and Savigar, 2017). People hardly see themselves as speeding "unacceptably" (Silcock and Smith, 1999). Therefore, if the police catch them, a humane and forgiving approach is sufficient to discipline them. In contrast, drivers are more critical of other speeding drivers than of themselves (Corbett and Simon, 1991). Therefore they agree to the severe punishment for speeding offenders. Police officers have the confidence that the community is keen to work with them to resolve the speeding

problem, although, in the police survey result, citizens' cooperation was found statistically insignificant in determining officers' job satisfaction.

To sum up, the attitude to speeding and enforcement was found highly subjective and often misperceived due to the non-existence of effective speed controls currently in Indonesia. However, strong deterrence from police routine operation has affected the perceived risk of police apprehension. This finding has also shown an excellent level of agreement between the police and the driving public in their perceptions of the seriousness of speeding offences.

10.2.2 High satisfaction on job as motivation and opportunity for development

Indonesian National Police and road safety stakeholders in Indonesia have long been concerned with how the performance of traffic police officers can be improved. Traffic enforcement units, like other police units, do have some problems that prevent them from functioning effectively on enforcing the speed limit on Indonesian road (WHO, 2013). One of the significant obstacles to achieving effective speed enforcement may be traffic enforcement officers who have low job satisfaction rates related to work itself.

The current study has adopted Zeitz et al.'s (1997) organizational culture index and also includes several different dimensions related to police work. The results of the police survey show that most police officers have a high degree of satisfaction with their work as traffic police. Although previously identified by WHO (2010, 2013) that speed enforcement in Indonesia has not been effective. The high level of job satisfaction found in this study is an excellent opportunity to begin the development of more effective speed enforcement.

Yahya et al. (2013) emphasise the great responsibility of Indonesian traffic police corps for road safety based on new traffic acts, although other organisations retain road safety structures within their organisations. For this reason, a positive work environment, as it is revealed from officers' response, is important to build strong relationships with colleagues, managers, the community, and with all other stakeholders.

High job satisfaction has a positive impact, to improve the discipline and work motivation of police officers. Speed enforcement is relatively new for most police officers in Indonesia, success or failure may be determined by officers' acceptance of newly proposed responsibility for, loyalty to, and solidity in the police organisation. The more enthusiastic and disciplined police officers to serve their respective jobs, the stronger the relationship will be, within the police organisation and in the community, the greater the opportunity for improvement. Police manager often encourages the member of the unit, quoting that police has a great opportunity to save somebody's life on the road.

10.3 The effectiveness of speed enforcement

The relationship between speed and safety is one of the most studied topics in road safety research. As speed is one of the critical factors in road crashes, the speed enforcement has turned out to be one of the key factors in road safety. As the main party responsible for enforcing the speed regulation, law enforcement agencies around the world are increasingly adopting combined enforcement strategies, primarily strategies that include publicity and training.

Traffic safety research shows that multidimensional approaches are rarely investigated. Mostly, road safety research considers only a single measure for groups of road users or groups of roads or groups of accidents (Nilsson, 2004). Therefore, the combined interventions in this study have not only enabled a higher degree of understanding of road safety factors but have also examined that certain interventionist methods and factors may or may not modify the effects of speed enforcement practices.

10.3.1 Change in the choice of speed

After gaining an understanding of motorists' attitude to speeding and enforcement, the subsequent section discusses the results of the experiment. This study aims to develop a more effective speed enforcement practice by investigating police enforcement and the supported measures along with the training and publicity involved. Therefore, the present study was designed to determine whether the addition of the training and the roadside publicity to the police enforcement would have synergistic effects regarding the choice of speed.

Firstly, it needs to be noted that the baseline of speed chosen by the participants is higher than the spot speed survey results. This finding is similar to what was stated by the Box and Bayliss (2012) that the posted speed limits are not always seen as appropriate and many drivers make their judgement about what is a safe speed to drive, and this is frequently higher than the posted speed limits. A plausible explanation is that because of the test routes were located on the rural road, which corresponded with the previous findings from the public survey that indicated motorists' desire to drive fast on the rural road is higher than the urban road.

The most interesting finding is that on the dual carriageway there was a statistically significant three-way interaction between police, training, and roadside publicity. Moreover, the combined intervention between training and publicity had a significant effect on the choice of speed, either with the absence or presence of police. The follow up also found that a significantly lower mean speed occurred when the police were present and publicity was present, though the police were not deployed on the road.

Schagen (2016) has argued that there is no evidence that publicity has any effect on speed behaviour, except for the very short-term effect of local speed limit reminders. Meanwhile, the OECD (2006) reported similar outcomes that the effects of publicity were hard to prove. The effects of publicity they observed are likely influenced by other factors, which have yet to be defined. Nevertheless, the findings of this research indicate that the roadside publicity has a powerful effect on driver behaviour, particularly for trained motorists. The result complements the results of OECD research where they did not identify the factors that influenced the effect of publicity. These results provide further support for the theory that the police and the training factors, work together mutually with publicity.

A decrease in mean speed was also observed during a single intervention with the publicity, although it was statistically insignificant. It is essential to understand that the size of this mean difference has practical importance, not only statistically and theoretically. These results from single and combined interventions suggest that lower mean speeds can be achieved through a combination of publicity. As, it has been suggested that publicity increases the effects of enforcement (Zaal, 1994; OECD/ECMT 2006).

In contrast, the subsequent results show that a significantly higher mean speed happened when police and publicity were absence. Thus, only training was a presence. The related result was also found in the single intervention training where there is a tendency that the participants drove faster and produced a higher proportion of speeding compared to the other groups. Henderson (1991) and Stradling, et al. (2003) expressed their concern that there is an increase in risky behaviours such as speeding as a result of training as they perceived their skills to increase as a result of the course. Results of this study demonstrated that training tends to increase the mean speed on a dual carriageway. Similarly, in the single carriageway, training result was the highest among all type of intervention, except when there was no intervention on the test. Nevertheless, the provision of information on the roadside has also been able to reduce the increased risk behaviour, i.e. speeding.

Therefore, the findings of this study offer two important considerations related to the effects of training and its interaction with the police and publicity. Firstly, any motorists' training that involved a skill or a knowledge improvement of vehicle operation on the road should be accompanied by a relevant psychological or behavioural awareness on how to prevent overconfidence bias. Confidence is beneficial for vehicle operation, but motorists must know when to be confident about their judgment on speed.

Secondly, instead of increasing the police unit deployment on the road, which is high cost and requires extensive labour, police can use roadside publicity which warns motorists about the speed limit, the presence of speed enforcement, the speeding consequences, and may provide

motivational messages to motorists. Thus, it is expected that motorists who have experienced training are able to apply the skill and knowledge confidently in the right time and place.

Furthermore, this finding should be able to complement what the OECD/ECMT (2006) expressed that the effects of information campaigns as a means of changing attitudes and behaviour are hard to prove. They further stated that it is not possible to judge the effects of the information alone as these results must be attributed to the combined components of the campaign. Therefore, the combination of intervention result in this study is appropriate to answer their allegations, and indeed the result proves that the publicity effect occurs significantly when police are present or when publicity reaches the competent motorists.

To sum up, this study has demonstrated the effectiveness of speed enforcement procedures on motorists' choice of speed. Each intervention, either single, separated, or combined, generate different effectiveness in influencing the changes in motorists' speed choice. However, the use of publicity to accompanied enforcement has demonstrated the positive effect by reducing the mean speed. The publicity works well for trained motorists who have a risky behaviour as a result of overconfidence from training.

10.3.2 Changes in the proportion of speed violation

Speeding is a primary road safety concern all over the world. The results show that there is a potential reduction of speeding proportion related to the type of intervention employed. Although the combination of police, training, and roadside publicity together did not produce a significant result, there was a two-factor combination that potentially offers more effective speed enforcement than a standalone procedure. The presence of roadside publicity was found to reduce the proportion of speeding as high as 42% when combined with training.

Elvik (2011) suggests that fatal accidents, in particular, could be reduced if excessive speeds could be eliminated or prevented. However, the speeding behaviour that is not very easy to eliminate. A series of studies on speed limit offenders gave a fresh conception about what drivers believe and consider about travelling above the speed limit, and why it is difficult to disregard. Aberg et al. (1997) and Campbell and Stradling (2003) found that drivers believe most other drivers speed and that they drive more slowly than average (Walton and Bathhurst, 1998). Nevertheless, this study has been able to demonstrate that more effective speed enforcement can reduce that proportion of speeding. It could be argued that the positive results occur during the implementation of combined intervention were due to persuasive materials in publicity and training that combined with the increased risk of police apprehension. However, this result needs to be interpreted with caution whether that persuasive material tends to be more effective when combined with an intervention that

promotes the elaboration of the messages. Publicity adds to the effectiveness of both police presence and motorists' training.

10.3.3 Estimated change in the number of accidents and casualties

In Indonesia, police continuously strive for preventing traffic accident and violations on the road. A particular program is often operated, to show the seriousness of the police in addressing traffic safety problems. They might as well correspond to the organisational policy and the dynamics of the community. However, the facts show that the quality of traffic safety is still at a very low level.

Different procedures of speed enforcement have proved to produce a different choice of speed, thus a different mean speed. Nilsson (1981, 2004) proposed power relationships connecting the changes in traffic speed with the changes in a road accident at various levels of injury severity (Cameron, 2010). The model was summarised into six formulas, as discussed in section 3.2. Elvik et al. (1997) evaluated the power model and provided the supported result that the overall power estimates for the fatal accident are close to 4, as predicted by Nilsson's power model. The lowest estimated number of accident and casualties occurred when it was intervened by the combinations of police, training, and publicity, although a similar estimation was also produced by training and publicity.

The effect of training alone on a dual carriageway has been discussed in the previous chapter whereby it has an impact on psychological effect toward a more confident in driving a vehicle (See section 3.4.2, 7.4.2 and 10.2 for detail explanation). It is somewhat surprising that the combination of training with publicity drastically increased its effectiveness when put together. To be precise, by providing information to those who have been trained, the effect that we expect as a result of training, unexpectedly appears with multiple effects. The result even surpassed the effect it had if the police were on the road. This finding challenges what Rothengatter (1997) and Rothengatter et al. (1989) were questioning about the effects of publicity as the effects of publicity alone are small, without enforcement procedure. The results show that well-communicated information was well responded to by well-trained people, even at times when the police were not present at the checkpoint or on the road. From another point of view, when someone is trained on a "speed related subject", they may find information related to speed, leading to a significant change in speed choice. It can be said that specific information provided on the roadside, works more effectively on someone who has been trained in that specific matter. Here, Rothengarter did not see that the effect of publicity was so great if they had reached the right motorist. The trained motorists

demonstrated a different choice of speed from the untrained driver when both were confronted with publicity on the roadside.

Accident risk is different for different types of roads (Taylor et al., 2000). The results show that there is a difference of choice of speed in response to interventions applied in the single and dual carriageway. Therefore, the result tells that the effect of the intervention was influenced by road layout, road geometry, and other road characteristics. Although two types of combined intervention, training and police, and police and publicity, were found to be statistically significant, all interventions were estimated to produce a similar number of fatal accident and casualties.

Elliot and Broughton (2004) hypothesised that at zero enforcement level, accidents and casualties are expected to be at their highest levels. They argued that the changes in enforcement have no noticeable effect at first. When motorists are aware of police presence, they were expected to modify their behaviour (i.e., to reduce their violations), so that the number of accidents and casualties would start to drop. As enforcement level increases, the number of accidents and casualties can be expected to decrease, but only up to a certain point, after which increased enforcement would have little or no effect because of a saturation effect.

The result of this study offers new insight into the general relationship expressed by Elliot and Broughton (2010). The change in the level of enforcement or an increase in the quantity of enforcement should not be limited to an increase in the number of checkpoints and personnel/units on the road, or the addition to the number of patrol vehicles and an increase of patrols hours, or the extra speed cameras on the road. The strengthening level of police enforcement methods can also be achieved by combining it with some police led training programs and roadside publicity. Nevertheless, saturation effects were expected to occur as found in this study. The addition of the third factor in the experiment proved to no longer produce a significant change in the choice of speed, as well as the number of accidents and casualties.

10.3.4 Estimated changes in crash risk

The faster the speed, the greater the chance of a crash and the more severe the injuries in a crash. Elvik et al. (2004) have argued how changes in speed affect the number of road accidents and the number and severity of injuries to road users. This study explored eight types of enforcement procedures and provided an estimation based on the changes of choice of speed for each intervention. The largest estimated decreased was found at 53% fatal casualties reduction when the mean speed was reduced by 14% due to a combination of

factors in policing, training, and publicity. There is a possibility to move further beyond what currently has been achieved in this study, but the ceiling effect would have prevented a further reduction. Moreover, the result also provides a new insight related to the different level of compliance expressed by a motorist, when the mean speed increased by 5% would follow by a risk increase of 21%. The result also shows that the reduction of casualties is larger in dual carriageway than single carriageway.

10.3.5 Different pattern of Halo effect related to different combination of intervention

There are several methods for determining the effect of enforcement on speeds. Alongside the safety implication, as discussed earlier, the time and the distance Halo effect are the established methods to evaluate the effectiveness of police enforcement. The measure of effect is typically some speed parameter, often the average speed of traffic (Waard and Rooijers, 1994; Christensen and Vaa, 1992; Vaa, 1997; ETSC, 1999,) or proportion of speeding offence (Holland and Conner, 1996). Nevertheless, this study has demonstrated the ability to detect and evaluate the distance Halo effect on an individual level by using the continuous speed data. The continuous speed data along the test route has allowed detecting precisely the difference distance of the Halo effect as a result of a different combination of enforcement. Therefore, it offers a more comprehensive evaluation of motorists' behaviour than the average traffic observation on fixed observation points.

The investigation of the Halo effect aimed to determine if and when participants who started driving above the speed limit changed their speed when the police were present at their checkpoint. In other words, we want to know the number of kilometres from the police checkpoint in which the effect is maintained. The result showed that as drivers approached the police checkpoint, they tended to reduce their speed. Upon passing the checkpoint, the drivers accelerated back to their original speed or higher. On average, after 2.2–3.6 km in the dual carriageway and 0.7–1.7 km in the single carriageway, participants would have started driving above the speed limit.

Previous research results, by Elliot and Broughton (2004), Elvik (2009) and Sisiopiku & Patel (1999) described that the effect of police presence on driving speeds typically lasted between 2.4 and 8 km, which is relatively similar to findings in this study for an overall combination of intervention (average result) on dual carriageway. However, the combined intervention of three factors was able to maintain the effect up to 4.2 km on a dual carriageway, which is the most effective procedure among the interventions implemented in this study. Nonetheless,

most of these studies were conducted in motorway or dual carriageway roads. This study found that the distance of Halo effect in single carriageway was shorter than dual carriageway.

Furthermore, one of the improvements offered by this study related to the Halo effect analysis is to estimate not only the distance of the effect but also the proportion of motorists who managed to keep the effects until the end of the route. Holland and Conner (1996) argued that an overt police presence can be effective in reducing the number of drivers who speed. The survival distribution in this study is considered to demonstrate the proportion of motorists who successfully drive below the speed limit after passing the police checkpoint. The result shows a beneficial effect of training and publicity that add to the effectiveness of police intervention. It appeared that the combination of three interventions significantly prolongs the distance taken until some participants started driving above the speed limit. 72% and 33% of motorists were able to travel below the speed limit, in dual and single carriageway respectively. These combined interventionist strategies may be effective in tackling speeding offenders.

The training and publicity containing information about speed enforcement strategies and consequence were found useful for deterring drivers from speeding in this study. Therefore, the Halo effect observed in this study reflected the specific and general deterrence. The combined intervention was able to discourage the motorists from future speeding by instilling an understanding of the consequences, as well as indirect deterrence for general prevention of speeding by showing enforcement action towards general traffic.

Nevertheless, the result is in contrast with the belief that increasing the severity of punishment increase the deterrent effect. The police must be aware that strengthening of the deterrent effect does not necessarily have to go through a large number of apprehension and the severity of the sanctions.

10.4 What lesson learned to make speed enforcement more effective?

10.4.1 Speed enforcement help to meet UN-DOA target

Universally, police duty entails protecting and serving communities. In performing this duty, the first principle of policing is the protection of life. In line with this principle, the police in Indonesia is given the mandate by the people that the main duties of the Indonesian National Police (INP) include maintaining security and public order, enforcing the law, and providing protection, guidance, and service to the community.

In the field of transportation and traffic, in accordance with Article 7 paragraph (2) sub-paragraph e of Traffic Act No. 22/2009, these main duties are distinguished as: conducting

traffic law enforcement; managing a temporary and emergency traffic engineering; motor vehicles and drivers licensing; and delivering traffic education. In addition, Article 226 of this law also requires the INP to coordinate the implementation of traffic accident prevention programs, under the road transport and traffic board.

Currently, in accordance with the United Nations Decade of Action (UN-DoA) for Road Safety 2011–2020, ratified by the Indonesian government, the INP has shown a strong commitment to accomplishing the UN's vision by developing the Indonesian Road Safety Plan 2011–2020 and implementing it in the police operation, with the target of reducing 50% the number of deaths due to traffic accidents, using 2010 data as a baseline. Various ways and approaches have been undertaken by the police to reduce the number of casualties, especially the death toll, but until now the accident data has not shown a downward trend. There is a need to accelerate in pursuing the targeted reduction of fatalities.

Many factors, measures, and programs are well known to have an impact of road casualty reduction, such as the use of helmets protective clothes for motorcyclists, road infrastructure improvements, use of in vehicles safety technology, and many others. However, speeding that has been recognized as a main contributing factor of fatal accidents, and has yet to be treated seriously by Indonesian law enforcement. Perhaps, it is fair to say that a strategy to control motorists travel speed has never been taken seriously by the road safety stakeholders in Indonesia. The experience from developed who succeeds in dramatically reducing the number of casualties through effective speed enforcement is a good example to mimic. There was a story in France at the time they were so focused on speeding, that if necessary a speeding police car would be ticketed, to show how serious the government was fighting speeding offences.

One strategy that has not been effectively implemented by the police is the enforcement of speed limit offence, because of various reasons that have been discussed in Chapters 1 and 2. All parties are aware that speed is a factor that contributes greatly to the high number of fatal victims in Indonesia. Police must take action to reduce speeds on their roads and consider speed management as a core element of their road safety strategy, as conducted in many countries that already enforce the speed limit successfully. Speed enforcement has improved safety by reducing the adverse impacts of speeding.

This study has proved that effective speed enforcement on a dual carriageway has changed the driver's choice of speed. The best-estimated reduction of fatal casualties is 52%, achievable if the mean speed is reduced by 14% due to police enforcement accompanied by roadside publicity and motorist training on a dual carriageway. Even, the deployment of the police unit on the road carrying out speed enforcement is expected to reduce the mean speed of 7% from

baseline, thereby decreasing the number of fatal casualties up to 32%. Similarly, in the single carriageway, the combination of police presence and training was estimated to reduce the mean speed about 9% from the baseline, with fatal casualties' reduction as high as 33%. Police deployment alone were expected to reduce 6% of mean speed which resulted in 24% fatal casualty reduction.

These numbers look very optimistic, because these results were obtained from a well-controlled study. Besides, there is still a question about long-term effects of these speed enforcement procedure. Nevertheless, as there is no other effective way yet conducted by the police to influence the motorist choice of speed, thus to reduce the number of deaths in traffic accidents, the speed-enforcement program should be put into practice as soon as possible. Speed enforcement has the potential to contribute to the achievement of UN-DOA goals.

10.4.2 Establishing key focus of speed enforcement

Since the speed enforcement is a new program in Indonesia road safety development, certainly it is not easy to do. It takes many requirements and conditions to allow the program to run effectively, for instance the clear and sufficient amount of speed limit signs. Based on researcher knowledge and the result of this study, it obviously wouldn't be reasonable to expect drivers to know whether they drive on a particular classification/status of roads to determine the valid speed limit. There are already concerns within the Indonesian police that in some circumstances the speed limit signing is insufficient and unclear.

Moreover, if signs are present, they often do not correspond to road and traffic environment conditions. Therefore, police may also initiate to review whether the existing speed limits respect the presence of vulnerable road users, traffic composition, road layout and geometry, and roadside characteristics. Police should emphasize and promote that speed enforcement is one of means of protection for vulnerable road users. Consequently, the focus for speed enforcement is not the whole road network, but particularly near residential areas, schools, pedestrian crossings, open market and roadside with community activity. In urban areas, where vulnerable road users, including children, cyclist, elderly, are particularly at risk, speed enforcement should increase the safety, quality, and acceptance of police operations from the public. In rural areas, where the roads are not maintained well, appropriate speed is a critical component of driving to avoid obstacles, potholes, and sudden changes of the road surface.

Typical rural roads in Indonesia include mixed traffic, where cars, motorcyclists, buses, trucks, non-motorized vehicle, and many pedestrians share the same roads. The road is also a social place for young people and children to play. During night time, for example, the risk of an accident is increased dramatically due to a lack of road lighting, road marking, and signage. If

police can introduce the speed enforcement in this area, their operation can reduce the traffic accidents and fatalities very quick.

The current speed limit was found to be set close to the 85th percentile speed approach. However, this study observed that many drivers travel without taking into account the actual levels of risk. Because of this issue, it is a challenging task to make the current speed limit look credible and thus equally as difficult to achieve a good level of acceptance among the public. Recommendations may be given to foresee the change of speed limit to average speed. Some countries, the UK for example, are using the mean speed of traffic as the basis for the local speed limits. This approach offers a better balance between the speed at which with the motorists choose to travel and the lower accident risk that can be achieved. OECD (2006) also suggests lowering the speed limits when the infrastructure cannot be upgraded to the standard required by the existing speed limit.

At the moment, there is no speed data collection and speed monitoring conducted by Indonesian police. Accurate data is essential for determining the targeted speed enforcement. Police should be encouraged to develop data collection system to have a better understanding of the speeding problem in particular road network. A speed monitoring system can help police assess the level of speeding in their area. It is also necessary to identify the drivers who commit speeding offences by applying point system in the drivers' database.

The speed enforcement technique may vary from one area to another and need to consider the current levels of safety in each area. A comprehensive package of speed enforcement measures must be developed. Regarding this variation of speed enforcement procedure, this study demonstrates that each combination produced different effects. However, police can develop the measures on a very broad scale for all types of vehicles, since the speeding behaviour of cars and motorcycles were not found to be significantly different on dual carriageways as well as on single carriageways. Furthermore, as a result of public survey highlights, people like to drive fast on rural roads. The focus of police enforcement should be on balance between urban and rural roads. Up to this day, police focus much more on urban traffic, particularly with respect to congestion issues. The police should be reinforced regarding their role in community safety, rather than managing traffic flow.

10.4.3 Formulating speed enforcement procedure to work more effectively

Speed enforcement is essential to make speed limits effective. Two different forms of speed enforcement are widely known, namely manual and automated speed enforcement. This study proved that manual speed control with a stationary unit equipped with a speed gun was very effective in influencing motorists' compliance to speed limits. In the future, Indonesian police

can implement more methods such as automated speed enforcement with fixed cameras on the roadside, as well as using mobile cameras, which are installed in police vehicles. Police officers need to be trained to operate such devices because it is their main tool for fighting speeding behaviour.

Moreover, to increase the effectiveness, as this study suggests, the police enforcement should be accompanied by other enforcement programmes that communicate its purpose and strategies to the public. The use of roadside publicity was tested successfully in this study, which can be further developed in other types of the campaign such as television, social media, and newspapers at national and local levels.

Police led training programs are also beneficial for promoting speed compliance, although there is a tendency for motorists to become overconfident after training. Therefore, training to improve the skills should always be tied in with behavioural measures to prevent such risky behaviour to emerge from the confidence bias.

Finally, police need to consult widely with all stakeholders and interest groups before the implementation of speed enforcement. Police must work together with all relevant stakeholders, road and traffic authority, transportation sectors, local governments, large fleet companies, driver associations, educational institutions, the media, insurance companies, automotive companies, and all levels of society in order to ensure speed limits and the laws of the road more generally. Each of these individuals, groups and organizations have different roles and responsibilities in realizing their roads are free from speeding drivers and ensure the safety of traffic for all road users. Therefore, good coordination and cooperation with all parties is an absolute condition for the success of speed enforcement.

10.5 Conclusion

It is important to understand how speed enforcement influence motorists' choice of speed since speed is one of the major contributing factors in accidents, particularly with the severity of casualties. However, speed enforcement in many developing countries, such as Indonesia, were found ineffective, and consequently low standards of safety were found everywhere in these countries. Therefore, this study aims to develop more effective speed enforcement that can influence drivers' choice of speed, and thereby reducing the speed limit offences, hence to reduce the risk of accidents.

The method used in this study was challenging to implement. Police presence, motorists' training and roadside publicity were investigated either as a single or combined intervention. Their effects on the choice of speed were tested by field experiments on predesigned routes under free-flow traffic condition. In addition, public attitudes to speeding and enforcement

were also surveyed, as well as the collection of police officers' job satisfaction related to enforcement. Both surveys contributed to the results of this study.

The public survey result shows that the attitude to speeding and enforcement was very positive, although motorists prefer the soft approach (no punishment). Their perception of speed is highly subjective and often misperceived due to the non-existent speed sign. However, a strong deterrence from police presence has affected the perceived risk of police apprehension. Police job satisfaction was found to be high. Their high motivation to implement speed enforcement as a new program is a great opportunity for the development of road safety in Indonesia. Taken together, the police and the public have also shown an excellent level of agreement of the seriousness of speeding offences.

The baseline of drivers' choice of speed was found to be higher than the posted speed limit, between 4.8 to 5.0 km/h higher on a dual carriageway and 2.3 to 3.1 km/h higher on a single carriageway. However, no significant differences were found between no intervention condition (experiment) and spot speed survey result. This indicates that the speed behaviour was confirmed in both data.

Evidence from the single intervention experiment suggests that there is a difference in the speed pattern depending on the type of intervention applied. On dual carriageways, the training created a slightly higher mean speed during the test, although the difference was not statistically significant with the baseline mean speed. There is a tendency that trained participants drive faster than no intervention condition on dual carriageway segments. In contrast, on single carriageways, trained participants were observed slower than the baseline. Moreover, the police presence intervention strongly influenced participants to decrease their speed on both routes. However, on single carriageway segments, there was clear evidence that the participants reacted to the presence of the police despite being on the opposite side of the checkpoint.

Furthermore, the most obvious finding to emerge from the combined intervention experiment is that three-factor combination of police presence, training, and roadside publicity on a dual carriageway has produced statistically significant differences, which mean the addition of training and publicity to police intervention increase the effectiveness of speed enforcement. Not only did they reduce the mean speed by 14% on dual carriageways, but they also increased compliance by 72% until the end of test route. In the absence of police, training, and publicity has produced an excellent combined effect. Surprisingly, training factor has increased the travel speed on a dual carriageway, although the effect has changed drastically when combined with police and roadside publicity. This finding could only be justified by the fact

that training increases motorists' confidence. Therefore, this result needs to be interpreted with caution.

Meanwhile, on single carriageways, the effect of the intervention was more difficult to detect, since motorists were found to respond to the presence of police and roadside publicity despite being on the opposite side of their locations. Nevertheless, the analysis shows that the three-factor combination was not statistically significant. It means that the addition of a third factor as an intervention did not add to the effectiveness of speed enforcement. Further investigation showed that only police presence generated statistically significant results in single carriageway routes. Nonetheless, the statistically no different result of the other intervention does not mean that it does not have practical implications since any reduction in mean speed is predicted to have an impact in accident risk. The combination of police and training was able to elicit 10% mean speed reduction which implies a nearly 30% fatal casualty reduction estimate. The proportion of speeding with police only intervention was able to reduce 17.5% proportion of speeding.

The second major finding is that there was a Halo effect observed on both test routes due to the presence of police. A different combination of intervention was found to have produced a different length of Halo effect distance. On dual carriageway, the combination of police, training, roadside publicity was maintained up to 4.2 km. At the same time, the combined treatment also prevented more than 70% of participants from breaking the speed limit again. In single carriageways, this three-factor effect was observed for 1.6 km, and also prevented 33% motorists to re-offend the speed limit.

Evidence from this study suggests that speed enforcement should be able to help police achieve their vision to meet the UN-DOA goals, that is the reduction of 50% of casualties. The enforcement of speed limits is more effective if it is supported by training and publicity. If Indonesia adopts this enforcement even without publicity and training, it would still affect a lot to motorist speed behaviour and in accident and casualty reduction.

Since speed enforcement is new in Indonesian road, police must set their priority to make this new enforcement method more effective and accepted by the public, such as target the speeding in residential areas or in the rural road that has public activity on the roadside. However, police need to consult and work together with all relevant stakeholders and interest groups before the implementation of speed enforcement. Lesson learned from this study as well as from other successful country has to be adopted carefully, as the results might not be generalized to every case of the speed enforcement in another site.

Finally, this study has implications for the Indonesian Police and for other enforcement agencies in the countries where speed enforcement was found ineffective on their road. The research contributes to the body of knowledge relating to the important predictor's public attitude to speed and speed enforcement and traffic police officers of job satisfaction. The findings in the experimental study can fill the gap of the extant research that the integration of training and roadside publicity significantly interacts to the presence of police. Additionally, the research contributes to the advancement of research methods and statistical analysis in the study of Halo effect.

10.6 Recommendations for further research

Finally, police enforcement and motorists' choice of speed are an important issue for future research in the area of road safety. It might be possible to use a different variable and method. Therefore, more research on this topic needs to be undertaken before the link between police enforcement, motorists' choice of speed and road safety is more clearly understood. As stated in the limitation, the study did not evaluate the long-term effect of speed enforcement procedures tested in this study, future research that evaluated them is very important.

Moreover, further research can be undertaken to gain a better understanding of attitudes around speeds, speeding and enforcement. Understanding compliance or non-compliance, investigating why the Halo effect was different for different interventions, before and after study to get a better understanding of motorists' speed behaviour for policymakers, law enforcement agency, and any interested parties in road safety.

Future studies that focus on financial and other penalties for speeding are essential. It is appropriate to see how punishment acts as a deterrent for the general public and specific offenders to persuade the public that breaking the speed limit in the future may result in severe punishments. As well as the research about other methods of police presence in conducting speed enforcement, such as patrol method, combined patrol and stationary, employing unmarked police vehicle, including modifying the levels of these methods, which are able to portray motorists' compliance and their effect on the choice of speed.

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Appendix A Questionnaires, ethical review and study operational agreement

This appendix consists of tools that have been used in the study which included supporting documents that helped this study run efficiently and effectively. The first tool is the questionnaire for police that used to collect police officers' response regarding their job satisfaction. The second questionnaire is public attitude questionnaire that used to understand motorists' perception on road safety, enforcement and speed. At the end of public questionnaire, an invitation letter was attached to invite motorists for further stage of study. An ethical review was overseen to ensure that this study meet the ethical standard that required by University of Leeds. As well as the operating agreement between the researcher and INPTC's supporting team that provide comprehensive guidelines to help all party involved and all road users safe, secure and comfortable.

A.1   Questionnaire for police

POLICE JOB SATISFACTION ON SPEED ENFORCEMENT

Job Satisfaction as traffic police officer:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I am satisfied with being a traffic police officer	1	2	3	4	5
2	If I had the opportunity to go back to the day I decided to become a police officer, I would choose to become a traffic police officer again	1	2	3	4	5
3	I really look forward to coming to work every day	1	2	3	4	5
4	I measure up to the job's standards	1	2	3	4	5

Management Support for speed enforcement:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
5	There is a strong commitment to speed enforcement at all levels of this organization.	1	2	3	4	5
6	Members of this organization show concern for speed enforcement and its improvement.	1	2	3	4	5

7	Continuous improvement on speed enforcement is one of important goals of this organization.	1	2	3	4	5
8	Top police managers in this organization follow up on suggestions for improvement on speed enforcement.	1	2	3	4	5
9	Our top management tries to make this traffic division a good place to work.	1	2	3	4	5
10	Top traffic police managers in my department set clear goals for quality improvement of speed enforcement.	1	2	3	4	5
11	Traffic police managers here try to plan ahead for changes that might affect our performance.	1	2	3	4	5
12	People in this organization are aware of its overall mission.	1	2	3	4	5

Job Challenges on speed enforcement:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
13	The job on speed enforcement requires me to use a number of complex or high-level skills	1	2	3	4	5
14	I have new and interesting things to do in enforcing speed on the public road	1	2	3	4	5
15	Speed enforcement challenges me	1	2	3	4	5
16	Speed enforcement is simple and repetitive (Reverse Coded)	1	2	3	4	5
17	I am never bored at work since I have many different things to do	1	2	3	4	5

Loyalty:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
18	If my fellow officer makes a mistake at work, it is my responsibility to protect him	1	2	3	4	5
19	I will never report against my fellow officer even if he has violated rules	1	2	3	4	5
20	If I violate a rule, I expect my fellow officer to protect me	1	2	3	4	5

Citizen Cooperation:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
21	Citizens would often call the traffic police if they saw speeding motorist.	1	2	3	4	5

22	Citizens would often provide information about a drivers' speeding behaviour if they knew something and were asked by traffic police.	1	2	3	4	5
23	Citizens are willing to work with the police and try to solve speeding problems in their neighbourhood.	1	2	3	4	5

Social Cohesion:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
24	Officers in my work unit enjoy their co-workers	1	2	3	4	5
25	Co-workers in my work unit are like a family.	1	2	3	4	5
26	Problems exist here between co-workers. (Reverse Coded)	1	2	3	4	5
27	I trust my fellow officers to do what is in the best interests of the organization.	1	2	3	4	5

This is the end of questionnaire. Thank you,

A.2 Questionnaire for motorists

PUBLIC ATTITUDE TO ROAD SAFETY, ENFORCEMENT AND SPEED

Part I: General perceived safety						
No	**Question**	**Scale**				
1	Urban roads are safe to travel on	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
2	Rural roads are safe to travel on	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
3	The design and standard of urban roads you use is safe	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
4	The design and standard of rural roads you use is safe	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
Part II: Perception related to road safety factors						
5	To achieve higher levels of road safety, it is important to improve road engineering and design?	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
6	Police effort into catching people breaking road safety laws should be increased	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
7	Penalties for breaking road safety laws should be increased	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
8	Publicity and advertising about road safety should be increased	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
9	Training about road safety should be increased	Strongly not agree	Not agree	Neutral	Agree	Strongly agree

Part III: Attitude to speeding						
10	Enjoy driving fast on open urban road	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
11	Enjoy driving fast on open rural road	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
12	There isn't much chance of accident when speeding on urban road if careful	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
13	There isn't much chance of accident when speeding on rural road if careful	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
14	The risk of being caught speeding is small	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
15	Penalties for speeding are not very severe	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
16	Most people who get caught speeding are just unlucky	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
Part IV: Perception on speed limit						
17	Enforcing the speed limit helps lower the road casualties	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
18	Speed limits on the urban roads I normally use are too high	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
19	Speed limits on the rural roads I normally use are too high	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
20	100 km/h limit on motorway should be raised	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
21	50 km/h limit on urban road should be raised	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
Part V: Perception related speeding and license						

22	Automatic loss of license for speeding at 140 km/h on the open rural road would be fair	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
23	Automatic loss of licence for speeding at 90 km/h in a 50 km zone would be fair	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
24	Automatic loss of licence for 3 speeding tickets in 12 months would be fair	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
Part VI: Perception on being caught by police						
25	Chance of receiving a speeding ticket if passing Police officer (without speed camera) at 110 km/h is high	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
26	Chance of speeding ticket if passing Police officer (without speed camera) at 120 km/h is high	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
27	Chance of speeding ticket if passing Police officer (without speed camera) at 130 km/h is high	Strongly not agree	Not agree	Neutral	Agree	Strongly agree
28	Chance of being stopped for traffic offences other than speeding (General Enforcement) is high	Strongly not agree	Not agree	Neutral	Agree	Strongly agree

This is the end of questionnaire.

There will be an interesting experimental study conducted shortly as part of the same study

If you are interested in later stage of this study, please read the information provided in next page.

A.3 Invitation to participate in experimental study

Dear Participants,

There will be an on-road test-drive study stage to be carried out in the next few days as part of my PhD project on "How can speed enforcement be made more effective". You will have a chance to drive along pre-defined route where your driving speed will be recorded using a GPS device. You just need to drive normally as you do in your daily activity. Some of participants will also have the chance to attend 2 hours training course related to speed and accident risk in Riau Safety Driving Centre.

I would like to assure that data collected from this study is for a PhD thesis and publishable only. This study has ethical approval by the University of Leeds. Your participation is voluntary and will be confidential. Responses will not be identified by individual. All responses will be compiled together and analysed as a group. You also could withdraw from study at any point until the data were written up.

Please provide your contact details below to indicate you are willing to participate in this study and choosing one of the options:

Name: …………………………………………………………………….

Phone: …………………………………………………………………….

Email: ………………………………………………………………….

I would like to participate in:

☐ Test-drive only

☐ Test-drive with speed awareness training in advance

Signature

(   )

I will contact you shortly to provide further information about the study. Thank you very much, again, for your time and valuable contribution to my PhD research.

Yours sincerely

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A.4   Ethical review: recruitment & consent processes, section C.7

How will potential participants in the study be:

(i) Identified?

There are two potential participants in this study. First potential participant is drivers/riders of selected mode of vehicle (car and motorcycle) who travel on free-flow speed traffic and, the second is traffic police officers from enforcement division.

The characteristics for the driver/rider are, both male and female, aged 18 years and over, and hold a valid driving licence. Participants will be selected randomly. Regarding the participants selection, police will conduct speed enforcement around the road network on roadside using speed gun. Police officer will request drivers/riders to stop and explain the recorded speed, speed limit, and, if applicable, inappropriate speed to the condition at the time. Police officer will introduce the researcher and, at the same time, offer the drivers to participate in the study. Participants are not under any obligation to take part if they choose not to do so.

It has been considered that respondents may feel under pressure due to being stopped by the police. However, from the time when police and drivers/riders interact, a brief opening statement will be explained to drivers/riders that the police speed check is conducted only for free flow speed survey and not for enforcement purpose. Drivers/riders have been selected based on free-flow speed measurement (minimum 3 seconds separation between vehicles) where the choice of speed is not under the influence of traffic volume or traffic flow. Speed measurement is not going to be used as a proof of traffic violation, but for research data only which will be anonymised.

Hence, there will be no statement from police mentioning that participants were speeding; instead, police will explain that the activity is the free flow speed measurement. In addition, researcher will convince the police that it is a duty to treat the participants ethically and respectfully. Without the voluntary contributions of participants, it will be impossible to conduct this study and, furthermore, to develop a more effective speed enforcement strategy. The advances made possible through this study will increase knowledge about motorists' choice of speed and effect of each enforcement strategy. Once again, researcher will closely observe and make sure that a duty to treat the participants ethically and respectfully is applied by the police officers.

The next participant is traffic police officer from enforcement division. The characteristics are their status as traffic police officers, including both male and female, aged 19 years and over, and assigned in enforcement division/unit. In the process of identifying the police officer

participants, the researcher will collaborate with the Indonesian National Traffic Police Corps (INTPC) and Regional Traffic Police Unit, particularly the Head of enforcement division/unit. Police participants in this study will be selected randomly and they are not under an obligation to take part if you choose not to do so.

(ii) approached?

For public questionnaire: researcher will respectfully request the driver/rider and traffic police officer to participate in the study by explaining the background and purpose of the study. They will be invited to ask question for more detail point and task which they will take part before they decided to participate in this study.

In addition, researcher will also explain to the driver/rider that the questionnaire for them (public perception questionnaire) contained a section at the end where they are invited to provide contact details (email, telephone or mobile number) if they thought that they would be interested in taking part in the test drive at a later stage of the study.

For traffic police questionnaire: participants that have been identified with the help of police manager will be contacted by phone or email to arrange the meeting or to deliver the questionnaire. They will be invited to ask question for more detail point and task which they will take part before they decided to participate in this study. Once again, researcher will explain that their information will be completely anonymous; it cannot and will not be linked with their position status or job or duty in any way.

For on-road test drive: Potential participants were then contacted if they provided contact details (email or telephone or mobile number) and asked if they would like more information about the test drive. Participants will also be offered to take free speed awareness training at Safety Driving Centre in advance of test drive on pre-defined routes. Details of who will and will not participated, either in test drive only or include the advanced training, will remain confidential.

(iii) recruited?

For both questionnaires study: participants are recruited once they agree to take part and sign the participants' consent form. Whilst, on road test-drive participants will be recruited through those who had completed the questionnaire and voluntarily offered contact details. Contact will be made by letter, email or phone.

A.5   Speed enforcement study operational agreements

The researcher and INPTC's supporting team have agreed to attend and to provide:

1. Research information sheet for police officers, interviewers, and all other individuals engaged in the survey identifying their role and responsibility together with broad details of the role and responsibility of the researcher with whom individuals on site should liaise;
2. Details of appropriate risk assessments undertaken for all people engaged in the survey;
3. Any specific survey requirements, e.g. free-flow speed measurement, whether to exclude HGV/LGV or particular vehicles, etc.; must be observed all the time.
4. Any specific requirements for additional traffic management such as floodlighting or more robust signage in appropriate circumstances;
5. Adverse weather contingency plan;
6. Details on the method of monitoring queue lengths and delays and an agreed action plan to speedily release any significant tailbacks of traffic that exceed agreed thresholds;
7. An agreed contingency plan to cater for emergency vehicles passing through the site;
8. Criteria for the temporary or permanent suspension of the survey due to congestion, or other operational reasons, and by whom such decisions will be taken;
9. A media/public relations strategy, including notification to emergency services (police, fire and ambulance) and bus service operators, but not publicising precise survey locations to the general public as this may cause re-routing and a consequent false sample of traffic;
10. A procedure for dealing with comments or queries, with accompanying leaflets or signs, which identify the commissioning authority to whom any such comments or queries should be addressed;
11. Instructions on the clear intention, at the beginning of the interview, to indicate to drivers that they are under no obligation to answer the survey questions and that any responses offered are entirely voluntary;
12. Details and confirmation, by liaison with the local highway authorities and public utility companies as appropriate, to ensure that no road works or other activities are occurring in the area which are likely to impact adversely upon the effective operation of the survey site;
13. Appropriate toilet and rest facilities for staff in accordance with the requirements of Health and Safety;
14. Traffic management arrangements in accordance with the requirements of Chapter 8 of the Traffic Signs Manual, to be both deployed and removed by the appointed traffic management worker; and
15. A concise on-site briefing immediately prior to the commencement of the survey and experiment.

Appendix B Three-way ANOVA result

This appendix presents a descriptive statistic and result of three-way ANOVA and further analysis of any significant interactions of variables of experiment. The study design was described as Between-Subject factors where there were two routes with three independent variables that were all categorical with two level in each independent variable. Furthermore, Levene test was applied to determine the equality of error variance, while to assess the outliers, the boxplots were utilized.

After running the three-way ANOVA with SPSS Statistics application, the tables of the test between subject result was generated that provide the starting point to interpret your results, primarily to determine whether a statistically significant three-way interaction exists. Next step was to investigate whether there was a statistically significant difference in the simple two-way interactions. In this study, the simple two-way interactions were significant which was followed by the investigation of simple-simple main effect. Any statistically significant simple-simple main effects with were followed by simple-simple comparisons.

B.1 Between-Subject factors

Between-Subjects Factors				Value Label	N
Test route					
Dual carriageway	Training	0		Absence	300
		1		Presence	300
	Police	0		Absence	300
		1		Presence	300
	Publicity	0		Absence	300
		1		Presence	300
Single carriageway	Training	0		Absence	300
		1		Presence	300
	Police	0		Absence	300
		1		Presence	300
	Publicity	0		Absence	300
		1		Presence	300

B.2 Levene test

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Mean speed

Test drive route	F	df1	df2	Sig.
Dual carriageway	5.038	7	592	.000
Single carriageway	3.024	7	592	.004

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + Age_group + Gender + Vehicle + Training + Police + Publicity + Training * Police + Training * Publicity + Police * Publicity + Training * Police * Publicity

B.3   Boxplot

Test_drive_route: Route B - Kulim, Speed_awareness_training: Absence, Police: Presence, Publicity_billboard: Absence

Test_drive_route: Route B - Kulim, Speed_awareness_training: Absence, Police: Presence, Publicity_billboard: Presence

Test_drive_route: Route B - Kulim, Speed_awareness_training: Presence, Police: Presence, Publicity_billboard: Absence

Test_drive_route: Route B - Kulim, Speed_awareness_training: Presence, Police: Presence, Publicity_billboard: Presence

B.4   Test between subject result
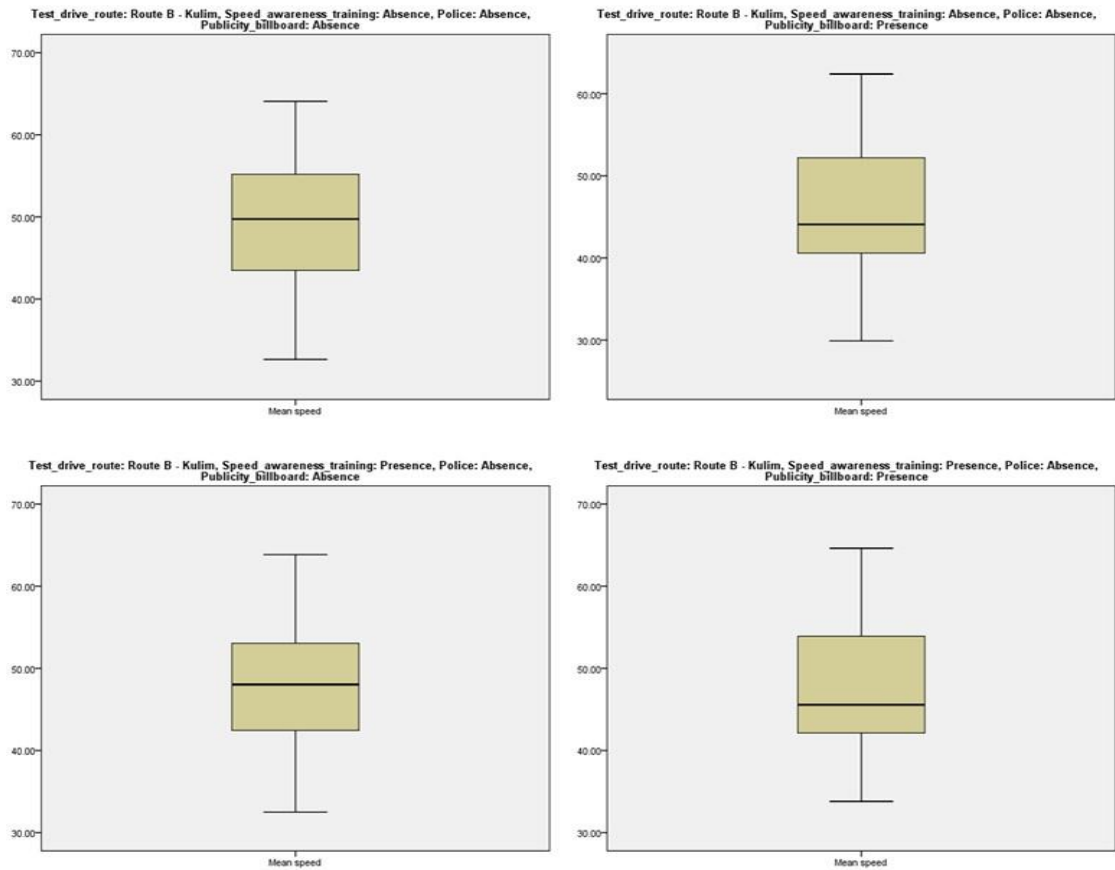
Tests of Between-Subjects Effects						
Dependent Variable: Mean speed						
Test_drive_route		Type III Sum of Squares	df	Mean Square	F	Sig.
Dual carriageway 60 km/h	Corrected Model	18168.732[a]	10.0	1816.9	15.0	0.000
	Intercept	81611.1	1.0	81611.1	675.3	0.000
	Age_group	687.9	1.0	687.9	5.7	0.017
	Gender	1803.3	1.0	1803.3	14.9	0.000
	Vehicle	662.6	1.0	662.6	5.5	0.020
	Training	752.7	1.0	752.7	6.2	0.013
	Police	3852.8	1.0	3852.8	31.9	0.000
	Publicity	4113.4	1.0	4113.4	34.0	0.000
	Training * Police	63.6	1.0	63.6	0.5	0.469
	Training * Publicity	4062.0	1.0	4062.0	33.6	0.000
	Police * Publicity	1246.2	1.0	1246.2	10.3	0.001
	Training * Police * Publicity	532.8	1.0	532.8	4.4	0.036
	Error	71183.8	589.0	120.9		
	Total	2042318.6	600.0			
	Corrected Total	89352.6	599.0			
Single carriageway 50 km/h	Corrected Model	1505.8	10.0	150.6	2.6	0.004
	Intercept	33489.8	1.0	33489.8	585.9	0.000
	Age_group	665.4	1.0	665.4	11.6	0.001
	Gender	138.9	1.0	138.9	2.4	0.120
	Vehicle	1.4	1.0	1.4	0.0	0.876
	Training	1.6	1.0	1.6	0.0	0.869
	Police	80.1	1.0	80.1	1.4	0.237
	Publicity	2.4	1.0	2.4	0.0	0.839
	Training * Police	0.1	1.0	0.1	0.0	0.968
	Training * Publicity	256.1	1.0	256.1	4.5	0.035
	Police * Publicity	269.4	1.0	269.4	4.7	0.030
	Training * Police * Publicity	24.1	1.0	24.1	0.4	0.516
	Error	33664.9	589.0	57.2		
	Total	1374132.3	600.0			
	Corrected Total	35170.6	599.0			
a. R Squared = .203 (Adjusted R Squared = .190)						
b. R Squared = .043 (Adjusted R Squared = .027)						

B.5 Simple two-way interactions

Tests of Between-Subjects Effects							
Dependent Variable:							
Test_drive_route			Type III Sum of Squares	df	Mean Square	F	Sig.
Dual carriageway	Absence	Corrected Model	7982.052ª	6	1330.342	10.909	.000
		Intercept	38591.029	1	38591.029	316.448	.000
		Age_group	801.415	1	801.415	6.572	.011
		Gender	1708.077	1	1708.077	14.006	.000
		Vehicle	265.649	1	265.649	2.178	.141
		Training	791.805	1	791.805	6.493	.011
		Police	4464.953	1	4464.953	36.613	.000
		Training * Police	175.002	1	175.002	1.435	.232
		Error	35731.576	293	121.951		
		Total	1116628.111	300			
		Corrected Total	43713.628	299			
	Presence	Corrected Model	6231.367ᵇ	6	1038.561	8.727	.000
		Intercept	41269.669	1	41269.669	346.798	.000
		Age_group	111.742	1	111.742	.939	.333
		Gender	444.210	1	444.210	3.733	.054
		Vehicle	561.809	1	561.809	4.721	.031
		Training	4231.282	1	4231.282	35.556	.000
		Police	411.712	1	411.712	3.460	.064
		Training * Police	485.896	1	485.896	4.083	.044
		Error	34867.611	293	119.002		
		Total	925690.522	300			
		Corrected Total	41098.978	299			
Single carriageway	Absence	Corrected Model	1001.785ᶜ	6	166.964	2.899	.009
		Intercept	16559.175	1	16559.175	287.548	.000
		Age_group	289.709	1	289.709	5.031	.026
		Gender	103.538	1	103.538	1.798	.181
		Vehicle	8.271	1	8.271	.144	.705
		Training	157.475	1	157.475	2.735	.099
		Police	319.833	1	319.833	5.554	.019
		Training * Police	9.298	1	9.298	.161	.688
		Error	16873.171	293	57.588		
		Total	691898.025	300			
		Corrected Total	17874.956	299			
	Presence	Corrected Model	506.723ᵈ	6	84.454	1.475	.186
		Intercept	15586.778	1	15586.778	272.269	.000
		Age_group	337.762	1	337.762	5.900	.016
		Gender	53.046	1	53.046	.927	.337
		Vehicle	.134	1	.134	.002	.961
		Training	104.265	1	104.265	1.821	.178
		Police	31.392	1	31.392	.548	.460
		Training * Police	10.619	1	10.619	.185	.667
		Error	16773.599	293	57.248		
		Total	682234.288	300			
		Corrected Total	17280.322	299			
a. R Squared = .183 (Adjusted R Squared = .166)							
b. R Squared = .152 (Adjusted R Squared = .134)							
c. R Squared = .056 (Adjusted R Squared = .037)							
d. R Squared = .029 (Adjusted R Squared = .009)							

B.6 Simple-simple main effect

				Type III Sum of Squares	df	Mean Square	F	Sig.
Tests of Between-Subjects Effects								
Dependent Variable:								
Test_drive_route								
Dual carriageway	Absence	Absence	Corrected Model	3605.799[a]	4	901.450	10.988	.000
			Intercept	18229.070	1	18229.070	222.200	.000
			Age_group	4.286	1	4.286	.052	.820
			Gender	1401.217	1	1401.217	17.080	.000
			Vehicle	.082	1	.082	.001	.975
			Police	1646.080	1	1646.080	20.065	.000
			Error	11895.667	145	82.039		
			Total	530608.903	150			
			Corrected Total	15501.466	149			
		Presence	Corrected Model	2221.531[b]	4	555.383	3.272	.013
			Intercept	26539.164	1	26539.164	156.336	.000
			Age_group	735.820	1	735.820	4.335	.039
			Gender	404.291	1	404.291	2.382	.125
			Vehicle	253.161	1	253.161	1.491	.224
			Police	761.191	1	761.191	4.484	.036
			Error	24614.727	145	169.757		
			Total	532793.050	150			
			Corrected Total	26836.258	149			
	Presence	Absence	Corrected Model	4409.098[c]	4	1102.275	6.839	.000
			Intercept	18971.888	1	18971.888	117.714	.000
			Age_group	1018.334	1	1018.334	6.318	.013
			Gender	648.346	1	648.346	4.023	.047
			Vehicle	350.797	1	350.797	2.177	.142
			Police	3341.104	1	3341.104	20.730	.000
			Error	23369.556	145	161.169		
			Total	586019.208	150			
			Corrected Total	27778.654	149			
		Presence	Corrected Model	627.486[d]	4	156.871	2.431	.050
			Intercept	14804.871	1	14804.871	229.434	.000
			Age_group	183.737	1	183.737	2.847	.094
			Gender	165.097	1	165.097	2.559	.112
			Vehicle	189.607	1	189.607	2.938	.089
			Police	2.695	1	2.695	.042	.838
			Error	9356.519	145	64.528		
			Total	392897.473	150			
			Corrected Total	9984.005	149			
Single carriageway	Absence	Absence	Corrected Model	948.168[e]	4	237.042	3.355	.012
			Intercept	9475.784	1	9475.784	134.127	.000
			Age_group	494.774	1	494.774	7.003	.009
			Gender	255.136	1	255.136	3.611	.059
			Vehicle	35.569	1	35.569	.503	.479
			Police	260.835	1	260.835	3.692	.057
			Error	10243.968	145	70.648		

			Total	360003.776	150			
			Corrected Total	11192.137	149			
		Presence	Corrected Model	261.970[f]	4	65.492	1.067	.375
			Intercept	8290.785	1	8290.785	135.136	.000
			Age_group	144.025	1	144.025	2.348	.128
			Gender	4.579	1	4.579	.075	.785
			Vehicle	37.462	1	37.462	.611	.436
			Police	48.259	1	48.259	.787	.377
			Error	8895.957	145	61.351		
			Total	337310.728	150			
			Corrected Total	9157.927	149			
	Presence	Absence	Corrected Model	302.412[g]	4	75.603	1.775	.137
			Intercept	7348.297	1	7348.297	172.485	.000
			Age_group	1.843	1	1.843	.043	.836
			Gender	2.608	1	2.608	.061	.805
			Vehicle	52.527	1	52.527	1.233	.269
			Police	220.328	1	220.328	5.172	.024
			Error	6177.362	145	42.602		
			Total	331894.249	150			
			Corrected Total	6479.775	149			
		Presence	Corrected Model	324.432[h]	4	81.108	1.514	.201
			Intercept	7311.109	1	7311.109	136.442	.000
			Age_group	204.114	1	204.114	3.809	.053
			Gender	71.009	1	71.009	1.325	.252
			Vehicle	30.358	1	30.358	.567	.453
			Police	.028	1	.028	.001	.982
			Error	7769.658	145	53.584		
			Total	344923.561	150			
			Corrected Total	8094.090	149			

a. R Squared = .233 (Adjusted R Squared = .211)

b. R Squared = .083 (Adjusted R Squared = .057)

c. R Squared = .159 (Adjusted R Squared = .136)

d. R Squared = .063 (Adjusted R Squared = .037)

e. R Squared = .085 (Adjusted R Squared = .059)

f. R Squared = .029 (Adjusted R Squared = .002)

g. R Squared = .047 (Adjusted R Squared = .020)

h. R Squared = .040 (Adjusted R Squared = .014)

B.7   Pairwise comparison

Pairwise Comparisons								
Dependent Variable:								
Test_drive_route					Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]
								Lower Bound	Upper Bound
Dual carriageway	Absence	Absence	Absence	Presence	6.750*	1.813	.000	3.189	10.311
			Presence	Absence	-6.750*	1.813	.000	-10.311	-3.189
		Presence	Absence	Presence	4.767*	1.799	.008	1.233	8.301
			Presence	Absence	-4.767*	1.799	.008	-8.301	-1.233
	Presence	Absence	Absence	Presence	9.226*	1.796	.000	5.698	12.754
			Presence	Absence	-9.226*	1.796	.000	-12.754	-5.698
		Presence	Absence	Presence	-.324	1.799	.857	-3.858	3.210
			Presence	Absence	.324	1.799	.857	-3.210	3.858
Based on estimated marginal means								
*. The mean difference is significant at the .05 level.								
b. Adjustment for multiple comparisons: Bonferroni.								